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Ultrasound Transducer & Exam Room Guidelines

Required tasks that should be performed following an Ultrasound exam:

All transabdominal transducers:

- Wipe the transducer with a “grey topped” Sani Cloth AF3 towelette (found in all rooms) before any imaging study is begun prior to patient contact.
- After the study is completed, the transabdominal transducer should be wiped with a clean towel to remove any residual contact gel.
- All transducers should be securely seated into the transducer holders on the unit. ****Transducers should never be left hanging on the unit****

All transvaginal transducers:

- Remove the protector cover and discard it. Using a clean towel, wipe off all the residual gel. Place the transducer in a “plastic dust cover bag”, seal the bag & attach a red biohazard sticker (found in the cabinet drawers).
- **Effective 12/10/21**, Take the transducer to the cubicle (behind to Dennis’ office) and place it in a labeled “dirty” box for decontamination processing during business hours.

Transducer labeling on all endocavitary/transvaginal exams:

- Indicate the transducer number as the first image for ALL endocavitary/transvaginal exams. This workflow is required for tracking the transducer should a future contamination be identified. The transducer number can be found on the transducer connector.
- When dictating, via the Power Scribe template(s) for both TV and Viability exams,
****please indicate the transducer number in the appropriate field under technique**.**

Housekeeping:

- The stretcher should be placed against the wall and set to the lowest position.
- Empty gel bottles should be discarded. All others should be returned to the warmer and the lid closed
- Ultrasound unit should be powered off when the study has been completed.
- All lights should be shut off, the exam door closed & locked upon leaving the Ultrasound section.

Dept. Procedure Title	Ultrasound Abdomen Limited Right Upper Quadrant (RUQ) Imaging Procedure - Radiology	Procedure ID	10713
Keywords	RUQ, right, upper, limited, quadrant, us, ultrasound, abdomen, hepatology		
Department	Ultrasound		

I. Purpose

To describe the procedures for performing limited abdominal ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Abdomen Limited Right Upper Quadrant (RUQ) Imaging

1. Liver

- i. Perform longitudinal and transverse views to assess the liver parenchyma for focal or diffuse abnormalities.
- ii. Compare the liver echogenicity to that of the right kidney.
- iii. Obtain images to include hepatic lobes (right, left, and caudate), inferior vena cava (IVC) and right hemidiaphragm.
- iv. Perform measurement of the liver length in a sagittal plane at the level of the right kidney (anterior axillary line).

2. Gallbladder and Biliary System

- i. Obtain longitudinal and transverse images of the gallbladder in the supine and decubitus positions.
- ii. Measure the gallbladder wall.
- iii. Assess for a sonographic “Murphy’s sign.
- iv. Evaluate for the presence or absence of intrahepatic and extrahepatic bile duct dilatation.

- v. Obtain measurement of the bile duct preferably over the right hepatic artery in the portal hepatitis.
 - Additional imaging in the upright position may be helpful in finding small stones in the gallbladder neck.

3. Pancreas

- i. Perform transverse and sagittal images of the pancreas to include head, body, and tail.
- ii. Evaluate and measure the pancreatic duct and the distal common bile duct in the region of the pancreatic if dilated.

4. Right Kidney

- i. Obtain representative images in the longitudinal and transverse planes of the right kidney.
 - Longitudinal images should document lateral and medial margins of the kidney.
- ii. Include transverse views of upper, mid, and lower poles.
- iii. Perform maximum measurements (minimum of 2) of renal length.
- iv. Compare renal echogenicity to that of the liver.
- v. Use a color Doppler to exclude mild hydronephrosis vs. hilar vessels.

B. Abdomen Limited - Hepatology Imaging Protocol

- **(Imaging of the spleen may also be requested. Check order for clarification)**

1. Liver

- i. Perform longitudinal and transverse views to assess the liver parenchyma for focal or diffuse abnormalities.
- ii. Compare the liver echogenicity to that of the right kidney.
- iii. Obtain images to include hepatic lobes (right, left, and caudate), inferior vena cava (IVC) and right hemidiaphragm.
- iv. Perform measurement of the liver length in a sagittal plane at the level of the right kidney (anterior axillary line).

2. Gallbladder and Biliary System

- i. Obtain longitudinal and transverse images of the gallbladder in the supine and decubitus positions.
- ii. Measure the gallbladder wall.
- iii. Assess for a sonographic “Murphy’s sign”.
- iv. Evaluate for the presence or absence of intrahepatic and extrahepatic bile duct dilatation.
- v. Obtain measurement of the bile duct preferably over the right hepatic artery in the portal hepatitis.
 - Additional imaging in the upright position may be helpful in finding small stones in the gallbladder neck.

3. Spleen

- **(Imaging may be requested. Check order for clarification)**
 - i. Obtain representative images of the spleen in the longitudinal and transverse planes.
 - ii. Perform longitudinal and transverse measurements of the spleen.
 - iii. Compare the splenic echogenicity to that of the left kidney.

VI. References **N/A**

Responsible Owner:	Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Connell, Chandler; Kvinlaug, Christine	Version #	4
Current Approval Date:	05/02/2022	Old Document ID:	
Date Procedure to go into Effect:	05/02/2022		
Related Polices & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Adult Native Kidney Imaging Procedure - Ultrasound - Radiology	Procedure ID	11182
Keywords	adult, native, kidney, sonographers, sonologists, interpretation, images, imaging, us, ultrasound, studies		
Department	Ultrasound		

I. Purpose of Procedure

To describe procedures for performing native kidney Ultrasound studies.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

The following standard images are required for interpretation.

1. Obtain representative images in the longitudinal and transverse planes of both kidneys.
2. Document lateral and medial margins of the kidneys for longitudinal images.
3. Include labeled images of upper, mid, and lower poles for transverse views of both kidneys.
4. Include the maximum measurements (minimum of 2) of renal length of both kidneys.
5. Compare renal echogenicity to that of the liver or spleen.
6. Obtain longitudinal and transverse images of the urinary bladder.
7. Utilize the Color Doppler to document urinary jets when hydronephrosis is present.
8. When there is a clinical suspicion of pyelonephritis, record color or Power Doppler images.
9. Use Color Doppler to exclude mild hydronephrosis versus hilar vessels when the gray scale images are equivocal.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Connell, Chandler; Kvinlaug, Christine	Version #	3
Current Approval Date:	10/28/2021	Old Document ID:	5643
Date Procedure to go into Effect:	10/28/2021		
Related Policies & Procedures:	Native and Transplant Kidney Biopsy Imaging Procedure - Ultrasound - Radiology		
Related Job Aids:			

Procedure Title	Airborne Precautions Procedure	Procedure ID	7417
Keywords	airborne, precautions, chickenpox, varicella, zoster, herpes, tuberculosis, tb, measles, PAPR, N95, checklist		

I. Purpose of Procedure

The purpose of this procedure is to standardize the process to safely place and maintain patients on Airborne Precautions.

II. Procedure Scope

All providers, staff, students, and volunteers at Dartmouth-Hitchcock.

III. Definitions

Airborne Precautions are used for diseases spread through aerosolizing tiny respiratory particles into the air, that remain suspended for long periods of time. Examples include tuberculosis (TB), disseminated herpes zoster (DHZ), chickenpox, and measles.

IV. Equipment

- Negative pressure room
- N95 respirator
- Powered air purifying respirator (PAPR) unit
- Half face elastomeric respirator
- Eye Protection (face shield, goggles, safety glasses)
- Level II masks
- Yellow precaution gowns
- Respiratory Isolation Cart (RIC)
- Airborne Precautions sign
- Contact Precautions sign
- Portable high efficiency particulate (HEPA) filter

V. Procedure

A. For Inpatient and Outpatient Areas When a Patient Requires Airborne Precautions

1. Obtain a respiratory isolation cart (RIC) from Inventory and Logistics (Stores) by calling 5-6101.
2. Store the cart outside the room, or in the anteroom.
3. Verify cart is plugged in to the nearest outlet at all times.
4. Post the specific isolation precautions sign on the door to the patient room:
 - a. Tuberculosis (TB) or measles: Airborne Precautions
 - b. DHZ or chickenpox: Airborne **and** Contact Precautions
 - c. Novel respiratory illnesses: Airborne **and** Contact Precautions

5. Patient is to be cared for in a negative pressure room.
 - a. If the patient is in an area that lacks a negative pressure room, a portable HEPA filter must be ordered by calling Engineering at 5-7150 or pager 9234.
 - b. Keep the door closed at all times; for negative pressure rooms with an anteroom both doors are to remain closed at all times.
6. Before the patient arrives in the room:
 - a. For areas with a negative pressure room, ensure the room is negative pressure and that the pressure monitor is functioning.
 - i. The pressure monitor must read -0.01 or less at all times (this means that the room is negative).
 - ii. Ensure the monitor alarm is on and test the monitor alarm. When working correctly, the monitor will alarm if the door to the room is left open. If you are unsure of the process for testing the monitor alarm, or if the monitor alarm is not functioning, please contact Engineering at 5-7150 (M-F 0800 -1600) or pager 9234.
 - b. In areas lacking a negative pressure room, the HEPA filter must be placed in the room and turned on prior to the patient's arrival.
7. Review staff respirator fit test records (available from Environmental, Health and Safety) to ensure anyone entering the room has been fit tested and trained within the last year.

The following table is used to guide the set up and proper use of the room:

	TB	DHZ, Chickenpox	Measles	Novel Respiratory Illnesses
Room type	Negative Pressure	Negative Pressure	Negative Pressure	Negative Pressure
Room setup	Remove any unnecessary equipment and supplies	Remove any unnecessary equipment and supplies	Remove any unnecessary equipment and supplies	Remove any unnecessary equipment and supplies
Respiratory protection	N95 respirator or PAPR (motor and hood)	No respiratory protection indicated for IMMUNE staff.	N95 respirator or PAPR (motor and hood)	N95 respirator OR half face elastomeric respirator OR PAPR
Eye/Face Protection	Disposable face shield or goggles (safety glasses not adequate)	Disposable face shield or goggles (safety glasses not adequate)	Disposable face shield or goggles (safety glasses not adequate)	Disposable face shield or goggles (safety glasses not adequate)
Gowns	Follow Standard Precautions	For contact with the patient or environment	Follow Standard Precautions	For contact with the patient or environment
Gloves	Follow Standard Precautions	For contact with the patient or environment	Follow Standard Precautions	For contact with the patient or environment

Trash/linen	Routine practices	Routine practices	Routine practices	Routine practices
Equipment	Discard or decontaminate prior to reuse	Discard or decontaminate prior to reuse	Discard or decontaminate prior to reuse	Discard or decontaminate prior to reuse
Visitors	Wear a level II mask but explain that it does not offer complete protection.	Wear a level II mask, but explain that it does not offer complete protection; gown and gloves not indicated	Wear a level II mask but explain that it does not offer complete protection.	Visitors are prohibited.

B. For Patients on Airborne Precautions Admitted to an Inpatient Unit

1. Follow steps in section A above.
2. Notify the following departments when the patient is placed on Airborne Precautions:
 - a. House Supervisor at pager 9732
 - b. Collaborative Healthcare-associated Infection Prevention Program (CHIP) at pager 8447 or email washyourhands@hitchcock.org
 - c. D-H Safety Office at 5-7233 or email safety@hitchcock.org
 - d. Nurse Manager or RN Unit Supervisor
2. Educate patient and/or family members on the use of Airborne Precautions and document education in patient chart.
3. Place an order in eD-H for the appropriate isolation. Nursing may place the order per protocol.
4. Patients may only leave the room for medically necessary procedures that cannot be performed in the room.
 - a. When scheduling patients for tests or procedures, notify the receiving area of the need for Airborne Precautions.
5. Patients MUST wear a level II mask when leaving the room. Patients DO NOT wear an N95 or PAPR when leaving the room.
6. Review the “Resuscitation of Patients on Airborne Precautions” procedure online.
7. For daily cleaning of the room, PPE is to be worn (as above).
8. After using the PAPR hood and motor, wipe the outside of each unit (motor and hood) with PDI Super Sani-Cloths.
 - a. Clean the inside of the face shield part of the hood with an alcohol wipe.
 - i. There may be special cleaning procedures in conjunction with central sterile reprocessing should the situation warrant such cleaning.
9. Go to the D-H Intranet to view a video refresher for proper donning, doffing, and disposal of PPE.

C. For Patients Requiring Airborne Precautions in the Clinic Area

1. Follow steps in section A above.
2. On the day of the appointment, give the reception staff the name and medical record number of the patient requiring Airborne Precautions.
3. Instruct the reception staff to carry out steps 4 and 5 below.
4. When the patient arrives, they must don a level II or higher mask covering the mouth and nose.
5. Room the patient immediately. These patients must not sit in the waiting area.

D. For Patients Requiring Airborne Precautions in Procedural Areas (non-OR)

1. Follow the steps in section A above.
2. Patients must don Level II mask covering the mouth and nose during transport. Patients DO NOT wear an N95 or PAPR when leaving the room.
3. Room patient immediately. Patients must not wait or recover in open areas (e.g. PACU, Same Day, waiting rooms)

E. Discharging or Transferring Patients From Inpatient and Outpatient Areas

1. After the patient is discharged or transferred, the room is to remain on negative airflow or the HEPA filter must remain on in the room with the door or doors closed for 60 minutes, unless room-specific time has been calculated by measured air changes. Signage remains on the door.
2. After that time, respiratory protection is no longer necessary, but all other PPE required for room cleaning is to be used.
3. Contact Environmental Services for terminal room cleaning.
4. Follow Environmental Services policies for terminal cleaning of Airborne Precaution and/or Contact Precaution rooms (linked below) and remove signage after room cleaning is complete.

F. Management of non-negative pressure rooms that a patient requiring Airborne Precautions has been discharged from (clinic, procedural (non-OR) inpatient areas)

1. After the patient has left the room, ensure the door to the room stays closed for 60 minutes in inpatient and 90 minutes in clinic areas unless room specific time has been calculated by measured air changes. Signage remains on the door.
 - a. Ensure the proper expanded precautions signage remains on the door until a terminal clean has been completed.
2. After that time, respiratory protection is no longer necessary, but all other PPE required for room cleaning is to be used.
3. Contact Environmental Services for terminal room cleaning. Clinic spaces may perform normal room cleaning practices for patients on precautions.

Note: Staff who believe they have had an unprotected exposure to a patient on Airborne Precautions are to report the exposure via the Occurrence with Learning (OWLs) system AND contact CHIP (Infection Prevention) at pager 8447 or washyourhands@hitchcock.org. Infection Prevention staff and Occupational Medicine work together to determine the type of exposure and the employee is informed if any further follow up or testing is needed.

VI. References N/A

Responsible Owner:	CHIP	Contact(s):	Caitlin Adams Barker washyourhands@hitchcock.org
Approved By:	Office of Policy Support - All Other Documents; Mercado, Jose; Michel, Melanie	Version #	5
Current Approval Date:	06/25/2021	Old Document ID:	INFC.0017
Date Procedure to go into Effect:	06/25/2021		
Related Polices & Procedures:	Standard and Expanded Precautions Policy Chickenpox and Shingles Management Procedure Resuscitation of Patients on Airborne Precautions Procedure Cleaning Powered Air Purifying Respirator (PAPR) Motor		

Printed copies are for reference ONLY. Please refer to the electronic copy for the latest version.

Reference ID #7417, Version #5

Approval Date: 06/25/2021

Related Job Aids:	Precautions for Specific Diseases and Conditions - Job Aid Airborne Precaution Room Cleaning Procedure - Environmental Services Airborne Precautions Sign Job Aid Contact Precautions Sign Job Aid Contact Precaution Discharge Patient Room Cleaning Procedure - Environmental Services Contact Precaution Occupied Patient Room Cleaning Procedure- Environmental Services
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Dept. Procedure Title	Abdominal Aorta Imaging Procedure - Ultrasound - Radiology	Procedure ID	11183
Keywords	interpret, interpretation, sonographers, sinologist, us, ultrasound, abdominal, aorta		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for performing abdominal aorta ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all Sonographers and Sonologists within the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Specific Scheduling Orders

- Screening evaluation of the Aorta should be ordered as IMG3585 (AAA screening).
- Follow up for a known aortic aneurysm or signs & symptoms should be ordered as IMG3502 (retroperitoneum limited).

B. Standard Images Required for Interpretation

- Obtain representative longitudinal and transverse images of the entire abdominal aorta to the bifurcation.
- Record a minimum of three levels (proximal, mid, distal) longitudinal AP and transverse measurements.
- Report the longitudinal (AP) and transverse (Trans) measurements only into the structured reporting package.
- Obtain the AP measurement from the longitudinal image.
- Obtain longitudinal and transverse images and measurements of the proximal common iliac arteries.
- Obtain color Doppler images of the abdominal aorta and proximal common iliac arteries documenting thrombus if present.
- Screening evaluation and/or assessment for known aneurysm require the same standard images.

VI. References N/A

Responsible Owner:	Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Connell, Chandler; Kvinlaug, Christine	Version #	3
Current Approval Date:	12/02/2021	Old Document ID:	
Date Procedure to go into Effect:	12/02/2021		
Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Appendix Imaging Procedure - Ultrasound - Radiology	Procedure ID	17876
Keywords	appendix, imaging		
Department	Radiology, Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographers and sonologists performing appendix specific Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This applies to all sonographers and sonologists with the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

- Using a linear high frequency transducer **and graded compression**, obtain static images of the right lower quadrant with particular attention to the site of patient's maximum discomfort.
- Attempt to identify the appendix as a blind ending tubular structure documenting any of the following features that may indicate appendicitis:
 - Appendix diameter greater than 6 mm (occasionally normal up to 8 mm).
 - Appendix wall thickness 3 mm or greater.
 - Non compressible
 - Appendicolith often with an acoustic shadow
 - Increased periappendiceal echogenicity suggesting inflammation
 - Increased appendiceal mural color flow suggesting hyperemia
 - Free or localized fluid in the RLQ
- Obtain cine through any area of question

VI. References N/A

Responsible Owner:	Department of Radiology	Contact:	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine	Version #	2
Current Approval Date:	12/03/2020	Old Document ID:	
Date Procedure to go into Effect:	12/03/2020		
Related Policies & Procedures:			
Related Job Aids:			

Departmental Policy Title	Changing Orders Protocol - Radiology - Ultrasound	Policy ID	26672
Keywords	change, changing, order, radiology, ultrasound		
Department	Dartmouth-Hitchcock – Lebanon Radiology		

I. Purpose of Policy

To describe the steps to amend orders so the appropriate examination can be performed based upon the clinical questions or diagnosis. Changes made to Ultrasound exams are to be considered within the clinical scope of practice or both Sonographers and Sonologists.

II. Policy Scope

This procedure applies to all Ultrasound imaging (Obstetrical, Gynecologic, Abdominal & Superficial) studies performed at Dartmouth-Hitchcock - Lebanon.

III. Definitions N/A

IV. Policy Statement

- All Ultrasound orders are reviewed pre-exam through the Radiant orders verification process.
- The indication and/or diagnosis listed determines the exam necessity. Communication to the attending/ ordering physician will be conducted via EPIC secure chat to request a new order be placed. Should the physician be unavailable, the Ultrasound attending Radiologist can give authorization and the order changed “per Radiology protocol”.
- Once communication is completed, a note will be placed in EPIC within “study notes” referencing the order change and include the date, time, and initials.
- The best imaging approach is to be defined in real time and should determine the exam necessity. Endo cavitory or transabdominal approach is considered within this clinical scope of practice.

V. References N/A

Responsible Owner:	Radiology - Ultrasound	Contact:	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Connell, Chandler; Kvinlaug, Christine	Version #	1
Current Approval Date:	01/20/2022	Old Document ID:	
Date Policy to go into Effect:	01/20/2022		
Related Policies & Procedures:			
Related Job Aids:			

Departmental Policy Title	Chaperone Policy for Ultrasound Exams - Radiology	Policy ID	1217
Keywords	chaperone, ultrasound, us		
Department	Radiology – Ultrasound Section		

I. Purpose of Policy

To define the circumstances under which a chaperone is required during an ultrasound examination and to describe the process for obtaining chaperones.

II. Policy Scope

D-H Department of Radiology, Ultrasound Section.

III. Definitions

Eligibility for chaperoning is limited to adult employees (male or female, as specified) of Dartmouth-Hitchcock and student doctors at the Geisel School of Medicine. Volunteers who are neither employees nor Geisel students are *not* eligible.

IV. Policy Statement

- Intracavitary, transperineal, or breast ultrasound examinations of a female patient may be performed by a male sonographer only in the presence of a female chaperone.
- A female sonographer may, at her discretion, request the presence of a chaperone during an examination of a male patient (i.e. testicular exam).
- Responsibility for securing chaperone services
 - During normal business hours (0800-1700, M-F), responsibility for arranging chaperone services rests with the sonographer performing the examination.
 - Outside of normal business hours, the ordering department will be asked to provide a chaperone (when required) for all on-call ultrasound studies.
 - If staffing limitations make it unfeasible to provide a chaperone, the Emergency Department (ED) Charge Nurse (or in the case of a non-ED patient, the requesting provider) will call the D-H House Supervisor (pager 9732) and request a chaperone.
 - The ED Charge Nurse (or in the case of a non ED patient, the requesting provider) will communicate with the on-call Radiology resident to ensure a timely process and scheduling for the ultrasound exam of the patient.

V. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Chief Officer - Operating (MHMH); Office of Policy Support - All Other Documents; Chertoff, Jocelyn	Version #	3
Current Approval Date:	05/07/2020	Old Document ID:	
Date Policy to go into Effect:	05/07/2020		
Related Policies & Procedures			
Related Job Aids:	Ultrasound Imaging of Emergency Department (ED) Patients - Job Aid - Radiology		

Dept. Procedure Title	Complete Abdomen Imaging Procedure - Ultrasound - Radiology	Procedure ID	11184
Keywords	complete, abdomen, abdominal, sonographers, sonologists, interpretation, studies, images, imaging, ultrasound, us, liver, gallbladder, pancreas, kidney		
Department:	Ultrasound		

I. Purpose of Procedure

To describe the procedures for performing abdominal Ultrasound studies which include Abdomen Limited, Abdomen Complete, Abdomen Limited and Abdomen Complete with Vascular studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Aorta

1. Obtain representative images in the longitudinal plane of the entire aorta.
2. Document enlargement if present.

B. Liver

1. Perform longitudinal and transverse views to assess the liver parenchyma for focal or diffuse abnormalities.
2. Compare the liver echogenicity to that of the right kidney.
3. Obtain images to include hepatic lobes (right, left and caudate), Inferior Vena Cava (IVC) and right hemi diaphragm.
4. Perform a measurement of the liver length in a sagittal plane at the level of the right kidney (anterior axillary line).
5. Perform a minimum of (2) longitudinal and (2) transverse plane cine captures of the liver for all clinical indications of liver disease. Cine captures should include sagittal right and left lobes and transverse right and left lobes.
6. Obtain 4-quadrant imaging to assess for ascites for Abdomen Complete studies only.

C. Gallbladder and Biliary System

1. Obtain longitudinal and transverse images of the gallbladder in the supine and decubitus positions.
2. Assess stone mobility.
3. Document the measurement of the gallbladder wall if the gallbladder appears thickened and assess and document if a sonographic “Murphy’s sign” is also present.
4. Determine the presence or absence of intrahepatic and extrahepatic bile duct dilatation.
5. Obtain a measurement of the bile duct preferably over the right hepatic artery in the portal hepatis.
 - Additional imaging of the patient the upright position may be helpful in finding small stones in the gallbladder neck.

D. Pancreas

1. Perform transverse and sagittal images of the pancreas.
2. Evaluate and measure the pancreatic duct and the distal common bile duct in the region of the pancreatic head if dilated.

E. Spleen

1. Obtain representative images of the spleen in the longitudinal and transverse planes.
2. Perform longitudinal and transverse measurements of the spleen.
3. Compare the splenic echogenicity to that of the left kidney.

F. Kidneys

1. Obtain representative images in the longitudinal and transverse planes of both kidneys.
2. Longitudinal images must document lateral and medial margins of the kidneys.
3. Transverse views of both kidneys must include labelled images of upper, mid, and lower poles.
4. Perform maximum measurements (minimum of 2) of renal length of both kidneys.
5. Compare renal echogenicity to that of the liver or spleen.
6. Record Color Power Doppler images when there is a clinical suspicion of pyelonephritis.
7. Use Color Doppler to exclude mild hydronephrosis vs. hilar vessels

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Connell, Chandler; Kvinlaug, Christine	Version #	3
Current Approval Date:	10/28/2021	Old Document ID:	
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Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Cranial Imaging Procedure - Ultrasound - Radiology	Procedure ID	11185
Keywords	cranial, cranium, sonographer, sonologist, interpretation, images, ultrasound, us, studies		
Department	Ultrasound		

I. Purpose of Procedure

To describe how to perform cranial Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This applies to all Sonographers and Sonologists within the Ultrasound section of Dartmouth-Hitchcock-Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

This exam is performed on infants less than or equal to 6 months.

Scans are principally performed through the anterior fontanel to evaluate for intracranial hemorrhage or periventricular leukomalacia (PVL). Additional images may be obtained through the posterior fontanel, foramen magnum or temporal bone.

If extra-axial fluid is present, utilize a linear transducer to further differentiate between subdural or subarachnoid fluid. Document vessels crossing in the fluid space.

Coronal views – Minimum 5 evenly spaced images

- Frontal lobes and orbits
- Frontal horns of the lateral ventricles
- Body of the lateral ventricles
- Occipital horns of the lateral ventricles
- Occipital region
- Perform cine capture in the coronal plane through the entire brain

Right para sagittal views – Minimum 3 images each side

- Brain lateral to lateral ventricle beginning at Sylvian fissure
- Maximum size of the lateral ventricle
- Choroid plexus leading into the caudo-thalamic groove (CTG)
- Perform cine capture in the sagittal plane beginning at the Sylvian fissure and moving medial to the midline
- Using a linear transducer, obtain sagittal cine capture(s) of the parenchyma

Midline sagittal view - Document the following:

- Corpus callosum
- Third ventricle region
- Fourth ventricle
- Vermis of the cerebellum
- Cisterna magna

Left para sagittal views – Minimum 3 images each side.

- Brain lateral to lateral ventricle beginning at Sylvian fissure
- Maximum size of the lateral ventricle
- Choroid plexus leading into the caudo-thalamic groove (CTG)
- Perform cine capture in the sagittal plane beginning at the Sylvian fissure and moving medial to the midline
- Using a linear transducer, obtain sagittal cine capture(s) of the parenchyma

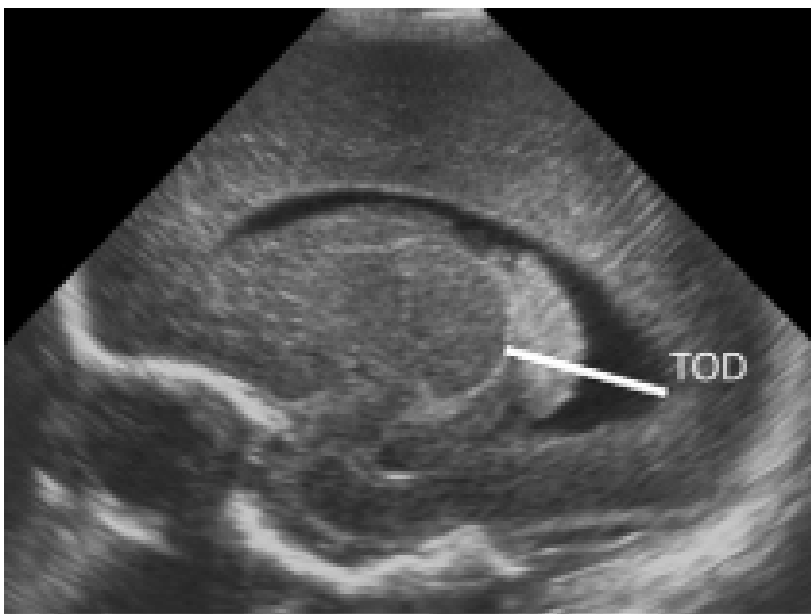
Posterior fossa views:

- Obtain images through the mastoid showing the cerebellum and posterior fossa structures.

Ventricular dilatation measurements (Inpatient studies only):

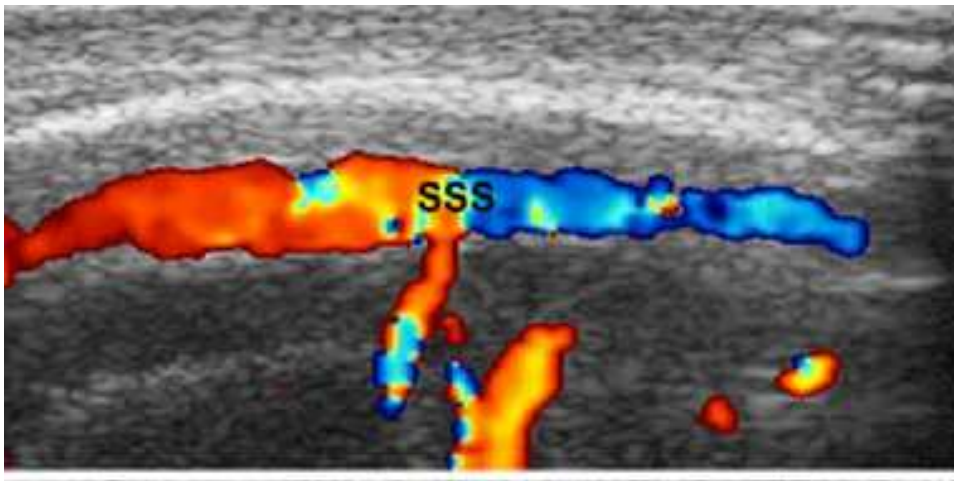
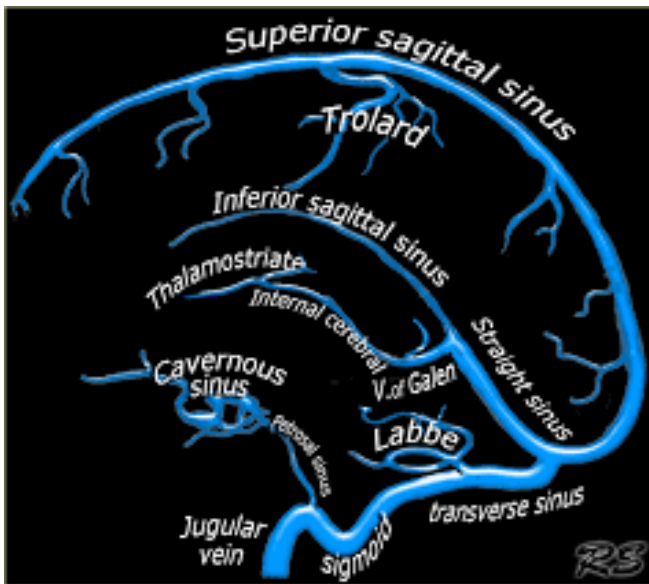
Obtain measurements and static images of the following:

- Ventricular index (VI)
- Anterior horn width (AHW)
- Thermo-occipital distance (TOD)



Additional imaging (Inpatient only):

- Applying very light pressure, obtain power Doppler static imaging of the superior sagittal sinus with a linear transducer in the coronal and sagittal planes.



VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine	Version #	3
Current Approval Date:	09/21/2020	Old Document ID:	
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Characterization of germinal matrix hemorrhage in extremely premature infants: recognition of posterior location and diagnostic pitfalls

Elizabeth J. Snyder¹ · Sumit Pruthi¹ · Marta Hernanz-Schulman¹

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Abstract

Background Traditionally, descriptions of germinal matrix hemorrhage (GMH), derived from observations in preterm and very preterm infants, indicate its location at the caudothalamic grooves. However, before the germinal matrix begins to recede at approximately 28 weeks' gestational age (GA), it extends along the floor of the lateral ventricles far posterior to the caudothalamic grooves. Germinal matrix–intraventricular hemorrhage (GMH-IVH) can occur along any site from which the germinal matrix has not yet involuted. Therefore, as current advances in neonatology have allowed the routine survival of extremely preterm infants as young as 23 weeks' GA, postnatal GMH-IVH can occur in previously undescribed locations. Hemorrhage in the more posterior GMH on head ultrasound, if unrecognized, may lead to errors in diagnosis and mislocalization of this injury to the periventricular white matter or lateral walls of the lateral ventricles instead of to the subependyma, where it is in fact located.

Objective Our aim is to describe posterior GMH in extremely premature infants, including its characteristic imaging appearance and potential pitfalls in diagnosis.

Materials and methods Over a 5-year period, all consecutive extremely preterm infants of 27 weeks' GA or less who developed GMH-IVH of any grade were included. A consecutive group of 100 very preterm infants of 31 weeks' GA with a GMH-IVH of any grade served as controls.

Results In 106 extremely preterm neonates (mean GA: 25 weeks, range: 23.1–26.6 weeks) with 212 potential lateral ventricular germinal matrix bleeding sites, 159 sites had bleeds. In 70/159 (44%), the GMH-IVH was located posterior to the caudothalamic grooves and the foramina of Monroe, 52 (32.7%) were both anterior and posterior and 21 (13.2%) were exclusively anterior. In 16 ventricles with intraventricular hemorrhage, an origin site in the germinal matrix could not be determined. In the control population of very preterm infants, all hemorrhages were at the anterior caudothalamic grooves and 95% were grade I.

Conclusion Unlike the older very preterm and moderately preterm infants that form the basis of our GMH-IVH description and classification, the extremely preterm infants now routinely surviving have a more fetal pattern of germinal matrix distribution, which is reflected in a different distribution and size of germinal matrix injury. We report the postnatal occurrence of subependymal GMH-IVH in extremely preterm infants in these more primitive, posterior locations, its potential imaging pitfalls and sonographic findings.

Keywords Germinal matrix hemorrhage · Head · Infants · Intraparenchymal hemorrhage · Intraventricular hemorrhage · Prematurity · Ultrasound

Introduction

Preterm birth is a wide spectrum dependent on the gestational age (GA) of the infant at birth. Preterm birth, defined as birth before 37 weeks' gestation, affects an estimated 15 million infants worldwide and nearly 10% of births in the United States [1]. The World Health Organization defines moderate or late preterm as birth between 32 and 37 completed weeks of

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gestation, very preterm as birth between 28 and 32 weeks of gestation, and extremely preterm as birth at less than 28 weeks of gestation [2].

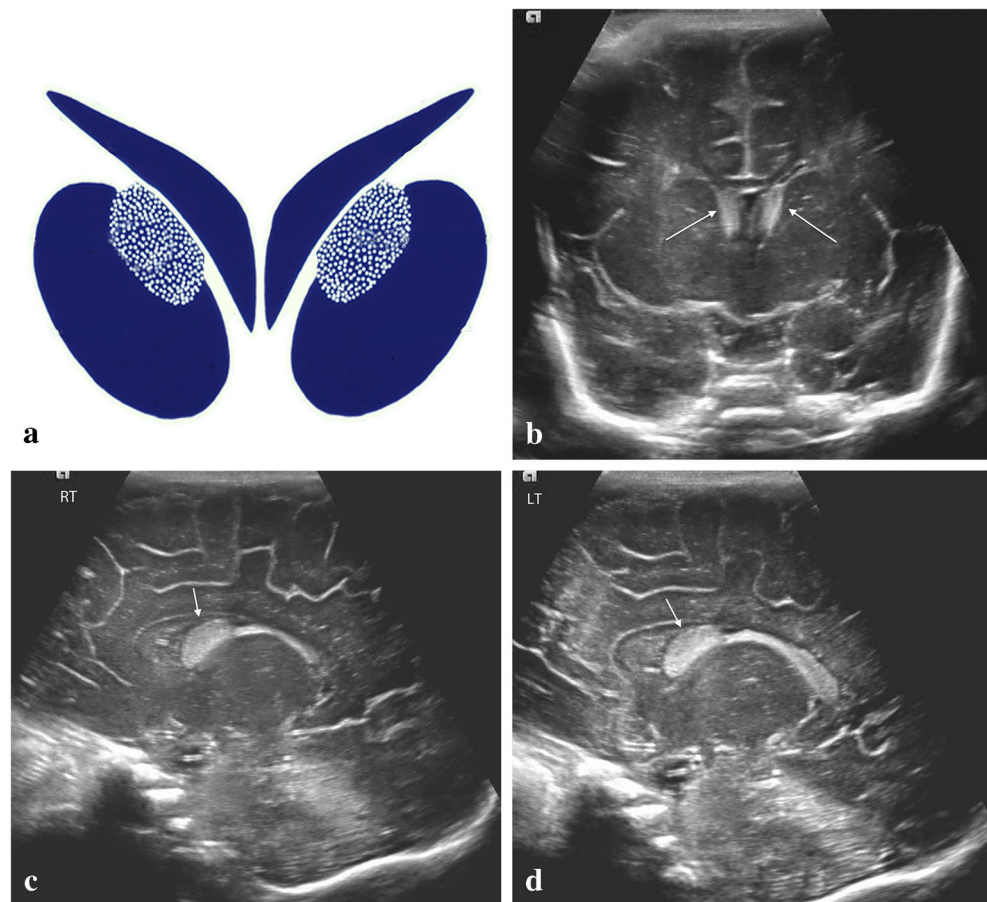
Germinal matrix–intraventricular hemorrhage (GMH-IVH) remains an important cause of morbidity and mortality in premature infants [3–5] despite advances in neonatal care, which have led to the survival of many extremely preterm infants who are at an increased risk for GMH-IVH [6, 7]. Thus, close to 10,000 extremely preterm infants survive with GMH-IVH each year in the United States [8].

GMH-IVH is traditionally stratified based on severity into grades I–IV, according to a grading system used for more than four decades, based initially on single-observation imaging findings described on computed tomography (CT) and subsequently on ultrasound in predominantly moderate preterm and very preterm infants because, at the time, extremely preterm infants approached the edges of viability and seldom survived [9–11]. In this more mature preterm population on which our concepts of GMH-IVH are still based, the residual germinal matrix is thinner and largely confined to the area anterior to the foramina of Monro under the frontal horns of the lateral ventricles at the caudate heads, described as the caudothalamic grooves (Fig. 1). However, as the limits of viability and routine resuscitation and survival have progressively extended to

extremely preterm infants, we have found that the location of the GMH-IVH has shifted to areas in which it is most abundant in this population, posterior to the traditional location. Further, advances in imaging, including magnetic resonance (MR) and fetal imaging and in ultrasound technology, allow for a more detailed evaluation of the neonatal brain. The routine extension of postnatal GMH-IVH posterior to the caudothalamic grooves, its appearance on head ultrasound and its potential imaging pitfalls to our knowledge have not been well-described in the imaging literature. The posterior location, despite being subependymal, can masquerade as a periventricular abnormality on posteriorly angled coronal/axial images, leading to a significant diagnostic pitfall in which the lesion mimics a periventricular hemorrhagic venous infarction or other isolated periventricular white matter injury, when it is not located in the white matter at all. The subependymal location of this abnormality can be confirmed on sagittal images (Figs. 2, 3 and 4; Online Supplementary Material 1).

Our purpose is to describe the posterior location of GMH-IVH in extremely preterm infants and its ultrasound appearance and differentiate this posterior subependymal injury from intraventricular and extraventricular parenchymal hemorrhages. A consecutive group of very preterm infants served as controls.

Fig. 1 An anterior caudothalamic germinal matrix hemorrhage (GMH; classic or traditional grade I hemorrhage). **a** A coronal schematic drawing shows the classic location of GMH in a very premature infant. **b–d** Coronal (**b**) and right- (**c**) and left- (**d**) angled parasagittal US images in a 31-week gestational age girl on day of life 7 show the classic grade I lesions (*arrows*) at the caudothalamic grooves



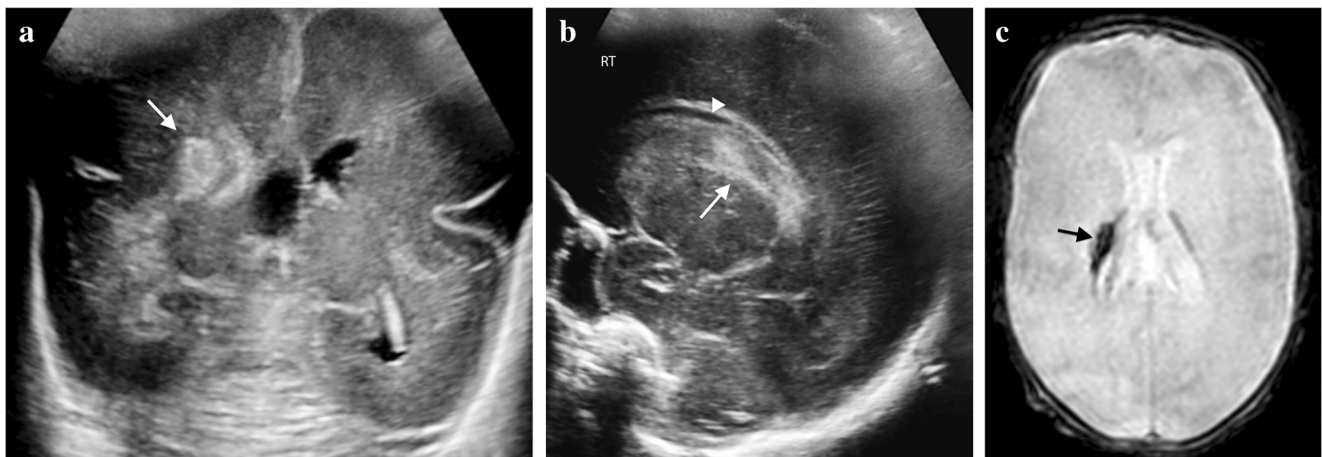


Fig. 2 A posterior subependymal grade I germinal matrix hemorrhage in a 25-week gestational age boy simulates a periventricular white matter hemorrhage. **a** A posteriorly angled coronal US image performed on day of life 7 shows a hyperechoic focus (*arrow*), seemingly in the periventricular white matter. **b** A right parasagittal US image shows that the hyperechoic focus (*arrow*) is located posterior to the caudothalamic groove, but along the floor of the lateral ventricle in the location of the posterior germinal matrix, and not in the periventricular white matter.

Materials and methods

This was an institutional review board (IRB)-approved retrospective observational study. Over a 5-year period from 2013 to 2018 all consecutive extremely preterm neonates with GA up to 27 weeks at birth with a GMH-IVH of any grade were included. Infants between 27 and 28 weeks were not included in order to obtain a distinct separation of the extremely preterm population from the very preterm population that begins at 28 weeks' GA. A consecutive group of 100 very preterm infants of 30–31 weeks' GA who had GMH-IVH of any grade served as controls. Infants transferred to our hospital without

This is clearly separated from the germinal matrix by the lateral ventricle, outlined by a cleft of cerebrospinal fluid (*arrowhead*) above the hemorrhage. The periventricular white matter is normal. **c** An axial T2-W fast field echo (FFE) MR image, performed at 3 months of age, confirms hemosiderin in the posterior germinal matrix (*arrow*). A small amount of hemosiderin also lines the posterior aspect of both lateral ventricles, and the posterior germinal matrix of the left lateral ventricle, not outlined on the sonographic images

initial examinations and infants with known underlying or preexisting conditions, such as congenital anomalies, were excluded.

All premature neonates at our institution receive a screening head ultrasound per institutional protocol on day of life 7, unless requested earlier based on the patient's clinical status. All head ultrasounds are performed by dedicated pediatric sonographers, who are required to pass pediatric sonography boards, including pediatric neurosonography, within 2 years of employment, and all head ultrasounds are reviewed and interpreted by fellowship-trained and experienced pediatric radiologists or pediatric neuroradiologists. Standard images

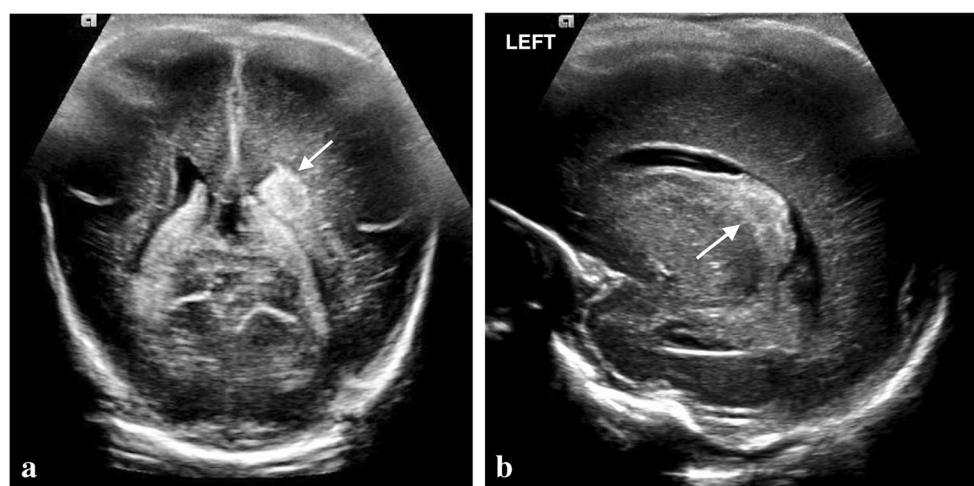


Fig. 3 A posterior germinal matrix hemorrhage in a 25-week gestational age boy, performed on day of life 7. **a** A posteriorly angled coronal US image shows a prominent hyperechoic focus along the lateral wall of the left ventricle (*arrow*), seemingly in the periventricular white matter. **b** A left parasagittal image shows the hemorrhage (*arrow*) to be posterior to

the caudothalamic grooves along the subependymal surface of the lateral ventricle, congruent with the posterior location of germinal matrix in this extremely preterm infant. Note that the periventricular white matter is normal, separated by a cleft of cerebrospinal fluid from the subependymal hemorrhage

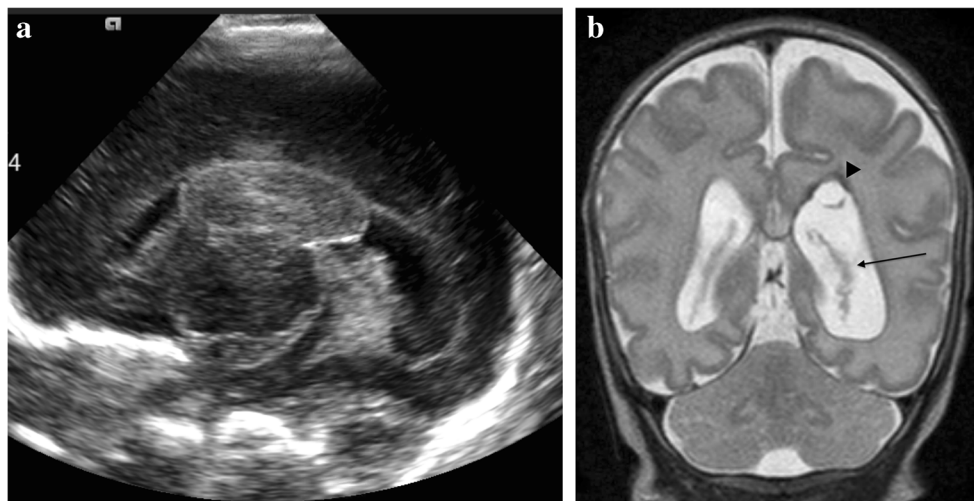


Fig. 4 A large posterior subependymal hemorrhage in a 24-week gestational age boy. **a** A left parasagittal US on day of life 7 shows a large posterior subependymal hemorrhage posterior to the caudothalamic groove and the foramina of Monro. **b** A coronal T2-W MR image at 11 weeks of age shows hemosiderin staining (*arrowhead*) along the

ependymal surfaces of the lateral ventricle posterior to the foramina of Monro. The choroid plexus of the left lateral ventricle appears normal in size and signal intensity (*arrow*) further distinguishing the large posterior subependymal bleed seen on the initial US from intraventricular choroid plexus hemorrhage

obtained during a routine head ultrasound include coronal and sagittal cine sweeps, including coronal left- and right-tilt angled sweeps, and coronal and sagittal still images through the anterior fontanelle using sector and linear transducers operating at 7–10 MHz. Additional images of the lateral ventricular atria and posterior fossa are acquired through the mastoid fontanelles.

All head ultrasounds of extremely preterm patients and very preterm controls were reviewed by two pediatric radiologists (M.H.-S. and E.J.S.) with 30 years and 2 years of experience, respectively, and by one pediatric neuroradiologist (S.P.) with 14 years of experience, blinded to the original report. Any discrepancy was resolved by consensus. For practical purposes in this report, we have defined anterior GMH-IVH as confined to the caudothalamic grooves over the heads of the caudate nuclei, anterior to the foramina of Monro, traditionally known as grade I GMH. Similarly, we have defined posterior hemorrhage as extending beyond the caudothalamic grooves, posterior to the foramina of Monro and posteriorly along the ependymal surface of the lateral ventricles, areas known to be occupied by germinal matrix at the gestational age of the extremely preterm infants [12]. Hemorrhage in the posterior germinal matrix mimicking periventricular white matter injury on coronal images was differentiated on parasagittal images. We subsequently reviewed the original reports, which had been generated over a time period before and after our awareness of these lesions, by dedicated fellowship-trained and certificate of added qualification (CAQ)-certified pediatric radiologists and pediatric neuroradiologists, including the authors of this manuscript.

Demographic data extracted from medical records included gestational age, sex, birth weight and APGAR (appearance,

pulse, grimace, activity and respiration) scores. We reported categorical data as counts and percentages, continuous variables as a mean and standard deviation, and APGAR scores as a median with interquartile range. All data were recorded using Excel (Microsoft, Redmond, WA).

Results

One hundred and six extremely preterm neonates were included in the study (Table 1). The average GA was 25 weeks (range: 23.1–26.6 weeks) and the average birth weight was 747.6 g (range: 457–1,300 g). The median APGAR scores at 1 min and 5 min were 3 (interquartile range [IQR]: 1–5) and 5 (IQR: 3–7), respectively. Sixty-three (58.5%) infants were boys.

There were 159 hemorrhages out of 212 potential sides in the 106 extremely preterm infants. The locations of the hemorrhagic sites were posterior (Figs. 2, 3 and 4; Online Supplementary Material 1) in 70/159 sites (44.0%), and

Table 1 Demographics of extremely preterm infants ($n=106$)

Demographic	
Mean gestational age in weeks (range)	25 (23 1/7 to 26 6/7)
Male sex (%)	63 (58.5%)
Birth weight in grams (range)	747.6 (457–1,300)
Median APGAR score at 1 min (IQR)	3 (1–5)

APGAR appearance, pulse, grimace, activity and respiration, IQR interquartile range

anterior and posterior (Fig. 5) in 52 sites (32.7%). In some of the posterior hemorrhages, if not recognized to be entirely subependymal, the size of the subependymal component was large enough to be classified as a grade III lesion by size criteria according to the Papile classification because it was larger than the diameter of a normal ventricle (Fig. 6). The hemorrhage was exclusively anterior in only 21 sites (13.2%). In 38/106 infants, there were bilateral hemorrhages involving the posterior germinal matrix. In one infant, the hemorrhage was in the occipital portion of the right germinal matrix (Fig. 7) and in the temporal portion in another. In 13/106 infants (12.3%), the GMH-IVH was extensive and associated with a large periventricular parenchymal hemorrhagic infarction (grade IV; Fig. 8). In 16 sites, intraventricular hemorrhage was seen, but the site of origin could not be determined.

The original reports reflected our realization of this new manifestation of posterior subependymal hemorrhage and its

differentiation from white matter injury during the study period. Therefore, the grade of GMH-IVH over the entire study period was misclassified in approximately half of the infants with posterior subependymal bleeds: as periventricular hemorrhagic infarction in approximately half and as other nonspecific white matter abnormality in the remainder.

The control population of 100 very preterm infants had a GA of 30–31 weeks. Of the hemorrhages in these infants, 95% were grade I, only 5% were grade II, and none was of a higher grade. All were in the typical location at the anterior caudothalamic grooves (Fig. 1).

Discussion

The germinal matrix is a fetal zone below the floor of the lateral ventricles paralleling the caudate nuclei. Between 10

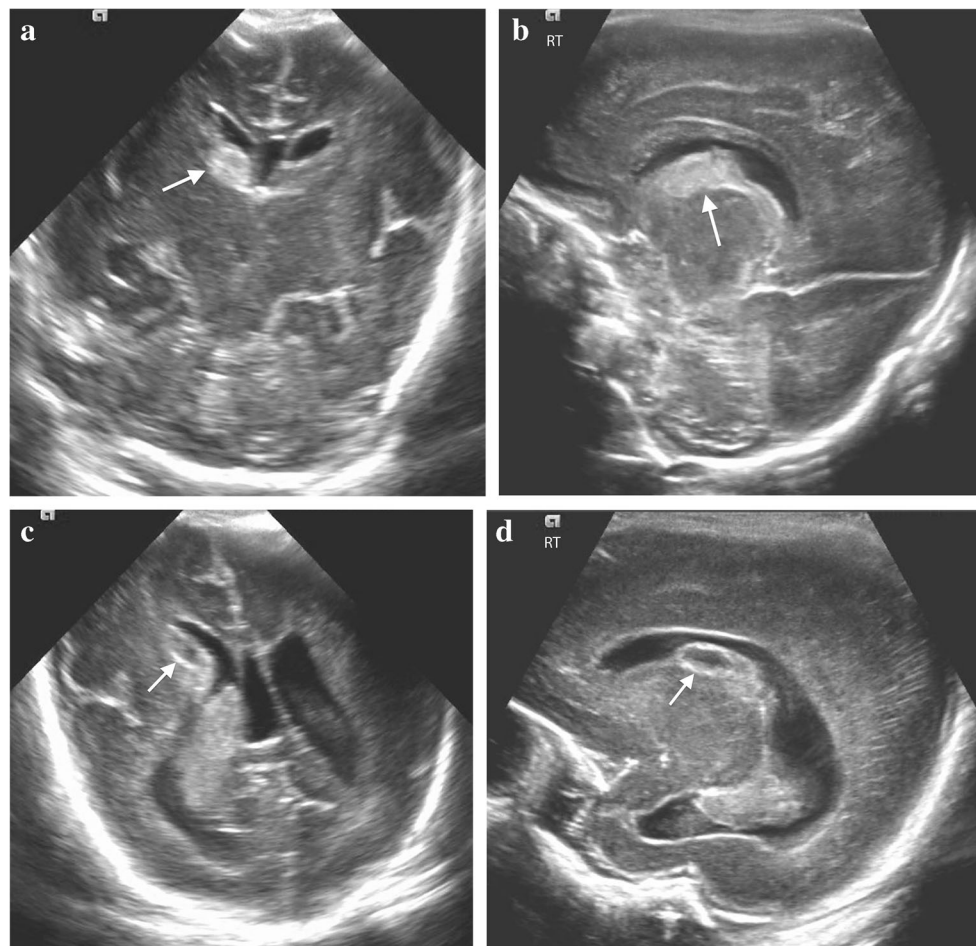


Fig. 5 Anterior and posterior subependymal hemorrhage in a 25-week gestational age male infant. **a** A coronal US image shows a hyperechoic hemorrhage in the right anterior caudothalamic groove (arrow). **b** A right parasagittal image shows the hyperechoic hemorrhage in the anterior caudothalamic groove (arrow). **c** A more posteriorly angled coronal image, tilted toward the right, shows a hypoechoic hemorrhage in the right posterior germinal matrix, simulating a right periventricular white matter injury (arrow). **d** A right parasagittal image with slightly more

lateral and posterior angulation shows the hypoechoic lesion to be located along the more posterior germinal matrix (arrow), not in the periventricular white matter as erroneously suggested on the coronal image. If this is not understood and appreciated, the more posterior lesion could easily be thought to represent an intraventricular hemorrhage–periventricular hemorrhagic infarction lesion. Cine images of this case can also be seen in Online Supplementary Material 1

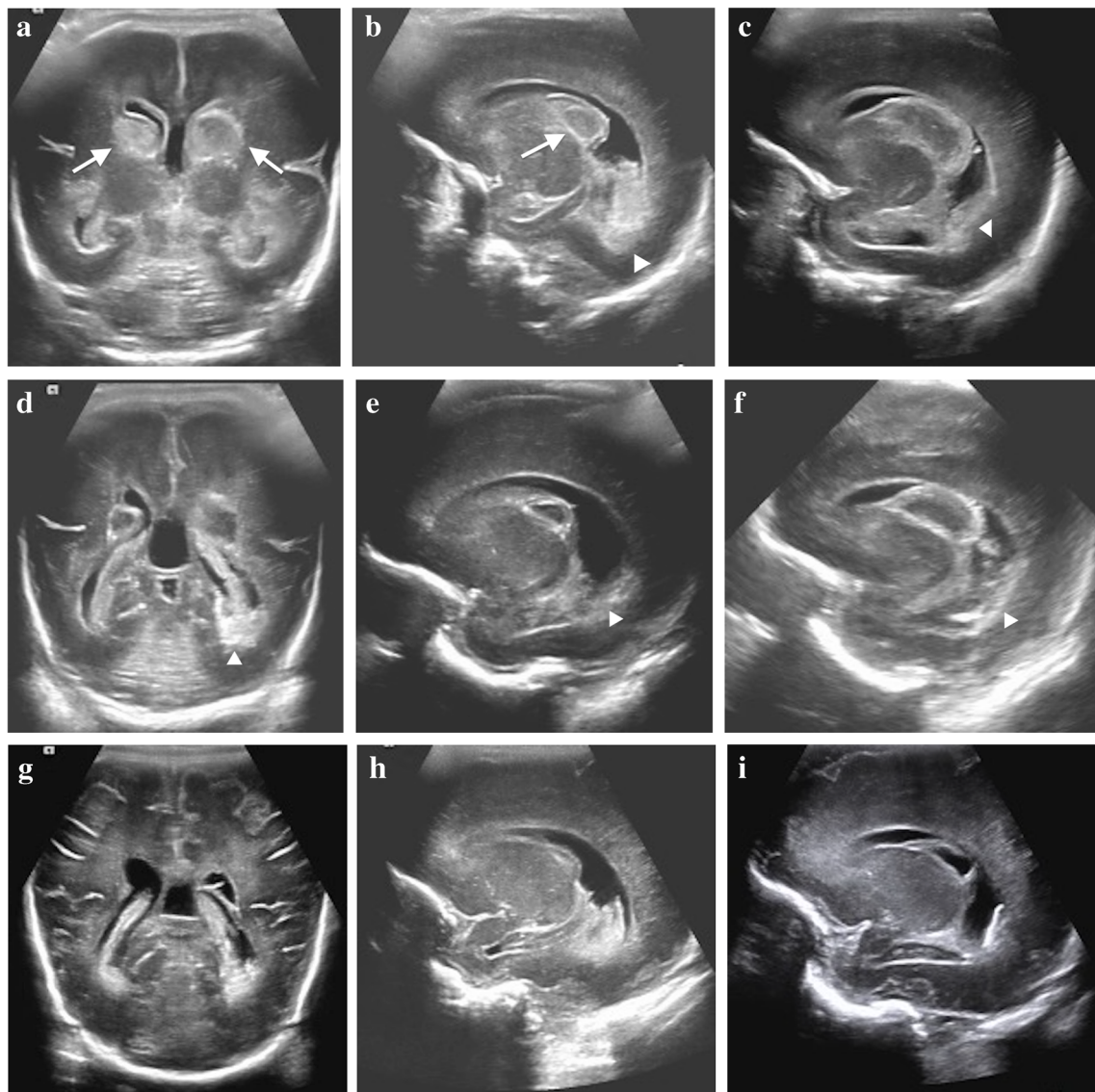


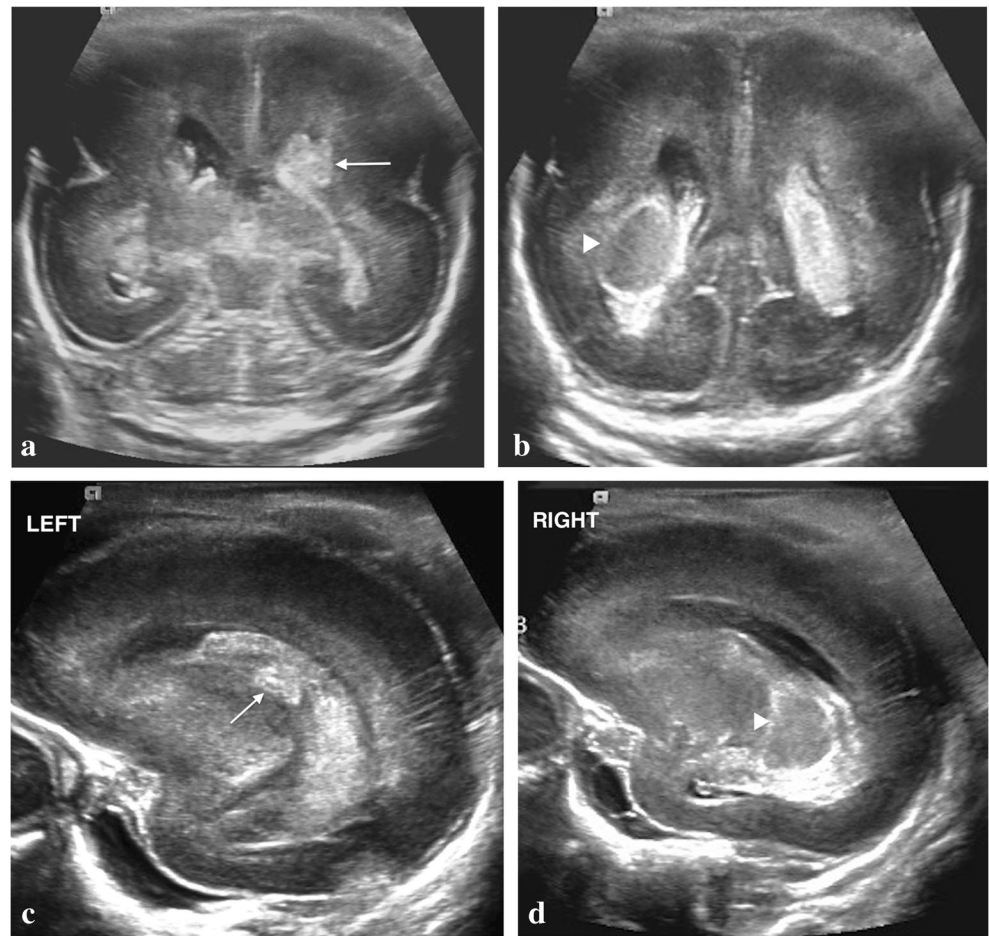
Fig. 6 Large posterior subependymal hemorrhages in a 23-week gestational age boy. **a** A coronal US image on day of life 10 shows very large subependymal hyperechoic hemorrhages adjacent to the lateral ventricles (*arrows*). **b** A right parasagittal US image shows the hemorrhage (*arrow*) extending into the area of the caudate nucleus, separate from the intraventricular thrombus layering dependently in the occipital horn (*arrowhead*). **c** A left parasagittal US image shows the larger left-side hemorrhage and the extension into the region of the caudate and separation from the posteriorly layering thrombus in the occipital horn (*arrowhead*). These subependymal lesions would be categorized as grade I according to the Papile classification based on location. However, based on volume, they would be classified as grade III. **d–f** Evolution of hemorrhages in the same infant at 4 weeks of age. A coronal image (**d**) shows the now hypoechoic bilateral subependymal hemorrhagic lesions, projecting laterally to the bodies of the lateral ventricles. A posteriorly layering thrombus in the occipital horn is again

seen (*arrowhead*). A right parasagittal image (**e**) shows the evolution of the subependymal lesion since the previous study, without change in location or shape. A posteriorly layering thrombus in the occipital horn is again seen (*arrowhead*). A left parasagittal image (**f**) shows the similar evolution of the larger, left-side subependymal lesion. A posteriorly layering thrombus in the occipital horn is again seen (*arrowhead*). **g–i** Evolution of hemorrhages in the same infant at 2 months of age. A coronal image (**g**) shows the now nearly resolved right subependymal lesion, and the cystic evolution of the larger left-side lesion; the coronal image erroneously suggests a periventricular white matter cyst. A right parasagittal image (**h**) confirms the near-total resolution of the right subependymal lesion. A left parasagittal image (**i**) shows continued liquefaction and volume loss of the larger left-side lesion in the same posterior subependymal location. This case illustrates the need for the paradigm change in our understanding of germinal matrix hemorrhage in the extremely preterm population

and 20 weeks of gestation it serves as the source of cerebral excitatory neurons and generates precursors of oligodendroglia and astrocytes as well as late-migrating gamma-aminobutyric acid-ergic (GABAergic) neurons that will go

on to populate both cerebral cortex and thalamus [8, 13]. As has been well described in the neurology literature, the germinal matrix undergoes extensive cellular proliferation during early fetal life and is thickest at 20–26 weeks of gestation

Fig. 7 Left posterior and right occipital subependymal germinal matrix hemorrhages in a 23-week gestational age boy on day of life 1. **a** A coronal US image shows a focus of hemorrhage along the left posterior germinal matrix projecting over the periventricular white matter (*arrow*), with some intraventricular blood in the left frontal horn. **b** A more posteriorly angled image shows a large hypoechoic hemorrhage (*arrowhead*) along the lateral wall of the posterior right ventricle. **c** A left parasagittal image shows the left focus of hemorrhage (*arrow*) at the level of the caudate nucleus but posterior to the caudothalamic groove, below the intraventricular blood. **d** A right parasagittal image shows the right hemorrhage to be contained and along the curvature of the thalamus (*arrowhead*), suggesting a location within the very posterior germinal matrix. There is also abundant intraventricular blood of differing echogenicity to this well contained focus



[12, 14]. During the period of extensive proliferation, the germinal matrix reaches a width of 2.5 mm at 23 weeks' GA, which decreases to 1.4 mm at 32 weeks, and is nearly

completely involuted by 36 weeks, being most prominent along the anterior caudothalamic groove between 28 and 32 weeks of gestation [8, 13–15] (Fig. 9). Fetal MRI literature

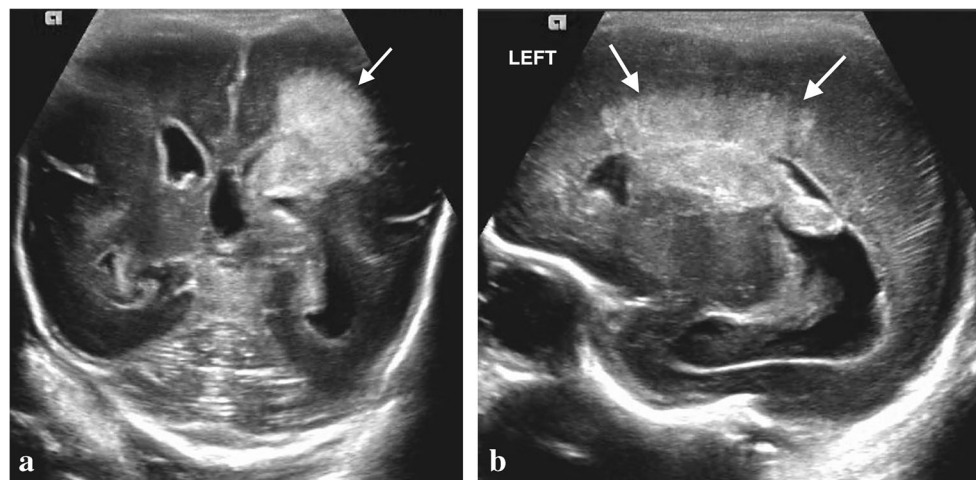


Fig. 8 Parenchymal hemorrhagic venous infarction in a 26-week gestational age boy on day of life 7. **a** A coronal US image shows a large left intraventricular hemorrhage and a large hyperechoic area in the left frontoparietal white matter (*arrow*), consistent with a periventricular hemorrhagic infarction. **b** A left parasagittal US image shows an intraventricular hemorrhage, which is confluent with and

difficult to distinguish from the posterior germinal matrix. However, the image confirms that the parenchymal component (*arrows*) is located above the lateral ventricle consistent with a germinal matrix hemorrhage–intraventricular hemorrhage associated with a periventricular hemorrhagic infarction

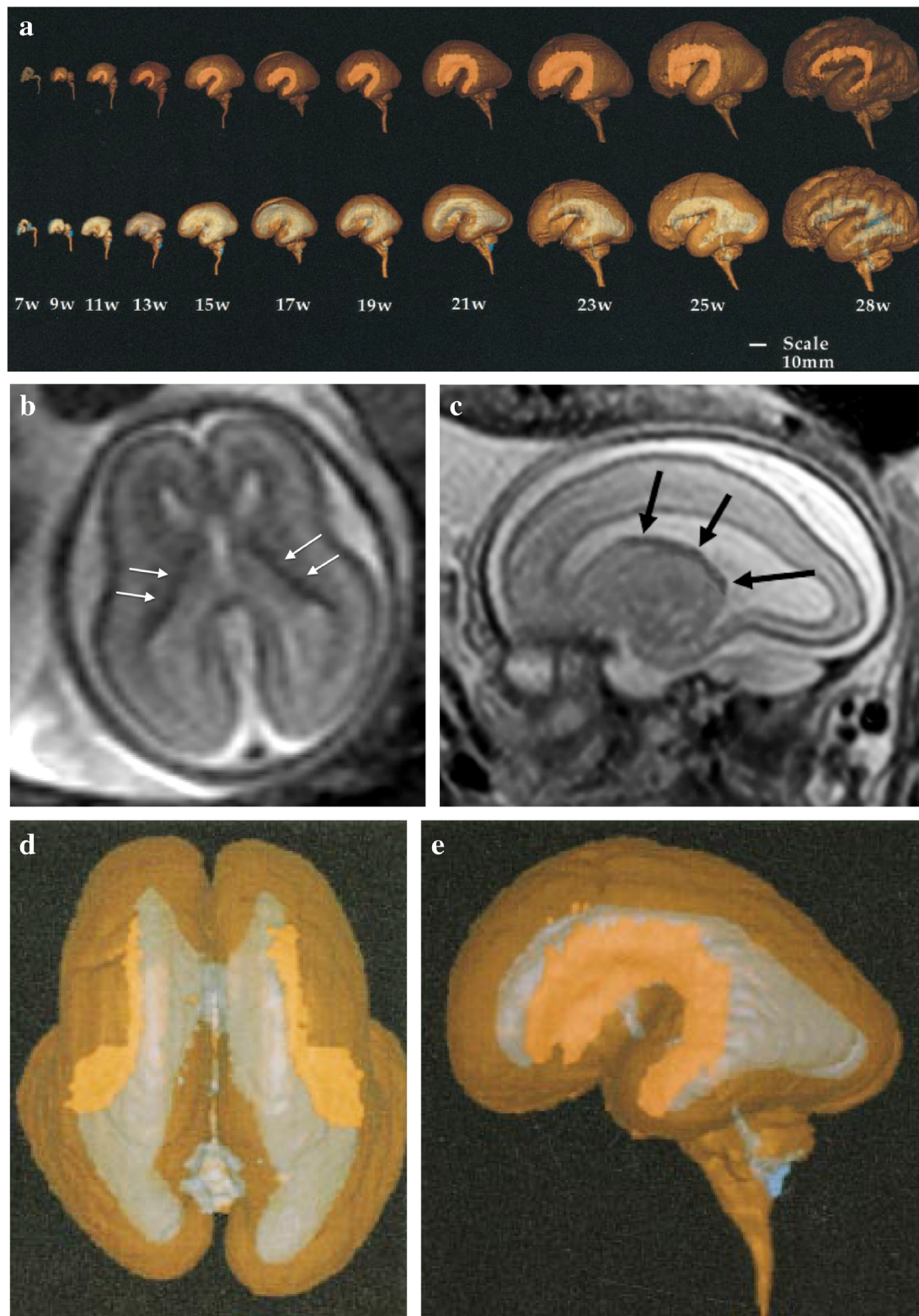


Fig. 9 Development of the germinal matrix. **a** Sequential images show concurrent developmental changes of the germinal matrix (*orange overlay*, top row) and ventricular systems (*light gray overlay*, bottom row) between 7 weeks' and 28 weeks' gestation. Note how the volume of the germinal matrix increases until 23 weeks of gestational age and is followed by a rapid decrease by 28 weeks. Reproduced with permission from [15]. **b, c** Axial (**b**) and parasagittal (**c**) prenatal MR images in a

21 weeks' gestation fetus obtained in our institution shows the posterior extent of the germinal matrix (*arrows*) far beyond the caudothalamic grooves at this gestational age. **d, e** Axial (**d**) and sagittal (**e**) sections show the ventricles (*light gray overlay*) and germinal matrix (*orange overlay*) over the surface-rendered brain of a 21 weeks' gestational age fetus. Reproduced with permission from [15]

also shows that, in fetuses younger than 28 weeks' gestation, a large volume of the germinal matrix extends along the entire length of the interface of the caudate nuclei with the ventrolateral floor of the lateral ventricles [12]. Extremely preterm infants, therefore, have a different distribution and volume of germinal matrix than their older counterparts on whom our current concepts and grading systems are largely based [9]. Although hemorrhage has been described in the posterior germinal matrix in fetal and neonatal MRI studies [16, 17], to our knowledge neither its appearance on ultrasound nor the potential for mislocalization of a germinal matrix injury to the periventricular white matter or within the lateral ventricles has.

The description of GMH-IVH with which most of us are familiar stems from the grading system of GMH-IVH adapted from Papile et al. [9] in general use today, with modifications by Volpe et al. [8]. GMH-IVH is traditionally stratified according to severity into grade I, confined to the subependyma, typically small and located at the caudothalamic grooves; grade II, extending into the ventricles without dilatation by blood products; and grade III, sufficient to dilate the ventricles with a larger intraventricular hemorrhagic burden. GMH-IVH with a periventricular hemorrhagic infarction, which has been considered a grade IV injury, is not strictly part of the continuum although it is typically associated with germinal matrix and intraventricular hemorrhage [8, 13]. In the Papile-based system, in use for more than four decades, a grade I lesion is defined as a lesion located in the subependyma and is typically small, and the classification implies an incremental rise in the severity of the lesion along grades I–IV.

Our study highlights the fact that the frequent survival of extremely preterm infants dictates new injury patterns that should be recognized, particularly with the potential for the erroneous resemblance to white matter injury on coronal imaging (Figs. 2, 3, 4, 5, 6 and 7; Online Supplementary Material 1). The differentiation is best delineated in parasagittal images, in which the hemorrhage is seen along the floor of the ventricles paralleling the caudate nuclei, and not above the ventricles in the periventricular white matter region (Figs. 2, 3, 4, 5, 6 and 7; Online Supplementary Material 1). Typically, when the ventricles are sufficiently distended with cerebrospinal fluid (CSF), the subependymal component can be further distinguished from the periventricular white matter by a band or cleft of CSF that delineates the edge of the ventricle below the periventricular white matter.

Similarly, we found that the size of the subependymal component in these posterior hemorrhages was often much larger than the anterior subependymal lesions that occur in the older very premature infant population (Fig. 6). We postulate that it is the larger volume of the germinal matrix in the extremely preterm infants [14, 15] (Fig. 9) that allows the subependymal component in the posterior lesions to be large, blurring the traditional volumetric distinction between grade I and grade

III injuries (Figs. 1 and 6). Thus, in the Papile [9] classification, the size of the subependymal, extraventricular lesion is moot and is always classified as a grade I lesion. However, in this different population in whom the germinal matrix is larger, the size of the lesion can sometimes blur the volumetric distinction between grades I and III lesions. Thus, the sometimes much larger size and the earlier gestational age at which it occurs conflict with the spectrum of severity implied in the Papile [9] classification. We therefore suggest that posterior subependymal GMH may be a more accurate description than grade I, with further description of location, size and extent.

Although we did not follow up on the infants' neurological and clinical status and did not investigate the clinical consequences of these lesions, our findings raise questions regarding their prognostic significance. Even subependymal lesions, as we have described, can be extensive and, at this stage in fetal development, affect a large volume of these germinal matrix cellular precursors of oligodendroglia and GABAergic neurons, as well as their subsequent migration and differentiation, potentially impairing myelination and cortical neuronal development [8, 17], thus heavily influencing the prognostic significance of a subependymal grade I lesion. As we follow these children into later life, this information should be taken into consideration in their follow-up and subsequent care, and inform the basis of future research, clearly beyond the scope of our initial report.

Limitations of this study include its retrospective nature and consensus readings. In addition, in some cases of large bleeds, hemorrhages adherent to the choroid and subependymal blood can appear confluent and difficult to compartmentalize to the site of origin with complete certainty. These issues may have affected the frequency of specific findings. In most of the cases, however, there was a large subependymal component clearly demarcated from the intraventricular hemorrhage, which could be followed to resolution (Fig. 2). Further, intraventricular blood does not masquerade as a periventricular white matter lesion on coronal images, as is the case with the posterior GMH. Confirmatory MRI is clearly difficult to perform contemporaneously in these fragile infants unless available in the neonatal intensive care unit, and follow-up images for clinical concerns when the infants are stable may no longer demonstrate the findings as clearly as during the acute event, although some of our patients did have follow-up imaging confirming the location of the hemorrhage (Fig. 2).

Conclusion

Germinal matrix–intraventricular hemorrhage in extremely premature infants frequently involves the posterior germinal

matrix, an area from which it has involuted in the more mature premature population and can simulate a periventricular hemorrhagic venous infarction (grade IV lesion) or other white matter lesion on posteriorly angled coronal (axial) ultrasound images. Knowledge of the typical involution patterns of the germinal matrix, its location in the extremely preterm population and the typical ultrasound appearance of posterior GMH is essential for accurate interpretation of head ultrasound studies. Given the stage of brain development at which they occur and the potential size of these lesions, we believe they should be described as posterior subependymal germinal matrix hemorrhages, and their potential prognostic implications explored by future research.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s00247-021-05189-3>.

Declarations

Conflicts of interest None

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Job Aid	Endometrial Biopsy Setup Job Aid - Ultrasound - Radiology	ID:	11355
Keywords	u/s, us, bx, ultrasound, biopsy, endometrial		
Department	Ultrasound, Radiology		

I. Purpose

To provide a list of necessary supplies for Ultrasound endometrial biopsy procedures.

- Speculum – (have all sizes available)
- Cotton Balls/Betadine Prep
- Surgical gloves (appropriate for physician)
- Long Curved Kelley
- Endometrial Biopsy Curette – 3 choices- have all available
- 10% Neutral Buffered Formalin
- Dilators – Tenaculum
- Surgical pathology request created in eD-H (created by MD)
- Patient Labels
- Specimen transport bag]
- Lidocaine (appropriate for physician)

Billing/ Supplies:

- Guidance only all charges included. No supplies required

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents, Jean Bolger	Version #	2
Current Approval Date:	10/15/2018	Old Document ID:	NEW
Date Policy to go into Effect:	10/15/2018		
Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Gynecologic Imaging Procedure - Ultrasound - Radiology	Procedure ID	11222
Keywords	gynecologic, imaging, ultrasound, study, studies		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographers and sonologist performing gynecologic Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Scheduling

1. Make every attempt to schedule examinations between cycle day 4 and 12.
 - In most cases transvaginal scanning is the preferred method of imaging.
 - Transabdominal approach should only be used if the patient is not a candidate for placement of a transvaginal probe, i.e., is not sexually active, has not yet had a gynecologic exam with a speculum, has been sexually abused, or refuses the endovaginal approach.

B. Ultrasound Imaging

- Annotate the plane of the scan, laterality, and structure(s) being imaged.
- High level decontamination is necessary after each use and the transducer used needs to be identified. Enter the transducer number (located on the connector) into the structured reporting package.
- Once the procedure is completed, the protective cover should be removed and discarded. The transducer should then be washed, placed in plastic bag and biohazard sticker attached. The transducer should then be transported to the decontamination room and processed according to Central Sterile and Reprocessing (CSR) decontamination guidelines.

C. Uterus

- Obtain representative images longitudinally and transversely of the uterus.
- Measurements of the uterine length from the fundus to the cervix and AP diameter perpendicular to the length should be documented.
- The uterine contour and any abnormalities should be documented.

- The double layer endometrial echo should also be analyzed for thickness and or focal abnormality.
- Color Doppler imaging should be performed to evaluate the endometrium.
 - If the entire uterine volume cannot be obtained transvaginally, measurements should be obtained transabdominally.

D. Ovaries & Adnexae

- Both ovaries should be measured in three dimensions and the volume recorded.
- Any abnormalities, size, echogenicity, characteristics (cystic, solid, complex) should be documented and measured.
- Color and spectral Doppler should be used to evaluate ovarian vascularity in the clinical setting when the suspicion of torsion or adnexal masses is suspected.
- Cysts which contain mural nodules/masses should have the size of them measured and images obtained. The presence or absence of vascularity within any mural nodule should be documented.

E. Cul de Sac

- Image and evaluated for the presence of free fluid or masses.

F. 3D & Cine Image Capture

- Obtain representative image of the endometrium to document contour and any questionable abnormalities.
- Also, perform a grey scale cine clip capture in sagittal and transverse planes when where the endometrial stripe appears thick on static images.
- A color cine capture should also be performed preferably in the sagittal plane.

G. Sonohysterogram (SHG)

- A pregnancy test must be performed prior to the study for women of reproductive age who have sexual relations with a male partner, and all of those patients undergoing treatment for infertility.
- This task is performed in the OB/GYN clinic prior to the Ultrasound appointment and documented in the electronic medical record.
- Perform a preliminary transvaginal ultrasound exam following the above guidelines. The ordering provider will request a comprehensive exam in the order.
- Follow Sonohysterogram (SHG) job aid for supplies and setup for this procedure.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s): email	Pamela Mazurek
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine	Version #	4
Current Approval Date:	03/29/2021	Old Document ID:	
Date Procedure to go into Effect:	03/29/2021		
Related Policies & Procedures:	Infertility Imaging Procedure - Ultrasound - Radiology		
Related Job Aids:	Sonohysterogram (SHG) Setup Job Aid - Ultrasound - Radiology		

Dept. Procedure Title	Hypertrophic Pyloric Stenosis (HPS) Imaging Procedure - Ultrasound - Radiology	Procedure ID	11470
Keywords	us, ultrasound, sonographers, sonologists, interpretation, studies, hypertrophic, pyloric stenosis, HPS		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographers and sonologists performing Hypertrophic Pyloric Stenosis Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Standard Images Required for Interpretation

- Using a linear high frequency transducer, image the pylorus in the right upper quadrant (RUQ) location.
 - Sonographic features: The suspicious area appears as a uniformly thickened, hypoechoic mass surrounding a hyperechoic center.
- Obtain measurements of the pyloric channel length (normal length <15mm length).
- Obtain transverse measurement of the single wall thickness (normal thickness <3mm).
- Obtain a cine image capture through suspicious area.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine	Version #	3
Current Approval Date:	11/04/2021	Old Document ID:	
Date Procedure to go into Effect:	11/04/2021		
Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Infertility Imaging Procedure - Ultrasound - Radiology	Procedure ID	11187
Keywords	studies, us, ultrasound, interpretation, images, imaging, infertility		
Department	Ultrasound		

I. Purpose of Procedure

To describe guidelines for performing infertility-specific Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all Sonographers and Sonologists within the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Ovulation Induction: (OI)

- Obtain the following images for Day 3, baseline or endometrial lining check:
 1. Obtain double layer endometrial echo measurement in the longitudinal axis.
 2. Obtain 3 measurements of both ovaries to determine ovarian volume.
 3. Evaluate for antral follicles of both ovaries (follicles less than 1.0 cm). Count all follicles less than 1.0 cm and record number for each ovary. The automated GE – SONOAVC option will not identify follicles under 10 mm.
 4. Measure all follicles greater than 1.0 cm – may use specific ultrasound unit enabled with follicular monitoring to evaluate (perform appropriate post-image acquisition processing).
 5. Obtain images of the cul-de-sac to assess for free fluid.
 6. Make note and record any adnexal masses seen.
- For subsequent studies, Day 7 and beyond:
 1. Obtain a longitudinal image of the uterus with an endometrial echo measurement.
 2. Use specific Ultrasound unit enabled with follicular monitoring capability.
 3. Review all sectional planes to include or exclude measurement error.
 4. **Best clinical judgement should always be used prior to saving the follicular volume and data.
 5. Obtain three orthogonal measurements of the 3 lead follicles on each ovary.
 6. Obtain images of the cul-de-sac to assess for free fluid.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Connell, Chandler; Kvinlaug, Christine	Version #	3
Current Approval Date:	10/28/2021	Old Document ID:	
Date Procedure to go into Effect:	10/28/2021		
Related Policies & Procedures:	Gynecologic Imaging Procedure - Ultrasound - Radiology		
Related Job Aids:			

Job Aid	Inter procedural Specific Laboratory Orders Verbal with Read Back Job Aid - Radiology - Ultrasound	ID	26696
Keywords	Inter procedural, Inter-procedural, Interprocedural, Laboratory, Orders, Verbal, Read, Back, Radiology, Biopsy, Biopsies, US, Ultrasound, Guided		
Department	Radiology - Ultrasound (US)		

I. Purpose

To safely care for patients scheduled for Ultrasound (US) guided elective procedures and provide direction to personnel who prescribe and implement medical orders for the provision of patient care.

- Inter procedural laboratory studies can be ordered by the Sonographer working in Mary Hitchcock Memorial Hospital when Ultrasound guided biopsies, i.e., Prostate, Native, Transplant and Musculoskeletal biopsies are performed.
- The Sonographer places procedural lab orders as specified in the attached documentation, using verbal with read back order mode in eD-H. Order(s) are placed on the scheduled procedure day after procedure consent and bedside ‘time out’ have been obtained.
- After the procedure has been completed, all orders are to be signed by attending provider (Urology, Nephrology, Transplant, or Musculoskeletal) specified as the Ordering Provider and/or Associate Provider.

Responsible Owner:	Radiology - Ultrasound	Contact:	Dennis Seguin
Approved By:	Office of Policy Support (OPS), Chandler Connell	Version #	1
Current Approval Date:	01/26/2022	Old Document ID:	
Date Policy to go into Effect:	01/26/2022		
Related Policies & Procedures:	Managing Medical Orders Policy		
Related Job Aids:			

Dept. Procedure Title	Intussusception Imaging Procedure - Ultrasound - Radiology	Procedure ID	11225
Keywords	intussusception, us, ultrasound, sonographers, sonologists, interpretation, studies		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographers and sonologists performing Intussusception Specific Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

1. Using a linear high frequency transducer, sweep from the right lower quadrant (RLQ) to the right upper quadrant (RUQ) and then across transverse colon to the left upper quadrant (LUQ) then down to the left lower quadrant (LLQ) in transverse and sagittal planes evaluating for a sonographic “bullseye” or target-like lesion.
2. Document static images in all locations.
3. Sonographic features: The suspicious area appears as a mass of concentric hyperechoic (mucosa) and hypoechoic (muscularis) layers (target appearance).
4. Obtain a cine image capture through suspicious areas.
5. If positive, obtain an image with color Doppler.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine	Version #	3
Current Approval Date:	10/26/2021	Old Document ID:	
Date Procedure to go into Effect:	10/26/2021		
Related Policies & Procedures:			
Related Job Aids:			

Job Aid	Intrauterine Device (IUD) Removal Setup Job Aid - Ultrasound - Radiology	ID:	11378
Keywords	u/s, IUD, ultrasound		
Department	Radiology, Ultrasound		

I. Purpose

To provide necessary supplies for Intrauterine device (IUD) removal procedures.

- Speculum – (have all sizes available)
- Betadine Prep
- Surgical gloves (appropriate for physician)
- Long Curved Kelley
- IUD Retriever (obtain from gynecology nurses as needed)
- Os finder
- Tenaculum
- Lidocaine Kit (local anesthesia)

Billing/ Supplies:

- Guidance only. No supplies

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents, Jean Bolger	Version #	2
Current Approval Date:	10/15/2018	Old Document ID:	NEW
Date Policy to go into Effect:	10/15/2018		
Related Policies & Procedures:			
Related Job Aids:			

Job Aid	Intrauterine Device (IUD) Placement Setup Job Aid - Ultrasound - Radiology	ID:	11377
Keywords	u/s, placement, iud		
Department	Ultrasound		

I. Purpose

To provide a list of necessary supplies for Intrauterine device placement (IUD) procedures.

- Pregnancy test if indicated
- Cotton Balls/Betadine Prep
- Surgical gloves (appropriate size for physician)
- Lidocaine Kit (local anesthesia)
- IUD sterile tray – (ask Gynecology nurse)
 - Gynecology nurse brings all necessary supplies to the exam room
- IUD – (ask Gynecology nurse for item)
- Tenaculum
- Os Finders
- Dilators
- Endometrial Biopsy Curette

Billing/ Supplies:

- Guidance only. No supplies required

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents, Jean Bolger	Version #	2
Current Approval Date:	10/15/2018	Old Document ID:	NEW
Date Policy to go into Effect:	10/15/2018		
Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Doppler Imaging of the Liver Scheduling and Imaging Procedure - Ultrasound - Radiology	Procedure ID	11380
Keywords	Doppler, liver, sonographer, sinologist, interpretation, images, studies, ultrasound, us, hepatology, protocol		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographers and sonologists performing Liver Doppler studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Scheduling

1. Requests for liver Doppler are to be performed for the clinical indications of hepatitis, cirrhosis, “liver disease,” or portal vein thrombosis.
2. Requests to evaluate TIPS patency should be scheduled \geq 10-14 days post procedure.

Abdomen Limited With Vascular - Hepatology Imaging Protocol

- (Imaging of the spleen may also be requested. Check order for clarification)

1. Liver

- Perform examination imaging per AIUM guidelines.
- Perform longitudinal and transverse views to assess the liver parenchyma for focal or diffuse abnormalities. Compare the liver echogenicity to that of the right kidney.
- Obtain images to include hepatic lobes (right, left, and caudate), inferior vena cava (IVC) and right hemidiaphragm.
- Perform measurement of the liver length in a sagittal plane at the level of the right kidney (anterior axillary line).
- Perform a minimum of (2) longitudinal and (2) transverse plane cine captures of the liver for all clinical indications of liver disease.
- Cine captures should include sagittal right and left lobes and transverse right and left lobes.

2. Gallbladder and Biliary System

- Perform examination imaging per AIUM guidelines.
- Obtain longitudinal and transverse images of the gallbladder in the supine and decubitus positions.
- Measure the gallbladder wall.
- Assess for a sonographic “Murphy’s sign.
- Evaluate for the presence or absence of intrahepatic and extrahepatic bile duct dilatation.
- Obtain measurement of the bile duct preferably over the right hepatic artery in the portal hepatitis.
- Additional imaging in the upright position may be helpful in finding small stones in the gallbladder neck.

3. Spleen

(Imaging as requested; check order for clarification).

- Perform examination imaging per AIUM guidelines.
- Obtain representative images of the spleen in the longitudinal and transverse planes.
- Perform longitudinal and transverse measurements of the spleen.
- Compare the splenic echogenicity to that of the left kidney.

4. Liver Doppler

- Perform examination imaging per AIUM guidelines.
- Perform color Doppler imaging of the main, left & right portal veins.
- Obtain color Doppler and a minimum of one (1) spectral waveform (angle corrected less than 60 degrees) in the main portal vein.
- Sample and measure the mean peak systolic velocity in the MPV and enter the value into the structured reporting package.
- Obtain 4-quadrant imaging to assess for ascites.

Abdomen Vascular Limited TIPS - Hepatology Imaging Protocol

○ **(Imaging of the spleen may also be requested; check order for clarification).**

- Perform examination imaging per AIUM guidelines.
- Imaging includes Liver, GB, CBD (spleen if requested) and Doppler interrogation.
- Perform color Doppler of the right, middle, & left hepatic veins.
- Perform color Doppler imaging of the main, left & right portal veins.
- Obtain a minimum of (1) spectral waveform (angle corrected less than 60 degrees) from the main portal vein.
- Measure and add the mean peak systolic velocity value into the structured reporting package.
- Obtain color Doppler images of the stent
- Obtain color and spectral Doppler imaging sampling at a minimum of three (3) different intervals (labeled as portal, mid, IVC end) along the stent using an angle of < 60 degrees.
- Measure and add the mean peak systolic velocity value at each level into the structured reporting package.
- Obtain 4-quadrant imaging to assess for ascites.

Abdomen Limited with Vascular - Non Hepatology Imaging Protocol - Limited RUQ Ultrasound
exam including Doppler evaluation.

- Perform examination imaging per AIUM guidelines.
- Exam includes, Liver, IVC, GB, CBD, Right Kidney, Pancreas and Doppler interrogation of the main, left & right portal veins (aorta, spleen, left kidney are excluded).
- Obtain 4-quadrant imaging to assess for ascites.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine	Version #	5
Current Approval Date:	07/28/2020	Old Document ID:	
Date Procedure to go into Effect:	07/28/2020		
Related Policies & Procedures:			
Related Job Aids:			



Hepatic Elastography Interpretation

Katy Lantz MD
Anne Silas MD

References/Resources

- Update to the Society of Radiologists in Ultrasound Liver Elastography Consensus Statement

<https://pubs.rsna.org/doi/full/10.1148/radiol.2020192437>

- Elastography Assessment of Liver Fibrosis: Society of Radiologists in Ultrasound Consensus Conference Statement

<https://pubs.rsna.org/doi/full/10.1148/radiol.2015150619>

****The following slides serve as a summary of key points****

How to perform

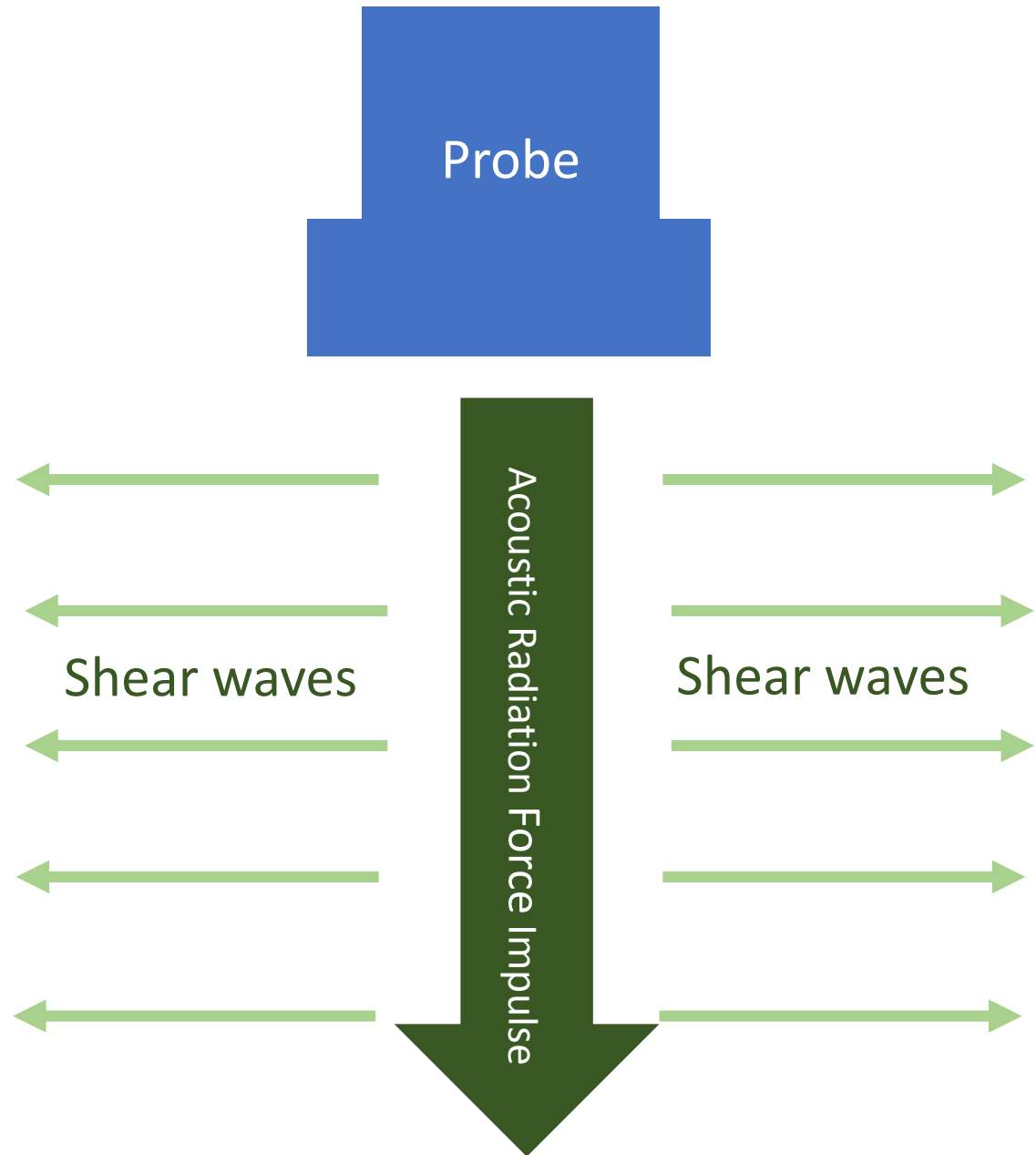
- 4hr fast
- Supine or <30 degrees left lateral decubitus
- Right arm over head
- Probe between ribs, perpendicular to liver capsule and color box
- Color box 1.5-2 cm below the capsule
 - Mitigate reverberation artifact
 - Max pulse at 4-4.5 cm, and attenuated by 6-7cm

How it works

- The probe sends out an Acoustic Radiation Force Impulse (ARFI) at 1-10 m/s.
- Shear waves spread perpendicular to the ARFI and deform the tissue
- The machine monitors the speed of the shear wave deformation.
- The machine uses Young's modulus to calculate the tissue stiffness in kPa or m/s.

$$E = 3\rho c_s^2$$

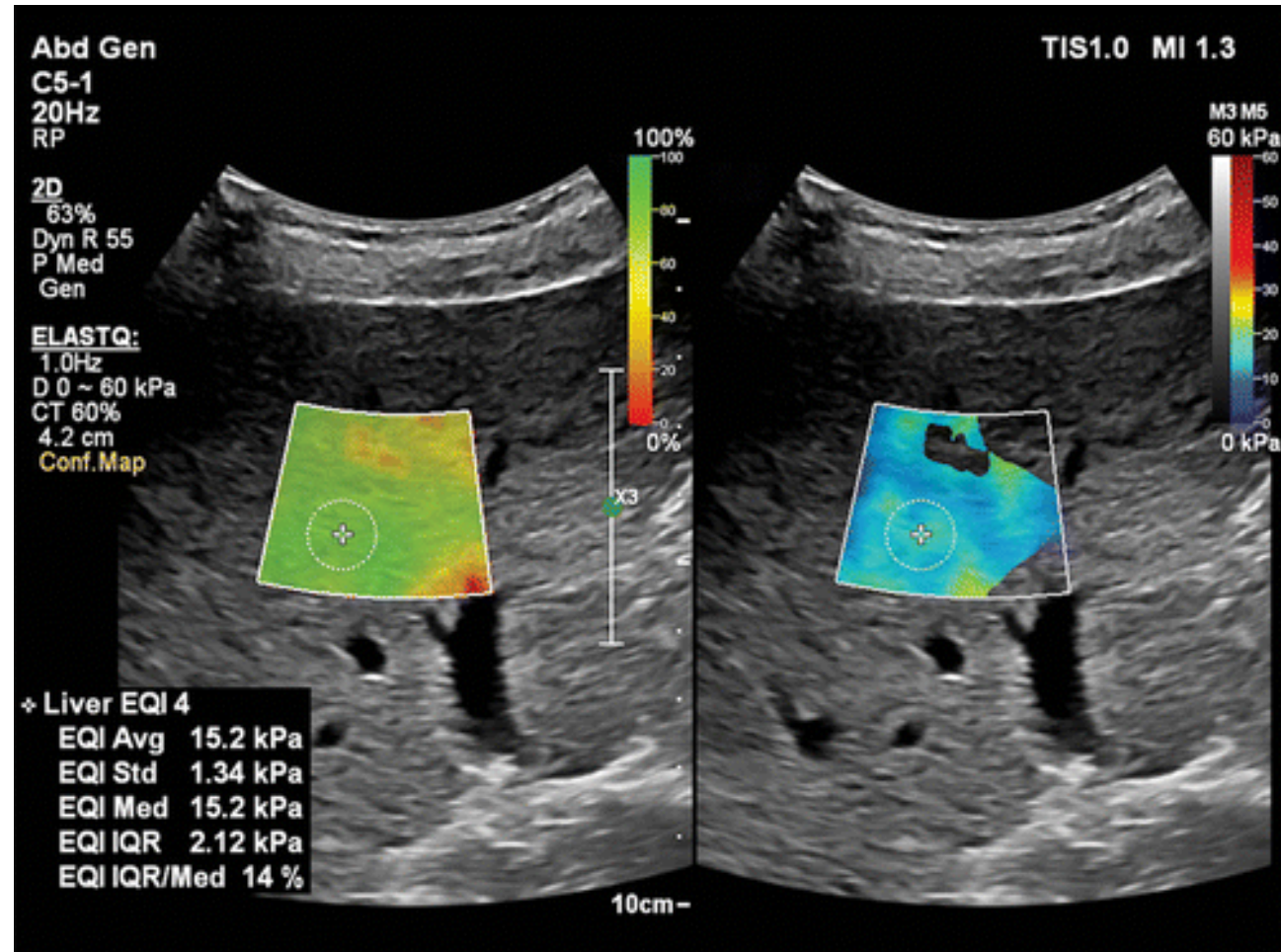
How it works



How it works

- Point shear wave elastography point shear wave (pSWE) sends one AFRI
 - The machine take the median of 10 values
- 2D sends multiple AFRI at a time
 - The machine takes the median of 5 values

Image example



IQR-to-median

- Interquartile range to median value ratio indicates quality/reliability of the study.
- You want the number to be low.
 - For kPa it should be <30%
 - For m/s it should be <15%

Rule of four for interpretation

Compensated advanced chronic liver disease (cACLD)

- Liver stiffness less than or equal to 5 kPa (1.3 m/sec) has high probability of being normal
- Liver stiffness less than 9 kPa (1.7 m/sec), in the absence of other known clinical signs, rules out cACLDV
- Values greater than 13 kPa (2.1 m/sec) are highly suggestive of cACLD

Result interpretation (rule of 4 wording)

Table 2: Recommendation for Interpretation of Liver Stiffness Values Obtained with ARFI Techniques in Patients with Viral Hepatitis and NAFLD

Liver Stiffness Value	Recommendation
≤ 5 kPa (1.3 m/sec)	High probability of being normal
< 9 kPa (1.7 m/sec)	In the absence of other known clinical signs, rules out cACLD. If there are known clinical signs, may need further test for confirmation
9–13 kPa (1.7–2.1 m/sec)	Suggestive of cACLD but need further test for confirmation
> 13 kPa (2.1 m/sec)	Rules in cACLD
> 17 kPa (2.4 m/sec)	Suggestive of CSPH

Note.—ARFI = acoustic radiation force impulse, cACLD = compensated advanced chronic liver disease, CSPH = clinically significant portal hypertension, NAFLD = non-alcoholic fatty liver disease.

**** Note if the liver is grossly cirrhotic on B-mode images than these results do not add anything.**

What can go wrong

Confounders

- ALT/AST 5x normal
- Obstructive cholestasis
- Eating recently
- Hepatic congestion
- Acute hepatitis
- Infiltrative diseases

** all falsely increase the result

Artifacts

- Reverberation from capsule
- Nearby blood vessels or bile ducts
- Not perpendicular to the liver capsule

** check B mode images for artifacts

Template report

1. Liver stiffness measurements were obtained on a [vendor, machine] following the SRU guidelines.
2. [#] valid measurements were obtained using a [point SWE or 2D SWE method].
3. The IQR-to median ratio was [#] suggesting a [quality data set or poor-quality data set].
4. The liver stiffness value was [X] suggesting [rule of 4 recommended wording]

Template report

Consider adding the following sentence(s) if appropriate

1. In the setting of [elevated liver function tests, non-fasting, vascular congestion etc] the stage of liver fibrosis may be overestimated.
2. In some patients with NAFLD, the cut-off values for cACLD may be lower (7-9 kPa)
3. In causes other than viral hepatitis and NAFLD, the cut-off values are not well established.

Departmental Policy Title	Liver Elastography Scheduling and Imaging Procedure - Radiology	Policy ID	25902
Keywords	schedule, scheduling, liver, elastography, us, ultrasound		
Department	Radiology - Ultrasound		

I. Purpose of Policy

To describe the procedures for scheduling and performing Liver Elastography Ultrasound studies. The following standard images are required for interpretation

II. Policy Scope

This scope applies to all Sonographers and Sonologists within the Ultrasound section of Dartmouth-Hitchcock – Lebanon

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Scheduling

1. Requires pre-approval from Triage before scheduling.
2. Schedule exams on the Philips EPIQ Ultrasound unit, preferably Room 2.
3. Evaluation of the liver echotexture and parenchyma (Abdomen limited exam) cannot be performed on the same day due to billing and coding guidelines.

B. Standard Images Required for Interpretation

- Position the transducer in the right intercostal space and aligned with the ribs.
- Image should avoid lung and narrow the field of view (FOV) if necessary.
- Image the liver keeping the liver capsule parallel to the transducer surface.
- Position the ROI (region of interest) box in the center of the image 1.5 - 2.0 cm below the liver capsule.
- Do not place the ROI near any liver vessels, near rib shadow, or the liver capsule.
- Ask the patient to pause breathing. Do not have them take a deep breath.

- Wait for stable image.
- Acquire a minimum of 10 samples, adding them to the scanner measurement report package.
- Print the calculations pages sending entire study to PACS.

Table 2: Recommendation for Interpretation of Liver Stiffness Values Obtained with ARFI Techniques in Patients with Viral Hepatitis and NAFLD

Liver Stiffness Value	Recommendation
≤5 kPa (1.3 m/sec)	High probability of being normal
<9 kPa (1.7 m/sec)	In the absence of other known clinical signs, rules out cACLD. If there are known clinical signs, may need further test for confirmation
9–13 kPa (1.7–2.1 m/sec)	Suggestive of cACLD but need further test for confirmation
>13 kPa (2.1 m/sec)	Rules in cACLD
>17 kPa (2.4 m/sec)	Suggestive of CSPH

Note.—ARFI = acoustic radiation force impulse, cACLD = compensated advanced chronic liver disease, CSPH = clinically significant portal hypertension, NAFLD = non-alcoholic fatty liver disease.

Liver Fibrosis Staging

Liver Fibrosis Staging	Metavir Score	kPa	m/s
Normal – Mild	F1	5.48 kPa – 8.29 kPa	1.35 m/s – 1.66 m/s
Mild – Moderate	F2	8.29 kPa – 9.40 kPa	1.66 m/s – 1.77 m/s
Moderate – Severe	F3	9.40 kPa – 11.9 kPa	1.77 m/s – 1.99 m/s
Cirrhosis	F4	> 11.9 kPa	> 1.99 m/s

V. References N/A

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Update to the Society of Radiologists in Ultrasound Liver Elastography Consensus Statement

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Conflicts of interest are listed at the end of this article.

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This multidisciplinary update of the Society of Radiologists in Ultrasound consensus statement on liver elastography incorporates the large volume of new information available in the literature since the initial publication. The recommended procedure for acquiring stiffness measurements is reviewed. There has been substantial improvement in the acoustic radiation force impulse (ARFI) technology—most notably the addition of a quality assessment of the shear wave propagation. Due to the efforts of the Quantitative Imaging Biomarkers Alliance, or QIBA, the variability of liver stiffness measurements between systems had decreased. There are now effective treatments for hepatitis B and hepatitis C, and follow-up after effective treatment should be based on the use of the delta change of the value obtained at viral eradication or suppression. Because the detection of compensated advanced chronic liver disease (cACLD) is very important, the new guidelines are made based on the probability of cACLD for given stiffness values. The panel recommends a vendor-neutral rule of four for interpretation for ARFI techniques. This new method simplifies interpretation of liver stiffness results and is more clinically relevant.

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This statement is an update produced by the Society of Radiologists in Ultrasound (SRU). Authors include the clinical members of the original statement and comprise society representatives and hepatologists with expertise in liver elastography in the United States and the European Union. The revision process involved identifying a panel leader (R.G.B.), who then selected relevant previous panelists to participate in the update. The panel chair and co-chair (G.F.) created a preliminary draft with recommended updates, which were reviewed by the panel. Consensus was obtained iteratively after successive reviews and revisions and finalized after review by the SRU Executive Board.

The use of shear-wave elastography (SWE) for the non-invasive assessment of liver fibrosis has grown rapidly, and substantial new information regarding disease-specific liver stiffness is available since the publication of the consensus statement of the SRU in September 2015 (1,2). Vibration-controlled transient elastography has been available for almost 20 years and has a large body of literature (3–5). Acoustic radiation force impulse (ARFI) techniques, both point SWE (pSWE) and two-dimensional (2D) SWE have been available for almost 10 years. Currently, several vendors implement ARFI technology (both pSWE and 2D SWE, which are described in detail elsewhere [2,6]) in their US equipment and provide suggestions for optimal technique and assessment of data quality. Since publication of the previous guidelines, several additional vendors have introduced ARFI techniques, and the development of quality or confidence maps have led to the ability to assess the quality of the results. With excellent, less-expensive treatments for both hepatitis C and hepatitis B, these patients are being treated regardless of the liver stiffness value.

This led to a need to update the SRU recommendations on the use of ARFI SWE for the assessment of fibrosis in patients with diffuse liver disease, as a guide for performing and interpreting the examination, taking into account the interim technology advances and published studies.

Chronic liver disease is a world-wide problem. It can be due to a wide range of inciting factors. Its major consequence is increasing deposition of fibrous tissue within the liver leading to the development of cirrhosis, which in turn may give rise to portal hypertension, hepatic insufficiency, and hepatocellular carcinoma. The stage of liver fibrosis is important to determine the prognosis, for surveillance, for prioritization for treatment, and even to determine the potential for reversibility (1,2,7–9). The spectrum of fibrosis is a continuum, and patients with a higher stage of liver fibrosis (stage F3–F4) are at risk for clinical complications (eg, ascites, variceal hemorrhage, hepatic encephalopathy). For patients with severe fibrosis or liver cirrhosis who are asymptomatic, the term “compensated advanced chronic liver disease” (cACLD) has been proposed (10,11). In patients with cACLD, the degree of portal hypertension is predictive of decompensation and/or death (10,11). A portal pressure (as assessed by means of the hepatic venous pressure gradient) of 10 mm Hg or higher (normal, 3–5 mm Hg)—a threshold that is designated “clinically significant portal hypertension” (CSPH)—has been associated with an almost four-fold higher risk of decompensation compared with lower pressures (12).

Many clinical guidelines recommend the use of non-invasive tests for the detection and staging of liver fibrosis (3,5,13,14). Although biopsy is historically the reference standard for staging fibrosis, it is imperfect, with

Abbreviations

ARFI = acoustic radiation force impulse, cACLD = compensated advanced chronic liver disease, CSPH = clinically significant portal hypertension, IQR = interquartile range, NAFLD = non-alcoholic fatty liver disease, pSWE = point SWE, SRU = Society of Radiologists in Ultrasound, SWE = shear wave elastography, 2D = two-dimensional

Summary

To follow-up patients, the consensus suggests using the delta changes of liver stiffness over time instead of the absolute values, using as a baseline value in case of viral hepatitis that obtained after viral eradication or suppression.

Key Results

- The variability between consecutive liver stiffness acquisitions, assessed by means of the interquartile range-to-median ratio, is the most important quality criterion; when this ratio is higher than 30% for measurements given in kilopascals or higher than 15% for measurements given in meters per second, the accuracy of the technique is reduced.
- Given the large overlap of stiffness values for mild-to-moderate fibrosis, the Society of Radiologists in Ultrasound continues to recommend a low cutoff value below which there is a high probability of no or mild fibrosis and recommends a high cut-off value above which there is a high probability of compensated advanced chronic liver disease (cACLD).
- Because the overlap of liver stiffness values between METAVIR scores is as large if not larger than the difference between vendors, separate cut-off values for each vendor are not required.
- The panel recommends a vendor-neutral “rule of four” for the acoustic radiation force impulse techniques in the viral causes and non-alcoholic fatty liver disease (NAFLD): Liver stiffness less than or equal to 5 kPa (1.3 m/sec) has high probability of being normal, liver stiffness less than 9 kPa (1.7 m/sec), in the absence of other known clinical signs, rules out cACLD, and values greater than 13 kPa (2.1 m/sec) are highly suggestive of cACLD; in some patients with NAFLD, the cut-off values for cACLD may be lower and follow-up or additional testing in those with values between 7 and 9 kPa is recommended.
- For pediatric patients with liver disease or congenital heart disease with Fontan surgery, it is expert opinion that each patient becomes his or her own control, and the stiffness delta changes over time should be used to evaluate the efficacy of the treatment or the progression of disease.

considerable interobserver variability and κ values varying from 0.5 to 0.9 in the literature (15,16). It should be emphasized, however, that histologic examination of liver specimens does provide information on inflammation that is not yet possible to evaluate with US. Despite this benefit, the use of noninvasive tests is favored due to the need for longitudinal monitoring and to safely extend screening to larger populations.

There are many different causes of chronic liver disease worldwide. Chronic viral hepatitis (hepatitis C in the West, hepatitis B in the East) remains a major risk factor. Although the incidence of cACLD may be lower because of the advent of highly effective interferon-free antiviral therapies, staging of liver fibrosis is still necessary before treatment because patients with cACLD require continued surveillance for hepatocellular carcinoma and/or varices even after the clearance of the virus (17,18).

A rising cause of chronic liver disease worldwide is nonalcoholic fatty liver disease (NAFLD). NAFLD is currently the most common liver disease in the United States, with a worldwide

prevalence of 25% with imaging estimation (19). NAFLD ranges from simple steatosis to nonalcoholic steatohepatitis, which may progress to liver fibrosis and cirrhosis with its complications. Although there is no specific therapy for nonalcoholic steatohepatitis, lifestyle modifications have been associated with a decrease in fibrosis and portal hypertension (20,21), and identification of cACLD allows for screening and surveillance of varices and hepatocellular carcinoma. Therefore, the availability of non-invasive tools to exclude or diagnose cACLD in these patients is of the utmost importance.

Protocol for ARFI SWE Acquisition

The patient preparation, imaging technique, and measurement recommendations for ARFI SWE (both pSWE and 2D SWE) are the same, and the recommended protocol in the original SRU consensus is unchanged and similar to the European Federation of Societies for Ultrasound in Medicine and Biology and World Federation for Ultrasound in Medicine and Biology guidelines (3,5). The protocol includes obtaining measurements between the ribs in the right upper quadrant, instructing the patient to fast for at least 4 hours, imaging the patient in a supine or slight left lateral decubitus position (not more than 30°) with their right hand above their head, obtaining measurements in a neutral breath hold, placing the transducer perpendicular to the liver capsule and the measurement box parallel to the liver capsule, and taking measurements 1.5–2.0 cm from the liver capsule to avoid reverberation artifact. A brief outline of how to perform the examination is included in Table 1.

Because B-mode is used to track the shear waves, high-quality B-mode imaging is required. Images should be free of artifacts. Several studies have shown that operators require only a short period of training to perform reliable liver stiffness measurements; however, the reproducibility of liver stiffness measurements over time is higher for expert operators than for novice operators (22–24).

Quality Criteria

The recommended quality criteria include the number of required acquisitions and the interquartile range (IQR)–to-median ratio (subsequently referred to as IQR/M). Furthermore, some vendors provide a quality or confidence factor for measurements obtained with 2D SWE. Some vendors also provide an assessment of the quality of each measurement for pSWE. Each vendor has recommendations for use of their quality criteria.

Obtaining Measurements

Measurements should be obtained in areas of high quality, which is determined by a high amplitude of the shear waves, a normal shear-wave propagation, and a linear slope of the time of the peak and distance from ARFI pulse of the displacement curves. Each vendor provides a confidence or quality number or map that combines these factors into one number for clinical use. Figure 1 demonstrates various methods used to assess the quality of an image. If the quality is poor in most of the image, a measurement should not be obtained from that image.

Table 1: Recommendations for Performing Liver Stiffness Measurements with the ARFI Technique

Recommendations

1. Patients should fast at least 4 hours before the examination
2. Measurement should be taken at an intercostal space with the patient in the supine or slight lateral decubitus (30°) position with right arm in extension
3. Measurements should be taken at neutral breathing during a breath hold
4. Measurement should be taken at least 15–20 mm below liver capsule in pSWE
5. The 2D SWE region of interest can be positioned closer to the liver capsule, if reverberation artifacts are avoided; however, the measurement box should be positioned at least 15–20 mm below the liver capsule
6. Results can be reported in meters per second or in kilopascals
7. In most systems, the maximum ARFI push pulse is at 4–4.5 cm from the transducer, which is the optimal location for obtaining measurements. In most systems, the ARFI push pulse is attenuated by 6–7 cm, limiting adequate shear wave generation
8. Major potential confounding factors include liver severe inflammation indicated by AST and/or ALT elevation greater than five times upper normal limits, obstructive cholestasis, liver congestion, acute hepatitis, and infiltrative liver disease (these all lead to overestimation of the stage of fibrosis)
9. Ten measurements should be obtained with pSWE, and the final result should be expressed as the median together with the IQR/M
10. Fewer than 10 measurements with pSWE can be obtained (at least five); however, the IQR/M should be within the recommended range
11. For 2D SWE, five measurements should be obtained when the manufacturer's quality criteria are available, and the final result should be expressed as the median together with the IQR/M
12. The most important reliability criterion is an IQR/M of $\leq 30\%$ of the 10 measurements (pSWE) or five measurements (2D SWE) for kilopascals and $\leq 15\%$ for measurements in velocity (in meters per second)
13. Adequate B-mode liver imaging is a prerequisite for point and 2D SWE as shear waves are tracked with B-mode

Note.—ALT = alanine aminotransferase, ARFI = acoustic radiation force impulse, AST = aspartate aminotransaminase, IQR/M = interquartile range-to-median ratio, pSWE = point SWE, SWE = shear-wave elastography, 2D = two-dimensional.

Number of Measurements

pSWE.—Ten measurements are still recommended; however, studies have shown that there is no loss in accuracy with five measurements when the quality criterion of IQR/M is fulfilled (25–28). In the study by Fang et al (25), six measurements were recommended; however, when only the values obtained with a high reliability (IQR/M, $\leq 30\%$) were considered, there was no difference between five and six measurements.

Two-dimensional SWE.—The measurement area is larger than that with pSWE, and thus each value is an average of several measurements. Hence, five measurements are adequate if a quality assessment is provided by the manufacturer. If a quality assessment is not available, 10 measurements are recommended.

IQR/M Values

Studies have shown that the level of variability between consecutive acquisitions, assessed by means of the IQR/M, is the most important quality criterion. When this ratio is higher than 30% (for measurements given in kilopascals), the accuracy of the technique is reduced (3,25,27). It is important to note that the IQR/M for measurements reported in kilopascals should be 30% or less, whereas that for measurements reported in meters per second (shear wave speed) should be 15% or less as the conversion of meters per second to kilopascals is nonlinear. If the IQR/M values are greater than 30% in kilopascals or 15% in meters per second, the measurement of liver stiffness should be judged as unreliable.

Cut-off Values

Cut-off values for fibrosis staging vary across US systems from different vendors; however, the variance has decreased due to the efforts of the Quantitative Image Biomarker Alliance, or QIBA (29,30). QIBA (an RSNA organization with vendors, scientists, members of the U.S. Food and Drug Administration, and clinicians) developed standardized phantoms that the vendors have used to standardize their measurements. The difference between various system measurements increases as liver stiffness increases. The difference in cut-off values is greatest as patients exceed the threshold of cACLD (31).

Given the large overlap of stiffness values for mild-to-moderate fibrosis, the SRU continues to recommend a low cut-off value below which there is a high probability of no or mild fibrosis and recommends a high cut-off value above which there is a high probability of cACLD. In this update, a new cut-off value to rule out CSPH has been added on the basis of some recent studies (32–35). The consensus panel also divides the liver stiffness values between no or minimal disease and cACLD into two categories. For these middle liver stiffness values, confirmation with an additional test may be needed to rule in or rule out cACLD. From a clinical perspective, it is more important to rule in or rule out significant disease than it is to provide an exact stage by using the METAVIR scoring system. Because of the large liver stiffness value overlap of METAVIR scores (1), which is greater than the measurement variability between vendors (31), separate cut-off values for each vendor are not required. Based on some published studies and mirroring the Baveno VI consensus conference (10,11), that is, the so-called “rule of five” (5, 10, 15, 20 kPa)

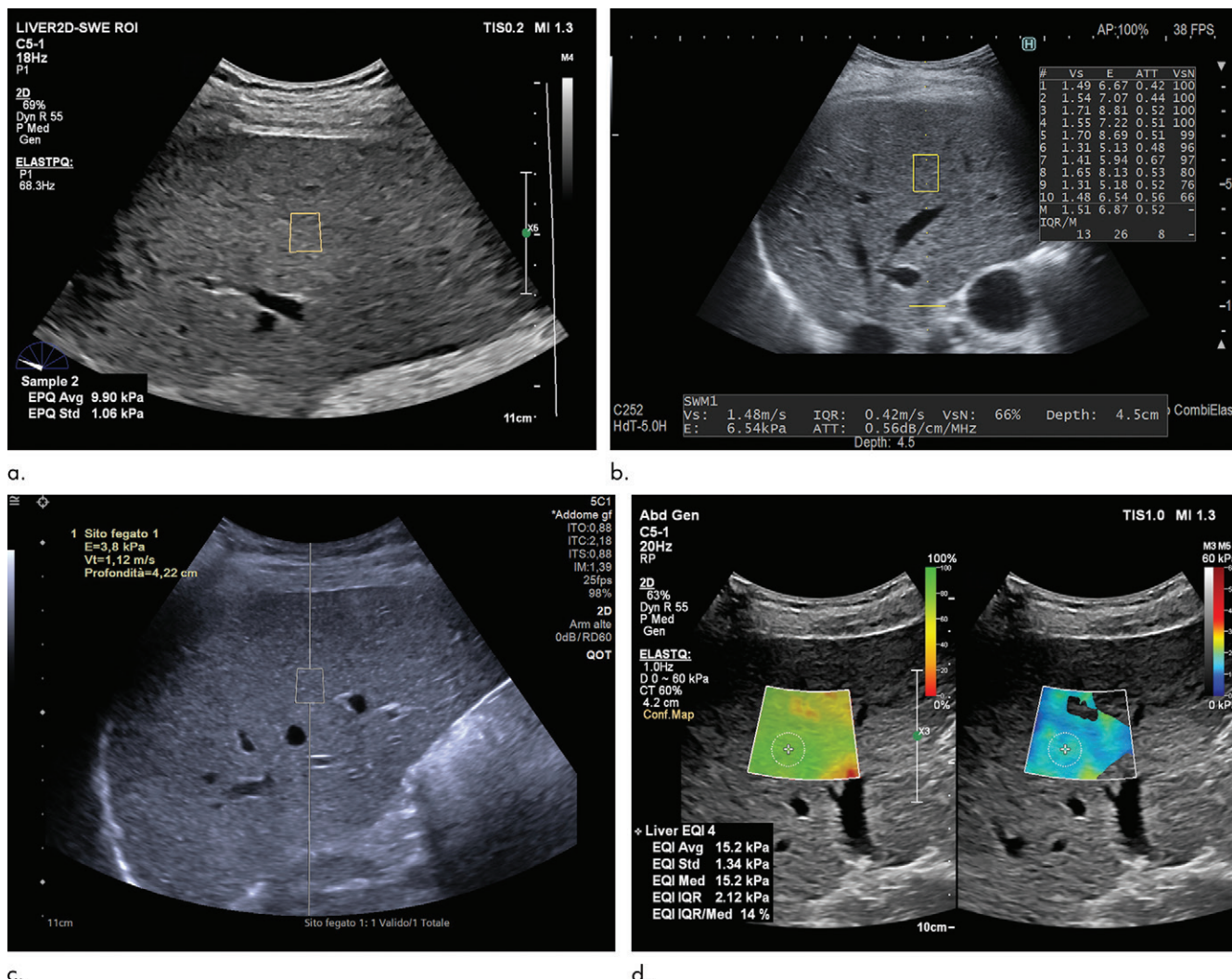


Figure 1: (a) Image obtained with point shear-wave elastography (pSWE) system (ElastPQ; Philips, Bothell, Wash). A standard deviation (Std) of 30% or less of the mean value is indicative of an acquisition of good quality. In this case, the standard deviation is 1.06/9.90 or 10.7%. When the signal-to-noise ratio of an acquisition is very low, the mean value is not shown. (b) Image obtained with pSWE (SWM; Hitachi, Tokyo, Japan). “VsN” is a reliability index that indicates the percentage of effective push-track sequences. When the signal-to-noise ratio of an acquisition is very low, the mean value is not shown. A good acquisition has a VsN of at least 50%. In this case, the VsN measurements are all above 66%. (c) Image obtained with pSWE (VTQ; Siemens, Mountain View, Calif). The system automatically filters out the measurements that are not good. In these cases, the numeric value of shear-wave speed is replaced by an “XXX” sequence. (d) Images obtained with two-dimensional (2D) shear-wave elastography (SWE) (EQI, Philips). The color-coded confidence map (left) is an evaluation of the quality of the acquired signals. The confidence threshold (CT) is set at 60%. Areas of low quality (red) are filtered out and left blank on the color-coded image of liver stiffness assessment (right); the yellow color on the confidence map is a warning, that is, it indicates that the acquisition in that area is not the highest quality (Fig 1 continues).

for the staging of liver fibrosis with vibration-controlled transient elastography, the consensus panel proposes a vendor-neutral “rule of four” (5, 9, 13, 17 kPa) for the ARFI techniques for viral etiologies and NAFLD: Liver stiffness of 5 kPa (1.3 m/sec) or less has high probability of being normal; liver stiffness less than 9 kPa (1.7 m/sec), in the absence of other known clinical signs, rules out cACLD; values between 9 kPa (1.7 m/sec) and 13 kPa (2.1 m/sec) are suggestive of cACLD but may need further test for confirmation; and values greater than 13 kPa (2.1 m/sec) are highly suggestive of cACLD. There is a probability of CSPH with liver stiffness values greater than 17 kPa (2.4 m/sec), but additional patient testing may be required. In some patients with NAFLD, the cut-off values for cACLD may be lower and follow-up or additional testing in those with values between 7 and 9 kPa is recommended.

For other causes such as alcoholic hepatitis, primary biliary cirrhosis, Wilson disease, autoimmune hepatitis, sclerosing cholangitis, and drug-induced liver disease, there is insufficient data to make a conclusion.

Table 2 summarizes these cut-off value recommendations and provides them in both kilopascals and meters per second. For those who would like a value to rule out significant fibrosis, most studies that used ARFI (pSWE and 2D SWE) suggest that a liver stiffness value of less than 7 kPa (1.5 m/sec) can help rule out significant fibrosis.

With vibration-controlled transient elastography, the alanine aminotransferase-adapted cut-off values of liver stiffness reportedly improved the staging of liver fibrosis in patients with chronic hepatitis B in a single study (36). The consensus

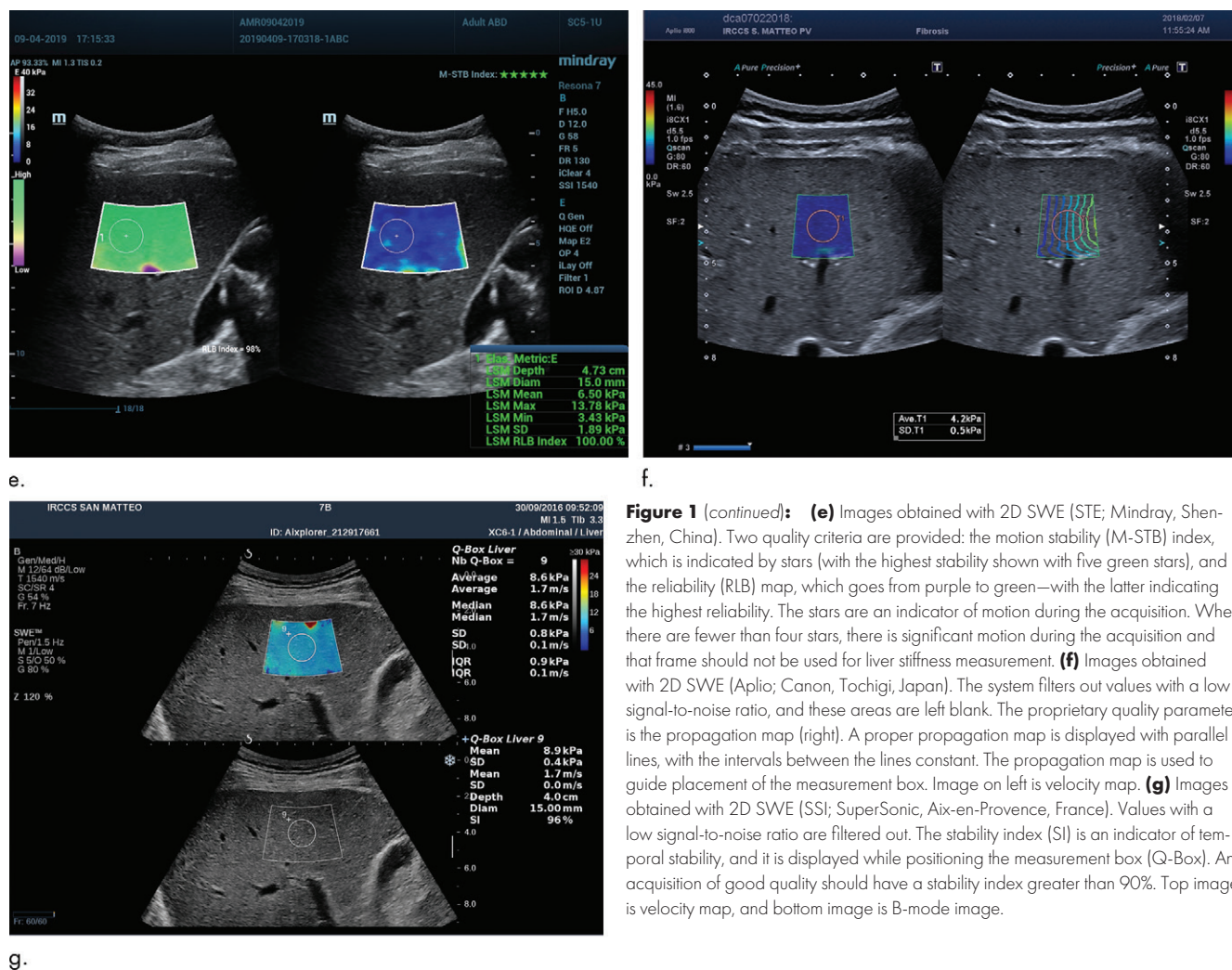


Figure 1 (continued): (e) Images obtained with 2D SWE (STE; Mindray, Shenzhen, China). Two quality criteria are provided: the motion stability (M-STB) index, which is indicated by stars (with the highest stability shown with five green stars), and the reliability (RLB) map, which goes from purple to green—with the latter indicating the highest reliability. The stars are an indicator of motion during the acquisition. When there are fewer than four stars, there is significant motion during the acquisition and that frame should not be used for liver stiffness measurement. (f) Images obtained with 2D SWE (Aplio; Canon, Tochigi, Japan). The system filters out values with a low signal-to-noise ratio, and these areas are left blank. The proprietary quality parameter is the propagation map (right). A proper propagation map is displayed with parallel lines, with the intervals between the lines constant. The propagation map is used to guide placement of the measurement box. Image on left is velocity map. (g) Images obtained with 2D SWE (SSI; SuperSonic, Aix-en-Provence, France). Values with a low signal-to-noise ratio are filtered out. The stability index (SI) is an indicator of temporal stability, and it is displayed while positioning the measurement box (Q-Box). An acquisition of good quality should have a stability index greater than 90%. Top image is velocity map, and bottom image is B-mode image.

Table 2: Recommendation for Interpretation of Liver Stiffness Values Obtained with ARFI Techniques in Patients with Viral Hepatitis and NAFLD

Liver Stiffness Value	Recommendation
≤5 kPa (1.3 m/sec)	High probability of being normal
<9 kPa (1.7 m/sec)	In the absence of other known clinical signs, rules out cACLD. If there are known clinical signs, may need further test for confirmation
9–13 kPa (1.7–2.1 m/sec)	Suggestive of cACLD but need further test for confirmation
>13 kPa (2.1 m/sec)	Rules in cACLD
>17 kPa (2.4 m/sec)	Suggestive of CSPH

Note.—ARFI = acoustic radiation force impulse, cACLD = compensated advanced chronic liver disease, CSPH = clinically significant portal hypertension, NAFLD = non-alcoholic fatty liver disease.

panel therefore does not recommend alanine aminotransferase-adapted cut-offs until additional publications confirm its usefulness. The updated World Federation of Ultrasound in Medicine and Biology guidelines provide a detailed review of the literature for several of the causes that progress to chronic liver disease and associated confounding factors (3).

Confounding Factors

There are several clinical conditions in which an increase of liver stiffness unrelated to liver fibrosis can be observed

(1,3,5). These conditions include, but are not limited to, acute hepatitis, liver inflammation, transaminitis flares with alanine aminotransferase value more than five times the upper limit of normal, obstructive cholestasis, hepatic congestion, and infiltrative liver diseases such as amyloidosis, lymphoma, or extramedullary hematopoiesis. Other factors may also affect liver stiffness measurement, such as postprandial hyperemia or intense physical exercise. In all these conditions, however, stiffness values within the normal range exclude significant liver fibrosis.

Table 3: Recommendations for Performing Spleen Stiffness Measurements with the ARFI Technique

Recommendations

1. Patients should fast at least 4 hours before the examination (56)
2. Measurement should be taken at an intercostal space with the patient in supine position with left arm in extension
3. Measurements should be taken during breath hold at neutral breathing (57)
4. Measurement should be taken at least 15 mm below spleen capsule with pSWE and reverberation artifacts avoided with 2D SWE. The region of interest should be placed perpendicular to the splenic surface
5. Results can be reported in meters per second or kilopascals
6. In most systems, the maximum ARFI push pulse is at 4–4.5 cm from the transducer, which is the optimal location for obtaining measurements. In most systems, the ARFI push pulse is attenuated by 6–7 cm, limiting adequate shear wave generation
7. Ten measurements should be obtained with pSWE, and the final result should be expressed as the median together with the IQR/M
8. For 2D SWE, five measurements should be obtained, and the final result should be expressed as the median together with the IQR/M
9. The most important reliability criteria is a IQR/M of $\leq 30\%$ of the recommended measurements for kilopascals and $\leq 15\%$ for meters per second

Note.—ARFI = acoustic radiation force impulse, IQR/M = interquartile range-to-median ratio, pSWE = point SWE, SWE = shear-wave elastography, 2D = two-dimensional.

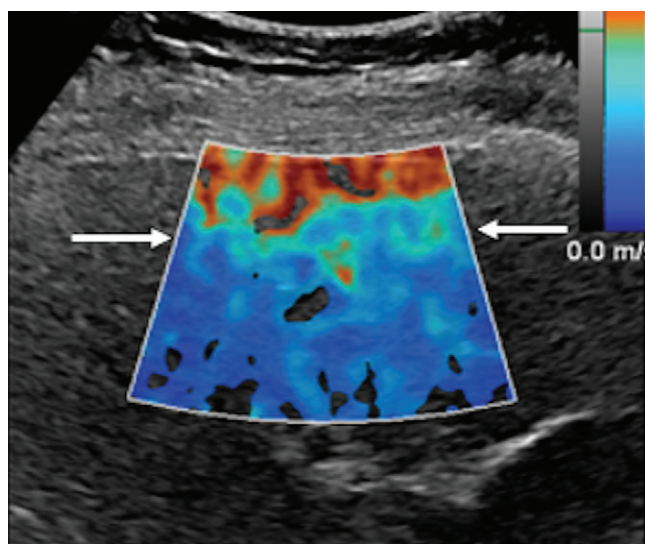


Figure 2: Image obtained with two-dimensional (2D) shear-wave elastography (SWE) demonstrates area of increased stiffness (red and teal, arrows) due to reverberation artifact. The reverberation artifact occurs below the liver capsule in both point SWE (pSWE) and 2D SWE. In pSWE, the artifact is not seen; therefore, it is important to obtain measurements at least 1.5 cm below the liver capsule to avoid the artifact. This area should be avoided when placing the measurement box for liver stiffness measurements.

Follow-up

In patients with chronic hepatitis B virus or hepatitis C virus who have been successfully treated with antiviral drugs, the cut-offs obtained in viremic patients should not be used because a rapid decline of stiffness values has been observed in these patients, likely due to the decrease of liver inflammation (3,5). When liver cirrhosis is evident with B-mode findings, elastography should not be used to rule out the disease because a value in the low range of liver stiffness may only indicate a successful response to antiviral treatment.

On the basis of results of both prospective and retrospective studies with more than 1000 patients (37–41), the delta change

of liver stiffness values over time should be used instead of the absolute values (37–40,42). Thus, every patient becomes his or her own control. Because there is an approximately 10% variability of the measurements within a vendor and between vendors (29,30), a clinically significant change should be considered when the delta change is greater than 10%. The panel recommends using the same equipment for follow-up studies. In patients with chronic viral hepatitis who are successfully treated, the baseline liver stiffness should be that obtained after viral eradication or suppression. Applying this rule, liver stiffness assessment can be suitable for evaluating all clinical conditions leading to an increase of liver stiffness, independent of the disease etiology including nonfibrotic causes of liver stiffness increase, such as congestive heart failure.

Spleen Stiffness

It has been reported that liver stiffness correlates with the severity of liver fibrosis up to the threshold of CSPH, defined as an increase in hepatic venous pressure gradient greater than 10 mm Hg (43). In patients with CSPH, the strength of the correlation between liver stiffness and fibrosis decreases, probably due to an increasing role played by extrahepatic factors, mainly the increase in portal venous inflow, as portal hypertension progresses (10,44). The acquisition technique is the same as that for liver, except the measurements are taken between the left ribs with the patient in a supine or slight right lateral position. It is the opinion of the expert panel that adequate studies have not been performed to provide cut-off values at this time. A review of the existing literature is provided below. In patients with chronic liver disease, splenic measurements should only be taken in patients with cACLD as significant portal pressures are not expected at lower levels of fibrosis.

CSPH is predictive of the development of complications of cirrhosis, including variceal rupture and death. However, it is also present in about 50%–60% of patients with compensated cirrhosis without gastroesophageal varices (12,45). It appears that spleen stiffness shows better correlation with portal pressure than does liver stiffness (46). Portal hypertension leads to splenic

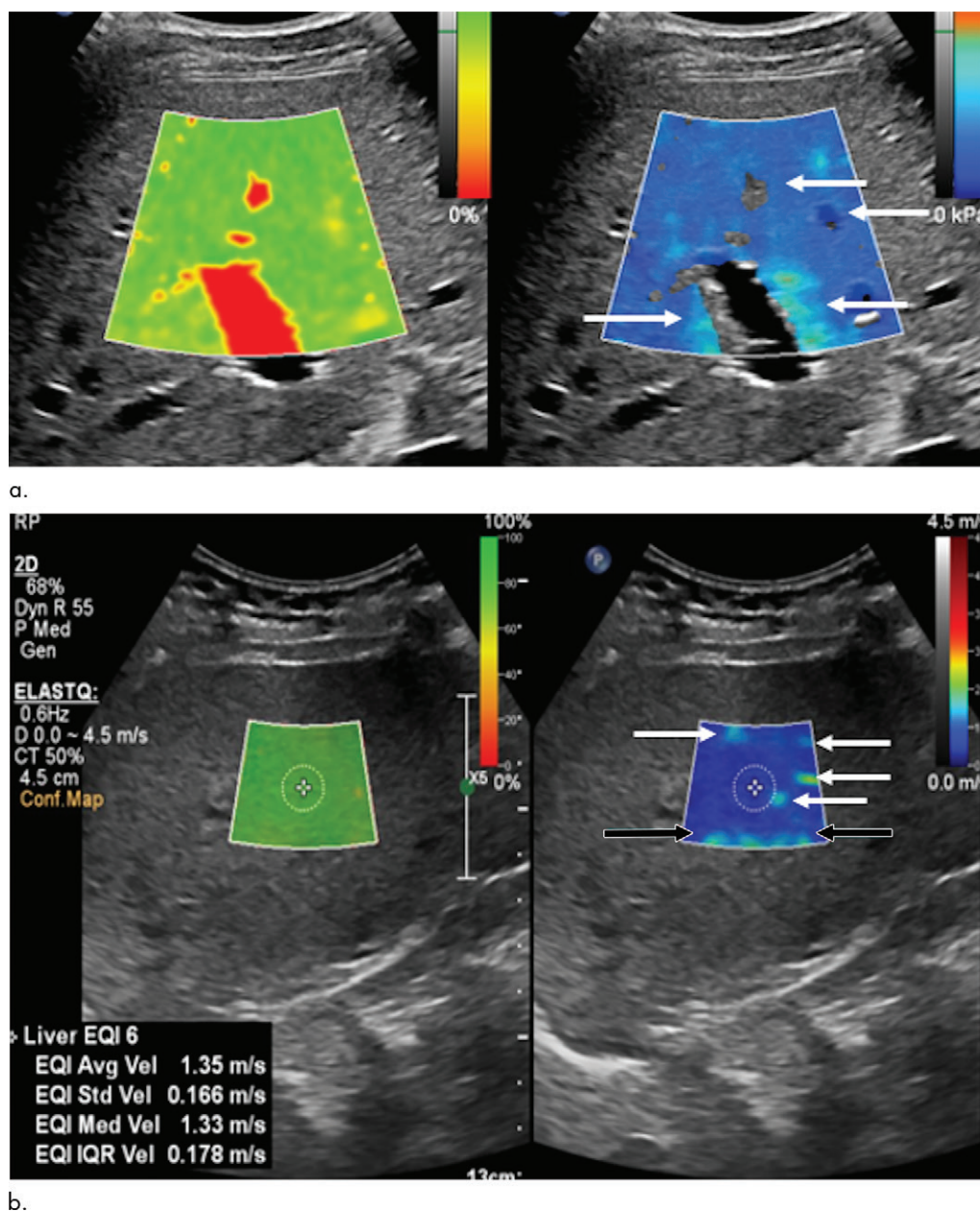


Figure 3: (a) Artifacts occur around large blood vessels and bile ducts. These artifacts are not seen in point shear-wave elastography (SWE), and therefore measurements should be obtained at least 5 mm from these structures. In two-dimensional SWE, these artifacts can be identified and avoided. Image on right is velocity map, and image on left is quality map. Arrows indicate artifacts. Depending on the vendor, artifacts may not be color-coded or appear as areas of increased stiffness (teal). These areas should be avoided when placing the measurement box. (b) Shear-wave propagation occurs in all directions perpendicular to the acoustic radiation force impulse (ARFI) pulse. Therefore, artifacts from a blood vessel just out of the image plane can also produce artifacts. Velocity image (right) shows artifacts in teal (white arrows). These artifacts are most likely from vessels just out of the image plane. The measurement box should not include these areas. Black arrows point to teal areas at the deep part of the image. These are artifacts from the ARFI pulse strength decreased due to attenuation, leading to weak shear waves that make it difficult to obtain accurate estimates of shear-wave speed. Note that the quality map (left) in this case suggests high quality throughout the field of view. The quality map does not identify all artifacts, and both the quality map and velocity map should be evaluated for artifacts.

congestion, increasing splenic stiffness. In fact, portal hypertension may cause splenic fibrosis (47).

In healthy individuals, the spleen is stiffer than the liver. Several studies, most of which were performed with vibration-controlled transient elastography, have shown that, in patients with portal hypertension, spleen stiffness is more reliable than liver stiffness for assessing the risk of CSPH and esophageal varices (46,48–50).

However, there are differences in cut-off values between studies, and the level of evidence is still too low to recommend spleen stiffness in the diagnostic work-up of patients with cirrhosis.

For ARFI-based techniques, limited studies suggest that abdominal wall thickness and splenic longitudinal diameter are independent predictors of successful spleen stiffness measurement (51,52). The feasibility of performing spleen

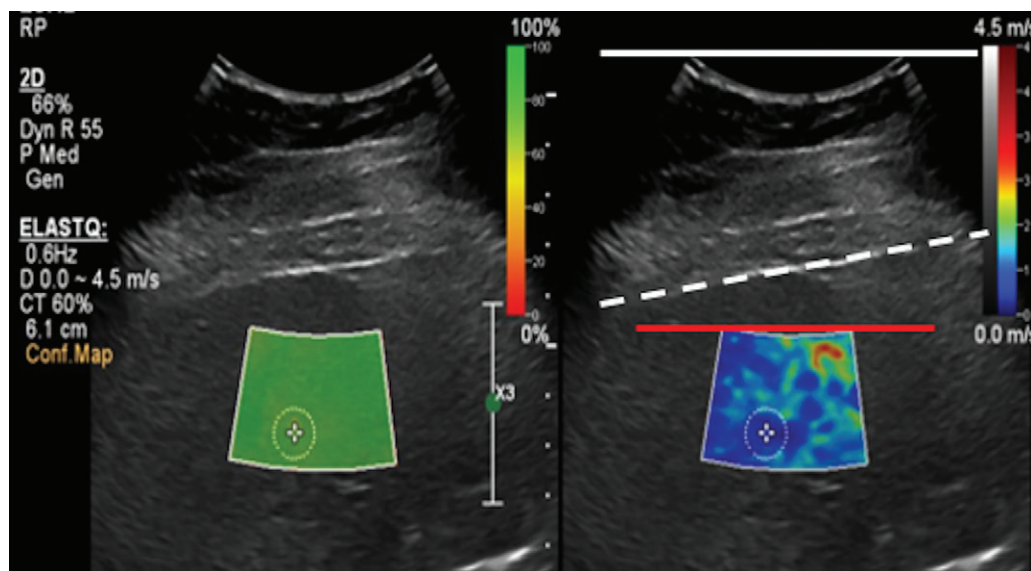


Figure 4: Images from two-dimensional shear-wave elastography. Image on left is confidence map, and image on right is velocity map. When the acoustic radiation force impulse pulse is not perpendicular to the liver capsule, artifacts occur. In this case, the liver capsule (dashed white line) is not parallel to the transducer (solid white line) or the field-of-view box (red line). The heterogeneous stiffness measurements in the field of view are due to artifacts occurring because the three lines are not parallel.

Suggested Reporting for Liver Stiffness Measurements

Liver stiffness measurements were obtained on a (list vendor and machine) using a (list probe) following the SRU guidelines. (# number of) valid measurements were obtained using a (point SWE or 2D SWE) method. The IQR-to-median ratio was (x), suggesting a (quality data set or poor-quality data set). The liver stiffness value was (X), suggesting (rule of 4 recommended wording). Consider adding the following sentence(s) if appropriate: In the setting of (elevated liver function tests, nonfasting, vascular congestion, etc), the stage of liver fibrosis may be overestimated; In some patients with NAFLD, the cut-off values for cACLD may be lower (7–9 kPa); In causes other than viral hepatitis and NAFLD, the cut-off values are not well established.

Figure 5: Suggested reporting format for liver stiffness measurements. cACLD = compensated advanced chronic liver disease, IQR = interquartile range, NAFLD = non-alcoholic fatty liver disease, SWE = shear wave elastography, SRU = Society of Radiologists in Ultrasound, 2D = two-dimensional.

stiffness measurement was evaluated by Procopet et al (53) in 88 patients undergoing hepatic venous pressure gradient measurement for portal hypertension. The overall success rate of obtaining an accurate measurement, defined as the system being able to estimate a stiffness value, was 66%. In that series, the patients with failure of spleen stiffness had higher body mass index (mean, $28.3 \text{ kg/m}^2 \pm 5.0$ vs $25.2 \text{ kg/m}^2 \pm 3.7$; $P = .002$) and smaller spleen (mean bipolar diameter, $11.8 \text{ cm} \pm 2.7$ vs $14.2 \text{ cm} \pm 4.0$; $P < .0001$). In a series composed of 313 consecutive patients who underwent liver stiffness and spleen stiffness measurements on the same day (52), the success rate of spleen stiffness measurement was 80% in patients with splenomegaly. Technical success of spleen stiffness measurements was 78% in another small series (54), including 54 patients with cirrhosis who either had low-grade esophageal varices or were without esophageal varices at upper endoscopy.

Normal values of spleen stiffness with ARFI-based techniques in published studies range from 20.5 kPa (2.6 m/sec) to 24.4 kPa (2.85 m/sec) (52,53,55). The suggested procedure

for performing spleen stiffness measurement is presented in Table 3.

With use of pSWE, investigators in one study reported a higher incidence of esophageal variceal bleeding in patients with a spleen stiffness value of at least 39 kPa (3.64 m/sec); no bleeding occurred in patients with spleen stiffness less than 36 kPa (3.48 m/sec) (58). With use of 2D SWE, other investigators showed that CPSH is unlikely in patients with spleen stiffness less than 26.6 kPa (3.0 m/sec) (35). Algorithms that combine liver stiffness and spleen stiffness, or platelets count, have been proposed (59).

In a multicenter study in which liver stiffness and spleen stiffness were available in 109 patients undergoing hepatic venous pressure gradient measurement, liver stiffness of 16.0 kPa (2.3 m/sec) or less and spleen stiffness of 21.7 kPa (2.7 m/sec) or less were able to help rule out CSPH, whereas liver stiffness values greater than 29.5 kPa (3.2 m/sec) and spleen stiffness values greater than 35.6 kPa (3.5 m/sec) were able to help rule in CSPH (specificity, $>92\%$). In patients with liver stiffness of 38.0 kPa (3.6 m/sec) or less, a splenic stiffness greater than 27.9 kPa (3.2 m/sec) ruled in CSPH. This algorithm had a sensitivity of 89.2% and a specificity of 91.4% to rule in CSPH (41). However, in a series of 191 patients (60), this algorithm has not been validated: Specificity and positive predictive value were 52% and 83%, respectively.

Interestingly, it has been reported that patients with hepatitis C virus hepatitis successfully treated with antiviral drugs show a rapid decline of liver stiffness but not of spleen stiffness because there is not an immediate effect on portal hypertension. Spleen stiffness is more accurate in assessing portal hypertension in this setting. Therefore, the risk of variceal hemorrhage remains in the short term (61).

Table 4: Summary of Recommendations

Protocol for acquisition: As reported in Table 1, the most important criterion is $IQR/M \leq 30\%$ for values in kilopascals and 15% for values in meters per second. In pediatric patients, the same protocol must be used

Protocol for 2D SWE acquisition in children who are unable to hold their breath: The consensus panel suggests recording a 2D SWE cine loop for up to 30 seconds if real-time 2D SWE is available, reviewing it, and choosing the image that demonstrates the most stable pattern for the stiffness measurement. No more than one image should be chosen in each recorded cine loop

Cut-off values: “rule of four” (5, 9, 13, 17 kPa) for the ARFI techniques for viral causes and NAFLD (Table 2)

NAFLD and rare diseases in pediatric patients: The number of published pediatric studies of NAFLD remains low, and the cutoff values for staging liver fibrosis varies between studies. It is expert opinion that each patient becomes his or her own control, using the stiffness delta changes over time to evaluate the efficacy of the treatment or the progression of disease—remembering that the measurement reflects stiffness and not fibrosis

Follow-up: The use the delta changes of LS values over time should be used instead of the absolute values. In patients with chronic viral hepatitis who are successfully treated, the baseline LS stiffness should be that obtained after viral eradication or suppression. A clinically significant change should be considered when the delta change is greater than 10%. Applying this rule, LS assessment can be suitable for evaluating all clinical conditions leading to an increase of LS, independent of the disease cause including nonfibrotic causes of LS increase (eg, congestive heart failure)

Spleen stiffness: It appears that spleen stiffness is better correlated with portal pressure than LS. However, there are differences in cut-off values between studies and the level of evidence is still low to recommend spleen stiffness in the diagnostic work-up of patients with cirrhosis

Reporting: The report should include the system vendor name, the SWE technique (pSWE or 2D SWE), the probe used, the number of acquisitions, the IQR/M , and conclusions (Fig 5)

Note.—ARFI = acoustic radiation force impulse, IQR/M = interquartile range-to-median ratio, LS = liver stiffness, NAFLD = non-alcoholic fatty liver disease, pSWE = point SWE, SWE = shear-wave elastography, 2D = two-dimensional.

Pediatric Patients

The use of a noninvasive technique for staging liver fibrosis is of great interest because it may avoid liver biopsy, which, in addition to its well-known complications, is particularly stressful for pediatric patients. In the pediatric age group, NAFLD is the most common cause of chronic liver disease. A 2015 meta-analysis (62) determined that the pooled mean prevalence of NAFLD in the United States was 7.6% in the general U.S. pediatric population and that it reached 34.2% in obese children. In one study of 347 children suspected of having NAFLD who were identified through screening in primary care and referral to pediatric gastroenterology, advanced fibrosis was present in 17% of 193 children diagnosed with NAFLD at liver biopsy. Conversely, in 242 consecutive adolescents undergoing bariatric surgery, the prevalence of NAFLD was 58.8%, and 6% of the cohort had definite nonalcoholic steatohepatitis. Fibrosis was mild: 81% had none, while 18% had stage 1 or 2 fibrosis (63,64).

The use of noninvasive techniques in this population is particularly appealing. However, the number of published pediatric studies of NAFLD to date remains low and the cut-off values for staging liver fibrosis vary between studies (65).

For liver stiffness assessment, the procedure used for adults should be adopted. In children who are unable to hold their breath, the consensus panel suggests recording a 2D SWE cine loop for up to 30 seconds if real-time 2D SWE is available, reviewing it, and choosing the image demonstrating the most stable pattern for the stiffness measurement. No more than one image should be chosen in each recorded cine loop.

For ARFI-based techniques, most published studies have shown that age has no significant influence on liver stiffness values (66–68). However, there is not enough literature at this time for the panel to recommend the rule of four for NAFLD in pediatric patients.

The mean normal shear-wave velocity value ranges from 1.07 to 1.16 m/sec (66–68).

For liver disease associated with cystic fibrosis, autoimmune hepatitis, biliary atresia and the Kasai procedure, or congenital heart disease with Fontan surgery or even NAFLD or viral hepatitis, it is expert opinion that each patient becomes his or her own control, using the stiffness delta changes over time to evaluate the efficacy of the treatment or the progression of disease—remembering that the measurement reflects stiffness and not fibrosis. Results must always be interpreted considering transaminase values and clinical condition.

Steatosis Assessment

Liver fat content has also been evaluated by using US-based methods. Several studies have demonstrated proof of concept. Although there is insufficient evidence at this time to provide recommendations regarding the use of US-based methods in this setting, early work suggests that these methods will be clinically useful (69–73).

Artifacts

Artifacts are common in ARFI-based techniques and can significantly change the liver stiffness value. It is important to recognize and avoid these artifacts (eg, liver capsule reverberation artifact [Fig 2], ARFI push artifacts, artifacts from blood vessels [Fig 3], and the artifact that occurs when the transducer is not parallel to the liver capsule [Fig 4]). Most systems now have a confidence map or quality map that helps identify most artifacts. However, none of the confidence maps or quality maps depict all artifacts and knowledge of artifacts is crucial for obtaining accurate liver stiffness values. Although a detailed discussion of artifacts is beyond the scope of this article, it is available elsewhere (74–77).

Reporting

The report should include the system vendor name, the SWE technique (pSWE or 2D SWE), the probe used, the number of acquisitions, the IQR/M, and conclusions. Conclusions should use the rule of four detailed earlier (Table 2). An example of a report is shown in Figure 5. A summary of recommendations is given in Table 4.

Future Directions

The development of new US techniques that will provide a measurement of liver steatosis and dispersion imaging (ie, evaluating the change in stiffness values by varying the ARFI frequency) are also being evaluated as a method to assess inflammation. This is extremely important to differentiate simple steatosis, a benign condition, from nonalcoholic steatohepatitis. However, evidence available for these techniques is not yet at a level where recommendations can be given. Other US techniques that do not use vibration-controlled transient elastography or ARFI technology techniques are being evaluated for liver stiffness evaluation (78).

Future Research Questions

Basic Questions

1. What are the sources of variability between commercial SWE systems? In particular, how does the ARFI frequency component affect measures of stiffness?
2. Should we measure in more than one location?
3. What are appropriate tissue-mimicking phantom materials for the liver?
4. Will liver dispersion be helpful in evaluating inflammation and/or steatosis?

Clinical Questions

1. How different are cut-offs depending on the cause of chronic liver disease?
2. How can US elastography complement hepatic venous pressure measurements in the assessment of portal hypertension and in the assessment of changes in portal venous pressure in patients with liver disease?
3. Inflammation and congestion are important processes to document in the evolution of liver disease. Histologic assessment of biopsy specimens can only be used to identify the cellular component of inflammation and is essentially blind to the fluid component. Quantitative elastography, conversely, seems to be sensitive to the effects of the fluid component of inflammation. How can this capability be exploited for diagnostic purposes?
4. Can we use elastography and measures of loss modulus to differentiate nonalcoholic or alcoholic steatohepatitis from simple steatosis?

Follow-up of Patients

1. What is a minimal clinically important difference in stiffness measurements over time? How often should these measures be obtained?

2. How should the use of elastography change the screening interval in patients at risk for hepatocellular carcinoma?

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Dept. Procedure Title:	Lymph Node Imaging Procedure - Ultrasound - Radiology	Procedure ID:	12483
Keywords	lymph, node, us, ultrasound, image, imaging, study		
Department:	Radiology, Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographers and sonologist performing lymph node Ultrasound studies.
The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock-Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Imaging: Lymph Node Imaging

1. Place the patient in a position that allows the best access to the area to be investigated for adenopathy.
2. Obtain images documenting the following:
 - i. Perform longitudinal and transverse images of the lymph nodes visualized.
 - ii. Measure each lymph node in the longest dimension with the AP diameter also recorded on that image.
3. Once representative longitudinal and transverse images have been obtained, use the split screen functionality on the scanner to measure and number the three (3) largest abnormal appearing lymph nodes so that measurements can be easily compared.
4. Perform Color Doppler imaging to evaluate for vascularity in each lymph node and record immediately after the split screen recording.
5. Repeat this for each site if more than one.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact:	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine	Version #	1
Current Approval Date:	09/21/2016	Old Document ID:	NEW
Date Procedure to go into Effect:	09/21/2016		
Related Policies & Procedures:			
Related Job Aids:			

Job Aid	Ultrasound Musculoskeletal (msk) Biopsy Setup Job Aid - Radiology	ID	23662
Keywords	radiology, ultrasound, musculoskeletal, msk, biopsy		
Department	Radiology - Ultrasound		

I. Purpose

To provide a list of supplies and discharge instructions (see attachments) necessary for ultrasound guided Musculoskeletal (msk) biopsy procedures.

• Equipment

- Sterile drape (4)
- Sterile OR towels
- Sterile transducer cover
- Sterile surgical gown
- Sterile gloves (physician preference)
- Telfa pad (physician preference)
- Sterile microscope slide (physician preference)
- Achieve or Bard disposable core biopsy needle (physician preference)
- Lidocaine 1% 10mL
- Sodium Chloride 0.9% – 10 mL
- 10 mL syringe (2)
- 25g needle (2)
- 18g needle (2)
- Kerlix gauze sponges (2 pkgs.)
- Chloraprep stick (2)
- Band-Aid
- Tegaderm (2)
- Alcohol prep pads (5)
- Formalin container
- # 11 scalpel
- Specimen transport bag
- Patient belonging bag
- PPE – 2 surgical masks, 2 hats, 2 non sterile gowns

Responsible Owner:	Radiology - Ultrasound	Contact:	Dennis Seguin
Approved By:	Office of Policy Support (OPS), Michael Patrick	Version #	1
Current Approval Date:	08/25/2020	Old Document ID:	
Date Policy to go into Effect:	08/25/2020		
Related Policies & Procedures:			
Related Job Aids:			

Job Aid	Ultrasound Musculoskeletal (msk) Injection / Aspiration Setup Job Aid - Radiology	ID	23659
Keywords	radiology, ultrasound, musculoskeletal, msk		
Department	Radiology - Ultrasound		

I. Purpose

To provide a list of supplies and discharge instructions (see attachments) necessary for ultrasound guided Musculoskeletal (msk) injection or aspiration procedures.

• Equipment

- Sterile drape (4)
- Sterile OR towels (1 pkg.)
- Steri-drape
- Sterile transducer cover
- Sterile gloves (physician preference)
- 10 mL syringe (2)
- 3 mL syringe
- *Lidocaine 1% - 10mL
- Sodium Chloride 0.9% - 10mL
- *Nesacaine MPF 2% (*if the patient has an allergy to lidocaine)
- Triamcinolone 40mg/mL – 1 mL vial (large joints or deep injections)
- Depo-Medrol vial 40mg – 1 mL vial (small joints or superficial injections)
- Ropivacaine 0.5% – 30 mL vial
- 20g needle (1.5” physician preference)
- 20g needle (3.5” physician preference)
- 22g needle (1.5” physician preference)
- 22g needle (3.5” physician preference)
- 25g needle
- 18g needle (2)
- Kerlix gauze sponges (1 pkg.)
- Chloraprep stick (2)
- Band-Aid
- Teraderm (2)
- Alcohol preps (5)
- PPE – 2 surgical masks, 2 hats, 2 non sterile gowns

Responsible Owner:	Radiology - Ultrasound	Contact:	Dennis Seguin
Approved By:	Office of Policy Support (OPS), Michael Patrick	Version #	1
Current Approval Date:	08/25/2020	Old Document ID:	
Date Policy to go into Effect:	08/25/2020		
Related Policies & Procedures:			
Related Job Aids:			

Job Aid	Ultrasound Native Renal Kidney and Transplant Biopsy Setup Job Aid - Radiology	ID	11356
Keywords	ultrasound, guided, renal, biopsy, biopsies		
Department	Ultrasound, Radiology		

I. Purpose

To provide a list of supplies and discharge instructions (see attachments) necessary for ultrasound guided renal biopsy procedures.

• Equipment

- 18 g needle (2)
- 25 g needle
- 10 mL syringe (2)
- Lidocaine 1%
- Sodium Chloride (2)
- Chloraprep stick
- Kerlix sponges
- Sterile drape (6)
- Sterile gloves (physician preference)
- Formalin bottle
- Sterile culture bottle
- Gluteraldehyde - (physician brings this)
- Standard Biopsy guide clip
- Sterile biopsy guide kit
- Sterile transducer cover
- 18 g or 16 g biopsy needle (physician preference - have both available)
- 20 g 6-inch spinal needle
- # 11 Scalpel
- Q-tips
- Tongue depressor
- Band-Aid
- Specimen transport bag
- PPE - (3) surgical hats, (3) surgical masks, (3) non sterile gowns
- Patient belongings bag
- Stretcher to transport the patient to the recovery room once procedure is complete

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents, Michael Patrick	Version #	3
Current Approval Date:	08/24/2020	Old Document ID:	
Date Policy to go into Effect:	08/24/2020		
Related Polices & Procedures:	Native and Transplant Kidney Biopsy Imaging Procedure - Ultrasound - Radiology		
Related Job Aids:			

Dept. Procedure Title:	Native and Transplant Kidney Biopsy Imaging Procedure - Ultrasound - Radiology	Procedure ID:	11471
Keywords	ultrasound guided, bx, sono, native, transplant, kidney, biopsy		
Department:	Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographer and sonologist performing Native and Transplant Kidney Biopsies under Ultrasound guidance.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions –

SDP – Same Day Program

IV. Equipment - N/A

V. Procedure

A. Required Kidney Images

The following standard images are required for interpretation.

1. Imaging: Native Kidneys – Scout imaging:
 - i. Obtain a longitudinal and transverse scout image of both native kidneys confirming location.
 - ii. Measure the renal length and record in the structured reporting package.
2. Imaging: Native Kidneys – Full study:
 - i. Obtain representative images in the longitudinal and transverse planes of both kidneys.
 - ii. Document longitudinal images that contain lateral and medial margins of the kidneys.
 - iii. Transverse views of both kidneys must include images of upper, mid, and lower poles.
 - iv. Perform maximum measurements (minimum of 2) of renal length of both kidneys.
 - v. Compare renal echogenicity to that of the liver or spleen.
 - vi. Obtain longitudinal and transverse images of the urinary bladder.
3. Imaging: Transplant Kidney – Scout Imaging:
 - i. Obtain longitudinal and transverse scout images of the transplant kidney.
 - ii. Measure the renal length and record in the structured reporting package.

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Reference ID #11471, Version #3

Approval Date: 10/15/2018

4. Imaging: Transplant Kidney – Full Study:
 - i. Obtain representative images documenting the following.
 - ii. Longitudinal measurements (2-3) of the maximum transplant kidney length.
 - iii. Transverse images through upper, mid, and lower poles.
 - iv. Assess for peri-renal fluid collections (urinomas, lymphoceles, etc.).
 - v. Assess for collecting system dilatation.
 - vi. Obtain longitudinal and transverse images of the urinary bladder.
 - vii. Color/Power images of the transplant kidney (adjust color scale and gain to visualize slow/venous flow).
 - viii. Obtain representative spectral Doppler tracings (2 per section) of arcuate vessels at the cortico-medullary junction at the upper, mid and lower renal poles.
 - ix. Obtain color and spectral Doppler tracing (2 per section) of the main renal artery (MRA) and main renal vein (MRV) at the renal hilum and proximal to the anastomosis.
5. Bedside timeout performed in eD-H with all procedural staff verifying pre-procedure questions.
6. Post Biopsy
 - i. Obtain post biopsy images (grey scale and color Doppler) to exclude retroperitoneal bleeding.
7. Lab specimens
 - i. Create a pathology request in eD-H (lab3175) for renal biopsy specimens.
 - ii. Specimens source label and corresponding form should state:
 - A. Formalyn
 - B. Saline
 - C. Glutaraldehyde
8. Paperwork- Discharge Instructions
 - i. Provide nursing recovery with after care instruction sheet (native or transplant).
 - ii. Post biopsy report must be given by the attending physician to the SDP nursing unit.
 - iii. SDP will assign the post procedure room location.
 - iv. Create transportation “hand off” document/checklist in eD-H for transportation. Request “Stat” transport to SDP.

VI. References - N/A

Responsible Owner:	Department of Radiology	Contact(s): email	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Bolger, Jean	Version #	3
Current Approval Date:	10/15/2018	Old Document ID:	RAD.0058
Date Procedure to go into Effect:	10/15/2018		
Related Policies & Procedures:			
Related Job Aids:	Ultrasound Native Renal Kidney and Transplant Biopsy Setup Job Aid - Radiology		

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Reference ID #11471, Version #3

Approval Date: 10/15/2018

Dept. Procedure Title	Ultrasound Neonatal Spine Scheduling and Imaging Procedure - Radiology	Procedure ID	11463
Keywords	ultrasound, us, neonate, neonatal, spine, study		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for Sonographers and Sonologists performing Neonatal spine Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all Sonographers and Sonologists within the Ultrasound section of Dartmouth-Hitchcock.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Scheduling

- This exam is to be performed on infants (less than) < 3 months of age.
- Any variations need to be approved by the Radiologist.

B. Spine

1. Obtain representative images of the entire spine through the sacrum in longitudinal and transverse planes.
2. Include longitudinal and transverse images of the conus and a longitudinal image from the conus to the sacrum.
3. Identify the conus.
 - a. The conus usually lies at or above the L2-L3 interspace.
4. Perform a cine capture if technically possible of the lumbar spine in a longitudinal projection demonstrating the normal motion of the nerve roots of the cauda equine.
 - a. It is helpful to label the lumbar vertebral bodies by identifying the last rib (T12).
5. Identify and measure the filum terminale (normal < 2mm).
6. If indication for scan is sacral dimple, pit, pigmented lesion, etc., scan the sacrum over the skin abnormality looking for communication into the spinal canal.
7. Obtain representative longitudinal image of each kidney

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine; Nystrom, Heidi	Version #	3
Current Approval Date:	11/08/2021	Old Document ID:	
Date Procedure to go into Effect:	11/08/2021		
Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Ultrasound Obstetrical Imaging Procedure - Radiology	Procedure ID	11223
Keywords	obstetrical, ultrasound, image, imaging, us, ob		
Department	Radiology, Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographers and sonologists performing Obstetrical Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions

AIUM – American Institute of Ultrasound in Medicine

MVP – Maximum Vertical Pocket

AFI – Amniotic Fluid Index

LVOT – Left Ventricular Outflow Tract

RVOT – Right Ventricular Outflow Tract

CRL – Crown-Rump Length

IV. Equipment N/A

V. Procedure

A. Special Considerations

- Procedure listed below are per AIUM Standards.
- Measurements are only obtained when the electronic order confirms the request (e.g., growth requested).
- Clarification of limited exam imaging components.
- Exam details may be amended based upon initial findings, which is within the clinical scope of practice or both sonographers and sonologists.

B. Dating

- Dating assessment is established by **best clinical judgment**. Suggested guidelines listed below:

Table 1. Guidelines for Redating Based on Ultrasonography

Gestational Age Range*	Method of Measurement	Discrepancy Between Ultrasound Dating and LMP Dating That Supports Redating
≤ 13 6/7 wk • ≤ 8 6/7 wk • 9 0/7 wk to 13 6/7 wk	CRL	More than 5 d More than 7 d
14 0/7 wk to 15 6/7 wk	BPD, HC, AC, FL	More than 7 d
16 0/7 wk to 21 6/7 wk	BPD, HC, AC, FL	More than 10 d
22 0/7 wk to 27 6/7 wk	BPD, HC, AC, FL	More than 14 d
[†] 28 0/7 wk and beyond	BPD, HC, AC, FL	More than 21 d

Abbreviations: AC, abdominal circumference; BPD, biparietal diameter; CRL, crown-rump length; FL, femur length; HC, head circumference; LMP, last menstrual period.

*Based on LMP

[†]Because of the risk of redating a small fetus that may be growth restricted, management decisions based on third-trimester ultrasonography alone are especially problematic and need to be guided by careful consideration of the entire clinical picture and close surveillance.

Committee Opinion No. 611

C. Amniotic Fluid

- Amniotic fluid evaluation:
 - Quantitative measurement or assessed subjectively at all obstetrical ultrasound examinations.
 - Maximal vertical pocket is the preferred method.
 - Early gestation: Subjective assessment.
 - Late second and third trimester: Either amniotic fluid index (AFI) or maximal vertical pocket (MVP).
 - Width of any measured fluid pocket must be 1 cm and exclude umbilical cord or fetal parts.
- Definitions (both singleton and multiple gestations):
 - Oligohydramnios:** MVP less than 2 cm
 - Hydraminos:** MVP greater than 8 cm or AFI greater than or equal to 24 cm.

D. Screening Morphology and Detailed Morphology Fetal Assessment

1. Obtain representative images documenting the following:

Table 2. Components of CPT 76811 (Basic and Detailed Examinations)

Component	Basic	Detailed
Head and neck	Lateral cerebral ventricles Choroid plexus Midline falx Cavum septi pellucidi Cerebellum Cisterna magna	3rd ventricle ^{A,36} 4th ventricle ^{A,36} Lateral ventricles ^{B,36} Cerebellar lobes, vermis, and cisterna magna ^{A,37} Corpus callosum ^{A,38} Integrity and shape of cranial vault ¹⁹ Brain parenchyma ²⁰ Neck ^{21,22} Profile ²³⁻²⁵ Coronal face (nose/lips/lens*) ²³ Palate,* maxilla, mandible, and tongue ^{A,26,27} Ear position and size ⁸ Orbits ⁸
Face	Upper lip	Aortic arch Superior and inferior venae cavae ^{28,29} 3-vessel view ²⁹ 3-vessel and trachea view ³⁰ Lungs ^{31,32} Integrity of diaphragm ³³ Ribs ^{A,34,35}
Chest Heart and thorax	Cardiac activity 4-chamber view Left ventricular outflow tract Right ventricular outflow tract	Small and large bowel ^{A,36-38} Adrenal glands ^{A,39} Gallbladder ^{A,40,41} Liver ^{38,42} Renal arteries ^{A,43} Spleen ^{A,42} Integrity of abdominal wall ⁴⁴ Integrity of spine and overlying soft tissue ^{A,45,46} Shape and curvature ^{45,46}
Abdomen	Stomach (presence, size, and situs) Kidneys Urinary bladder Cord insertion site into fetal abdomen Umbilical cord vessel number	Number, architecture and position ⁴⁹⁻⁵¹ Hands ⁵²⁻⁵³ Feet ⁵³⁻⁵⁴ Digits; number and position ^{A,51,52} Sex ^{A,55}
Spine	Cervical Thoracic Lumbar Sacral spine	Masses ^{54,57} Placental cord insertion ⁵⁸ Accessory/succenturiate lobe with location of connecting vascular supply to primary placenta ^{A,59,60}
Extremities	Legs Arms	
Genitalia	In multiple gestations When medically indicated	
Placenta	Location Relationship to internal os Appearance Placental cord insertion (when possible)	
Standard evaluation	Fetal number Presentation Qualitative or semiquantitative estimate of amniotic fluid	
Maternal anatomy	Cervix (transvaginal when indicated) Uterus Adnexa	
Biometry	Biparietal diameter Head circumference Femur length Abdominal circumference Fetal weight estimate	Cerebellum ^{A,61} Inner and outer orbital diameters ^{A,62} Nuchal thickness (16–20 wk) ⁶³⁻⁶⁵ Nasal bone measurement (15–22 wk) ⁶³⁻⁶⁶ Humerus ^{A,63-65} Ulna/radius ⁸ Tibia/fibula ⁸

*Performed when medically indicated.

^BAlso included in the basic obstetric examination.

E. Follow-up for Growth-Amniotic Fluid

1. Only obtain measurements when the electronic order verifies the request (i.e., growth requested).
2. Perform fetal assessment to include fetal anatomy appropriate for gestational age.
3. Clinical Ultrasound findings should determine the necessity (if something new is seen, for example; previously appeared normal, now appears abnormal).
4. Obtain representative images documenting the following:
 - Longitudinal image documenting the bladder and cervix
 - Fetal position
 - Placenta location
 - Placental cord origin images in grey scale and color Doppler
 - Amniotic fluid – 4-quadrant measurement if greater than 28 weeks (adhere to amniotic fluid guidelines)
 - Intra-cranial anatomy
 - 4-chamber heart & cine loop capture
 - LVOT – cine loop capture if feasible
 - RVOT– cine loop capture if feasible
 - M-mode tracing with heart rate measurement
 - Diaphragm
 - Stomach
 - Kidneys
 - Bladder
 - Fetal cord insertion
 - Adnexal structures

F. Morphology Limited Follow-up

1. Fetal assessment re-check for a prior incomplete morphology assessment.
2. Clinical Ultrasound findings should determine the necessity (if something new is seen, for example; previously appeared normal, now appears abnormal) and should include the following:
 - Longitudinal image documenting the bladder and cervix
 - Fetal position
 - Placenta location
 - Amniotic fluid – 4-quadrant measurement if greater than 28 weeks (adhere to amniotic fluid guidelines)
 - 4-chamber heart & cine loop capture if feasible
 - M-mode tracing with heart rate measurement

G. OB Limited > 14 Weeks

1. Clinical Ultrasound findings should determine the necessity (if something new is seen, for example; previously appeared normal, now appears abnormal) and should include the following:
 - Longitudinal image documenting the bladder and cervix
 - Fetal position
 - Placenta location
 - Amniotic fluid – 4-quadrant measurement if greater than 28 weeks (adhere to amniotic fluid guidelines)

- 4-chamber heart & cine loop capture if feasible
- M-mode tracing with heart rate measurement

H. Viability

1. Obtain representative images documenting the following:
 - Sagittal wide field of view to include the entire uterus, cervix to fundus
 - CRL measurement
 - Placental location (> than 15 weeks)
 - Amniotic fluid
 - Gestational Sac
 - Identify and document yolk sac
 - Adnexal structures
 - M-mode tracing with heart rate measurements
 - Cine loop capture documenting the presence or absence of fetal cardiac activity
 - In the clinical setting of a prior C-section, obtain sagittal wide field of view to include the entire uterus, cervix to fundus to ascertain location/implantation of the gestational sac.

I. Nuchal Translucency

1. Obtain representative images documenting the following:
 - NT measurement
 - CRL length
 - Placental location
 - Amniotic fluid
 - Gestational Sac
 - Adnexal structures
 - M-mode tracing with heart rate measurement
 - Cine loop capture if feasible

J. Cervical Length

1. Obtain representative images documenting the following:
 - Position
 - Cervical length with & without fundal pressure or valsalva
 - Observe cervix for three minutes after applying fundal pressure
 - Placental location
 - Adnexal structures
 - M-mode tracing with heart rate measurement
 - Cine loop capture if feasible

K. Amniotic Fluid (AFV) – Post Dates

1. Obtain representative images documenting the following:
 - Presentation
 - Placenta location
 - Amniotic fluid – 4-quadrant measurement (adhere to amniotic fluid guidelines).
 - M-mode tracing with heart rate measurement
 - Cine loop capture if feasible

- For Twins/ multiples – Measure and report the deepest vertical pocket in each gestational sac.

L. Position Only

1. Obtain representative images documenting the following:
 - Position
 - Amniotic fluid – 4-quadrant measurement (adhere to amniotic fluid guidelines).
 - M-mode tracing with heart rate measurement
 - Cine loop capture if feasible

M. Biophysical Profile (BPP)

1. Obtain representative images documenting the following:
 - BPP parameters – Use the grading score parameters (2-8) in the structured reporting system
 - Do not use NST section.
 - Presentation
 - Amniotic fluid – 4-quadrant measurement (adhere to amniotic fluid guidelines).
 - Placenta location
 - M-mode tracing with heart rate measurement
 - Cine loop capture if feasible

N. Fetal mechanical PR Interval

1. GE unit is required for these studies.
2. Obtain representative images documenting the following:
 - Presentation
 - Placenta location
 - Amniotic fluid – 4-quadrant measurement (adhere to amniotic fluid guidelines).
 - M-mode tracing with heart rate measurement.
 - PR interval (5 chamber view) – See enclosed document in attachments.
 - Measure time from the onset of mitral valve A wave to Aortic valve opening.

O. Middle Cerebral Artery (MCA) Doppler

Obtain representative images documenting the following

- MCA Doppler assessment with measurements entered into appropriate boxes
- Report Peak Systolic (PSV), S/D Ratio and multiple of the mean (MoM)
- SV gate size should be set to 1.0 mm
- Position
- Placenta location
- Amniotic fluid – 4-quadrant measurement (adhere to amniotic fluid guidelines).
- Assessment for hydrops
- M-mode tracing with heart rate measurement
- Cine loop capture if feasible

P. Umbilical Artery (UA) Doppler

1. Indications:
 - AC less than 10%
 - EFW less than 10%
 - Oligohydramnios
 - Multiple gestation: discordant growth or twin-twin transfusion syndrome
2. Obtain representative images documenting the following:
 - S/D ratio & RI
 - Position
 - Placenta location
 - Amniotic fluid – 4-quadrant measurement (adhere to amniotic fluid guidelines)
 - M-mode tracing with heart rate measurement

Q. Ultrasound Guided Procedures

Amniocentesis

1. Obtain representative images documenting the following:
 - Position
 - Placenta location
 - Amniotic fluid – 4-quadrant measurement if greater than 28 weeks (adhere to amniotic fluid guidelines)
 - M-Mode tracing with heart rate measurement pre and post procedure
 - Cine loop capture if feasible

Therapeutic

1. Obtain representative images documenting the following:
 - Position
 - Amniotic fluid – 4-quadrant measurement (adhere to amniotic fluid guidelines)
 - M-Mode tracing with heart rate measurement pre & post procedure
 - Cine loop capture if feasible

Note: To access attachments, click on the notification (bell) icon located in the upper right hand corner of the document.

VI. References

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Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine; Nystrom, Heidi	Version #	4
Current Approval Date:	11/30/2021	Old Document ID:	
Date Procedure to go into Effect:	11/30/2021		
Related Policies & Procedures:			
Related Job Aids:			

Obstetrical Imaging Guidelines

Purpose:

To establish guidelines for sonographers/ sonologists performing selected Ultrasound examinations.

Dating:

Dating assessment is established by **best clinical judgment**. The following are guidelines only.

General guidelines:

1st Trimester:

Use the LMP if the difference between Ultrasound dating and LMP date is ≤ 7 days to establish the EDD.

If difference is > 7 days use the Ultrasound dating to establish the EDD.

2nd Trimester:

Use the LMP if the difference between Ultrasound dating and LMP date is $\leq 10-14$ days to establish the EDD.

If the difference is $> 10-14$ days use the Ultrasound dating to establish the EDD.

Oligohydramnios is an overall sum of the 4 quadrants that is ≤ 8 cm

Procedure Guidelines listed below are per AIUM Standards

OBS- MORPHOLOGY:

Obtain representative images documenting the following:

- Longitudinal image documenting the bladder and cervix
- Fetal position
- Placenta location (if low lying perform trans vaginal study)
- Placental cord insertion images in grey scale and color Doppler
- AFV if specific to gestational age
- Adnexal structures
- Lateral ventricle measurement
- Cerebellar hemispheres

- Cisterna magna measurement
- Cavum septi pellucidum
- Nuchal fold measurement
- Nasal bone measurement
- Face and upper lip
- Fetal profile
- Fetal orbits documenting lens
- 4-chamber heart & cine loop capture
- LVOT – cine loop capture if feasible
- RVOT – cine loop capture if feasible
- M-mode tracing with heart rate measurement
- Stomach
- Fetal cord insertion
- Kidneys
- Bladder
- Color Doppler umbilical vessels surrounding fetal bladder
- Fetal limbs – documenting feet at 90 degrees and open hands
- Longitudinal and transverse images of fetal spine
- Cine image capture of the entire spine in transverse section
- Adnexal structures
- Measurements specific to gestational age

OB FOLLOW-UP/ EFW:

Obtain representative images documenting the following:

- Perform fetal assessment to include fetal anatomy appropriate for gestational age.
- Document areas NOT well seen on prior scan. If for example, the fetal spine was well seen at 18 weeks, a full re-assessment is not necessary.
- Re-check are of prior documented abnormality.

- If it has been more than 2 weeks from the last scan, measurements should be considered. Clinical Ultrasound findings should determine the necessity.
- Longitudinal image documenting the bladder and cervix
- Fetal position
- Placenta location
- Placental cord insertion images in grey scale and color Doppler
- AFI- 4 quadrant measurement if ≥ 28 weeks
- Intra-cranial anatomy
- 4-chamber heart & cine loop capture
- LVOT – cine loop capture if feasible
- RVOT– cine loop capture if feasible
- M-mode tracing with heart rate measurement
- Stomach
- Kidneys
- Bladder
- Fetal cord insertion
- Longitudinal and transverse images of fetal spine
- Adnexal structures

VIABILITY:

Obtain representative images documenting the following:

- CRL measurement
- Placental location
- Amniotic fluid
- Gestational Sac
- Identify and document yolk sac
- Adnexal structures
- M-mode tracing with heart rate measurements
- Cine loop capture documenting the presence or absence of fetal cardiac activity

NUCHAL TRANSLUCENCY:

Obtain representative images documenting the following:

- NT measurement
- CRL length
- Placental location
- Amniotic fluid
- Gestational Sac
- Adnexal structures
- M-mode tracing with heart rate measurement

CERVICAL LENGTH:

Obtain representative images documenting the following:

- Position
- Cervical length with & without fundal pressure
- Observe cervix for three minutes after applying fundal pressure
- Adnexal structures
- M-mode tracing with heart rate measurement

AFV- POST DATES:

Obtain representative images documenting the following:

- Presentation
- Placenta location
- AFI- 4 quadrant measurement
- M-mode tracing with heart rate measurement
- ** For Twins/ multiples**
- Measure and report the deepest vertical pocket in each gestational sac

POSITION ONLY:

Obtain representative images documenting the following:

- Position
- AFI- 4 quadrant measurement
- M-mode tracing with heart rate measurement

BIOPHYSICAL PROFILE

Obtain representative images documenting the following:

- BPP parameters – Use the grading score parameters (2-8) in AS- Ob-Gyn
- Do not use NST section.
- Presentation
- AFI- 4 quadrant measurement
- Placenta location
- M-mode tracing with heart rate measurement

MCA DOPPLER:

Obtain representative images documenting the following:

- MCA Doppler assessment with measurements entered into appropriate boxes
- Report Peak Systolic Velocity (PSV) & S/D Ratio
- SV gate size should be set to 1.0mm
- Position
- Placenta location
- AFI - 4 quadrant measurement
- Assessment for hydrops
- M-mode tracing with heart rate measurement

UA DOPPLER:

Indications:

AC < 10%

EFW < 10%

AFV < 10%

If the individual AC percentile falls $< 10\%$ a UA Doppler should be performed

HC/ AC ratio $>$ the upper limits of normal for GA

(Example: small abdominal circumference, relatively large head)

Significant drop off the growth curve

Obtain representative images documenting the following:

S/D ratio & RI

Position

Placenta location

AFI- 4 quadrant measurement

M-mode tracing with heart rate measurement

AMNIOCENTESIS:

Obtain representative images documenting the following:

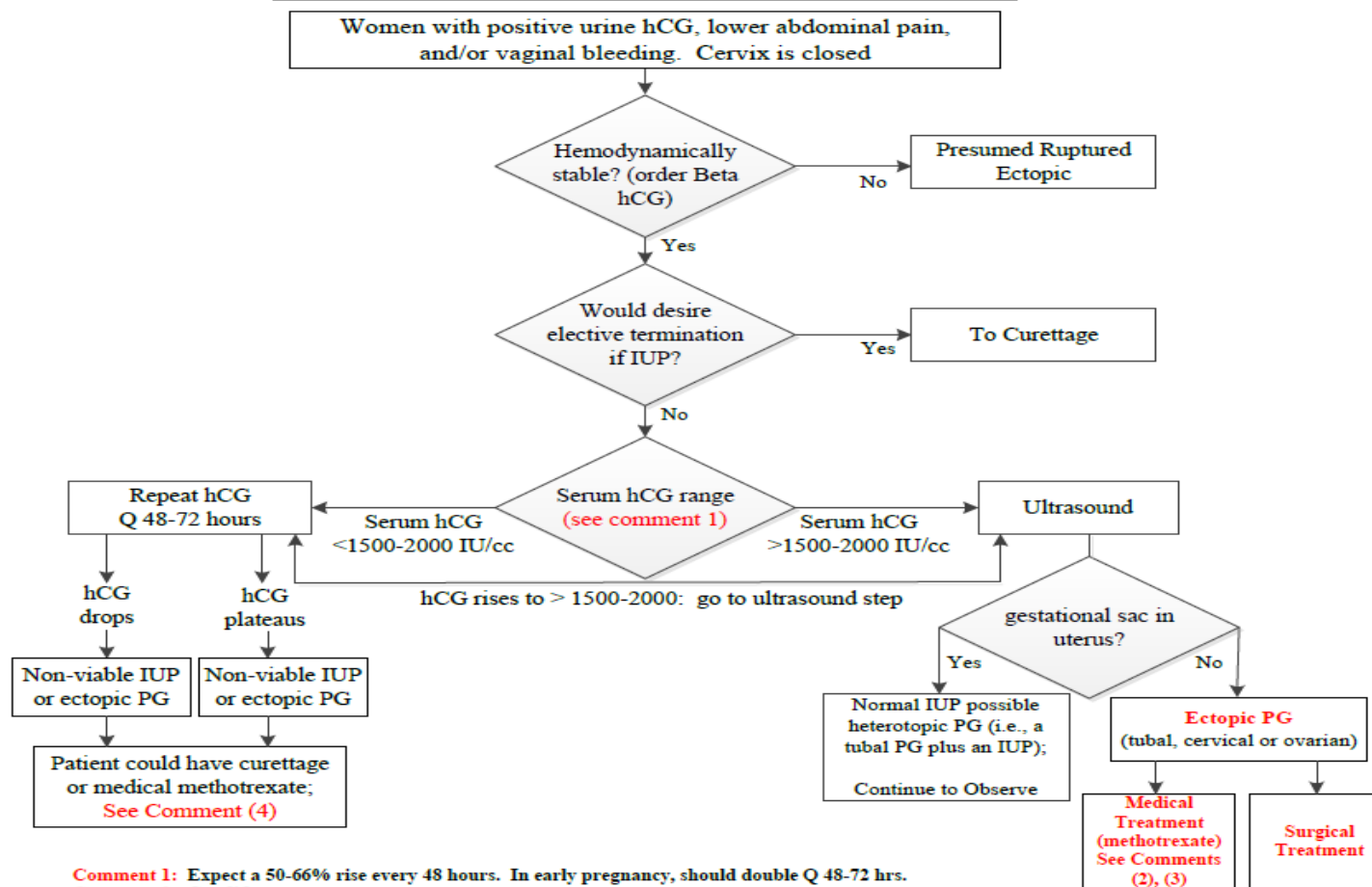
- Position
- Placenta location
- AFI- 4 quadrant measurement if ≥ 28 weeks
- M- Mode tracing with heart rate measurement pre and post procedure

KCL Procedure:

Obtain representative images documenting the following:

- Position
- AFI- 4 quadrant measurement
- M- Mode tracing with heart rate measurement pre & post procedure

Suspected Ectopic Presents to ER (Protocol)



Comment 1: Expect a 50-66% rise every 48 hours. In early pregnancy, should double Q 48-72 hrs.

Comment 2: Candidates:

- a. Hemodynamically stable
- b. hCG < 5000 IU (*)
- c. Compliant
- d. Adnexal mass, 3cm, no cardiac activity (*)

* Relative contra-indication

Comment 3: Need to call pharmacy to call in a qualified pharmacist. Need methotrexate (chemotherapy form) in ER. Can be administered by ER Nurse or inpatient Hem-Onc Nurse. Dosage 50 mg/M2 (sq. meters of body surface area). Baseline Labs: (CBC, LFTs, Rh, hCG).

Repeat labs in 7 days; expect 25% drop in hCG; then weekly hCG until undetectable (less than 100 days)

Comment 4: Curettage if villi present, from viable IUP. Observe. If patient refuses curettage, should suggest methotrexate protocol.

Dept. Procedure Title	Pediatric Hip Scheduling and Imaging Procedure - Ultrasound - Radiology	Procedure ID	11464
Keywords	pediatric, hip, study, studies, us, ultrasound, images, interpretation, sonographers, sonologists		
Department	Ultrasound		

I. Purpose

To describe guidelines for performing pediatric hip Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock.

III. Definitions N/A

IV. Equipment N/A

V. Procedure imaging:

A. Scheduling:

1. Evaluation of infants suspected of hip dysplasia.
 - Infants should be at least 4 weeks of age (preferably 6 weeks) and NOT older than 6 months of age.
 - Infants younger than 4 weeks old may be scanned if clinically suspected of hip dislocation.
 - Prior approval required from attending Radiologist.
 - Scans should not be performed for rule out development dysplasia of the hip (DDH) after 6 months of age.
 - Examinations may be performed at any age to rule out joint effusion.

B. Scanning Procedure:

The following standard images are required for interpretation.

1. Scan both hips with a linear transducer.
2. Obtain images in a flexed position.
3. Obtain the following images:
 - a. Coronal view of hip (2-3 measurements to obtain “alpha” hip angle).
 - Determine the degree of coverage.
 - Report alpha angle into designated structured reporting system.
 - b. Transverse view of the hip to show the femoral head in relation to the triradiate cartilage.

- c. Obtain a D:D ratio measurement for each hip to determine the degree of femoral head coverage. Enter this value into the structured reporting package.
- d. Stress views of both hips (if not in harness) in transverse view.
- e. Image both hips for comparison.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine; Silas, Anne	Version #	3
Current Approval Date:	02/18/2020	Old Document ID:	
Date Procedure to go into Effect:	02/18/2020		
Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title:	Pediatric Kidney Procedure - Ultrasound - Radiology	Procedure ID:	11475
Keywords	pediatric, kidney, us, ultrasound, images, interpretation, studies		
Department:	Ultrasound		

I. Purpose of Procedure

To describe guidelines for sonographers and sonologists performing Pediatric Kidney Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Scheduling

- Infants must be at least 2 days old.
- Exceptions must be approved by the Attending Radiologist

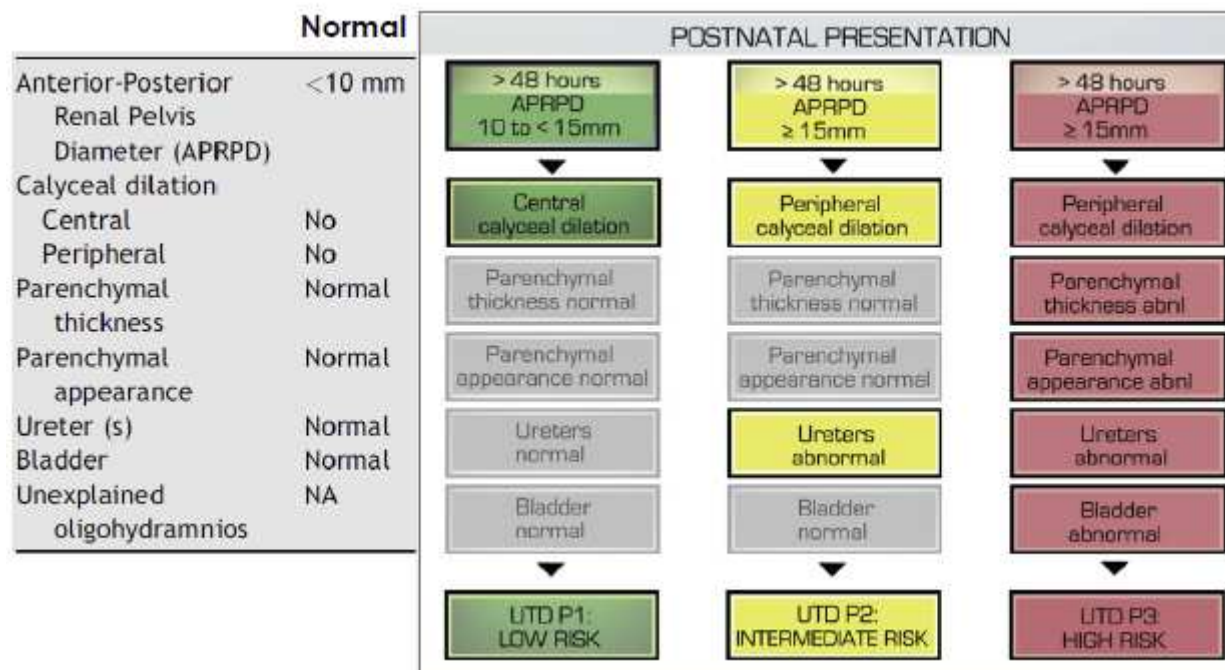
B. Kidney Imaging

- Obtain representative images in the longitudinal and transverse planes of both kidneys.
- Document longitudinal images of the lateral and medial margins of the kidneys.
- Include labeled images of the transverse views of upper, mid, and lower poles of both kidneys.
- Perform maximum measurements (minimum of 2) of renal length of both kidneys.
- Compare renal echogenicity to that of the liver or spleen.
- Obtain measurements in the longitudinal and transverse planes of the urinary bladder adding these to the structured reporting package.
- Use Color Doppler to document urinary jets when hydronephrosis is present.
 - Record Color or Power Doppler images when there is a clinical suspicion of pyelonephritis.
 - Use Color Doppler to exclude mild hydronephrosis vs. hilar vessels when the gray scale images are equivocal.
- Obtain cine captures through both kidneys when hydronephrosis is present.

C. Pediatric Nephrology Doppler Imaging

- Obtain representative images of both kidneys per section B above.
- Perform Color Doppler and Spectral Waveforms (2 per section) of the intra-renal arteries.
- Calculate measurements of the Resistive Index (RI).

Urinary Tract Dilatation (UTD)



Journal of Pediatric Urology (2014) 10, 982-999

VI. References

Nguyen, H., Benson, C., Bromley, B., Campbell, J., Chow, J., Coleman, B., . . . Stein, D. (2014). Multidisciplinary consensus on the classification of prenatal and postnatal urinary tract dilatation (UTD classification system). Journal of Pediatric Urology, 10, 982-998.

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine	Version #	3
Current Approval Date:	02/21/2020	Old Document ID:	3194
Date Procedure to go into Effect:	02/21/2020		
Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Prostate Scheduling and Imaging Procedure - Radiology	Procedure ID	11469
Keywords	prostate, schedule, scheduling, sonographer, sinologist, us, ultrasound, scan, image, studies, interpretation		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for Sonographers and Sonologists performing Prostate Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This applies to all Sonographers and Sonologists within the Ultrasound section of Dartmouth-Hitchcock-Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Scheduling

- Prostate biopsies (fusion directed and regular) are performed in conjunction with the Urology service.
- Prostate imaging (non-biopsy) can be scheduled into specific Radiant exam resources with adherence to prep instructions.
- All other requests must be approved by Triage.

B. Standard Images Required for Interpretation.

- Obtain axial images equally spaced from the seminal vesicles, to the apex of the gland. Targeted images should be obtained from the right, mid and left. Note and measure any focal abnormalities.
- In the mid axial plane, measure the prostate at the widest portion in two (2) dimensions, and add to the calculation package. Note any cystic changes or calcifications.
 - In the setting of infertility evaluation, identify and measure the ejaculatory ducts at the level of the verumontanum.
- Obtain longitudinal images of the right gland to include the seminal vesicle, right base, mid and apex. Note and measure any focal abnormalities.
- Obtain longitudinal image of the mid gland identifying the bladder and prostatic urethra if possible. Measure the prostate size and add to the calculation package. Note any cystic changes or calcifications.

- Obtain longitudinal images of the left gland to include the seminal vesicle, left base, mid and apex. Note and measure any focal abnormalities.
- Import measurements obtained including the transducer # into the structured reporting package.
- Complete the bedside “time out” checklist prior to beginning the procedure.

C. Standard Imaging for Prostate Size Only

- Obtain a cine capture from the seminal vesicles to the apex of the gland.
- In the mid-axial plane, measure the prostate at the widest portion in two (2) dimensions, and add to the calculation package.
- Obtain a cine capture to include the right base, mid and apex
- Obtain longitudinal image of the mid gland identifying the bladder and prostatic urethra if possible.
- Measure the prostate size and add to the calculation package.
- Obtain a cine capture to include the left base, mid, and apex.
- Import measurements obtained including the transducer # into the structured reporting package.

D. Prostate Biopsy - Pathology specimen order (fusion and regular)

- Generate a pathology request in eD-H (lab3175) per Radiology Per Protocol guidelines for the prostate biopsy specimens.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine; Nystrom, Heidi	Version #	3
Current Approval Date:	11/22/2021	Old Document ID:	
Date Procedure to go into Effect:	11/22/2021		
Related Policies & Procedures:			
Related Job Aids:			

Job Aid	Ultrasound Prostate Biopsy Setup Job Aid - Radiology	ID	20248
Keywords	supply list, bx, us, guided, ultrasound, prostate, biopsy		
Department	Radiology - Ultrasound		

I. Purpose

To provide a list of supplies needed and specimen bottle setup/labeling for ultrasound guided prostate biopsy procedures.

Supplies

- 10cc syringe
- 18g hypodermic needle
- Bottle of 1% Lidocaine
- 22g, 15cm spinal needle
- 18g, 20cm biopsy needle
- 2 large specimen transport bags
- Large transducer cover
- Disposable prostate needle guide (institution standard)
- Disposable bracket for fusion biopsies only (institution standard)
- 4 packets sterile Surgilube
- Double ID on each specimen container (MD and sonographer initials)
- Non sterile latex free gloves (have S, M, L available)

Specimen Bottle Setup/Labeling

Right lateral base (A)	Right base (D)
Right lateral mid (B)	Right mid (E)
Right lateral apex (C)	Right apex (F)
Left lateral base (G)	Left base (J)
Left lateral mid (h)	Left mid (K)
Left lateral apex (I)	Left apex (L)
Label additional bottles beginning with (M)	

Responsible Owner:	Radiology - Ultrasound	Contact:	Dennis Seguin
Approved By:	Office of Policy Support (OPS), Christine Kvinlaug	Version #	2
Current Approval Date:	01/17/2022	Old Document ID:	
Date Policy to go into Effect:	01/17/2022		
Related Policies & Procedures:	Prostate Scheduling and Imaging Procedure - Radiology		
Related Job Aids:			

Job Aid	Sonohysterogram (SHG) Setup Job Aid - Ultrasound - Radiology	ID:	11357
Keywords	sonohysterogram, SHG, setup, us, ultrasound		
Department	Ultrasound, Radiology		

I. Purpose

To provide necessary supplies for Sonohysterogram (SHG) procedures.

- Pregnancy test if indicated
- Speculum - (have all sizes available)
- Betadine swab sticks
- SHG catheter
- 20 mL syringe
- Sterile Saline
- Surgical gloves (appropriate for physician)
- Os finder
- Dilators
- Tenaculum

Billing / Supplies:

- Catheter already added. Add additional supplies as needed

Responsible Owner:	Department of Radiology	Contact(s): email	Dennis Seguin
Approved By:	Office of Policy Support (OPS), Jean Bolger	Version #	2
Current Approval Date:	01/04/2018	Old Document ID:	RAD.0053
Date Policy to go into Effect:	01/04/2018		
Related Polices & Procedures:			
Related Job Aids:			

Society for Maternal-Fetal Medicine Consult Series #52: Diagnosis and management of fetal growth restriction



(Replaces Clinical Guideline Number 3, April 2012)

Society for Maternal-Fetal Medicine (SMFM); Juliana Gevaerd Martins, MD; Joseph R. Biggio, MD, MS; Alfred Abuhamad, MD

The American Institute of Ultrasound in Medicine (AIUM) supports this document review of the subject matter and believes it contributes to our understanding of the topic.

Fetal growth restriction can result from a variety of maternal, fetal, and placental conditions. It occurs in up to 10% of pregnancies and is a leading cause of infant morbidity and mortality. This complex obstetrical problem has disparate published diagnostic criteria, relatively low detection rates, and limited preventative and treatment options. The purpose of this Consult is to outline an evidence-based, standardized approach for the prenatal diagnosis and management of fetal growth restriction. The recommendations of the Society for Maternal-Fetal Medicine are as follows: (1) we recommend that fetal growth restriction be defined as an ultrasonographic estimated fetal weight or abdominal circumference below the 10th percentile for gestational age (GRADE 1B); (2) we recommend the use of population-based fetal growth references (such as Hadlock) in determining fetal weight percentiles (GRADE 1B); (3) we recommend against the use of low-molecular-weight heparin for the sole indication of prevention of recurrent fetal growth restriction (GRADE 1B); (4) we recommend against the use of sildenafil or activity restriction for in utero treatment of fetal growth restriction (GRADE 1B); (5) we recommend that a detailed obstetrical ultrasound examination (current procedural terminology code 76811) be performed with early-onset fetal growth restriction (<32 weeks of gestation) (GRADE 1B); (6) we recommend that women be offered fetal diagnostic testing, including chromosomal microarray analysis, when fetal growth restriction is detected and a fetal malformation, polyhydramnios, or both are also present regardless of gestational age (GRADE 1B); (7) we recommend that pregnant women be offered prenatal diagnostic testing with chromosomal microarray analysis when unexplained isolated fetal growth restriction is diagnosed at <32 weeks of gestation (GRADE 1C); (8) we recommend against screening for toxoplasmosis, rubella, or herpes in pregnancies with fetal growth restriction in the absence of other risk factors and recommend polymerase chain reaction for cytomegalovirus in women with unexplained fetal growth restriction who elect diagnostic testing with amniocentesis (GRADE 1C); (9) we recommend that once fetal growth restriction is diagnosed, serial umbilical artery Doppler assessment should be performed to assess for deterioration (GRADE 1C); (10) with decreased end-diastolic velocity (ie, flow ratios greater than the 95th percentile) or in pregnancies with severe fetal growth restriction (estimated fetal weight less than the third percentile), we suggest weekly umbilical artery Doppler evaluation (GRADE 2C); (11) we recommend Doppler assessment up to 2–3 times per week when umbilical artery absent end-diastolic velocity is detected (GRADE 1C); (12) in the setting of reversed end-diastolic velocity, we suggest hospitalization, administration of antenatal corticosteroids, heightened surveillance with cardiotocography at least 1–2 times per day, and consideration of delivery depending on the entire clinical picture and results of additional evaluation of fetal well-being (GRADE 2C); (13) we suggest that Doppler assessment of the ductus venosus, middle cerebral artery, or uterine artery not be used for routine clinical management of early- or late-onset fetal growth restriction (GRADE 2B); (14) we suggest weekly cardiotocography testing after viability for fetal growth restriction without absent/reversed end-diastolic velocity and that the frequency be increased when fetal growth restriction is complicated by absent/reversed end-diastolic velocity or other comorbidities or risk factors (GRADE 2C); (15) we recommend delivery at 37 weeks of gestation in pregnancies with fetal growth restriction and an umbilical artery Doppler waveform with decreased diastolic flow but without absent/reversed end-diastolic velocity or with severe fetal growth restriction with estimated fetal weight less than the third percentile (GRADE 1B); (16) we recommend delivery at 33–34 weeks of gestation for pregnancies with fetal growth restriction and absent end-diastolic velocity (GRADE 1B); (17) we recommend delivery at 30–32 weeks of gestation for pregnancies with fetal growth restriction and reversed end-diastolic velocity (GRADE 1B); (18) we suggest delivery at 38–39 weeks of gestation with fetal growth restriction when the estimated fetal weight is between the 3rd and 10th percentile and the umbilical artery Doppler is normal (GRADE 2C); (19) we suggest that for pregnancies with fetal growth restriction complicated by absent/reversed end-diastolic velocity, cesarean delivery should be considered based on the entire clinical scenario (GRADE 2C); (20) we recommend the use of antenatal corticosteroids if delivery is anticipated before 33 6/7 weeks of gestation or for pregnancies between 34 0/7 and 36 6/7 weeks of gestation in women without contraindications who are at risk of preterm delivery within 7 days and who have not received a prior course of antenatal corticosteroids (GRADE 1A); and (21) we recommend intrapartum magnesium sulfate for fetal and neonatal neuroprotection for women with pregnancies that are <32 weeks of gestation (GRADE 1A).

Key words: cardiotocography, Doppler, fetal growth restriction, fetal weight, umbilical artery

Introduction

Fetal growth restriction (FGR) can result from a variety of maternal, fetal, and placental conditions.¹ Although the primary underlying mechanisms for FGR are varied, they often share the same final common pathway of **suboptimal fetal nutrition and uteroplacental perfusion**.^{1,2} Chromosomal disorders and congenital malformations are responsible for approximately 20% of FGR cases.^{2,3} **Suboptimal perfusion of the maternal placental circulation is the most common cause of FGR and accounts for 25–30% of all cases.**^{2,3}

FGR occurs in up to 10% of pregnancies and is a leading cause of infant morbidity and mortality.^{1,4,5} **In fetuses at all gestational ages with weights below the 10th percentile, the stillbirth rate is approximately 1.5%, which is twice the rate in fetuses with normal growth.** With fetal weights below the fifth percentile, the stillbirth rate can be as high as 2.5%.^{6,7} Furthermore, infants with birthweights below the 10th percentile are more likely to have severe acidosis at birth, low 5-minute Apgar scores, and neonatal intensive care unit admissions.⁸ Prematurity further compounds the risk of adverse outcomes in FGR.⁹ **Studies report a 2- to 5-fold increased rate of perinatal death among preterm FGR fetuses compared with term FGR fetuses.**⁹ **Perinatal outcomes are largely dependent on the severity of FGR, with the worst outcomes noted in fetuses with estimated fetal weights (EFWs) at less than the third percentile or in association with fetal Doppler abnormalities.**^{5,10}

In addition to its significant perinatal impact, FGR also has an impact on long-term health outcomes. It has been associated with metabolic programming that increases the risk of future development of metabolic syndrome and consequent cardiovascular and endocrine diseases.^{11,12} It also can contribute to cardiac remodeling, leading to cardiovascular dysfunction that can persist into childhood and adolescence.^{13,14} In addition, studies have shown an association between FGR and long-term neurologic impairment,^{15–20} with rates of cognitive and learning disabilities as high as 20%–40% by school age.²¹

FGR remains a complex obstetrical problem with disparate published diagnostic criteria, relatively low detection rates, and limited preventative and treatment options.^{22–25} Antenatal care of FGR is often complicated by the presence of maternal disease, such as hypertension, and optimal management involves balancing maternal, fetal, and neonatal risks. The purpose of this document is to outline an evidence-based, standardized approach for the prenatal diagnosis and management of FGR.

Terminology and diagnostic criteria

FGR and small for gestational age (SGA) are terms sometimes used interchangeably in the literature and clinical

practice. The term FGR has been used to describe a fetus with an EFW below the 10th percentile and SGA to describe a newborn whose birthweight is less than the 10th percentile for gestational age.²⁶ The use of the term intrauterine growth restriction (IUGR) should be abandoned in favor of FGR.

Fetuses with FGR are not always SGA at birth, and SGA neonates have often not been diagnosed as growth restricted on prenatal ultrasound.²⁷ **Of fetuses diagnosed with FGR, approximately 18%–22% will be constitutionally small but healthy at birth with a normal outcome.**²⁴ A significant challenge in the prenatal management of FGR is **differentiating the constitutionally small fetus from one who is pathologically growth restricted and at risk for postnatal complications.**

FGR is commonly defined as an ultrasonographic EFW below the 10th percentile for gestational age. A review of national guidelines for the diagnostic criteria for FGR from 6 countries (United States, United Kingdom, France, Ireland, Canada, and New Zealand) reveals a broad consensus on this definition of FGR.²⁴ However, there is significant variation in the diagnostic criteria used for FGR. Some diagnostic criteria are limited to fetal biometric measurements, whereas others incorporate abnormal Doppler findings.²⁸ Moreover, the biometric component of the FGR diagnostic criteria differs according to the choice of population vs customized reference growth standards, whether EFW is used alone or together with abdominal circumference (AC), and which cutoff is used to define abnormal growth.^{24,29,30} For example, 3 of the 6 countries also include AC as a diagnostic criterion, with the United Kingdom and Canada using an AC cutoff of less than the 10th percentile and New Zealand using an AC cutoff of less than the 5th percentile.²⁴

Evidence supports the use of AC as a diagnostic criterion for FGR. In a prospective study in 1000 low-risk pregnancies, an AC of less than the 10th percentile was found to have diagnostic accuracy similar to EFW less than the 10th percentile for the prediction of SGA.³¹ In a meta-analysis published in 2017, an AC of less than the 10th percentile predicted SGA as well as ultrasonographic EFW less than the 10th percentile, with comparable sensitivity and specificity. Compared with other cutoffs, an AC of less than the fifth percentile has significantly lower sensitivity but higher specificity in predicting SGA.³² Another systematic review and meta-analysis reported that AC and EFW performed similarly, and for a 10% fixed false-positive rate, AC had higher sensitivity.³³

An alternative approach to the diagnosis of FGR includes the determination of fetal growth trajectory, generated from multiple ultrasound examinations, and the identification of the fetus that drops off its own growth trajectory. Theoretically, this approach takes into consideration the dynamic aspect of growth and the individualized growth potential of each fetus.³⁴ However, this approach requires multiple ultrasound examinations, and prospective studies fail to demonstrate the superiority of this approach in improving clinical outcomes.³⁵ **We recommend that FGR be defined as an**

ultrasonographic EFW or AC below the 10th percentile for gestational age (GRADE 1B).

Ultrasonographic estimation of fetal weight

Accurate pregnancy dating is an important prerequisite for diagnosing FGR. Parameters for assigning gestational age by ultrasound have been recently updated.³⁶ Pregnancy dating is best established when first-trimester crown-rump length is used to either confirm menstrual dates or assign new dates.³⁶ Ultrasonographic fetal weight estimation is generated by the use of regression equations that combine biometric measurements of the fetal biparietal diameter, head circumference (HC), AC, and femur length; a multi-society task force has recently standardized criteria for these images obtained for fetal biometry.³⁷ The ultrasonographic EFW is then compared with a reference chart to generate a weight percentile.

The first ultrasonographic equation used to estimate fetal weight was published by Warsow et al in 1977, and since then, many others have been developed.³⁸ Considerable variation in accuracy was noted in a retrospective review of 26 formulas for ultrasonographic fetal weight estimation. For birthweights in the range of 1000–4500 g, formulas based on 3 or 4 fetal biometric indices were significantly more accurate in estimating fetal weights than formulas based on 1 or 2 indices.³⁹ In a review of the literature relating to methods and sources of inaccuracies in the estimation of fetal weight, the authors concluded that averaging of multiple measurements, improvements in image quality, uniform calibration of equipment, and regular audits may help to improve fetal weight estimation and reduce errors.⁴⁰

Fetal growth nomograms generally represent either unadjusted population standards or customized standards that adjust for constitutional or physiological variations of fetal size based on sex and race.^{35,41–44} The most widely used method for estimating fetal weight and calculating weight percentile in the United States is based on the Hadlock formula, which was generated from a study involving 392 pregnancies in predominantly white, middle-class women conducted at a single institution in Texas.⁴¹ In some studies, the use of customized growth standards has been shown to improve the ability to distinguish growth-restricted fetuses from constitutionally small fetuses.^{45–47}

Whether the use of customized growth standards translates to improved pregnancy outcomes was the subject of several recent studies: the INTERGROWTH-21st standard,⁴⁴ the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) standards,⁴⁸ and the World Health Organization (WHO) standard.^{49,50} The INTERGROWTH-21st study included healthy pregnant women with no maternal or fetal risk factors from 8 countries and created a single universal standard for fetal growth without adjusting for ethnic variation.⁴⁴ The NICHD study, performed at 12 sites in the United States, developed racial/ethnic-specific standards of fetal growth.⁴⁸ Finally,

the WHO study developed an overall growth standard based on data collected from 10 countries.^{49,50}

Although both the NICHD and WHO studies identified racial/ethnic differences in fetal growth, evidence to date indicates that the use of these new formulas in clinical practice does not improve the detection and outcome of FGR.^{51–53} In a preterm population in France, the INTERGROWTH-21st formula was associated with a higher mean percentage error and a higher underestimation of birthweight at >28 weeks of gestation when compared with Hadlock. The Hadlock formula classified more infants within 10% of actual birthweight and was more accurate than the INTERGROWTH-21st in the overall estimation of weight for fetuses delivered between 22 and 34 weeks of gestation.⁵³ The diagnostic accuracy for estimating fetal weight and the prediction of neonatal morbidity was compared using the NICHD standard and Hadlock in 1514 pregnant women with different ethnicities. The Hadlock formula better predicted SGA and composite neonatal morbidity at birth and had a lower ultrasound-to-birthweight percentile discrepancy than the NICHD growth standard. Fetuses classified as growth restricted by Hadlock, but not by the NICHD growth standard, had significantly higher composite morbidity than fetuses of normal growth.⁵¹ In view of these findings, we recommend the use of population-based fetal growth references (such as Hadlock) in determining fetal weight percentiles (GRADE 1B).

Classification of fetal growth restriction

Timing of diagnosis

FGR has been categorized as early or late onset based on gestational age at prenatal ultrasound diagnosis, with early-onset FGR diagnosed before 32 weeks of gestation and late-onset FGR diagnosed at or after 32 weeks of gestation. In a cohort of 656 pregnancies with FGR, a gestational age of 32 weeks at diagnosis was identified as the optimal cutoff to maximize the differences in associated comorbidities and pregnancy outcomes between early- and late-onset FGR.⁵⁴ The clinical spectrum of early- and late-onset FGR also differs; early-onset FGR is typically more severe, tends to follow an established Doppler pattern of fetal deterioration, is more commonly associated with maternal hypertensive disorders of pregnancy, and shows more significant placental dysfunction than late-onset FGR.^{23,28,54–56} Fetuses with genetic abnormalities can also present with early-onset FGR, commonly in association with fetal and amniotic fluid abnormalities.³ Late-onset FGR represents approximately 70%–80% of FGR cases and is typically milder in presentation.^{55,56} Unlike early-onset FGR, late-onset FGR is less likely to be associated with maternal hypertensive disorders and typically has less extensive placental histopathologic findings of underperfusion.^{57–59} In early-onset FGR, the pattern of Doppler deterioration progresses from abnormalities in the umbilical arteries and the ductus venosus to abnormal biophysical parameters.^{55,56} In contrast, cardiovascular adaptation of late-onset FGR is

typically limited to the cerebral circulation and is commonly associated with normal Doppler of the umbilical arteries.^{57,60,61}

Severity of fetal growth restriction

Studies have reviewed various ultrasonographic parameters to better identify growth-restricted fetuses at increased risk for perinatal morbidity and mortality.²⁸ The presence of abnormal umbilical artery Doppler indices has been found to predict adverse perinatal outcomes.⁶² An EFW below the third percentile has also been associated with an increased risk of adverse perinatal outcome irrespective of umbilical and middle cerebral artery Doppler indices.¹⁰ In a large retrospective cohort of more than 3 million singleton pregnancies, the risk of stillbirth at birthweights of less than the 3rd percentile was increased approximately 3-fold over the 3rd to 5th percentile group at nearly all gestational ages, and there was an increased risk of 4-fold to 7-fold over the 5th to 10th percentile group.⁶³ These results are consistent with neonatal data showing a significantly increased risk of morbidity and mortality in infants born at term with birthweights below the third percentile.⁶⁴ Therefore, an EFW below the third percentile has been found to represent a more severe form of FGR.

Symmetric and asymmetric fetal growth restriction

FGR has been classified as symmetric or asymmetric based on the ratio between the head circumference and the abdominal circumference (HC/AC). In the past, such classification was thought to provide valuable information about the timing of pregnancy insult and the etiology and prognosis of FGR.⁶⁵ More recently, growth and developmental delay have been evaluated from birth to the age of 4 years and shown to be similar in symmetric and asymmetric growth-restricted preterm newborns.⁶⁶ Furthermore, HC/AC was not found to be an independent predictor of adverse pregnancy outcomes.⁶⁷

Management of fetal growth restriction

General considerations

There are currently no preventative strategies or treatments for FGR that have been proven to be effective. There is no consistent evidence that nutritional and dietary supplements or bed rest prevents FGR or reduces the incidence of SGA births.^{68–71} The use of prophylactic low-dose aspirin was shown to provide a modest risk reduction in FGR and SGA in 2 meta-analyses.^{72,73} However, this finding was not confirmed in the Aspirin for Evidence-Based Preeclampsia Prevention (ASPREE) trial, which was primarily designed for preterm preeclampsia prevention.^{74,75} Due to the conflicting evidence on the role of low-dose aspirin in the prevention of recurrent FGR in otherwise low-risk women, the American College of Obstetricians and Gynecologists recommends against the use of low-dose aspirin for the sole indication of FGR

prevention.⁷⁶ Furthermore, the use of low-molecular-weight heparin has not been shown to reduce the risk of recurrent placenta-mediated pregnancy complications in at-risk women.^{75,77,78} At present, there is no evidence that therapeutic interventions, including sildenafil to augment uteroplacental perfusion through vasodilation, improve placental perfusion and outcome in pregnancies with FGR.^{75,79} **We recommend against the use of low-molecular-weight heparin for the sole indication of prevention of recurrent FGR (GRADE 1B). We also recommend against sildenafil or activity restriction for in utero treatment of FGR (GRADE 1B).**

Management of FGR is based on early diagnosis, optimal fetal surveillance, and timely delivery that reduces perinatal mortality and minimizes short- and long-term morbidity. In pregnancies with FGR, delivery decisions require balancing the risk of prematurity against that of stillbirth. The decision to deliver is typically guided by maternal factors, such as the presence of maternal hypertension, and by fetal comorbidities, such as the degree of growth restriction and the severity of abnormal fetal surveillance results. There is currently no consensus on the best approach to the management of FGR, despite a large body of literature on the subject. This lack of agreement is primarily due to the paucity of randomized trials and the heterogeneity of study populations.

Despite these limitations, accumulating evidence suggests a benefit to the use of umbilical artery Doppler in the surveillance of FGR. Furthermore, the presence of a standardized protocol for diagnosis and management appears to be associated with more favorable outcomes, as evidenced in the better-than-expected perinatal morbidity and mortality in the Trial of Randomized Umbilical and Fetal Flow in Europe (TRUFFLE).⁸⁰ Results of this trial, which standardized the approach to care and criteria for delivery, are in contrast to those of the Growth Restriction Intervention Trial (GRIT),^{81,82} which left management to the discretion of the managing providers. **The single most important prognostic factor in preterm fetuses with growth restriction is the gestational age at delivery.**^{80,83} A large longitudinal cohort study on FGR showed an increase of 1%–2% in intact survival for every additional day spent in utero up until 32 weeks of gestation.⁸³ An algorithm for the diagnosis and management of FGR is provided in Figure 1.

Maternal hypertensive disease is common in early-onset FGR and plays an important role in pregnancy outcomes. In TRUFFLE, maternal hypertension was present in 50% of pregnancies during the study and 70% of pregnancies at the time of delivery. The presence of maternal hypertension was one of the most important independent determinants of poor outcomes.^{16,80} Pregnant women with hypertension had a significantly shorter median interval from study enrollment to delivery, and newborns of mothers with hypertension were delivered at an earlier gestational age and had lower birthweights.⁸⁰ Women with early-onset FGR should be closely monitored for the development of hypertensive disorders of pregnancy.

Summary of recommendations

Number	Recommendations	Grade
1	We recommend that FGR be defined as an ultrasonographic EFW or AC below the 10th percentile for gestational age.	1B Strong recommendation, moderate-quality evidence
2	We recommend the use of population-based fetal growth references (such as Hadlock) in determining fetal weight percentiles.	1B Strong recommendation, moderate-quality evidence
3	We recommend against the use of low-molecular-weight heparin for the sole indication of prevention of recurrent FGR.	1B Strong recommendation, moderate-quality evidence
4	We recommend against the use of sildenafil or activity restriction for in utero treatment of FGR.	1B Strong recommendation, moderate-quality evidence
5	We recommend that a detailed obstetrical ultrasound examination (CPT code 76811) be performed with early-onset FGR (<32 weeks of gestation) because up to 20% of cases are associated with fetal or chromosomal abnormalities.	1B Strong recommendation, moderate-quality evidence
6	We recommend that women be offered fetal diagnostic testing, including CMA, when FGR is detected and a fetal malformation, polyhydramnios, or both are also present regardless of gestational age.	1B Strong recommendation, moderate-quality evidence
7	We recommend that pregnant women be offered prenatal diagnostic testing with CMA when unexplained isolated FGR is diagnosed at <32 weeks of gestation.	1C Strong recommendation, low-quality evidence
8	We recommend against screening for toxoplasmosis, rubella, or herpes in pregnancies with FGR in the absence of other risk factors and recommend PCR for CMV in women with unexplained FGR who elect diagnostic testing with amniocentesis.	1C Strong recommendation, low-quality evidence
9	We recommend that once FGR is diagnosed, serial umbilical artery Doppler assessment should be performed to assess for deterioration.	1C Strong recommendation, low-quality evidence
10	With decreased end-diastolic velocity (ie, flow ratios greater than the 95th percentile) or in pregnancies with severe FGR (EFW less than the 3rd percentile), we suggest weekly umbilical artery Doppler evaluation.	2C Weak recommendation, low-quality evidence
11	We recommend Doppler assessment up to 2–3 times per week when umbilical AEDV is detected because of the potential for deterioration and development of REDV.	1C Strong recommendation, low-quality evidence
12	In the setting of REDV, we suggest hospitalization, administration of antenatal corticosteroids, heightened surveillance with CTG at least 1–2 times per day, and consideration of delivery depending on the entire clinical picture and results of additional evaluation of fetal well-being.	2C Weak recommendation, low-quality evidence
13	We suggest that Doppler assessment of the ductus venosus, middle cerebral artery, or uterine artery not be used for routine clinical management of early- or late-onset FGR.	2B Weak recommendation, moderate-quality evidence
14	We suggest weekly CTG testing after viability for FGR without AEDV/REDV and that the frequency be increased when FGR is complicated by AEDV/REDV or other comorbidities or risk factors.	2C Weak recommendation, low-quality evidence
15	We recommend delivery at 37 weeks of gestation in pregnancies with FGR and an umbilical artery Doppler waveform with decreased diastolic flow but without AEDV/REDV or with severe FGR with EFW less than the third percentile.	1B Strong recommendation, moderate-quality evidence
16	We recommend delivery at 33–34 weeks of gestation for pregnancies with FGR and AEDV.	1B Strong recommendation, moderate-quality evidence
17	We recommend delivery at 30–32 weeks of gestation for pregnancies with FGR and REDV.	1B Strong recommendation, moderate-quality evidence
18	We suggest delivery at 38–39 weeks of gestation with FGR when the EFW is between the 3rd and 10th percentile and the umbilical artery Doppler is normal.	2C Weak recommendation, low-quality evidence

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(continued)

Summary of recommendations *(continued)*

Number	Recommendations	Grade
19	We suggest that for pregnancies with FGR complicated by AEDV/REDV, cesarean delivery should be considered based on the entire clinical scenario.	2C Weak recommendation, low-quality evidence
20	We recommend the use of antenatal corticosteroids if delivery is anticipated before 33 6/7 weeks of gestation or for pregnancies between 34 0/7 and 36 6/7 weeks of gestation in women without contraindications who are at risk of preterm delivery within 7 days and who have not received a previous course of antenatal corticosteroids.	1A Strong recommendation, high-quality evidence
21	We recommend intrapartum magnesium sulfate for fetal and neonatal neuroprotection for women with pregnancies that are <32 weeks of gestation.	1A Strong recommendation, high-quality evidence

AC, abdominal circumference; AEDV, artery absent end-diastolic velocity; CMA, chromosomal microarray analysis; CMV, cytomegalovirus; CPT, current procedural terminology; CTG, cardiotocography; EFW, estimated fetal weight; FGR, fetal growth restriction; PCR, polymerase chain reaction; REDV, reversed end-diastolic velocity.

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Initial diagnosis

With the initial diagnosis of FGR and if not previously performed, **we recommend that a detailed obstetrical ultrasound examination (current procedural terminology code 76811) be performed with early-onset FGR because up to 20% of cases are associated with fetal or chromosomal abnormalities^{2,3,84,85} (GRADE 1B).** The combination of FGR with a fetal malformation or polyhydramnios should prompt genetic counseling and consideration of prenatal diagnostic testing.⁸⁶ **We recommend that women be offered fetal diagnostic testing, including chromosomal microarray analysis (CMA), when FGR is detected and a fetal malformation, polyhydramnios, or both are also present regardless of gestational age (GRADE 1B).**

Although chromosome abnormalities are more frequent in pregnancies with structural anomalies and FGR, in a systematic review that included fetuses with no structural malformations, the mean rate of chromosomal abnormalities was 6.4%. Only a fraction of the studies included women in the third trimester with apparently isolated FGR, but no karyotype abnormalities were identified in those women. Due to substantial heterogeneity of the selected studies in the systemic review, meta-analytic methods, such as calculating the effect estimates, could not be applied.⁸⁷ More recent studies have evaluated the role of CMA in fetuses with early-onset growth restriction and no structural malformations; such studies have identified a 4%–10% incremental yield of CMA over karyotype.^{88–90}

We recommend that pregnant women be offered prenatal diagnostic testing with CMA when unexplained isolated FGR is diagnosed at <32 weeks of gestation (GRADE 1C).

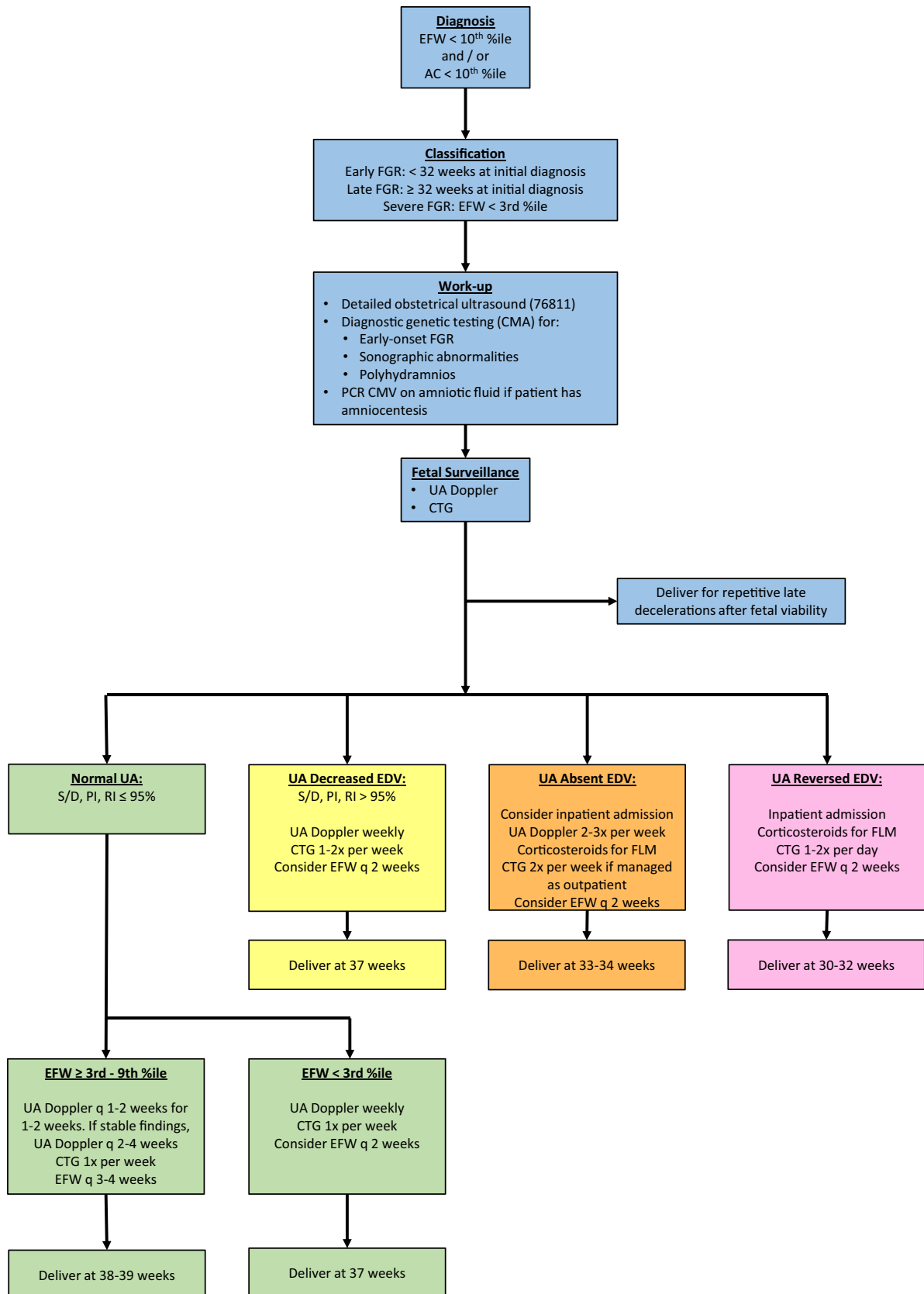
The association of maternal infections with FGR was recently evaluated in a study that included 319 pregnancies. No cases of maternal or congenital infection with toxoplasma, rubella, or herpes were found, whereas 6 (1.8%) fetuses were diagnosed as having congenital cytomegalovirus (CMV). Two (0.6%) of the fetuses with congenital CMV had no ultrasonographic findings other than FGR.⁹¹ In

another prospective cohort study of 48 pregnancies with FGR, 1 newborn (2.1%) was diagnosed with congenital CMV.⁹² **We recommend against screening for toxoplasmosis, rubella, or herpes in pregnancies with FGR in the absence of other risk factors and recommend polymerase chain reaction (PCR) for CMV in women with unexplained FGR who elect diagnostic testing with amniocentesis (GRADE 1C).** However, given the low incidence of CMV in cases of FGR, the lack of effective antenatal interventions, and the limited utility of serologic testing for CMV in the third trimester, routine infectious serologies may not be warranted in the absence of risk factors or ultrasonographic markers of fetal infection.^{91–94} PCR is the preferred testing approach for CMV and should be performed in women with unexplained FGR who undergo diagnostic testing with amniocentesis.

Umbilical artery Doppler

Umbilical artery Doppler assesses the impedance to blood flow along the fetal component of the placental unit. As early as 14 weeks of gestation, low impedance of the fetal placental circulation permits continuous forward flow in the umbilical artery throughout the cardiac cycle.⁹⁵ Doppler waveforms of the umbilical artery can be obtained from any segment along the umbilical cord. Waveforms obtained near the placental end of the cord reflect downstream impedance and show higher end-diastolic blood flow velocity than waveforms obtained near the fetal cord insertion.⁹⁵ In general, this variation in umbilical artery Doppler end-diastolic flow along the umbilical cord is minimal and not significant enough to affect clinical decision-making.

The pulsatility index (PI), resistance index (RI), or systolic-to-diastolic (S/D) ratio can be used for quantification of the Doppler waveform in the umbilical artery, although recent studies have generally used either the PI or RI.^{5,16,28,30,80,83} An abnormal umbilical artery Doppler is defined as a PI, RI, or S/D ratio greater than the 95th percentile for gestational age or an absent or reversed end-diastolic velocity (AEDV or

FIGURE 1
Algorithm for the diagnosis and management of fetal growth restriction


REDV). The progression from an abnormal umbilical artery Doppler with a decreased diastolic flow to AEDV/REDV can take several days to weeks, especially in the absence of maternal disease. In a large study on FGR, the mean time-to-delivery interval for umbilical artery PI greater than the 95th percentile, AEDV, and REDV was 26, 13, and 4 days, respectively.⁶²

An abnormal umbilical artery Doppler waveform reflects the presence of placental insufficiency and can help differentiate the growth-restricted fetus from the constitutionally small fetus. Incorporation of umbilical artery Doppler evaluation in the management of high-risk pregnancies has been shown to significantly reduce the risk of perinatal death, induction of labor, and cesarean delivery. As such, it is an essential component of fetal surveillance in FGR.^{96,97} In contrast, a systematic review of 5 trials found no evidence of maternal or neonatal benefit from the routine use of umbilical artery Doppler in low-risk pregnancies.⁹⁸

AEDV/REDV in the umbilical artery reflects the presence of significant placental deterioration and is associated with high perinatal mortality. The finding of AEDV/REDV of the umbilical artery can be intermittent; this likely represents the continuum of Doppler deterioration that occurs before the absent or reversed flow becomes persistent.⁹⁹ A meta-analysis of 31 studies on the risk of fetal death in FGR before 34 weeks of gestation reported odds ratios for fetal death of 3.59 (95% confidence interval [CI], 2.3–5.6) and 7.27 (95% CI, 4.6–11.4) for AEDV and REDV, respectively. Pooled data from this meta-analysis also revealed a risk of stillbirth of 6.8% for AEDV and 19% for REDV in the umbilical artery or ductus venosus.¹⁰⁰ These risks of stillbirth are higher than the risk of infant mortality or severe morbidity at 33–34 weeks for AEDV and at 30–32 weeks for REDV as reported in TRUFFLE.⁸⁰

Evidence suggests that umbilical artery Doppler does not reliably predict adverse pregnancy outcome in late-onset FGR.¹⁰¹ This result is probably related to the lower frequency of placental pathologic findings in late-onset FGR when compared with early-onset FGR.^{102–104} Experimental modeling suggests that a threshold of placental vascular obliteration is required before umbilical artery Doppler abnormalities are seen; therefore, the presence of a normal umbilical artery Doppler in late-onset FGR does not rule out placental disease.^{105,106}

There are currently no randomized trials with adequate sample size to inform recommendations regarding the optimal frequency of umbilical artery Doppler for FGR surveillance.¹⁰⁷ Protocols vary from weekly umbilical artery Doppler to a 2- to 4-week interval.^{24,108} A prospective observational study of the progression of Doppler

abnormalities in FGR suggests that rapid progression, if it is going to occur, is typically noted within the first 2 weeks after diagnosis.^{24,108} **We recommend that once FGR is diagnosed, serial umbilical artery Doppler assessment should be performed to assess for deterioration (GRADE 1C).** This assessment should initially occur every 1–2 weeks. If the umbilical artery Doppler remains normal after this initial assessment, a less frequent interval of umbilical artery Doppler testing (eg, every 2–4 weeks) may be considered.¹⁰⁸

With decreased end-diastolic velocity (ie, flow ratios greater than the 95th percentile) or in pregnancies with severe FGR (EFW less than the 3rd percentile), we suggest weekly umbilical artery Doppler evaluation^{24,95} (GRADE 2C). We recommend Doppler assessment up to 2–3 times per week when umbilical artery AEDV is detected due to the potential for deterioration and development of REDV (GRADE 1C). In the setting of REDV, we suggest hospitalization, administration of antenatal corticosteroids, heightened surveillance with cardiotocography (CTG) at least 1–2 times per day, and consideration of delivery depending on the entire clinical picture and results of additional evaluation of fetal well-being (GRADE 2C). Hospital admission should be considered if fetal surveillance of more often than 3 times per week is deemed necessary. Once FGR is diagnosed, assessment of fetal growth and weight should be performed at least every 3–4 weeks; consideration can be given for a 2-week interval in cases of severe FGR or with abnormal umbilical artery Doppler.¹⁰⁹

Ductus venosus Doppler

Longitudinal studies have shown that Doppler abnormalities of the ductus venosus in FGR reflect an advanced stage of fetal compromise, associated with increased perinatal morbidity and mortality.^{2,23,55,110–117} A meta-analysis of FGR at <34 weeks of gestation reported odds ratios for stillbirth of 11.16 (95% CI, 6.31–19.73) for absent or reversed A-wave of the ductus venosus and a frequency of stillbirth of 20%; the risk of stillbirth with a reversed A-wave was 46%.¹⁰⁰ In FGR, Doppler abnormalities of the ductus venosus primarily reflect increased central venous pressure, resulting from increased right ventricular end-diastolic pressure and decreased cardiac muscle compliance.^{110,118} Reversed A-wave of the ductus venosus in FGR signifies more significant fetal cardiac compromise.¹¹⁹ Doppler abnormalities of the ductus venosus in the setting of a normal umbilical artery Doppler indicate an alternative pathophysiological etiology, possibly related to the presence of fetal cardiac, vascular, or genetic abnormalities, and thus are most often not reflective of significant placental disease.

TRUFFLE compared ductus venosus Doppler and computer-generated short-term fetal heart rate variability (cSTV)

AC, abdominal circumference; CMA, chromosomal microarray analysis; CMV, cytomegalovirus; CTG, cardiotocography; EDV, end-diastolic velocity; EFW, estimated fetal weight; FGR, fetal growth restriction; FLM, fetal lung maturity; PCR, polymerase chain reaction; PI, pulsatility index; RI, resistance index; S/D, systolic-to-diastolic ratio; UA, umbilical artery.

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in the monitoring and timing of delivery in early-onset FGR. After correction for prematurity, survival without neurologic impairment was found to be significantly higher in the group delivered according to late ductus venosus changes (95%) compared with cSTV (85%).¹⁶ However, caution is urged when extrapolating the findings of TRUFFLE to practice in the United States. TRUFFLE compared cSTV with ductus venosus Doppler, and results cannot be generalized to the visual interpretation of CTG. Furthermore, absent or reversed A-wave of the ductus venosus represents an advanced stage of fetal compromise and is uncommon. Even in pregnancies with AEDV/REDV of the umbilical artery, late Doppler abnormalities of the ductus venosus are noted in only about 41% of fetuses.¹¹⁷ After 32 weeks of gestation, abnormal CTG findings will almost invariably precede Doppler abnormalities of the ductus venosus.¹¹¹ In TRUFFLE, delivery decisions guided by ductus venosus Doppler findings only accounted for about 11% of pregnancies allocated to the late ductus venosus findings group because most delivered due to other fetal or maternal indications.^{115,120,121} Prospective research is needed to further elucidate the role of ductus venosus Doppler in pregnancies with early-onset FGR before its use in routine surveillance of pregnancies with FGR can be recommended.

Middle cerebral artery Doppler

The middle cerebral artery is the largest vessel of the fetal cerebral circulation and carries about 80% of cerebral blood flow.¹²² Fetal hypoxemia associated with growth restriction results in cerebral vasodilation, an early adaptive mechanism termed the brain-sparing effect. Measurement of flow through the middle cerebral artery using Doppler can identify cerebral vasodilation, which can be quantified using PI or the cerebroplacental ratio (CPR). CPR is calculated by dividing the middle cerebral artery PI by the umbilical artery PI.^{123–126} The role of middle cerebral artery Doppler in the management of early-onset FGR has been evaluated in several studies.^{127–129} In a meta-analysis of 35 studies, abnormal middle cerebral artery Doppler had a low likelihood ratio (LR) for prediction of perinatal mortality (LR 1.36 [1.10–1.67]) and adverse perinatal outcome (LR 2.77 [1.93–3.96]).¹³⁰ Similarly, in a secondary analysis of data from TRUFFLE, middle cerebral artery Doppler did not add useful information beyond umbilical artery and ductus venosus Doppler assessments for optimizing the timing of delivery.¹³¹

Studies have found that 15%–20% of late-onset growth-restricted fetuses with normal umbilical blood flow have middle cerebral artery Doppler findings of cerebral vasodilation, and CPR has also been studied for its utility in predicting adverse outcomes and guiding the timing of delivery in late-onset cases.^{101,115,132–137} The Prospective Observational Trial to Optimize Pediatric Health in IUGR (PORTO) study evaluated the optimal management of fetuses with FGR at 24 0/7 to 36 6/7 weeks of gestation, including

multivessel Doppler measurement and CPR. Data from this study showed that CPR evaluation had a sensitivity of 66% and specificity of 85% for the prediction of adverse outcomes.¹³⁸ However, a large systematic review and meta-analysis on the prognostic accuracy of CPR and middle cerebral artery Doppler for adverse perinatal outcomes in FGR revealed few high-quality studies and reported large variations in sensitivity and specificity.¹³⁹ The available evidence does not indicate improved accuracy of CPR over umbilical artery Doppler, and clinical trials are needed to evaluate the effectiveness of CPR in guiding clinical management, especially in late-onset FGR, before its use in routine surveillance of pregnancies with FGR can be recommended.¹³⁹

Uterine artery Doppler

Uterine artery Doppler assesses the maternal component of placental blood flow and is a marker of remodeling of the spiral arteries by trophoblastic cellular invasion. In normal pregnancies, spiral artery remodeling results in a low-impedance circulation, which is reflected in the uterine arteries by the presence of high velocity and continuous forward flow in diastole.¹⁴⁰ This pregnancy adaptation optimizes the intervillous placental blood flow and delivery of oxygen and nutrients to the fetus. Severe early-onset FGR is characterized by failure of trophoblastic invasion of the myometrial spiral arteries, resulting in reduced uteroplacental perfusion.¹⁴⁰

Abnormal uterine artery Doppler, defined as a PI greater than the 95th percentile for gestational age or the presence of a diastolic notch, has been associated with adverse pregnancy outcomes, including preeclampsia, FGR, and perinatal mortality.^{137,141–147} However, uterine artery Doppler has limited diagnostic accuracy and clinical utility in predicting FGR, SGA birth, and perinatal mortality.^{148,149} Although FGR detection rates >90% have been reported in first- and second-trimester prediction models that combine maternal factors, biochemical markers, and uterine artery Doppler, lack of external validation or demonstration of improved pregnancy outcomes limits their clinical applicability.^{145,150,151} Based on the available evidence, uterine artery Doppler does not add clinically valuable information for diagnosis or management. **We suggest that Doppler assessment of the ductus venosus, middle cerebral artery, or uterine artery not be used for routine clinical management of early- or late-onset FGR (GRADE 2B).**

Cardiotocography

CTG is currently accepted as the primary method for fetal surveillance in high-risk pregnancies in the United States. Despite the absence of large prospective studies on the role of CTG in the management of FGR, a normal CTG in pregnancies with FGR is more likely to be associated with a normal perinatal outcome, and the presence of spontaneous repetitive late decelerations is accepted as an indication for delivery in viable pregnancies with FGR, irrespective of Doppler findings.¹²¹ Although there is limited

evidence to support the frequency of CTG in pregnancies with FGR, it is reasonable to initiate testing at diagnosis after viability, or at a gestational age at which an abnormal finding would trigger intervention.²⁴ **We suggest weekly CTG testing after viability for FGR without AEDV/REDV and that the frequency be increased when FGR is complicated by AEDV/REDV or other comorbidities or risk factors (GRADE 2C).**

Biophysical profile

Observational studies have indicated that an abnormal biophysical profile (BPP) is a late manifestation of placental disease that appears to become abnormal 48–72 hours after ductus venosus Doppler abnormalities in 90% of cases.¹⁵² More recent studies have questioned the value of BPP in fetal surveillance of high-risk pregnancies, including early-onset severe FGR, because of a high prevalence of false-positive and false-negative results. A Cochrane review concluded that available evidence from randomized controlled trials does not support the use of BPP as a test of fetal well-being in high-risk pregnancies.^{153,154} Although fetal deterioration has been reported to be independently reflected by Doppler and BPP testing, further studies are required to prove the usefulness of BPP or of combining these testing modalities.¹⁵⁵

Amniotic fluid volume

Oligohydramnios is defined as a single deepest vertical pocket of amniotic fluid of less than 2 cm. The PORTO study, which included more than 1100 pregnancies with FGR, noted that amniotic fluid volume abnormalities did not independently increase the risk for adverse outcomes in FGR.³⁰ There is currently a paucity of data on the role of amniotic fluid volume measurement in FGR management and delivery.³⁰ However, current guidelines on medically indicated late-preterm and early-term deliveries suggest delivery at 34 0/7 to 37 6/7 weeks of gestation for FGR associated with oligohydramnios.¹⁵⁶

Neonatal outcomes and delivery timing

The decision for delivery in FGR is driven by fetal and maternal factors. Fetal factors include EFW, gestational age, and findings on fetal surveillance. Maternal factors include the presence of comorbidities, such as hypertension. In the periviable period, the decision for delivery may be challenging because the rates of perinatal death, neurodevelopmental impairment, and other adverse outcomes are high in this gestational age window.^{157–159}

Survival of very preterm neonates gradually decreases with decreasing weight percentiles.^{160–163} Neonatal mortality in SGA infants born between 24 and 29 weeks of gestation is increased 2-fold to 4-fold when compared with appropriately grown neonates.^{4,164–166} In a large European study, birthweights between the 10th and 25th percentiles were associated with a 2-fold increase in mortality when compared with the 50th to 75th percentile weight group.¹⁶⁷ In early-onset FGR associated with abnormal Doppler

studies, neonatal survival increased from 13% at 24 weeks to 43% at 25 weeks and 58%–76% at 26 weeks of gestation. Intact survival was 0% at 24 weeks, 13% at 25 weeks, and 6%–31% at 26 weeks of gestation.¹⁵⁹ Given the high rate of adverse outcomes, thresholds of 26 weeks of gestation, 500 g, or both have been suggested for the delivery of pregnancies with severe early-onset FGR.^{55,80,83,159} With recent advances in neonatal care and survival of fetuses at the limits of viability, the decision for delivery before 26 weeks of gestation or at 500 g should include coordination of care between maternal-fetal medicine and neonatology services, along with comprehensive patient counseling on neonatal morbidity and mortality and shared decision-making regarding pregnancy management.

The evidence supporting the timing of delivery in pregnancies with FGR and abnormal umbilical artery Doppler but without AEDV/REDV is limited.¹⁶⁸ In a retrospective cohort study of pregnancies with FGR, no difference in composite neonatal outcome was seen between delivery at 39 weeks of gestation in fetuses with normal umbilical artery Doppler and delivery at 37 weeks of gestation in fetuses with elevated umbilical artery S/D ratio.¹⁶⁸ A large US cohort study reported that delivery at 37 weeks of gestation results in a decrease in the stillbirth rate in the presence of risk factors, such as FGR.¹⁶⁹ **We recommend delivery at 37 weeks of gestation in pregnancies with FGR and an umbilical artery Doppler waveform with decreased diastolic flow (S/D, RI, or PI greater than the 95th percentile) but without AEDV/REDV or with severe FGR with EFW less than the 3rd percentile (GRADE 1B).**

As discussed previously, neonatal morbidity and mortality rates associated with AEDV are higher than rates of complications of prematurity at 33–34 weeks of gestation.¹⁰⁰ **Therefore, we recommend delivery at 33–34 weeks of gestation for pregnancies with FGR and AEDV (GRADE 1B).** In the presence of REDV, neonatal morbidity and mortality rates are higher than complications of prematurity at 30–32 weeks of gestation.¹⁰⁰ **Therefore, we recommend delivery at 30–32 weeks of gestation for pregnancies with FGR and REDV (GRADE 1B).** **We suggest delivery at 38–39 weeks of gestation with FGR when the EFW is between the 3rd and 10th percentile and the umbilical artery Doppler is normal (GRADE 2C).**

There are limited data to inform recommendations regarding the mode of delivery in pregnancies complicated by FGR. Growth-restricted fetuses, particularly those with AEDV/REDV, are at an increased risk for decelerations in labor, emergency cesarean delivery, and metabolic acidemia at delivery.^{170,171} Older studies reported rates of intrapartum fetal heart rate decelerations requiring cesarean delivery in 75%–95% of pregnancies with FGR and AEDV/REDV.^{172,173} National guidelines from 4 countries recommend cesarean delivery when FGR is complicated by AEDV/REDV of the umbilical artery.²⁴ In recent studies that reported outcomes of pregnancies complicated by FGR with AEDV/REDV, the mode of delivery was primarily by cesarean, thus rendering it impossible to determine the likelihood of adverse outcomes associated with

The Society for Maternal-Fetal Medicine grading system: grading of recommendations assessment, development, and evaluation¹⁷⁶

Grade of recommendation	Clarity of risk and benefit	Quality of supporting evidence	Implications
1A. Strong recommendation, high-quality evidence	Benefits clearly outweigh risks and burdens or vice versa.	Consistent evidence from well-performed, randomized controlled trials or overwhelming evidence of some other form. Further research is unlikely to change confidence in the estimate of benefit and risk.	Strong recommendation that can apply to most patients in most circumstances without reservation. Clinicians should follow a strong recommendation unless a clear and compelling rationale for an alternative approach is present.
1B. Strong recommendation, moderate-quality evidence	Benefits clearly outweigh risks and burdens or vice versa.	Evidence from randomized controlled trials with important limitations (inconsistent results, methodologic flaws, indirect or imprecise) or very strong evidence of some other research design. Further research (if performed) is likely to have an impact on confidence in the estimate of benefit and risk and may change the estimate.	Strong recommendation that applies to most patients. Clinicians should follow a strong recommendation unless a clear and compelling rationale for an alternative approach is present.
1C. Strong recommendation, low-quality evidence	Benefits seem to outweigh risks and burdens or vice versa.	Evidence from observational studies, unsystematic clinical experience, or randomized controlled trials with serious flaws. Any estimate of effect is uncertain.	Strong recommendation that applies to most patients. Some of the evidence base supporting the recommendation is, however, of low quality.
2A. Weak recommendation, high-quality evidence	Benefits closely balanced with risks and burdens.	Consistent evidence from well-performed randomized controlled trials or overwhelming evidence of some other form. Further research is unlikely to change confidence in the estimate of benefit and risk.	Weak recommendation; best action may differ depending on circumstances or patients or societal values.
2B. Weak recommendation, moderate-quality evidence	Benefits closely balanced with risks and burdens; some uncertainty in the estimates of benefits, risks, and burdens.	Evidence from randomized controlled trials with important limitations (inconsistent results, methodologic flaws, indirect or imprecise), or very strong evidence of some other research design. Further research (if performed) is likely to have an effect on confidence in the estimate of benefit and risk and may change the estimate.	Weak recommendation; alternative approaches likely to be better for some patients under some circumstances.
2C. Weak recommendation, low-quality evidence	Uncertainty in the estimates of benefits, risks, and burdens; benefits may be closely balanced with risks and burdens.	Evidence from observational studies, unsystematic clinical experience, or randomized controlled trials with serious flaws. Any estimate of effect is uncertain.	Very weak recommendation; other alternatives may be equally reasonable.
Best practice	Recommendation in which either (1) there is an enormous amount of indirect evidence that clearly justifies strong recommendation (direct evidence would be challenging, and inefficient use of time and resources, to bring together and carefully summarize) or (2) recommendation to the contrary would be unethical.	—	—

Adapted from Guyatt et al.¹⁷⁷

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spontaneous or induced vaginal delivery.⁸⁶ Given these data and outcomes, we suggest that for pregnancies with FGR complicated by AEDV/REDV, cesarean delivery should be considered based on the entire clinical scenario (GRADE 2C).

In accordance with other guidelines,¹⁷⁴ we recommend the use of antenatal corticosteroids if delivery is anticipated before 33 6/7 weeks of gestation or for pregnancies between 34 0/7 and 36 6/7 weeks of gestation in women without contraindications who

are at risk of preterm delivery within 7 days and who have not received a previous course of antenatal corticosteroids¹⁷⁵ (GRADE 1A). We also recommend intrapartum magnesium sulfate for fetal and neonatal neuroprotection for women with pregnancies that are less than 32 weeks of gestation (GRADE 1A). ■

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Multidisciplinary consensus on the classification of prenatal and postnatal urinary tract dilation (UTD classification system)

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Abstract *Objective:* Urinary tract (UT) dilation is sonographically identified in 1–2% of fetuses and reflects a spectrum of possible uropathies. There is significant variability in the clinical management of individuals with prenatal UT dilation that stems from a paucity of evidence-based information correlating the severity of prenatal UT dilation to postnatal urological pathologies. The lack of correlation between prenatal and postnatal US findings and final urologic diagnosis has been problematic, in large measure because of a lack of consensus and uniformity in defining and classifying UT dilation. Consequently, there is a need for a unified classification system with an accepted standard terminology for the diagnosis and management of prenatal and postnatal UT dilation.

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Methods: A consensus meeting was convened on March 14–15, 2014, in Linthicum, Maryland, USA to propose: 1) a unified description of UT dilation that could be applied both prenatally and postnatally; and 2) a standardized scheme for the perinatal evaluation of these patients based on sonographic criteria (i.e. the classification system). The participating societies included American College of Radiology, the American Institute of Ultrasound in Medicine, the American Society of Pediatric Nephrology, the Society for Fetal Urology, the Society for Maternal-Fetal Medicine, the Society for Pediatric Urology, the Society for Pediatric Radiology and the Society of Radiologists in Ultrasounds.

Results: The recommendations proposed in this consensus statement are based on a detailed analysis of the current literature and expert opinion representing common clinical practice. The proposed UTD Classification System (and hence the severity of the UT dilation) is based on six categories in US findings: 1) anterior-posterior renal pelvic diameter (APRPD); 2) calyceal dilation; 3) renal parenchymal thickness; 4) renal parenchymal appearance; 5) bladder abnormalities; and 6) ureteral abnormalities. The classification system is stratified based on gestational age and whether the UT dilation is detected prenatally or postnatally. The panel also proposed a follow-up scheme based on the UTD classification.

Conclusion: The proposed grading classification system will require extensive evaluation to assess its utility in predicting clinical outcomes. Currently, the grading system is correlated with the risk of postnatal uropathies. Future research will help to further refine the classification system to one that correlates with other clinical outcomes such as the need for surgical intervention or renal function.

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Introduction

Prenatal diagnosis of urinary tract (UT) dilation occurs in 1–2% of all pregnancies. Based on an estimated birth rate in the United States of 4 million per year [1], approximately 40–80,000 children are diagnosed annually with this condition. The prenatal sonographic identification of UT dilation reflects a spectrum of potential etiologies and uropathies. The rationale of prenatal detection is to identify pathology prior to the development of complications such as urinary tract infection (UTI), urinary stone formation, and renal dysfunction. In the majority of the cases, the prenatal finding of UT dilation is transient or physiologic and has no clinical significance. In other cases, it represents obstructive conditions such as posterior urethral valves (PUV) that have significant morbidities and even mortalities (Table 1). In many of the cases, the etiology of UT dilation is unable to be determined before birth and is diagnosed postnatally with additional imaging including ultrasound (US) and voiding cystourethrogram (VCUG).

Clinical practice patterns vary considerably regarding recommendation for the follow-up evaluation of fetuses and children who have been diagnosed with prenatal UT dilation. This stems from the challenge of predicting which children will have a clinically significant uropathy and would benefit from postnatal imaging. Evaluating every child with prenatal UT dilation results in the expenditure of significant healthcare resources and could cost over \$90 million annually (1–3 prenatal US scans at \$500; antibiotics at \$25; 1–3 postnatal US scans at \$400; 1 VCUG at \$1200 per child). This does not factor in the cost associated with travel, time off from work for the parents, unnecessary parental anxiety, childhood radiation, and antibiotic

exposure. Alternatively, not evaluating any child with prenatal UT dilation could avoid these initial costs but might delay the diagnosis of significant uropathies such as PUV and consequently, incur higher long-term health and financial costs.

Evidence correlating the severity of prenatal UT dilation with postnatal urological pathologies is lacking for several reasons. First, there is no uniformity on how to define, classify, and grade UT dilation both within and between the prenatal and postnatal periods. As a result, several different classification systems have evolved, leading to varying nomenclature. Second, different terminologies with overlapping meanings are used to describe UT dilation, and different clinicians may use the terms to mean different things. This causes misunderstanding, which further leads to confusion as to the specific US findings identified. For example, the term hydronephrosis is often used by imagers to describe even mild degrees of UT dilation, while clinicians (especially among primary care providers) consider the term hydronephrosis to mean distension of the renal pelvis and calyces from obstruction of urine flow that, if left untreated, results in progressive renal deterioration. Thus, the communication of the findings, which is transmitted between the imager and the clinician, may be misinterpreted. Third, UT dilation is a dynamic process, which can fluctuate over time and with varying conditions. The distension of the renal pelvis and calyces may vary depending on factors such as hydration status, degree of bladder filling, and patient position. Finally, uropathies present in a spectrum of severity. As an example, not all cases of PUV present with a severe UT dilation. Therefore, minimal UT dilation does not necessarily exclude the diagnosis of PUV. Given the lack of

Table 1 Etiology of urinary tract dilation detected on antenatal ultrasound.

Etiology	Incidence (%)
Transient/physiologic	50–70
Ureteropelvic junction obstruction	10–30
Vesicoureteral reflux	10–40
Ureterovesical junction obstruction/megaureter	5–15
Multicystic dysplastic kidney disease	2–5
Posterior urethral valves	1–5
Ureterocele, ectopic ureter, duplex system, urethral atresia, Prune belly syndrome, polycystic kidney diseases, l cysts	Uncommon

Adapted from Nguyen et al. 2010 [16].

uniformity in the description of the sonographic findings and paucity of evidence on which to base clinical management, our goal is to develop a unified classification system with an accepted standard terminology for the diagnosis and management of prenatal and postnatal UT dilation.

Methods and conference preparations

Eight societies with a special interest in the diagnosis and management of fetuses and children with UT dilation (The American College of Radiology (ACR), the American Institute of Ultrasound in Medicine (AIUM), the American Society of Pediatric Nephrology (ASPN), the Society for Fetal Urology (SFU), the Society for Maternal-Fetal Medicine (SMFM), the Society for Pediatric Urology (SPU), the Society for Pediatric Radiology (SPR), and the Society of Radiologists in Ultrasound (SRU)) agreed to collaborate on the development of a unified grading system for perinatal UT dilation and propose a standardize scheme for follow-up evaluation.

The panel consisted of a director (HTN) and 12 panelists who each have specialized clinical and research experience with the perinatal diagnosis of UT dilation. The panel members were appointed by their respective societies and were representative of several medical disciplines including obstetrics (maternal fetal medicine, MFM), radiology, pediatric radiology, pediatric urology, and pediatric nephrology. Prior to the conference, specific aspects of prenatal and postnatal diagnosis of UT dilation were assigned to society representatives, based on his/her area of expertise. The current literature was reviewed and summarized for presentation (see References).

The consensus conference took place on March 14–15, 2014, in Linthicum, MD. An audience consisting of clinicians and researchers from the various specialties observed the proceedings in person or via webinar. The first day of the conference was devoted to presentations and discussion regarding the current classification systems for prenatal and postnatal UT dilation, correlation of prenatal US findings with postnatal outcomes, current recommendations for postnatal evaluation and follow-up, and long-term renal

outcomes in children with prenatal UT dilation. At the end of the first day, the panelists spent the evening drafting a consensus statement. The following day, this statement was presented to the audience and discussed until the entire group arrived at a consensus.

Background and summary of the literature

Correlation between prenatal and postnatal US findings and the ultimate urological diagnosis has been problematic, partly because of the lack of uniformity in defining and grading urinary tract (UT) dilation. Currently, there are several grading systems utilized. Some are descriptive (e.g. mild-moderate-severe [2]); others are quantitative (e.g. numeric value of the anterior-posterior renal pelvic diameter (APRPD) [3]) or semi-quantitative (e.g. SFU [4], European Society of Pediatric Radiology (ESPR), Uroradiology Task Force [5], and Onen grading system [6]). Certain grading systems are preferentially used in prenatal evaluation while others are preferred for postnatal evaluation. Based on a survey regarding prenatal diagnosis, MFM physicians overwhelmingly preferred using the APRPD, while pediatric urologists were equally divided between using the APRPD and the SFU grading system [7]. Pediatric radiologists were not included in the survey study results because most who were surveyed did not perform prenatal evaluation. For postnatal evaluation, pediatric radiologists preferred using the descriptive grading system, while urologists preferred using the quantitative (APRPD) or semi-quantitative (SFU) grading system [7]. Moreover, Swenson et al. (publication in progress) demonstrated that even when the same grading system was utilized, there was significant inter-rater variability as to which grade a specific sonographic image represented. All the current grading systems have less than ideal inter-observer reproducibility (kappa ranging from 0.2 to 0.6 [5,8,9]), and there are no defined correlations between grading systems.

A single grading system that can be used across the prenatal and postnatal time period to describe UT dilation would be beneficial to promote communication between different specialists. In the majority of the cases, oral communication or the report of the findings is not dependable. Although providing the actual US images would be optimal, non-imagers may not be familiar with interpreting gray-scale images, and, in practice, actual images are often not available. Developing a common grading system would allow for information transfer without the ambiguities of interpretation by different providers. Additionally, by having a consistent grading system utilized in both the prenatal and postnatal evaluation, more rigorous outcomes research could be performed to correlate the prenatal sonographic findings to specific consequences such as resolution of renal dilation, specific uropathies, risks for urinary tract infection, surgery, or renal dysfunction.

Prenatal imaging

In the United States, US evaluation is routinely performed during pregnancy with an average of two scans for low-risk

patients and four scans for high-risk patients [10]. National practice guidelines for obstetrical imaging include evaluation of the fetal kidneys and bladder as a required component of a complete survey [11]. The kidneys and bladder can be reliably seen on US by the end of the first trimester [12]. The incidence of detecting UT dilation prenatally after the first trimester is 1–2%, but is reported to be as high as 5% in some studies [13]. The majority of MFM specialists (91%) favor measuring the APRPD to characterize the severity of the renal dilation [7]. Several studies have evaluated the APRPD of the renal pelvis in normal fetuses as a function of gestational age to establish normative data [13,14]. The threshold used for diagnosing UT dilation based on APRPD typically varies depending on the gestational age of the fetus. The gestational age ranges used for various cut-off values were not consistent across studies, such that the number of gestational age groups and what cut-off values are applied to each group, is highly variable and erratic. The most common clinical practice is to use two gestational age groups, with the first typically starting in the second trimester (16–20 weeks) and the second in the third trimester (28–32 weeks). An APRPD of ≥ 4 mm is the most common threshold for diagnosing UT dilation in the earlier gestational age range, and ≥ 7 mm in the older age range [13,14].

Additional US findings that are important for defining the severity and clinical significance of the prenatal UT dilation include: laterality, extent of calyceal dilation, parenchymal abnormalities, bladder and ureteral abnormalities, gender, amniotic fluid volume (AFV), and other organ system abnormalities. Dilation of the calyces is an important predictor of clinically significant UT dilation [15]; consequently, some grading systems incorporate the degree of dilation of the calyces in characterizing the severity of UT dilation. Grignon et al. [3] proposed five grades of UT dilation that take into account the measurement of the APRPD, the degree of calyceal dilation, and parenchymal thickness. The SFU grading system [4] is composed of five grades that subjectively evaluate the dilation of the renal pelvis, distinguish between central (major) and peripheral (minor) calyceal dilation, and assess parenchymal thickness with different diagnostic criteria for second trimester and again for third trimester findings [16]. During the second trimester, the SFU system defined APRPD as mild for 4 to <7 mm, moderate 7 to ≤ 10 mm, and severe >10 mm. During the third trimester, mild is defined as APRPD of 7 to <9 mm, moderate as 9 to ≤ 15 mm, and severe as >15 mm.

Correlation with outcomes

Several studies have assessed outcome based on prenatal APRPD measurements, and most have found that the larger the APRPD, the more likely it is to be caused by obstructive uropathies [17–19], the greater the risk of requiring surgery postnatally [18,20–22], and the lower the spontaneous resolution rate [18,23]. However, it should be noted that these studies varied widely, applying different APRPD cut-offs, different gestational age ranges, and different outcome measures. Looking at the SFU grading system, a meta-analysis of the literature found that the severity of UT dilation based on the SFU criteria correlated with urological pathologies, except for vesicoureteral reflux (VUR)

[19,24]. Postnatal pathology (including VUR) was detected in only 12% of children with isolated second trimester UT dilation, but in 40% of those with dilation observed in both the second and third trimester [25]. Progressive UT dilation observed during pregnancy, rather than lack of progression or regression, is more often associated with uropathies [26]. In the diagnosis of lower urinary tract obstruction (such as from PUVs), oligohydramnios, renal cortical abnormalities, and early gestational age at diagnosis (e.g. <24 weeks) were found to be independent predictors of poor postnatal renal function [27].

Follow-up fetal imaging

In evaluating the need for follow-up US evaluation, it has been observed that prenatal UT dilation can resolve during pregnancy, remain stable, or may progress. The likelihood of resolution is related to the severity of the APRPD at initial diagnosis. Prenatal resolution occurred in approximately 80% of the cases when APRPD was between 4 and 7–8 mm during the second trimester [28–30], but less than 15% when APRPD was greater than 9 mm at that stage [28]. Consequently, follow-up US during the third trimester to assess interval change is usually recommended. For fetuses in which the UT dilation is mild (4–6 mm prior to 28 weeks gestation and 7–9 mm after 28 weeks onward), follow-up US during the third trimester detects those in which resolution has occurred and hence, those that do not require further prenatal or postnatal evaluation. In cases of moderate UT dilation (7–10 mm prior to 28 weeks and 10–15 mm 28 weeks onward) and severe cases (>10 mm prior to 28 weeks and >15 mm 28 weeks onward), US is warranted to evaluate for progression of UT dilation [16,28,30,31]. For the vast majority of cases, follow-up prenatal US evaluation is sufficient. In a few unique situations, prenatal MRI may provide additional information in diagnosis of UT dilation [32–34].

Fetal pyelectasis on mid-trimester US is associated with an increased risk of trisomy 21 [35–39]. The sonographic finding should prompt a targeted anatomic evaluation of the fetus, and as an isolated finding, carries a likelihood ratio of 1.5–1.6 for Down syndrome [36]. The finding of isolated fetal pyelectasis must be interpreted in the context of the *a priori* risk of trisomy 21 based on an accepted screening protocol. In addition, there are monogenic syndromes with congenital renal anomalies, some of which are associated with UT dilation [40].

Postnatal imaging

In current clinical practice, it is common that the prenatal US findings are not available to the physicians taking care of infants postnatally. Often, it is only mentioned that there is a history of prenatal kidney problems, without any additional details characterizing the extent and severity of the UT dilation. Postnatally, US is often the first imaging modality to evaluate these patients. In a recent survey of 284 pediatric radiologists with experience in interpreting postnatal US of UT dilation, 66% utilize the mild-moderate-severe grading system, while others routinely measure the APRPD or use the SFU grading system to characterize the

severity of the UT dilation (Swenson et al., publication accepted *Pediatric Radiology*) Based on intravenous pyelogram (IVP) [41] and magnetic resonance imaging (MRI) measurements (Swenson et al., publication accepted *Pediatric Radiology*), the normal APRPD in children is commonly considered to be 3 mm at 1 year of age and 6 mm at 18 years with the 99th percentile for children <5 years of age being <10 mm. It is important to recognize that these normative values are based on MRI, while most postnatal studies are performed with US. Furthermore, the distension of the urinary tract can be affected by the degree of bladder distension, hydration, and the position of the patient in which the US is performed. Furthermore, the accuracy of these measurements may be dependent on the US image resolution, the site of measurement, the technical skill of the sonographer, and the supervising physician.

It has been long recognized that the timing of the first postnatal US is important. Up to 48 h after birth, there is a tendency to underestimate the severity of hydronephrosis, in part because of dehydration [41,42]. It is generally recommended that the first postnatal US be delayed for at least 48 h after birth, except for cases of oligohydramnios, urethral obstruction, bilateral high-grade dilation, and concerns about patient compliance with postnatal evaluation [43]. Hydration can increase the size of a normal renal pelvis by increasing the volume of excreted fluid and also by affecting the bladder volume [44–48]. Consequently, it is recommended that in the presence of UT dilation, the patient should be rescanned after bladder emptying to accurately assess the severity of UT dilation. Patient position can also affect the accurate measurement of UT dilation, as in many cases the APRPD decreases when measured in the prone position [49]. As there are pros and cons to imaging the kidneys in either the prone or supine position, the current recommendation is that the same position be used in the same patient during each follow-up measurement to make for more accurate comparisons.

Multiple methods of grading UT dilation postnatally have been utilized. The descriptive grading system assesses the degree of renal pelvis dilation, calyceal dilation, and parenchymal thickness, categorizing variations as mild, moderate, or severe. This grading system was developed by correlating US with IVP grading [2]. The SFU grading system emphasizes the importance of intrarenal calyceal dilatation rather than the size of renal pelvis [4]. Consequently in this grading system, the APRPD is not measured. The intra-rater reliability is good and the inter-rater reliability is modest using this grading system [8,50]. A meta-analysis of the literature indicated that the SFU grading system is the most widely used with the best consistency (11/25 studies) [51]. In an attempt to improve further the accuracy of the grading system, ESPR proposed a modification of the SFU grading system in which APRPD was incorporated [5]. Onen proposed an alternative grading system in which Grade 1 represents pelvic dilation alone, Grade 2 with calyceal dilation, Grade 3 with less than 50% loss of the renal parenchyma, and Grade 4 with severe loss of renal parenchyma [6]. Compared with the SFU grading system, the Onen system has increased intra-rater reliability but decreased inter-rater reliability [9].

Alternative US parameters used to evaluate the severity of the UT dilation include pelvicalyceal area [52],

hydronephrosis index (parenchymal to pelvicalyceal area [53], calyx to parenchymal ratio [54], and pelvicalyceal volume using 3D US [55]. These methods are more complicated to perform and therefore less commonly used in routine clinical practice.

In addition to US, IVP and static MR urography (MRU) can provide additional information on morphology. Diuretic urosonography, radionuclide renography (NUC), and functional MR urography (MRU) can provide functional information. Diuretic urosonography is not widely used. The assessment of VUR can be performed by radionuclide cystography (RNC), voiding cystourethrography (VCUG), or contrast enhanced voiding urosonography (VUS).

Correlation with outcomes

Similar to APRPD measured on prenatal US, the APRPD measured on the first postnatal US correlates with the risk of uropathies [56]. Multivariate analysis demonstrated that the severity of renal pelvic dilation, ureteral dilation, parenchymal thinning, renal hyperechogenicity, and thickened bladder were independently predictive of uropathies. An APRPD >16 mm (sensitivity = 99.8%, specificity = 89.5%, and OR 106) has been correlated with the child undergoing pyeloplasty [21]. Recent studies have attempted to combine several grading systems to improve correlation with outcomes. Based on multivariate analysis, Longpre et al. observed that the larger initial APRPD and SFU Grade 4 both independently predicted lower likelihood of resolution [57].

Postnatal management

Follow-up US evaluation. An initial normal postnatal US may be misleading. Aksu et al. observed that 21–28% of children with prenatal UT dilation had a normal initial postnatal US [58]; 45% of these children with an initial normal first postnatal scan had an abnormal US at follow-up [58]. In another study, 5% of those requiring surgery for obstructive uropathies had a normal US at 1 week of age but an abnormal US at 1 month of age [26]. It has been reported that approximately 15% of children with prenatal UT dilation develop later worsening or recurrent hydronephrosis after an initial normal postnatal US [59]. Consequently, many advocate that, in children with prenatal UT dilation, a second postnatal US should be performed even if the first postnatal US is normal.

It is generally agreed that those with moderate and severe hydronephrosis (SFU Grade 3 and 4) require earlier and more frequent postnatal US evaluation than those with mild (SFU Grade 1 and 2) UT dilation [16]. In a meta-analysis, SFU Grade 2 resolved in 70% of the cases and SFU Grade 1 and 2 stabilized in 98% of the cases [51]. Sencan et al. observed in their study population of children with a history of prenatal UT dilation and mild (SFU Grade 1 and 2) hydronephrosis on the first postnatal US, that subsequent follow-up US demonstrated resolution of UT dilation in 67%, improvement in 13%, stabilization in 16%, and worsening in 3% [60].

Evaluation for vesicoureteral reflux. In children with a history of prenatal UT dilation, the incidence of reflux

ranges from 12% to 38% [24,56]. When UT dilation is observed on the postnatal US, approximately 40% of the children have VUR, compared with less than 5% when two postnatal US evaluations are normal [25]. Similarly, in children with SFU grade 1 and 2 (mild), the incidence of VUR was 3% [60]. Notably, VUR is the only uropathy in which the degree of UT dilation observed on the prenatal and postnatal US does not correlate with increasing risk of pathology. Moreover, there is poor correlation between VUR grade and severity of UT dilation [61–64]. Controversies remain over the management of VUR. This raises the question as to the utility of diagnostic evaluation for VUR in this population, but this was outside the scope of this consensus conference.

Functional imaging. It is generally recommended that children with mild hydronephrosis (SFU Grade 1 and 2) do not need any functional imaging studies such as nuclear renography. With moderate (SFU Grade 3), the risk for surgical intervention was greater in those with differential renal function (DRF) < 40% (33% vs. 3%) [65]. Most clinicians recommend that severe hydronephrosis (SFU Grade 4) be evaluated with functional studies.

Risk for UTI. Systematic review of the literature suggests benefit of selective use of prophylactic antibiotics in children with a prenatal diagnosis of UT dilation [66]. The incidence of UTI in children with SFU Grade 1–2 was approximately 5%, compared with 23% in those with SFU Grade 3–4 [60]. The risk of UTI with and without antibiotic prophylaxis in children with SFU Grade 1 and 2 or APRPD < 15 mm was similar (2.2% vs. 2.8%), but was significantly different in those with SFU Grade 3 and 4 or APRPD ≥ 15 mm (14.6% (95% CI: 9.3–22) vs. 28.9% (95% CI: 24.6–33.66), $p < 0.01$) [66]. The estimated number needed to treat to prevent one UTI in patients with SFU Grade 3 and 4 was seven. The risk for UTI is also significantly higher in those with ureteral dilation [67]. Several studies have suggested that circumcision appears to be an equally effective alternative to antibiotic prophylaxis in preventing UTI in children with UT dilation [66,68,69].

Long-term renal function. Many of the uropathies that manifest UT dilation prenatally (known collectively as the Congenital Abnormalities of the Kidney and Urinary Tract or CAKUT) have concomitant renal developmental anomalies. In fact, CAKUT is the most frequent cause of chronic kidney disease (CKD) and end stage renal disease (ESRD) in children [70]. How these uropathies affect long-term GFR is determined by: 1) the extent of renal developmental injury and its impact on nephrogenesis; 2) the integrity of the nephron mass that develops and its ability to maintain renal reserve in the face of normal glomerular obsolescence and any new insults that may adversely impact the reserve; and 3) the ability to decrease the tempo of loss of GFR over time by blunting any hyperfiltration injury that ensues from reduced renal reserve.

Nephron development begins early in fetal life and reaches completion by 35 weeks of gestation. With

morphologically normal kidneys, there are on average approximately 600 000–1,000,000 nephrons present at birth [71]. For most individuals, such a nephron endowment provides enough renal reserve to maintain renal function throughout life. Developmental or genetic abnormalities affecting nephron development or integrity, as well as acquired conditions or renal trauma or surgeries resulting in nephron loss, can lead to a reduced renal reserve with an ensuing increased risk of CKD or even ESRD. Children who are born with a reduced reserve, or who are left with a significantly reduced reserve early in life, are particularly at risk for manifesting renal functional abnormalities, as normal somatic growth places ever-increasing demands on their already compromised kidneys, in addition to the effect of hyperfiltration injury.

An individual's overall GFR reflects the sum of the filtration that occurs in all of that individual's functioning nephrons. As physiologically it is important to maintain GFR, a compensatory process termed hyperfiltration can occur when there is a reduced number of functioning nephrons. In hyperfiltration, the remaining nephrons try to maintain overall GFR by increasing their single nephron GFR, essentially increasing their filtration burden to take over for the absence or loss of normal nephron mass [72,73]. This process can accelerate normal obsolescence in these nephrons, leading to glomerular and tubular dysfunction and in many cases, the ultimate loss of enough overall function that effective GFR wanes.

As serum creatinine levels are maintained or even appear better than expected in the early phases of hyperfiltration, this process may initially present with what looks like a picture of functional renal adequacy. Over time, however, with ongoing nephron loss, there can be the development of proteinuria, hypertension, and renal insufficiency. In other words, although hyperfiltration may begin as a compensatory mechanism to maintain function in a variety of congenital or acquired conditions in which nephron mass is reduced, the accelerated glomerular obsolescence that ensues is often a final common pathway to advanced kidney disease.

In children with CAKUT, high grade obstructing lesions and diffuse anomalies in development such as hypoplasia and dysplasia are associated with earlier onset of CKD and progression to ESRD; however, any prenatally diagnosed CAKUT increases the risk of CKD substantially. In the general pediatric population, CKD is very rare, with a prevalence of about 75 cases/million children [74]. On the other hand, in children with any prenatally diagnosed CAKUT, up to 6% may manifest CKD by 10 years of age, an 800-fold increased risk over normal rates [75].

Minimizing new or ongoing insults to the kidney when there is already pre-existing CKD improves long-term renal survival and slows down progression to ESRD [76]. Importantly, recurrent UTI in children is associated with the risk of new renal scarring and accompanying nephron loss in children, from 10% with two UTIs to 60% after five UTIs [77]. In addition to addressing any necessary urologic issues such as obstruction or vesicoureteral reflux, medical management of associated sequelae of CKD may have significant implications for both renal survival and the child's overall long-term health. For example, in infants with prenatally diagnosed CAKUT, the incidence of hypertension increases

from <5% in children under 5 years of age to nearly 20% in older adolescents [75], and uncontrolled hypertension is certainly a co-factor for accelerating renal dysfunction. Along these same lines, high-grade proteinuria also portends poorer outcomes such as poorer blood pressure control [78].

The role of angiotensin blockade in dampening the progression of chronic kidney disease has been a focus of attention for many years, especially since the ready availability of angiotensin converting enzyme inhibitors or angiotensin receptor blockers. These therapies are well tolerated, making such intervention attractive to both clinicians and patients [79]. The beneficial role of angiotensin blockade in CKD is thought to stem not only from anti-hypertensive effect, but also by general renoprotection as a result of decreasing intraglomerular filtration pressure, proteinuria, and profibrogenic cytokines [80].

All of these factors are, in turn, thought to play a role in the development and progression of hyperfiltration injury and the loss of renal reserve in CAKUT and other clinical entities with CKD. There is indeed clinical evidence that in some populations angiotensin blockade can slow down the progression from hyperfiltration to albuminuria and can stabilize proteinuria once present [81].

Accordingly, angiotensin blockade serves at present as an important adjunctive therapy to blunt disease progression in children with CKD. As other therapies are developed to impede disease progression or even to induce disease regression, accurate risk stratification for children with abnormal renal development and abnormal urinary tracts will be of utmost importance to help determine potential efficacy.

Consensus discussion and statement

The goals of the Consensus Panel

The principal goals for the Consensus Panel were:

1. To propose a unified description of UT dilation that can be applied both prenatally and postnatally with consistent terminology. This grading system should be simple

but detailed enough to be meaningful for both clinical use and future research endeavors. It should also allow for communication of information between specialists who care for these patients, both as fetuses and children.

2. To propose a standardized scheme for the perinatal evaluation of these patients based on sonographic criteria; this is intended to be a starting point for observation and study and will likely require modification over time based on the accumulated evidence.

There are several important caveats that the Consensus Panel considered in developing the following recommendations. First, this grading system is not designed with the intent of developing a definitive final classification system for prenatal UT dilation. The proposed grading system is expected to be validated and/or modified with clinical experience and evidence-based research results. Second, it is based on the current available literature, which is inconsistent and limited. Third, the grading system is designed to be used in cases of isolated UT dilation and not to be applied to unique situations or anomalous kidneys such as solitary, ectopic, multicystic dysplastic kidneys (MCDK) or other cystic diseases of the kidney. Finally, while the grading system can be used for post-surgical evaluation, the proposed scheme for subsequent evaluation is not intended for application to patients who have undergone urinary tract surgery.

Recommendations

Recommendation #1: terminology

Because of the apparent confusion associated with the implied meanings of various terminologies for UT dilation, the Consensus Panel recommended avoiding the use of non-specific terms in describing UT dilation (e.g. hydronephrosis, pyelectasis, pelviectasis, uronephrosis, UT fullness or prominence, and pelvic fullness). The panel recommends the consistent use of the term "UT dilation." Further determination of the severity of UT dilation is characterized by specific sonographic findings, delineated by the UTD classification system below.

Table 2 US parameters included in the Urinary Tract Dilation Classification System.

US parameters	Measurement/findings	Note
Anterior-Posterior Renal Pelvic Diameter (APRPD)	(mm)	Measured on transverse image at the maximal diameter of intrarenal pelvis
Calyceal dilation	Central (major calyces) Peripheral (minor calyces)	Yes/No Yes/No
Parenchymal thickness	Normal/Abnormal	Subjective assessment
Parenchymal appearance	Normal/Abnormal	Evaluate echogenicity, corticomedullary differentiation, and for cortical cysts
Ureter	Normal/Abnormal	Dilation of ureter is considered abnormal; however, transient visualization of the ureter is considered normal postnatally
Bladder	Normal/Abnormal	Evaluate wall thickness, for the presence of ureterocele, and for a dilated posterior urethra

Table 3 Normal values for Urinary Tract Dilation Classification System.

Ultrasound findings	Time at presentation		
	16–27 weeks	≥28 weeks	Postnatal (>48 h)
Anterior-Posterior Renal Pelvis Diameter (APRPD)	<4 mm	<7 mm	<10 mm
Calyceal dilation			
Central	No	No	No
Peripheral	No	No	No
Parenchymal thickness	Normal	Normal	Normal
Parenchymal appearance	Normal	Normal	Normal
Ureter (s)	Normal	Normal	Normal
Bladder	Normal	Normal	Normal
Unexplained oligohydramnios	No	No	NA

Recommendation #2: consultation and communication of information

Communication of prenatal findings to physicians taking care of the infant postnatally is essential for clinical care as well as for future outcomes research. The sonographic findings should be described in accordance with the recommended grading system, and if feasible, representative images should be included with the final US report. The panel recommends that when it is feasible, the parents of fetuses with prenatal UT dilation and/or the eventual primary care provider should be provided with the actual US images. When this is not practical, the panel recommends providing the family and/or treating physician with the necessary US findings as delineated by the UTD classification system. When the prenatal findings are concerning enough for a potential need for surgical intervention or risk for renal compromise, the panel recommends that

consultation prior to delivery with a pediatric urologist and/or pediatric nephrologist be undertaken to help outline the care that the child may require postnatally.

Recommendation #3: classification system

The panel concluded that the following sonographic features are important factors in characterizing the severity of the UT dilation (Table 2). The ideal technique for APRPD measurement is based on images of the kidney obtained with the fetus or the child in an anterior-posterior plane. For optimal visualization of the fetal kidneys and measurement of the APRPD, the spine should be demonstrated at the 12 or 6 o'clock positions. In addition, the measurement should be taken at the maximal diameter of intrarenal pelvis dilation. In postnatal evaluation, imaging in the transverse plane at the hilum and in the prone position is encouraged, although consistency of position (prone or supine) at the time of measurement should take precedence in serial evaluations.

Additional sonographic features that should be evaluated include: 1) calyceal dilation, making a distinction between central and peripheral location (recognizing that this may be difficult to evaluate prenatally, especially before the third trimester); 2) parenchymal thickness (a subjective assessment); 3) parenchymal appearance with respect to echogenicity (subjectively determined by comparison with the adjacent liver or spleen), the presence or absence of cortical cysts and corticomedullary differentiation (the latter finding on postnatal imaging only); 4) ureteral dilation (transient visualization of the ureter is considered normal postnatally); 5) bladder abnormalities such as increased wall thickness, the presence of ureterocele or dilated posterior urethra; and 6) the presence of otherwise unexplained oligohydramnios on prenatal imaging. We acknowledge that ureteroceles are part of the ureter and not the bladder, but for simplicity we consider them as an abnormality in the bladder.

The threshold values for the diagnosis of UT dilation based on sonographic imaging are stratified based on gestational age at presentation (Table 3). The renal pelvis is considered not to be dilated (normal) when the APRPD



Figure 1 Ultrasound appearance of normal fetal kidneys at 32 weeks gestation. A: Imaging in the transverse plane demonstrates an anterior-posterior renal pelvis diameter (APRPD) measuring < 7 mm, which is within the normal range for this gestational age. The measurement is taken with the spine at the 12 o'clock position and the calipers are placed at the widest part of the intrarenal fluid collection. B: Imaging in the sagittal plan demonstrates normal appearing parenchyma and no peripheral calyceal dilation. This fetus has a normal appearing bladder (not shown) and the ureters are not visualized.

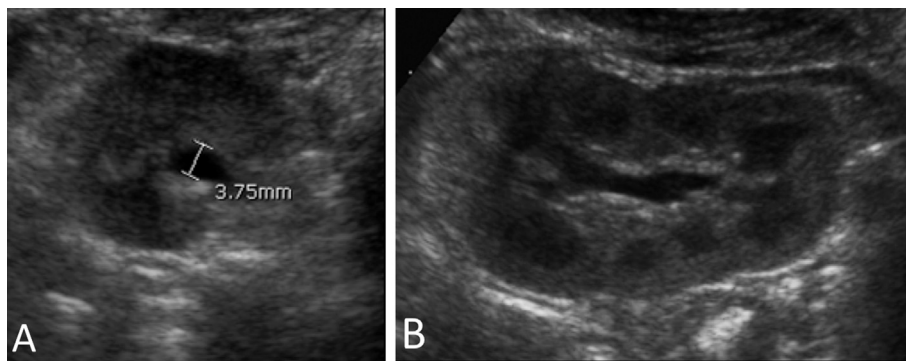
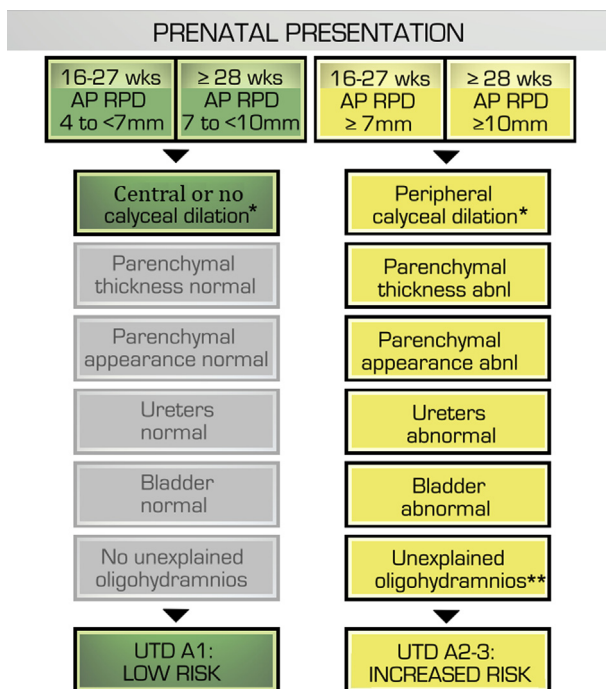


Figure 2 Appearance of normal kidneys on postnatal ultrasound. A: Imaging in the transverse plane demonstrates an anterior-posterior renal pelvis diameter (APRPD) < 10 mm, which is normal for age. Note that the APRPD is measured at the maximal diameter of intrarenal pelvis dilation rather than that of extrarenal pelvis dilation. B: Imaging in the sagittal plane demonstrates normal renal parenchyma without any calyceal dilation. The bladder is normal (not shown), and the ureters are not visualized.

measures <4 mm at <28 weeks gestation, <7 mm at ≥28 weeks (Fig. 1A and B), and <10 mm postnatally (Fig. 2A and B). In the normal fetus, calyceal dilation is absent, the renal parenchyma has normal thickness and appearance, the ureter is not seen, and the bladder is normal. Additionally, there is no unexplained oligohydramnios.



*Central and peripheral calyceal dilation may be difficult to evaluate early in gestation

**Oligohydramnios is suspected to result from a GU cause

Figure 3 Urinary Tract Dilation (UTD) Risk Stratification - Prenatal Presentation for UTD A1 (low risk) and UTD A2–3 (increased risk). Note: Classification is based on the presence of the most concerning feature. For example, a fetus with an anterior-posterior renal pelvis diameter (APRPD) within the UTD A1 range but with peripheral calyceal dilation would be classified as UTD A2–3 (as illustrated in Fig. 5C and D).

When the UT dilation is detected prenatally (denoted as A for antenatally), we suggest stratifying the findings into a low risk group (UTD A1) and an increased risk group (UTD A2–3) (Fig. 3). With UTD A1 the APRPD considered to be low risk for postnatal uropathies is 4 to <7 mm at <28 weeks (Fig. 4A and B), and 7 to <10 mm at ≥28 weeks (Fig. 4C and D). Fetuses in the low-risk category UTD A1 may also have central calyceal dilation but the presence of peripheral calyceal dilation is considered to increase risk. The renal parenchyma has normal thickness and appearance, the ureter is not seen, and the bladder is normal. There should not be unexplained oligohydramnios. Fetuses with UTD A2–3, are considered at increased risk for postnatal uropathy, based on an APRPD ≥7 mm at <28 weeks (Fig. 5A and B) and ≥10 mm at ≥28 weeks, or any one of the following findings: dilation of peripheral calyces (Fig. 5C and D); abnormal parenchymal thickness or appearance (Fig. 5E and F); visibly dilated ureter (Fig. 5G, H, and I); an abnormal bladder; or the presence of oligohydramnios suspected to be related to the urinary tract.

Initially, the panel intended to create low (A1), intermediate (A2), and high-risk (A3) groups to parallel the postnatal classification system, with the distinction between the intermediate and high-risk groups being dilation of the central versus the peripheral calyces. However, the panel noted that based on the literature and clinical experience, it was often difficult to distinguish between central and peripheral calyceal dilation on prenatal US. Consequently, the panel recommends combining the intermediate and high-risk groups to create one category of increased risk (A2–3).

When UT dilation is detected postnatally (denoted as P), we recommend stratification of risk into three groups: low risk (UTD P1); intermediate risk (UTD P2); and high-risk (UTD P3) groups (Fig. 6). With UTD P1, the APRPD considered to be low risk for postnatal uropathies is 10 to <15 mm (Fig. 7A and B). Again it should be emphasized that the first postnatal US should be done more than 48 h after birth to ensure it does not underestimate dilation, and be repeated once to ensure the appropriate management. In the low-risk group, central calyceal dilation may be present, but again, peripheral calyceal dilation is considered to increase

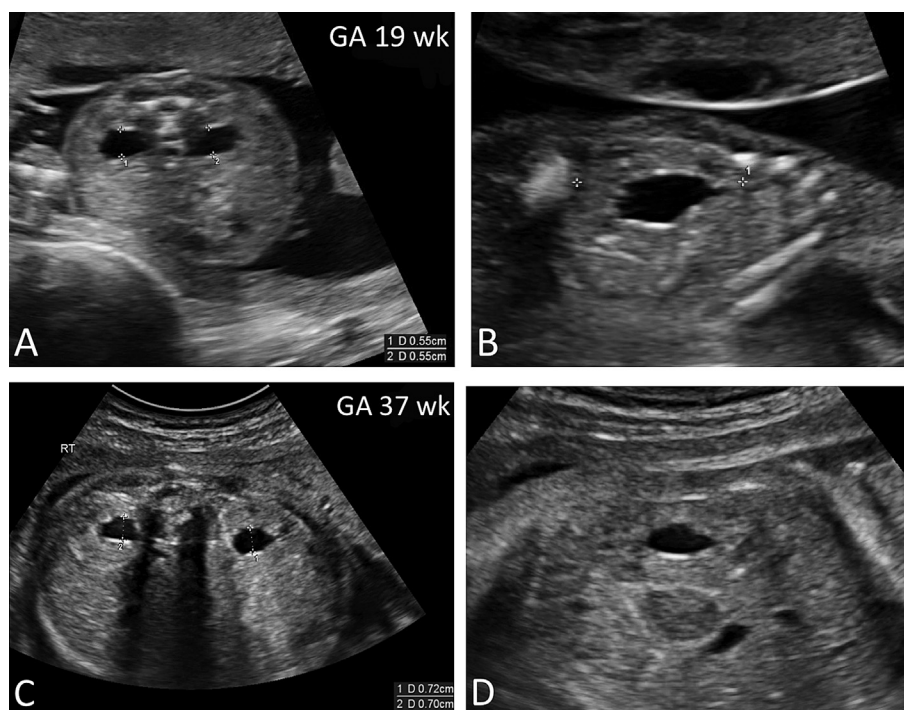


Figure 4 Ultrasound appearance of UTD A1. A and B: Fetal kidneys at 19 weeks gestation. A: Imaging in the transverse plane demonstrates an anterior-posterior renal pelvis diameter (APRPD) measuring less than 7 mm, which is within the UTD A1 range for this gestational age. B: Imaging in the sagittal plane demonstrates normal appearing parenchyma and no peripheral calyceal dilation. C and D: Fetal kidneys at 37 weeks gestation. C: Imaging the transverse plane demonstrates an APRPD measuring less than 10 mm, which is within the UTD A1 range for this gestational age. D: Imaging in the sagittal demonstrates normal appearing parenchyma and no peripheral calyceal dilation. In each case, the bladder is normal, and the ureters are not visualized (not illustrated).

risk. The renal parenchyma should have normal thickness and appearance, the ureter is not seen, and the bladder is normal. If there is central calyceal dilation but the APRPD is less than 10 mm, it is still considered UTD P1 (Fig. 7C and D). With UTD P2, which is considered to be intermediate risk for postnatal uropathies, the APRPD is ≥ 15 mm (Fig. 8A and B). The calyces may be dilated centrally and peripherally or a dilated ureter is visible. For this classification, the parenchymal thickness and appearance as well as the bladder are normal. Cases in which there is peripheral calyceal dilation but the APRPD is less than 15 mm are still classified as UTD P2 (Fig. 8C and D). Finally, with UTD P3, the sonographic findings for APRPD, calyceal dilation, and the ureter are the same as those in UTD P2. However, in UTD P3, the renal parenchyma is thinned, has increased echogenicity and/or has decreased corticomedullary differentiation, or the bladder is abnormal (wall thickening, ureterocele, posterior urethral dilation) (Fig. 9A and B). Cases in which there are parenchymal abnormalities but the APRPD is < 15 mm, are still classified as UTD P3.

Recommendation #4: proposed management scheme

Based on the suggested UTD classification system's risk stratification, the panel proposed a follow-up management scheme. For UTD A1 diagnosed before 32 weeks, a follow-up prenatal US is recommended at ≥ 32 weeks (Fig. 10). If the US at ≥ 32 weeks reveals resolution of the UT dilation

with normal renal parenchyma, bladder and ureters, no further prenatal or postnatal follow-up is necessary. If there is persistent UTD A1 or UTD A2–3 (Fig. 3), evaluation after birth is recommended. Postnatal evaluation should include two US evaluations: the first at > 48 h but less than 1 month after birth; and the second 1–6 months later. In fetuses considered at increased risk for postnatal uropathy (UTD A2–3), a follow-up prenatal US is recommended within 4–6 weeks of the initial diagnosis of UT dilation. Because of the variability of US findings on prenatal US in these cases, recommendations for subsequent interval assessment are at the discretion of the clinician. Prenatal consultation with a pediatric urologist and/or pediatric nephrologist is recommended in situations where there is substantial risk for surgery or renal dysfunction. After birth, a follow-up US is recommended at > 48 h of life but before 1 month. Follow-up should be performed sooner for obstructive uropathies, such as suspected PUV (as suggested by the finding of a thick-walled bladder with persistent dilation and a fusiform appearance and/or posterior urethral dilation on prenatal US) or for bilateral conditions.

For UTD P1, a follow-up US is recommended in 1–6 months (Fig. 11). As there is significant controversy regarding the clinical importance of diagnosing VUR and the effectiveness of prophylactic antibiotics, recommendations for evaluation with VCUG and the use of prophylactic

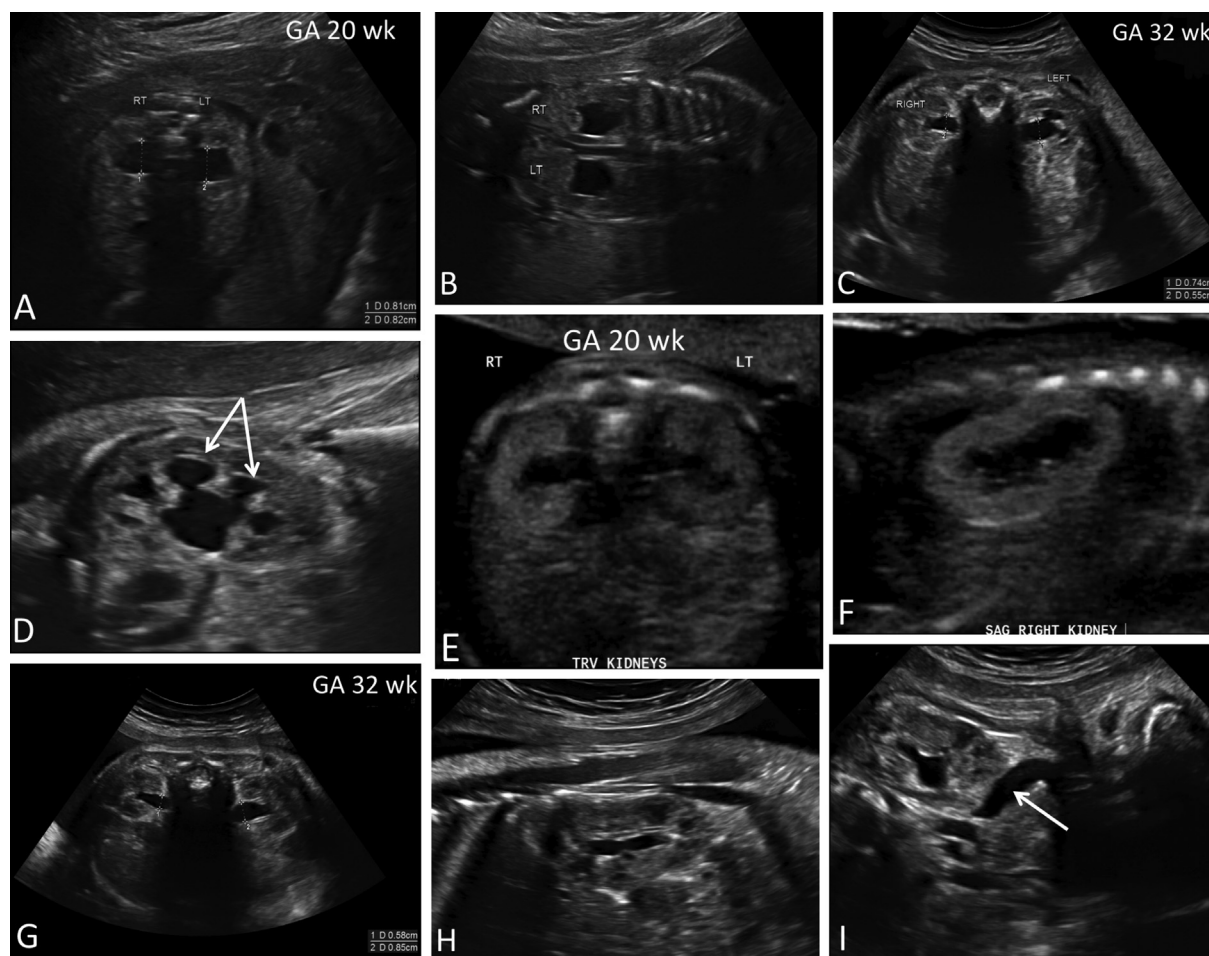


Figure 5 Ultrasound appearance of UTD A2–3. A and B: Fetal kidneys at 20 weeks gestation. A: Imaging in the transverse plane demonstrates an anterior-posterior renal pelvis diameter (APRPD) measuring greater than 7 mm, which is within the UTD A2–3 range for this gestational age. B: Imaging in the coronal plane demonstrates normal appearing parenchyma. C and D: Fetal kidneys at 32 weeks gestation. C: Imaging in the transverse plane demonstrates an APRPD measuring 7 mm, which is below the UTD A2–3 range for gestational age; however, note the presence of peripheral calyceal dilation. D: Imaging in the sagittal plane demonstrates normal appearing parenchyma but clear peripheral calyceal dilation leading to the classification as UTD A2–3. E and F: Fetal kidneys at 20 weeks gestation. E: Imaging in the transverse plane demonstrates fluid within the renal pelvis (not measured). F: Imaging in the sagittal plane demonstrates abnormal appearing parenchyma that is more echogenic than adjacent liver, prompting classification UTD A2–3. G, H, and I: Fetal kidneys at 32 weeks. G: Imaging in transverse plane demonstrates an APRPD of 8 mm, which is below the usual range for UTD A2–3 classification. H: Imaging in the sagittal plane demonstrates normal renal parenchyma and no calyceal dilation. I: However, imaging in the modified sagittal plane demonstrates a clear hypoechoic tubular structure that has peristalsis in real time, characteristic of a hydroureter. Consequently, the urinary tract classification in this case is UTD A2–3 based on the presence of a visualized ureter on prenatal US imaging.

antibiotics are left to the discretion of the clinician. For UTD P2, a follow-up US is recommended in 1–3 months. As with UTD 1, recommendations for evaluation with VCUG and the use of prophylactic antibiotics are left to the discretion of the clinician. There is significant variability in the practice of performing functional scans in children with SFU Grade 3. Consequently, recommendations for functional scans in patients with UTD P2 are left to the discretion of the clinician. For UTD P3, a follow-up US is recommended within 1 month. Evaluation with VCUG and the use of prophylactic antibiotics is recommended in this group, depending in part on the pathology suspected. As

with UTD P2, recommendation for functional scans in patients with UTD P3 is left to the discretion of the clinician.

Recommendation #5: modifiers of UTD classification system

Worsening findings on serial prenatal or postnatal US are associated with increased risk of genitourinary pathology. With regards to fetal gender, the panel feels there is insufficient evidence to suggest that the risk for postnatal uropathies is significantly different, the exception being the diagnosis of PUV in males. With regards to unilateral vs. bilateral UT dilation, there is insufficient evidence to

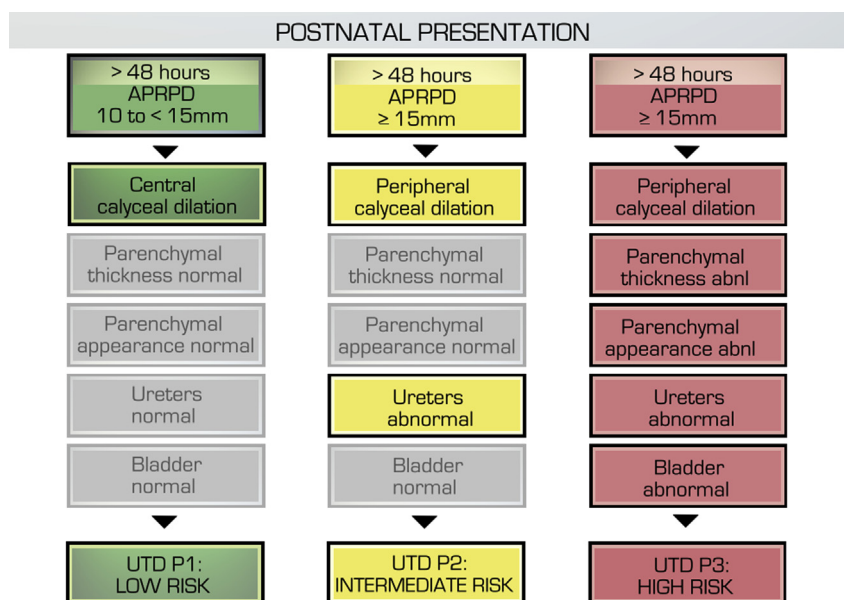


Figure 6 Urinary Tract Dilation (UTD) Risk Stratification – Postnatal Presentation for UTD P1 (low risk), UTD P2 (intermediate risk), and UTD P3 (high risk). Note: Stratification is based on the most concerning ultrasound finding. For example, if the anterior-posterior renal pelvis diameter (APRPD) is in the UTD P1 range, but there is peripheral calyceal dilation, the classification is UTD P2. Similarly, the presence of parenchymal abnormalities denotes UTD P3 classification, regardless of APRPD measurement.

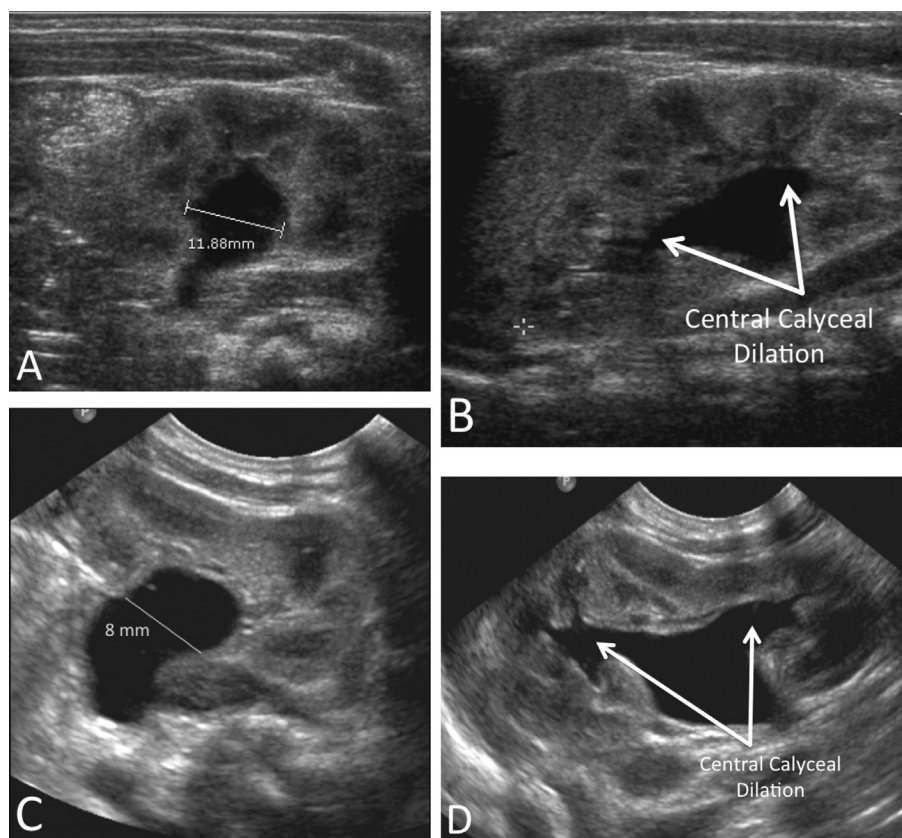


Figure 7 Appearance of UTD P1 on postnatal ultrasound. A: Imaging in the transverse plane demonstrates an anterior-posterior renal pelvis diameter (APRPD) 10 to <15 mm. B: Imaging in the sagittal plane demonstrates central but no peripheral calyceal dilation. The renal parenchyma is otherwise normal. The bladder is normal (not shown), and the ureters are not visualized. Another example of UTD P1 on postnatal US. C: Imaging in the transverse plane demonstrates an APRPD <10 mm. D: However, imaging in the sagittal plane demonstrates central calyceal dilation.

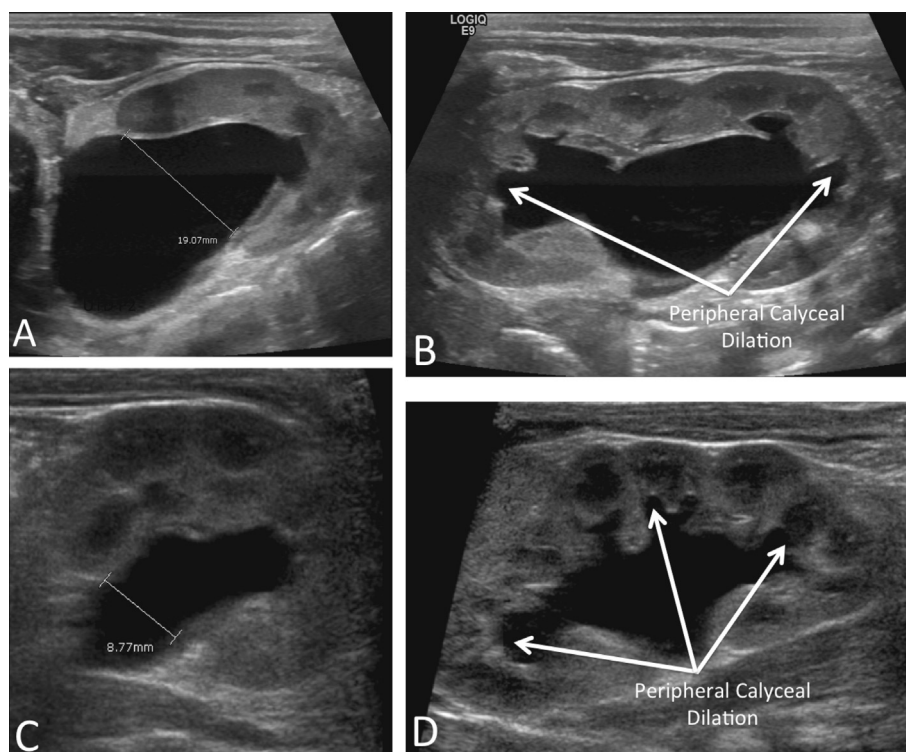


Figure 8 Appearance of UTD P2 on postnatal ultrasound. A: Imaging in the transverse plane demonstrates an anterior-posterior renal pelvis diameter (APRPD) ≥ 15 mm. B: Imaging in the sagittal plane demonstrates peripheral calyceal dilation but normal renal parenchymal thickness and appearance. In addition, there are no bladder abnormalities (not shown). Another example of UTD P2 on postnatal US. C: Imaging in the transverse plane demonstrates an APRPD < 10 mm. D: However, imaging in the sagittal plane demonstrates peripheral and central calyceal dilation.

suggest that the risks for postnatal uropathies are significantly different. The panel recommends that stratification of risk should be based on the grading of UT dilation in the most severely affected side.

Recommendation #6: reporting

When reporting UT dilation, the panel recommends that a description of the above seven imaging parameters (Table 3, Figs. 3 and 6) be reported in the written report. In the Impression section, the specific UTD category (Normal, UTD

A1, UTD A2–3, UTD P1, UTD P2, or UTD P3) should be reported along with the suggested management scheme. Ideally, representative images should be provided with the report.

Discussion

In this consensus statement, the panel integrated existing grading systems and recommendations and attempted to

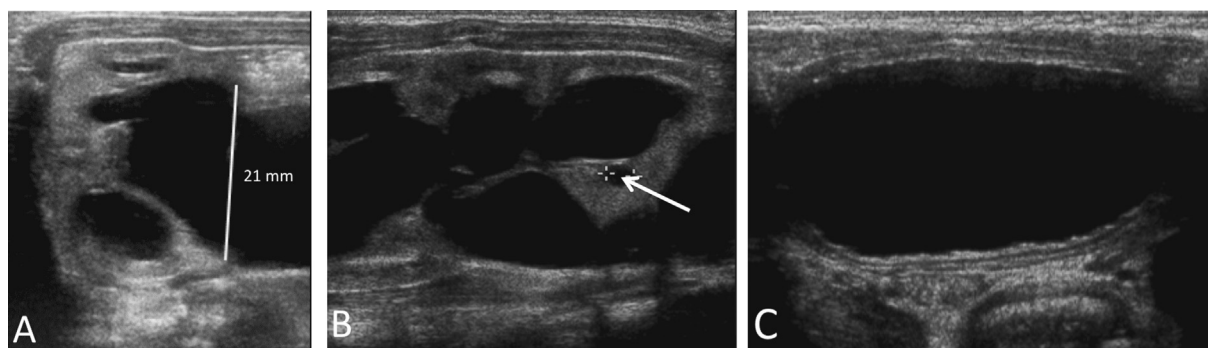
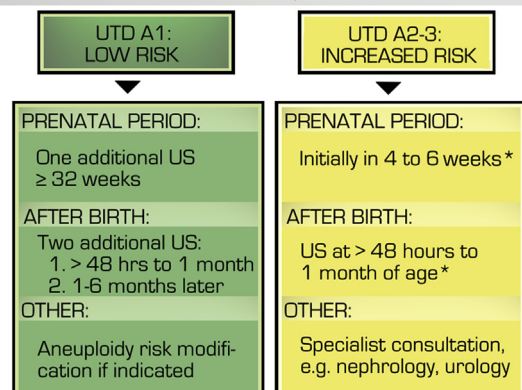


Figure 9 Appearance of UTD P3 on postnatal ultrasound. A: Imaging in the transverse plane demonstrates an anterior-posterior renal pelvis diameter (APRPD) ≥ 15 mm with peripheral calyceal dilation. B: Imaging in the sagittal plane demonstrates parenchymal thinning and cysts (arrow). C: Imaging of the bladder demonstrates increased wall thickness.

RISK-BASED MANAGEMENT, PRENATAL DIAGNOSIS



* certain situations (e.g. posterior urethral valves, bilateral severe hydronephrosis) may require more expedient follow up

Figure 10 Management schema based on UTD classification system's risk stratification of UTD A1 and UTD A2–3.

adapt them to current clinical care. The UTD classification system incorporates three broad categories of sonographic findings – degree of UT dilation, parenchymal quality, and associated anomalies. Specific aspects of the existing grading systems have been simplified and incorporated into a single unified system. Consequently, conversion from existing grading systems to the UTD classification system should be relatively uncomplicated. For example, SFU Grade 1–2 would be equivalent to UTD P1, SFU Grade 3 to UTD P2, and SFU Grade 4 to UTD P3.

In categorizing the severity of the UT dilation, the panel felt that it was appropriate to correlate the sonographic findings to postnatal urological pathology (not transient or physiologic hydronephrosis) because it was the most objective and best-characterized outcome identified in the literature. Further research will be needed to correlate the UTD classification system risk stratification to other specific clinical outcomes such as surgical intervention, renal function, urinary tract infection, and others.

In addition, the panel recognized that not all urinary tract dilation is associated with renal pelvic dilation as in some cases of primary megaureter or reflux where there is ureteral dilation, but there may be little to no pelvic or calyceal dilation. The classification system proposed is primarily for different degrees of renal pelvic dilation and is thus the main criteria for the UTD classification system with ureteral dilation as a modifier of renal pelvic dilation. The visualization of dilated ureter(s) categorizes the UT dilation as either UTD A2–3 or UTD P2, regardless of the APRPD measurements.

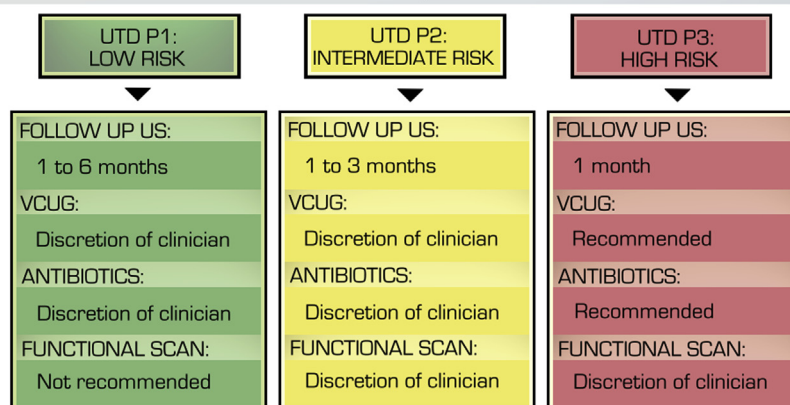
The panel recommendations are in agreement with the Executive Summary on Fetal Imaging by NICHD [82]. Specifically, an abnormal APRPD is defined as ≥ 4 mm in the second trimester and ≥ 7 mm at ≥ 32 wk. We concur with the Executive Summary that UT dilation is most often transient and carries an increased risk of Trisomy 21, warranting a detailed US and correlation with accepted aneuploidy-screening protocols. In addition, we agree that follow-up US evaluation should be performed at 32 weeks to rule out persistent UT dilation. If the APRPD is ≥ 7 mm at 32 weeks, we agree with the recommendation of postnatal radiological evaluation.

Future research directions

The Consensus Panel identified several important areas that require future research evaluation.

1. The proposed grading classification system will require extensive evaluation to assess its utility in predicting clinical outcomes. Currently, the grading system is correlated with the risk of postnatal uropathies. Future research will help to further refine the classification system to one that correlates with other clinical outcomes such as the need for surgical intervention or renal function.
2. The seven sonographic parameters utilized in the UTD classification system were selected based on the current

RISK-BASED MANAGEMENT, POSTNATAL DIAGNOSIS



The choice to utilize prophylactic antibiotics or recommend voiding cystourethrogram will depend on the suspected underlying pathology

Figure 11 Management schema based on Urinary Tract Dilation (UTD) classification system risk stratification of UTD P1, UTD P2, and UTD P3.

literature. Further research may help to identify other US findings that may be more predictive of uropathies and clinical outcomes.

3. While it is beyond the scope of this consensus statement, the panel identified that the issue of UTI and the evaluation of VUR in children with prenatal UT dilation is controversial. Prospective studies in this area are needed to define the role of prophylactic antibiotic or circumcision and the clinical significance of identifying VUR in this patient population.

Conflict of interest

None.

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None.

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Commentary to 'Multidisciplinary consensus on the classification of prenatal and postnatal urinary tract dilation (UTD classification system)'



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Appropriate management of neonatal urinary tract dilation is a challenge to clinicians in various medical specialties. One initial obstacle to good care, or even to high-quality clinical evidence to guide care, is the lack of a widely accepted method of categorizing this problem. The development of standardized classification criteria for chronic kidney disease [1] and acute kidney injury [2,3] has allowed for large-scale studies [4,5] that have greatly advanced our understanding of these diseases. Currently, many classification schemes exist for neonatal urinary tract dilation, none of which are widely accepted by all medical specialties involved in the care of patients with this condition.

A new classification and management strategy for neonatal urinary tract dilation is proposed in this issue of the *Journal of Pediatric Urology*. It represents a multidisciplinary consensus among radiologists, urologists, maternal-fetal medicine practitioners, and nephrologists. This has great appeal. It allows for all clinicians caring for

neonates with urinary tract dilation to have a common language for communication. Representatives from all interested parties participated in the development of this document. There are explicit criteria for classification that are clear and (for the most part) objective. There are a small number of categories for classification, which lends itself to outcomes-oriented research as well as to communication with patients.

While this consensus statement is useful, it does not resolve all the obstacles to excellent care of patients with neonatal urinary tract dilation. It will be meaningful only if its classification system is widely adopted. As the authors acknowledge, management recommendations are vague. This reflects both the lack of conclusive evidence to guide management and the wide variability in current clinical practice. As with any guideline, there will be isolated clinical situations where application will not be appropriate.

Summary, UTD Grading Scale Postnatal US

Stephen Foster

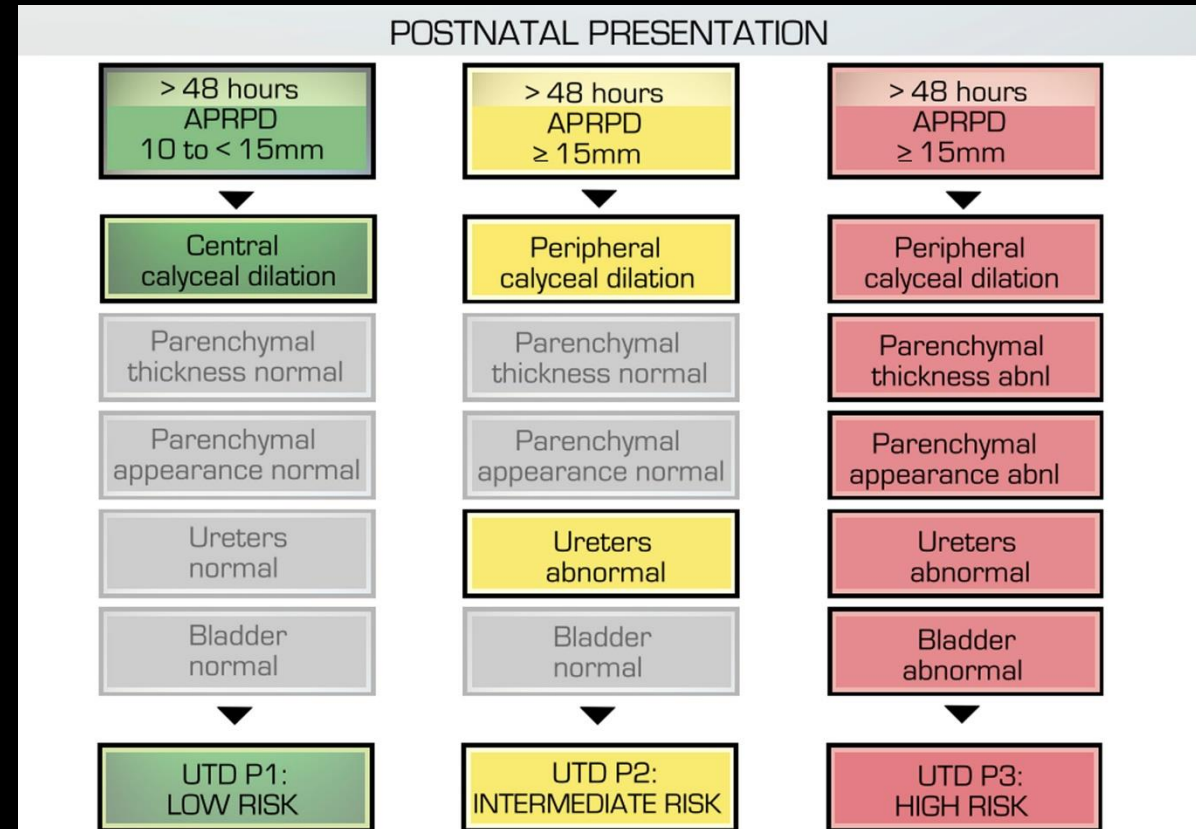
- The Urinary Tract Dilation (UTD) scale came about as an attempt to improve inter-observer variability when classifying Pediatric hydronephrosis
- It was released as a consensus statement in the Journal of Pediatric Urology in 2014 [https://www.jpurology.com/article/S1477-5131\(14\)00310-6/abstract#articleInformation](https://www.jpurology.com/article/S1477-5131(14)00310-6/abstract#articleInformation)
- It is now in general use in the Pediatrics community. They will know what you mean if you use the scale in an impression.
- There is pre-natal and post-natal. I will concentrate on Post-Natal here as OB has reclaimed the prenatal.
- All images are shamelessly stolen from the article referenced above under fair use for education rules. Plus I assume this is staying here in house.

Criteria

- AP diameter of renal pelvis. Measured on transverse images, at the level of the parenchymal margin
- Central calyceal dilation
- Peripheral Calyceal dilation
- Ureter normal or dilated
- Parenchymal thinning +/-
- Parenchymal echotexture abnormal
- Appearance of the bladder

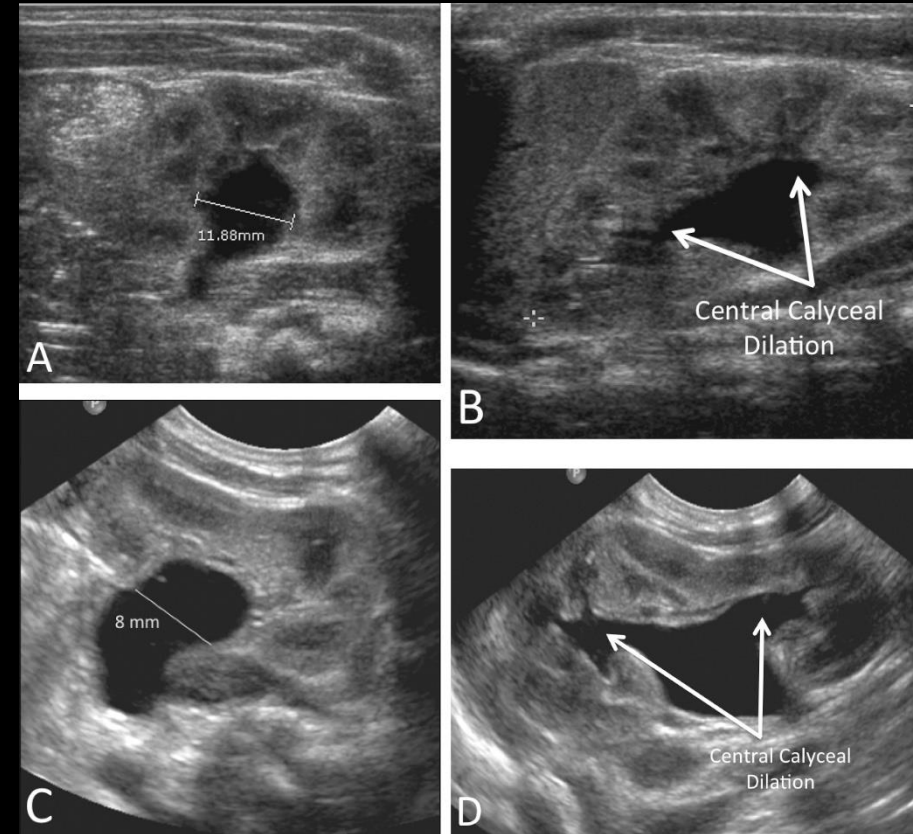
Whatever single item is the WORST will bump the scale to that level

- Central calyceal dilation with loss of corticomedullary differentiation = UTD P3



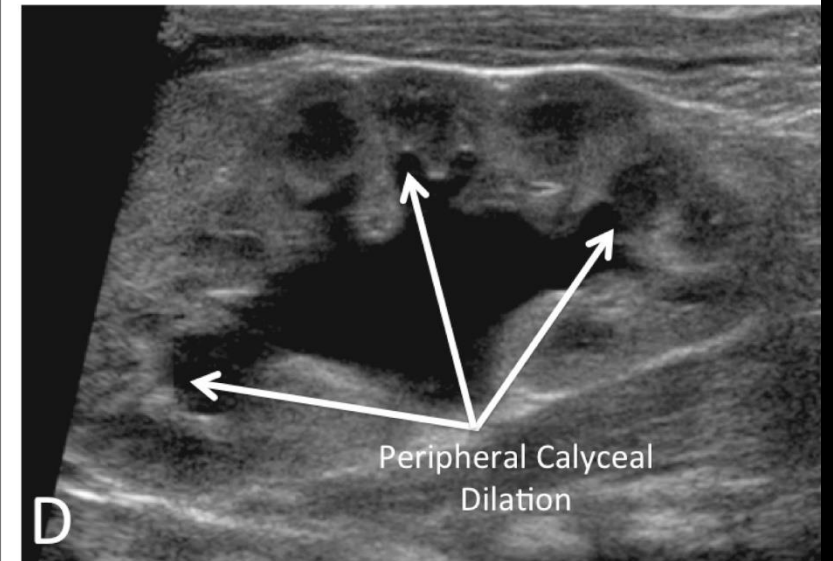
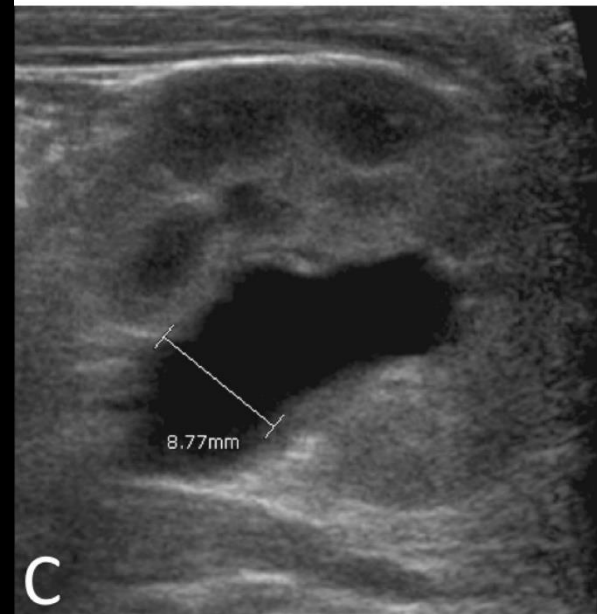
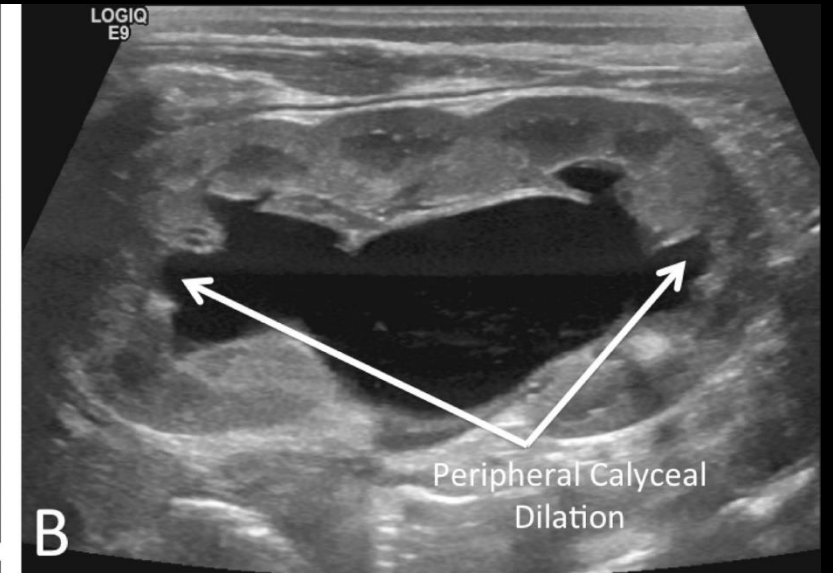
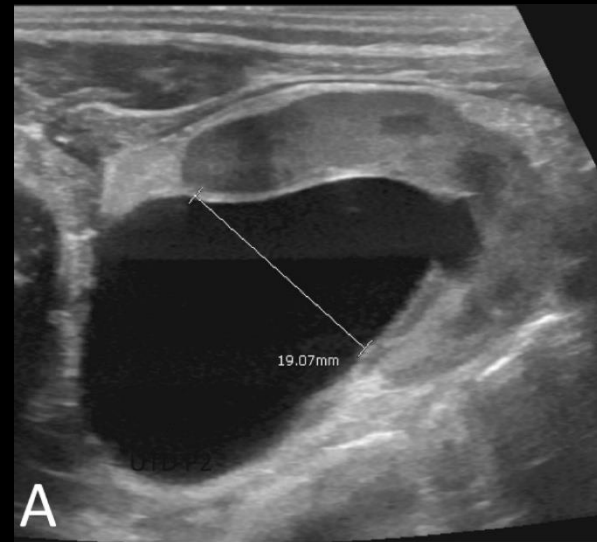
What's dilated?

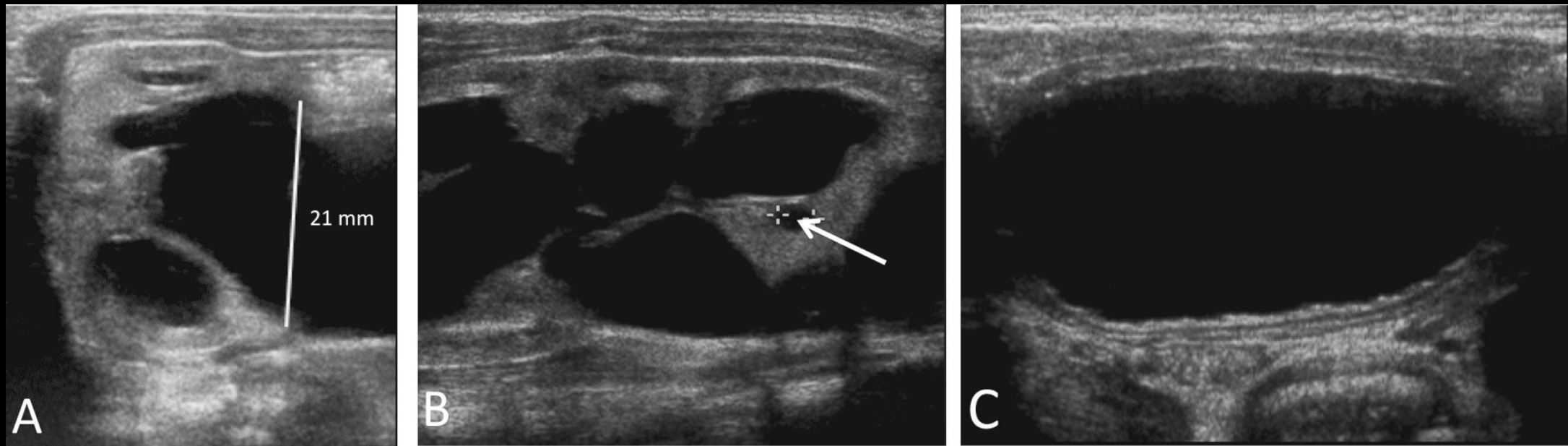
- Everyone is entitled to some minimal splitting of the renal pelvis (urine has to go somewhere)
- Central calyces as shown in B and D
- Location of measurement for the AP diameter of pelvis is pretty good in C. Not so great in A, and these are the images from the article
- Pelvis diameter IMO is the least reproducible and by far the least useful criteria. One can easily have a rather large pelvis and no central collecting system dilation (I call these normal), or a 4mm pelvis and completely blown out center.
- However, because it's a number, people will ask for it and persevere on it. I gave up fighting it, but just know it's not that helpful.



What's Dilated?

- B and D now show peripheral dilation
- Notice the difference between A and C for pelvis diameter. These kidneys end up the same UTD grade
- Given the wide range of variability in central collecting system dilation with visibility of the minor/peripheral calyces, people do use intermediate grades, i.e. UTD 1-2, or UTD 2-3 for a little more flexibility. I do it and have never had push back, though the original article does not specify this.
- An argument could be made that there is cortical thinning in B here.
- I would call D a UTD P2, and B a UTD 2-3 based on these single images.

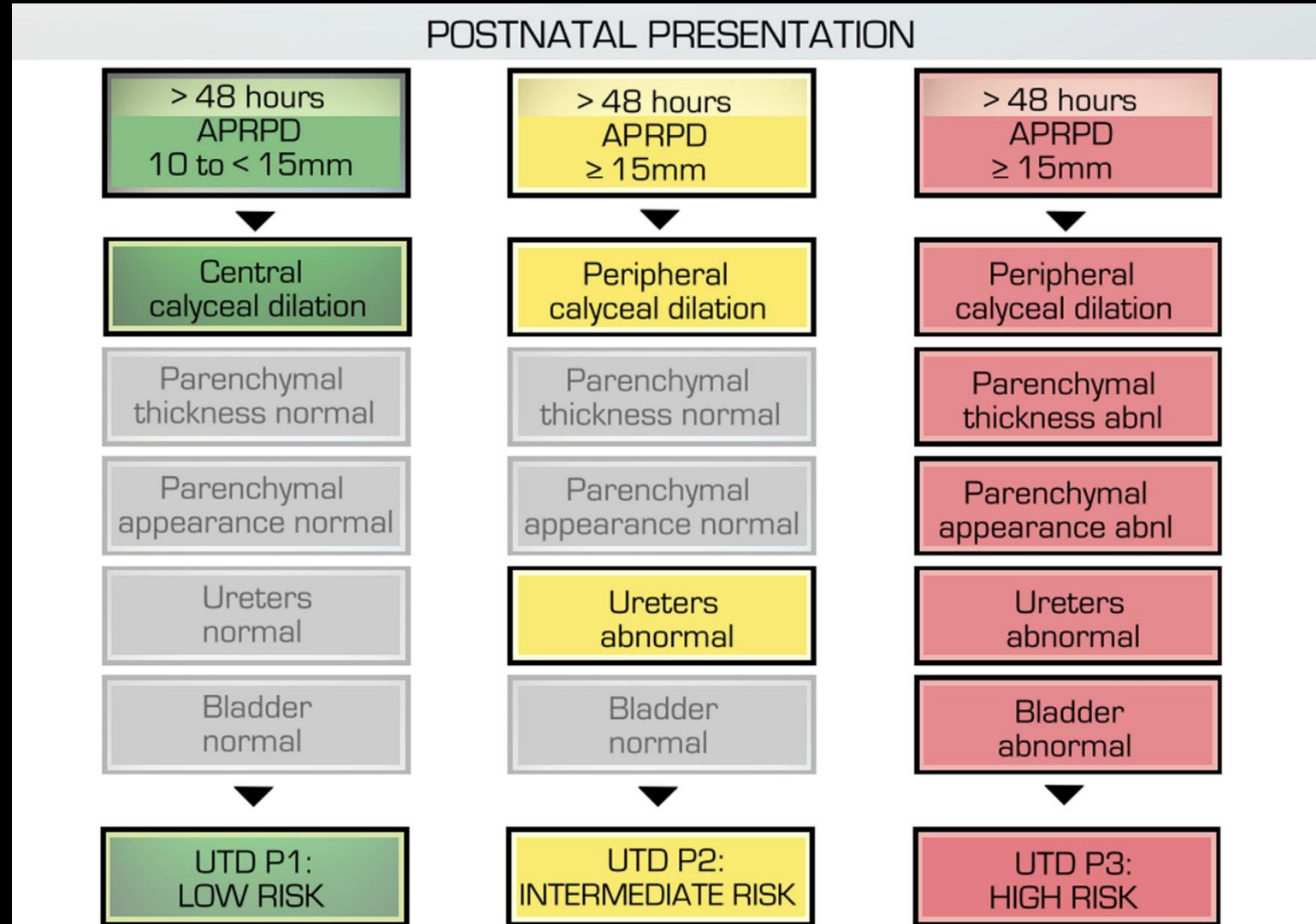




- In this case, we have parenchymal thinning and cystic change
- Gross dilation of the peripheral/minor calyces
- Dilation of the proximal ureter
- Abnormal bladder trabeculation
- Any 1 of these would elevate the case to a UTD P3

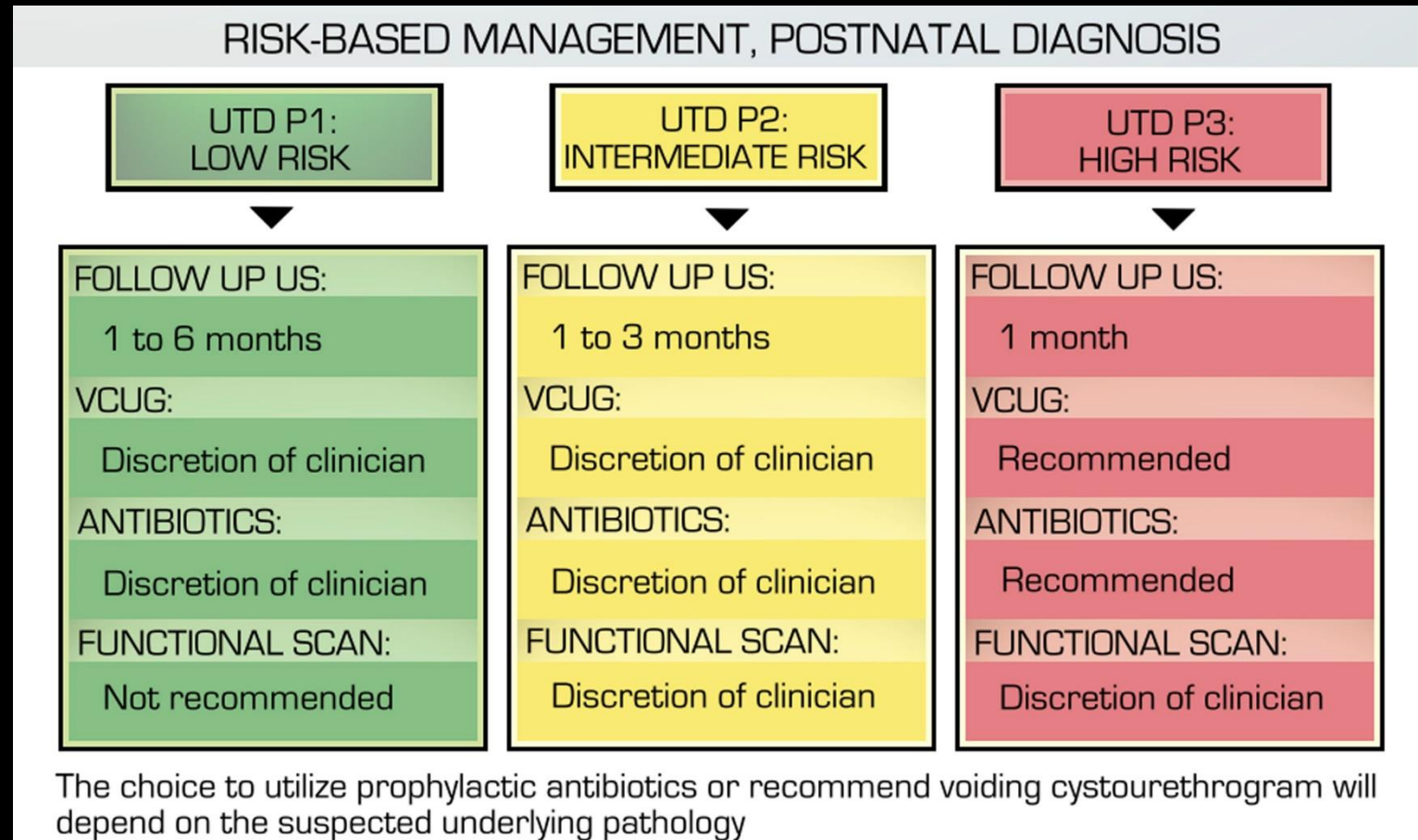
UTD Grading Helps drive management

- The world changing (for Peds Rads) article in the Journal Pediatrics in 2011, allowing clinicians to NOT do a VCUG on females with first UTIs, made my life and the lives of innumerable little girls better.
- But, now that everyone didn't get a full work up, how do we know who does?
- The UTD scale drives next steps, so it is very helpful for the Pediatricians if we use it widely.



Management

- UTD scaling via Ultrasound determines risk level, in conjunction with clinical information such as UTI number, male vs female, etc.
- Like most scales and clinical decision making, I rarely mention these recommendations specifically in a report. Definitely not for urology, possibly for the busy APRN with the 6 minute office visits.
- If I am calling an initial 2 or 3, I do recommend Pediatric Urology consultation be considered.
- In the end, this system isn't perfect and does leave some room for inter-observer variability. But, it is better than "mild, moderate, severe"



Thanks for Helping out the Little Ones



Dept. Procedure Title	Testicular Imaging Procedure - Ultrasound - Radiology	Procedure ID	11472
Keywords	us, ultrasound, testicle, testicular		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for Sonographers and Sonologists performing Testicular Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all Sonographers and Sonologists within the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Standard Images for Interpretation

- Obtain representative images documenting each testicle separately
 - Longitudinal view of the head of epididymis and upper portion of testicle.
 - A minimum of 3 longitudinal views documenting the lateral, midline, and medial aspects of each testicle.
 - Longitudinal right and left epididymis.
 - Longitudinal tail of epididymis and lower portion of the testicle.
 - Transverse inferior to include epididymal tail.
 - Transverse lower, mid and upper portion of the testicle.
 - Transverse head of epididymis.
- Perform 3 measurements to estimate the testicular volume.
- Obtain appropriate measurements of any suspicious lesions.
- Transverse, grey scale, and color Doppler of both testicles on the same image to compare echogenicity and color Doppler blood flow.
- Color Doppler of the epididymal head and upper portion of each testicle for blood flow comparison relative to the testicle.
- Obtain (3) equally spaced color Doppler images of each testicle.

7. In the clinical setting of suspected torsion, obtain color and spectral Doppler waveforms of each testicle.
8. Perform Color Doppler and grey scale imaging of the spermatic cord structures with and without valsalva to document presence or absence of varicocele. A varicocele is a change in the internal spermatic vein > 3 mm.
9. If an isolated right sided varicocele is identified a limited bilateral renal ultrasound (uretrolim) exam is required. Perform representative longitudinal and transverse imaging and measurements to document the kidneys and the renal hilum to exclude a mass.
10. Evaluate the inguinal canals bilaterally for presence or absence of hernia.

VI. References N/A

Responsible Owner:	Ultrasound	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine; Nystrom, Heidi	Version #	3
Current Approval Date:	11/22/2021	Old Document ID:	
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Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Thyroid Imaging Procedure - Ultrasound - Radiology	Procedure ID	11473
Keywords	thyroid, imaging		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographers and sonologists performing thyroid Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

1. Place patient in supine position with neck slightly hyperextended. If necessary, place a rolled up towel or pillow under the patient's neck.
2. Obtain representative images documenting the following:
 - i. Perform longitudinal and transverse images of both thyroid lobes including transverse images of the isthmus.
 - ii. Measure the size of the thyroid in 3 dimensions.
 - iii. Document and measure any abnormalities within the thyroid as well as adjacent structures (lymph nodes).
 - iv. Once the representative longitudinal and transverse images have been obtained, use the split screen functionality on the scanner to measure and number the two (2) largest nodules in each lobe so that measurements can be easily compared with prior and subsequent studies.
3. Perform color Doppler imaging to evaluate for vascularity in the thyroid and within any thyroid nodule.
4. In the presence of thyroidectomy, or if a thyroid nodule 1 centimeter (cm) or greater in size is seen, evaluate the cervical lymphatic chain, both anterior and posterior to sternocleidomastoid muscle, in longitudinal and transverse, to exclude enlarged lymph nodes.
5. Record, and number the two (2) largest lymph nodes seen on each side using the split screen function.
6. Measure each lymph node in its longest dimension with the AP diameter also recorded on that image.
7. Evaluate each lymph node with Color Doppler.
8. TiRads criteria will assigned to the structured report template by the attending Radiologist.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Patrick, Michael	Version #	5
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Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Transplant Kidney Imaging Procedure - Ultrasound - Radiology	Procedure ID	11474
Keywords	us, ultrasound, kidney, transplant		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for Sonographers and Sonologists performing transplant kidney Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all Sonographers and Sonologists within the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

1. Obtain longitudinal measurements (minimum of 2) of the maximum transplant kidney length.
2. Obtain labeled transverse images through upper, mid, and lower poles.
3. Assess for peri-renal fluid collections (urinomas, lymphoceles, etc.).
4. Assess for collecting system dilatation.
5. Obtain longitudinal and transverse images of the urinary bladder.
6. Color/Power images of the transplant kidney (adjust color scale and gain to visualize slow/venous flow).
7. Obtain and label representative spectral Doppler tracings (2 per section) of intra-renal vessels at the cortico-medullary junction at the upper, mid, and lower renal poles.
 - a. Enter resistive index (RI) measurements into structured reporting package
8. Obtain color and spectral Doppler tracing (2 per section, mid and proximal to the anastomosis) of the main renal artery (MRA) and main renal vein (MRV).
 - a. Enter the peak systolic velocity (PSV), end diastolic velocity (EDV) and resistive index (RI) measurements into structured reporting package.

VI. References N/A

Responsible Owner:	Ultrasound	Contact(s):	Dennis Seguin
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Related Policies & Procedures:			
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Trophon Guidelines

1. Non latex gloves and eye goggles will be used when a transducer is placed into and taken out of the Trophon unit. Purple nitrile gloves are not required for this activity.
2. The Sonex-HL cartridge must be changed in an area with immediate access to a plumbed eye wash station. Eye goggles and gloves will be worn when the SonoEX- HL cartridge is replaced. Recap the empty bottle of Sonex-HL before discarding in the trash.
3. The transducer will be wiped at the point of use to remove any excess gel from the transducer. Once completed, it will then be wiped with "grey top" Sani Wipe AF3 product (dwell 3 minutes). Any remaining AF3 product will be wiped with a lint free cloth (institution standard) prior to starting the Trophon disinfection cycle.
4. Plastic bags are not required over the 'cleaned' transducer once it is removed from the Trophon unit. The clean transducer must be stored in the dust free cabinet located in each exam room.
5. One (1) label will be generated from the Trophon printer and this will be attached to the transducer connector (specific location) prior to the transducer being placed into the dust free cabinet
6. Transducers used for all endocavitary exams are assigned a number based upon the DH asset ID #. Documentation of the transducer(s) used can be found within the Ultrasound report/EPIC imaging tab. All exams performed after normal business hours will also be documented in the same manner. Should an infection be discovered, the transducer used for the specific study can be easily identified.
7. Plastic bags will only be used for the following activities
 - Transport of a transducer(s) outside the department to an offsite clinic.
 - The 'transducer' will be placed in a plastic bag and into a dust cover bag, sealed, and placed into a rigid clean container for transport. Double bagging will reduce the chance of cross contamination (ie; cord touching the clean transducer tip)
 - Clean transducers returned back to the department will be placed into the dust free cabinet.
8. Exterior and interior cleaning of the Trophon unit will be performed weekly and documented in the Ultrasound 'I' drive for review as needed.
9. Each Trophon unit permanently stores 100,000 disinfection cycles. The data from the disinfection cycles from each unit (5) will be exported via encrypted USB devices every 6 months and stored electronically in the Ultrasound 'I' drive for CSR & TJC review as necessary.
10. The exported document(s) will include the DH asset ID# for ease of identification because the units are mobile. The export frequency will be will reviewed by CSR and changes made as needed.

Departmental Procedure Title	Trophon2 High Level Disinfection (HLD) Procedure - Ultrasound - Radiology	ID	26678
Keywords	Trophon, High, Level, Disinfection, HLD, Probe, CI		
Department	Radiology - Ultrasound		

I. Purpose

To safely and effectively perform igh level disinfection (HLD) of semi-critical items that touch mucous membranes or non-intact skin in accordance with the manufacturer's recommendations (IFU).

II. Procedure Scope

This applies to all ultrasound transducers utilized at Dartmouth-Hitchcock, Lebanon.

III. Definitions N/A

IV. Equipment

- trophon®2 high level disinfection (HLD) device
- Non-latex gloves
- Disinfecting wipes

V. Procedure

Transducer validation must be performed before any transducer is processed by trophon®2.

A complete list can be found at: <https://www.nanosonics.us/products/trophon-epr>

- Non-latex gloves must be worn during the cleaning process to protect against exposure to infectious agents and cross-contamination.
- Remove the protective cover from the transducer and wipe residual gel off the transducer with a clean dry towel.
- Pre-clean the transducer with a hospital approved low level disinfection (LLD) wipe and dried BEFORE the High Level Disinfection process can commence.
- Scan the medical instrument tag against the Acutrace reader.
- Load the clean, dry probe into the trophon®2 disinfection chamber ensuring that the probe is straight and not touching the walls or the bottom and that the tip of the probe is above the embossed line.
- Place a chemical indicator red side up at the base of the chamber door. A chemical indicator (CI) must be used for each disinfection cycle and can only be used once.
- Close the chamber door.
- The next screen message will confirm: *Is the probe clean and dry?*
- Respond YES if the probe has been pre-cleaned and dried.
- If NO, follow the trophon2 touch screen prompts.
- Scan your operator card.

- Press Start Disinfection on the touch screen to begin disinfection cycle.
- At the end of the 7-minute HLD cycle, the blue status bar at the top of the trophon2's touch screen states: Disinfection Finished.
- Perform proper hand hygiene and put on a new set of gloves before opening the chamber door and removing the probe.
- Open chamber door, verify the chemical indicator (CI) pass status using the color assessment chart on the chemical indicator packaging (**Note:** must be lighter than the MEC-orange on the fail-side of the color assessment chart) and then discard into the nearest trash receptacle.
 - **Important:** Both CI and trophon2 touch screen must indicate a successful cycle for the probe to be ready for use. If either the CI or trophon2 touch screen indicates a fail, the cycle **MUST** be repeated.
- Select chemical indicator result on the touch screen and then scan your operator card to confirm.
- Remove the probe after the cycle is complete. Wipe the probe with a dry, clean, single-use, lint-free cloth.
- Visually inspect the probe and remove any disinfectant residue.
- Store clean probe with the HLD label attached (on connector) and place in the Ultrasound probe storage cabinet.
- The Acutrace information recorded on the trophon2 printer label:
 - Date and time
 - Trophon serial number
 - Cycle number
 - Disinfectant lot number and expiration date
 - Chemical Indicator lot number and expiration date
 - Operator names
 - Trophon cycle status (pass or fail)
 - chemical indicator status (pass or fail)
 - Probe identification (including transducer number)

Chemical Indicators

- Chemical indicators should be stored at room temperature 59-86°F.
- Store in a dry, clean environment out of direct heat.
- Do not store near chemicals such as sterilizing agents, acids, bases, bleaches, and other disinfectants.

SONEX-HL Cartridge Storage

- Cartridge should be stored at temperatures between 59-77°F.
- Store cartridge in all original packaging in correct directional orientation until use.
- Keep away from excessive heat.

Removing and Installing the Disinfectant Cartridge

- The device will automatically prompt you to run a purge cycle if the cartridge has been in the device too long and has expired (30 days). Follow prompts on the LCD screen.
- Screen message will say: ***Replace the cartridge and close cartridge door.***
- Cartridge door opens automatically. Do **NOT** use excessive force to pull down the cartridge door.
- Wearing non-latex gloves and in a designated eye wash station location, lift the cartridge out by touching the areas exposed while the bottle is in the holder and avoid touching pierced areas.

- Recap the empty cartridge and dispose in the nearest waste receptacle.
- Verify the expiration date before inserting a new SONEX-HL cartridge.
- Once the cartridge is in place, close the cartridge door and the device is ready for use.

Contingency Plans

- USB encrypted device will be used to download trophon2 data (cleaning cycles, solution and chemical indicator expiration) every 6 months.
- An Excel document displaying all recorded data will be kept locally and sent to CSR as requested.
- **trophon2 service:**
 - 1-800-437-1171 option 1, option 1, option 5.
- Acceptable alternatives to the trophon2 process are as follows:
 - Temporarily suspend or postpone procedures.
 - Transport all transducers to Central Sterilization (CSR) for High Level Disinfection (HLD) processing
- Annual competencies (training video) will be completed by each staff member who uses the trophon2.
- Training certificate will be printed by the employee to verify successful completion of training course.
- A copy of the training certificate will be kept in the employee file

VI. References

User Manual & Transducer compatibility list

<https://www.nanosonics.us/products/trophon-epr>

Nanosonics / Trophon training website

<https://nanosonicsacademy.com/>

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Ultrasound Transducer & Exam Room Guidelines

Required tasks that should be performed following an Ultrasound exam:

All transabdominal transducers:

- Wipe the transducer with a “grey topped” Sani Cloth AF3 towelette (found in all rooms) before any imaging study is begun prior to patient contact.
- After the study is completed, the transabdominal transducer should be wiped with a clean towel to remove any residual contact gel.
- All transducers should be securely seated into the transducer holders on the unit. ****Transducers should never be left hanging on the unit****

All transvaginal transducers:

- Remove the protector cover and discard it. Using a clean towel, wipe off all the residual gel. Place the transducer in a “plastic dust cover bag”, seal the bag & attach a red biohazard sticker (found in the cabinet drawers).
- **Effective 12/10/21**, Take the transducer to the cubicle (behind to Dennis’ office) and place it in a labeled “dirty” box for decontamination processing during business hours.

Transducer labeling on all endocavitary/transvaginal exams:

- Indicate the transducer number as the first image for ALL endocavitary/transvaginal exams. This workflow is required for tracking the transducer should a future contamination be identified. The transducer number can be found on the transducer connector.
- When dictating, via the Power Scribe template(s) for both TV and Viability exams,
****please indicate the transducer number in the appropriate field under technique**.**

Housekeeping:

- The stretcher should be placed against the wall and set to the lowest position.
- Empty gel bottles should be discarded. All others should be returned to the warmer and the lid closed
- Ultrasound unit should be powered off when the study has been completed.
- All lights should be shut off, the exam door closed & locked upon leaving the Ultrasound section.

Dept. Procedure Title:	Ultrasound Abdomen Limited Right Upper Quadrant (RUQ) Imaging Procedure - Radiology	Procedure ID:	10713
Keywords	RUQ, right, upper, quadrant, us, ultrasound, abdomen, hepatology protocol		
Department:	Ultrasound		

I. Purpose

To describe the procedures for performing limited abdominal ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Abdomen Limited Right Upper Quadrant (RUQ) Imaging

1. Liver

- i. Perform longitudinal and transverse views to assess the liver parenchyma for focal or diffuse abnormalities.
- ii. Compare the liver echogenicity to that of the right kidney.
- iii. Obtain images to include hepatic lobes (right, left, and caudate), inferior vena cava (IVC) and right hemidiaphragm.
- iv. Perform measurement of the liver length in a sagittal plane at the level of the right kidney (anterior axillary line).

2. Gallbladder and biliary system

- i. Obtain longitudinal and transverse images of the gallbladder in the supine and decubitus positions.
- ii. Measure the gallbladder wall.
- iii. Assess for a sonographic “Murphy’s sign.
- iv. Evaluate for the presence or absence of intrahepatic and extrahepatic bile duct dilatation.
- v. Obtain measurement of the bile duct preferably over the right hepatic artery in the portal hepatitis.
 - Additional imaging in the upright position may be helpful in finding small stones in the gallbladder neck.

3. Pancreas

- i. Perform transverse and sagittal images of the pancreas to include head, body, and tail.
- ii. Evaluate and measure the pancreatic duct and the distal common bile duct in the region of the pancreatic if dilated.

4. Right Kidney

- i. Obtain representative images in the longitudinal and transverse planes of the right kidney.
 - o Longitudinal images should document lateral and medial margins of the kidney.
- ii. Include transverse views of upper, mid, and lower poles.
- iii. Perform maximum measurements (minimum of 2) of renal length.
- iv. Compare renal echogenicity to that of the liver.
- v. Use a color Doppler to exclude mild hydronephrosis vs. hilar vessels.

B. Abdomen Limited Right Upper Quadrant - RUQ Hepatology Imaging Protocol

- o **(Imaging of the spleen may also be requested. Check order for clarification)**

1. Liver

- i. Perform longitudinal and transverse views to assess the liver parenchyma for focal or diffuse abnormalities.
- ii. Compare the liver echogenicity to that of the right kidney.
- iii. Obtain images to include hepatic lobes (right, left, and caudate), inferior vena cava (IVC) and right hemidiaphragm.
- iv. Perform measurement of the liver length in a sagittal plane at the level of the right kidney (anterior axillary line).

2. Gallbladder and biliary system

- i. Obtain longitudinal and transverse images of the gallbladder in the supine and decubitus positions.
- ii. Measure the gallbladder wall.
- iii. Assess for a sonographic “Murphy’s sign.
- iv. Evaluate for the presence or absence of intrahepatic and extrahepatic bile duct dilatation.
- v. Obtain measurement of the bile duct preferably over the right hepatic artery in the portal hepatitis.
 - o Additional imaging in the upright position may be helpful in finding small stones in the gallbladder neck.

3. Spleen

(Imaging may be requested. Check order for clarification)

- i. Obtain representative images of the spleen in the longitudinal and transverse planes.
- ii. Perform longitudinal and transverse measurements of the spleen.
- iii. Compare the splenic echogenicity to that of the left kidney.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
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Related Polices & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Adult Native Kidney Imaging Procedure - Ultrasound - Radiology	Procedure ID	11182
Keywords	adult, native, kidney, sonographers, sonologists, interpretation, images, imaging, us, ultrasound, studies		
Department	Ultrasound		

I. Purpose of Procedure

To describe procedures for performing native kidney Ultrasound studies.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

The following standard images are required for interpretation.

1. Obtain representative images in the longitudinal and transverse planes of both kidneys.
2. Document lateral and medial margins of the kidneys for longitudinal images.
3. Include labeled images of upper, mid, and lower poles for transverse views of both kidneys.
4. Include the maximum measurements (minimum of 2) of renal length of both kidneys.
5. Compare renal echogenicity to that of the liver or spleen.
6. Obtain longitudinal and transverse images of the urinary bladder.
7. Utilize the Color Doppler to document urinary jets when hydronephrosis is present.
8. When there is a clinical suspicion of pyelonephritis, record color or Power Doppler images.
9. Use Color Doppler to exclude mild hydronephrosis versus hilar vessels when the gray scale images are equivocal.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
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Related Policies & Procedures:	Native and Transplant Kidney Biopsy Imaging Procedure - Ultrasound - Radiology		
Related Job Aids:			

Procedure Title	Airborne Precautions Procedure	Procedure ID	7417
Keywords	airborne, precautions, chickenpox, varicella, zoster, herpes, tuberculosis, tb, measles, PAPR, N95, checklist		

I. Purpose of Procedure

The purpose of this procedure is to standardize the process to safely place and maintain patients on Airborne Precautions.

II. Procedure Scope

All providers, staff, students, and volunteers at Dartmouth-Hitchcock.

III. Definitions

Airborne Precautions are used for diseases spread through aerosolizing tiny respiratory particles into the air, that remain suspended for long periods of time. Examples include tuberculosis (TB), disseminated herpes zoster (DHZ), chickenpox, and measles.

IV. Equipment

- Negative pressure room
- N95 respirator
- Powered air purifying respirator (PAPR) unit
- Half face elastomeric respirator
- Eye Protection (face shield, goggles, safety glasses)
- Level II masks
- Yellow precaution gowns
- Respiratory Isolation Cart (RIC)
- Airborne Precautions sign
- Contact Precautions sign
- Portable high efficiency particulate (HEPA) filter

V. Procedure

A. For Inpatient and Outpatient Areas When a Patient Requires Airborne Precautions

1. Obtain a respiratory isolation cart (RIC) from Inventory and Logistics (Stores) by calling 5-6101.
2. Store the cart outside the room, or in the anteroom.
3. Verify cart is plugged in to the nearest outlet at all times.
4. Post the specific isolation precautions sign on the door to the patient room:
 - a. Tuberculosis (TB) or measles: Airborne Precautions
 - b. DHZ or chickenpox: Airborne **and** Contact Precautions
 - c. Novel respiratory illnesses: Airborne **and** Contact Precautions

5. Patient is to be cared for in a negative pressure room.
 - a. If the patient is in an area that lacks a negative pressure room, a portable HEPA filter must be ordered by calling Engineering at 5-7150 or pager 9234.
 - b. Keep the door closed at all times; for negative pressure rooms with an anteroom both doors are to remain closed at all times.
6. Before the patient arrives in the room:
 - a. For areas with a negative pressure room, ensure the room is negative pressure and that the pressure monitor is functioning.
 - i. The pressure monitor must read -0.01 or less at all times (this means that the room is negative).
 - ii. Ensure the monitor alarm is on and test the monitor alarm. When working correctly, the monitor will alarm if the door to the room is left open. If you are unsure of the process for testing the monitor alarm, or if the monitor alarm is not functioning, please contact Engineering at 5-7150 (M-F 0800 -1600) or pager 9234.
 - b. In areas lacking a negative pressure room, the HEPA filter must be placed in the room and turned on prior to the patient's arrival.
7. Review staff respirator fit test records (available from Environmental, Health and Safety) to ensure anyone entering the room has been fit tested and trained within the last year.

The following table is used to guide the set up and proper use of the room:

	TB	DHZ, Chickenpox	Measles	Novel Respiratory Illnesses
Room type	Negative Pressure	Negative Pressure	Negative Pressure	Negative Pressure
Room setup	Remove any unnecessary equipment and supplies	Remove any unnecessary equipment and supplies	Remove any unnecessary equipment and supplies	Remove any unnecessary equipment and supplies
Respiratory protection	N95 respirator or PAPR (motor and hood)	No respiratory protection indicated for IMMUNE staff.	N95 respirator or PAPR (motor and hood)	N95 respirator OR half face elastomeric respirator OR PAPR
Eye/Face Protection	Disposable face shield or goggles (safety glasses not adequate)	Disposable face shield or goggles (safety glasses not adequate)	Disposable face shield or goggles (safety glasses not adequate)	Disposable face shield or goggles (safety glasses not adequate)
Gowns	Follow Standard Precautions	For contact with the patient or environment	Follow Standard Precautions	For contact with the patient or environment
Gloves	Follow Standard Precautions	For contact with the patient or environment	Follow Standard Precautions	For contact with the patient or environment

Trash/linen	Routine practices	Routine practices	Routine practices	Routine practices
Equipment	Discard or decontaminate prior to reuse	Discard or decontaminate prior to reuse	Discard or decontaminate prior to reuse	Discard or decontaminate prior to reuse
Visitors	Wear a level II mask but explain that it does not offer complete protection.	Wear a level II mask, but explain that it does not offer complete protection; gown and gloves not indicated	Wear a level II mask but explain that it does not offer complete protection.	Visitors are prohibited.

B. For Patients on Airborne Precautions Admitted to an Inpatient Unit

1. Follow steps in section A above.
2. Notify the following departments when the patient is placed on Airborne Precautions:
 - a. House Supervisor at pager 9732
 - b. Collaborative Healthcare-associated Infection Prevention Program (CHIP) at pager 8447 or email washyourhands@hitchcock.org
 - c. D-H Safety Office at 5-7233 or email safety@hitchcock.org
 - d. Nurse Manager or RN Unit Supervisor
2. Educate patient and/or family members on the use of Airborne Precautions and document education in patient chart.
3. Place an order in eD-H for the appropriate isolation. Nursing may place the order per protocol.
4. Patients may only leave the room for medically necessary procedures that cannot be performed in the room.
 - a. When scheduling patients for tests or procedures, notify the receiving area of the need for Airborne Precautions.
5. Patients MUST wear a level II mask when leaving the room. Patients DO NOT wear an N95 or PAPR when leaving the room.
6. Review the “Resuscitation of Patients on Airborne Precautions” procedure online.
7. For daily cleaning of the room, PPE is to be worn (as above).
8. After using the PAPR hood and motor, wipe the outside of each unit (motor and hood) with PDI Super Sani-Cloths.
 - a. Clean the inside of the face shield part of the hood with an alcohol wipe.
 - i. There may be special cleaning procedures in conjunction with central sterile reprocessing should the situation warrant such cleaning.
9. Go to the D-H Intranet to view a video refresher for proper donning, doffing, and disposal of PPE.

C. For Patients Requiring Airborne Precautions in the Clinic Area

1. Follow steps in section A above.
2. On the day of the appointment, give the reception staff the name and medical record number of the patient requiring Airborne Precautions.
3. Instruct the reception staff to carry out steps 4 and 5 below.
4. When the patient arrives, they must don a level II or higher mask covering the mouth and nose.
5. Room the patient immediately. These patients must not sit in the waiting area.

D. For Patients Requiring Airborne Precautions in Procedural Areas (non-OR)

1. Follow the steps in section A above.
2. Patients must don Level II mask covering the mouth and nose during transport. Patients DO NOT wear an N95 or PAPR when leaving the room.
3. Room patient immediately. Patients must not wait or recover in open areas (e.g. PACU, Same Day, waiting rooms)

E. Discharging or Transferring Patients From Inpatient and Outpatient Areas

1. After the patient is discharged or transferred, the room is to remain on negative airflow or the HEPA filter must remain on in the room with the door or doors closed for 60 minutes, unless room-specific time has been calculated by measured air changes. Signage remains on the door.
2. After that time, respiratory protection is no longer necessary, but all other PPE required for room cleaning is to be used.
3. Contact Environmental Services for terminal room cleaning.
4. Follow Environmental Services policies for terminal cleaning of Airborne Precaution and/or Contact Precaution rooms (linked below) and remove signage after room cleaning is complete.

F. Management of non-negative pressure rooms that a patient requiring Airborne Precautions has been discharged from (clinic, procedural (non-OR) inpatient areas)

1. After the patient has left the room, ensure the door to the room stays closed for 60 minutes in inpatient and 90 minutes in clinic areas unless room specific time has been calculated by measured air changes. Signage remains on the door.
 - a. Ensure the proper expanded precautions signage remains on the door until a terminal clean has been completed.
2. After that time, respiratory protection is no longer necessary, but all other PPE required for room cleaning is to be used.
3. Contact Environmental Services for terminal room cleaning. Clinic spaces may perform normal room cleaning practices for patients on precautions.

Note: Staff who believe they have had an unprotected exposure to a patient on Airborne Precautions are to report the exposure via the Occurrence with Learning (OWLs) system AND contact CHIP (Infection Prevention) at pager 8447 or washyourhands@hitchcock.org. Infection Prevention staff and Occupational Medicine work together to determine the type of exposure and the employee is informed if any further follow up or testing is needed.

VI. References N/A

Responsible Owner:	CHIP	Contact(s):	Caitlin Adams Barker washyourhands@hitchcock.org
Approved By:	Office of Policy Support - All Other Documents; Mercado, Jose; Michel, Melanie	Version #	5
Current Approval Date:	06/25/2021	Old Document ID:	INFC.0017
Date Procedure to go into Effect:	06/25/2021		
Related Polices & Procedures:	Standard and Expanded Precautions Policy Chickenpox and Shingles Management Procedure Resuscitation of Patients on Airborne Precautions Procedure Cleaning Powered Air Purifying Respirator (PAPR) Motor		

Printed copies are for reference ONLY. Please refer to the electronic copy for the latest version.

Reference ID #7417, Version #5

Approval Date: 06/25/2021

Related Job Aids:	Precautions for Specific Diseases and Conditions - Job Aid Airborne Precaution Room Cleaning Procedure - Environmental Services Airborne Precautions Sign Job Aid Contact Precautions Sign Job Aid Contact Precaution Discharge Patient Room Cleaning Procedure - Environmental Services Contact Precaution Occupied Patient Room Cleaning Procedure- Environmental Services
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Dept. Procedure Title	Abdominal Aorta Imaging Procedure - Ultrasound - Radiology	Procedure ID	11183
Keywords	interpret, interpretation, sonographers, sinologist, us, ultrasound, abdominal, aorta		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for performing abdominal aorta ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all Sonographers and Sonologists within the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Specific Scheduling Orders

- Screening evaluation of the Aorta should be ordered as IMG3585 (AAA screening).
- Follow up for a known aortic aneurysm or signs & symptoms should be ordered as IMG3502 (retroperitoneum limited).

B. Standard Images Required for Interpretation

- Obtain representative longitudinal and transverse images of the entire abdominal aorta to the bifurcation.
- Record a minimum of three levels (proximal, mid, distal) longitudinal AP and transverse measurements.
- Report the longitudinal (AP) and transverse (Trans) measurements only into the structured reporting package.
- Obtain the AP measurement from the longitudinal image.
- Obtain longitudinal and transverse images and measurements of the proximal common iliac arteries.
- Obtain color Doppler images of the abdominal aorta and proximal common iliac arteries documenting thrombus if present.
- Screening evaluation and/or assessment for known aneurysm require the same standard images.

VI. References N/A

Responsible Owner:	Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Connell, Chandler; Kvinlaug, Christine	Version #	3
Current Approval Date:	12/02/2021	Old Document ID:	
Date Procedure to go into Effect:	12/02/2021		
Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Appendix Imaging Procedure - Ultrasound - Radiology	Procedure ID	17876
Keywords	appendix, imaging		
Department	Radiology, Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographers and sonologists performing appendix specific Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This applies to all sonographers and sonologists with the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

- Using a linear high frequency transducer **and graded compression**, obtain static images of the right lower quadrant with particular attention to the site of patient's maximum discomfort.
- Attempt to identify the appendix as a blind ending tubular structure documenting any of the following features that may indicate appendicitis:
 - Appendix diameter greater than 6 mm (occasionally normal up to 8 mm).
 - Appendix wall thickness 3 mm or greater.
 - Non compressible
 - Appendicolith often with an acoustic shadow
 - Increased periappendiceal echogenicity suggesting inflammation
 - Increased appendiceal mural color flow suggesting hyperemia
 - Free or localized fluid in the RLQ
- Obtain cine through any area of question

VI. References N/A

Responsible Owner:	Department of Radiology	Contact:	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine	Version #	2
Current Approval Date:	12/03/2020	Old Document ID:	
Date Procedure to go into Effect:	12/03/2020		
Related Policies & Procedures:			
Related Job Aids:			

Departmental Policy Title	Changing Orders Protocol - Radiology - Ultrasound	Policy ID	26672
Keywords	change, changing, order, radiology, ultrasound		
Department	Dartmouth-Hitchcock – Lebanon Radiology		

I. Purpose of Policy

To describe the steps to amend orders so the appropriate examination can be performed based upon the clinical questions or diagnosis. Changes made to Ultrasound exams are to be considered within the clinical scope of practice or both Sonographers and Sonologists.

II. Policy Scope

This procedure applies to all Ultrasound imaging (Obstetrical, Gynecologic, Abdominal & Superficial) studies performed at Dartmouth-Hitchcock - Lebanon.

III. Definitions N/A

IV. Policy Statement

- All Ultrasound orders are reviewed pre-exam through the Radiant orders verification process.
- The indication and/or diagnosis listed determines the exam necessity. Communication to the attending/ ordering physician will be conducted via EPIC secure chat to request a new order be placed. Should the physician be unavailable, the Ultrasound attending Radiologist can give authorization and the order changed “per Radiology protocol”.
- Once communication is completed, a note will be placed in EPIC within “study notes” referencing the order change and include the date, time, and initials.
- The best imaging approach is to be defined in real time and should determine the exam necessity. Endo cavitory or transabdominal approach is considered within this clinical scope of practice.

V. References N/A

Responsible Owner:	Radiology - Ultrasound	Contact:	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Connell, Chandler; Kvinlaug, Christine	Version #	1
Current Approval Date:	01/20/2022	Old Document ID:	
Date Policy to go into Effect:	01/20/2022		
Related Policies & Procedures:			
Related Job Aids:			

Departmental Policy Title	Chaperone Policy for Ultrasound Exams - Radiology	Policy ID	1217
Keywords	chaperone, ultrasound, us		
Department	Radiology – Ultrasound Section		

I. Purpose of Policy

To define the circumstances under which a chaperone is required during an ultrasound examination and to describe the process for obtaining chaperones.

II. Policy Scope

D-H Department of Radiology, Ultrasound Section.

III. Definitions

Eligibility for chaperoning is limited to adult employees (male or female, as specified) of Dartmouth-Hitchcock and student doctors at the Geisel School of Medicine. Volunteers who are neither employees nor Geisel students are *not* eligible.

IV. Policy Statement

- Intracavitary, transperineal, or breast ultrasound examinations of a female patient may be performed by a male sonographer only in the presence of a female chaperone.
- A female sonographer may, at her discretion, request the presence of a chaperone during an examination of a male patient (i.e. testicular exam).
- Responsibility for securing chaperone services
 - During normal business hours (0800-1700, M-F), responsibility for arranging chaperone services rests with the sonographer performing the examination.
 - Outside of normal business hours, the ordering department will be asked to provide a chaperone (when required) for all on-call ultrasound studies.
 - If staffing limitations make it unfeasible to provide a chaperone, the Emergency Department (ED) Charge Nurse (or in the case of a non-ED patient, the requesting provider) will call the D-H House Supervisor (pager 9732) and request a chaperone.
 - The ED Charge Nurse (or in the case of a non ED patient, the requesting provider) will communicate with the on-call Radiology resident to ensure a timely process and scheduling for the ultrasound exam of the patient.

V. References

N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Chief Officer - Operating (MHMH); Office of Policy Support - All Other Documents; Chertoff, Jocelyn	Version #	3
Current Approval Date:	05/07/2020	Old Document ID:	
Date Policy to go into Effect:	05/07/2020		
Related Policies & Procedures			
Related Job Aids:	Ultrasound Imaging of Emergency Department (ED) Patients - Job Aid - Radiology		

Dept. Procedure Title	Complete Abdomen Imaging Procedure - Ultrasound - Radiology	Procedure ID	11184
Keywords	complete, abdomen, abdominal, sonographers, sonologists, interpretation, studies, images, imaging, ultrasound, us, liver, gallbladder, pancreas, kidney		
Department:	Ultrasound		

I. Purpose of Procedure

To describe the procedures for performing abdominal Ultrasound studies which include Abdomen Limited, Abdomen Complete, Abdomen Limited and Abdomen Complete with Vascular studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Aorta

1. Obtain representative images in the longitudinal plane of the entire aorta.
2. Document enlargement if present.

B. Liver

1. Perform longitudinal and transverse views to assess the liver parenchyma for focal or diffuse abnormalities.
2. Compare the liver echogenicity to that of the right kidney.
3. Obtain images to include hepatic lobes (right, left and caudate), Inferior Vena Cava (IVC) and right hemi diaphragm.
4. Perform a measurement of the liver length in a sagittal plane at the level of the right kidney (anterior axillary line).
5. Perform a minimum of (2) longitudinal and (2) transverse plane cine captures of the liver for all clinical indications of liver disease. Cine captures should include sagittal right and left lobes and transverse right and left lobes.
6. Obtain 4-quadrant imaging to assess for ascites for Abdomen Complete studies only.

C. Gallbladder and Biliary System

1. Obtain longitudinal and transverse images of the gallbladder in the supine and decubitus positions.
2. Assess stone mobility.
3. Document the measurement of the gallbladder wall if the gallbladder appears thickened and assess and document if a sonographic “Murphy’s sign” is also present.
4. Determine the presence or absence of intrahepatic and extrahepatic bile duct dilatation.
5. Obtain a measurement of the bile duct preferably over the right hepatic artery in the portal hepatis.
 - Additional imaging of the patient the upright position may be helpful in finding small stones in the gallbladder neck.

D. Pancreas

1. Perform transverse and sagittal images of the pancreas.
2. Evaluate and measure the pancreatic duct and the distal common bile duct in the region of the pancreatic head if dilated.

E. Spleen

1. Obtain representative images of the spleen in the longitudinal and transverse planes.
2. Perform longitudinal and transverse measurements of the spleen.
3. Compare the splenic echogenicity to that of the left kidney.

F. Kidneys

1. Obtain representative images in the longitudinal and transverse planes of both kidneys.
2. Longitudinal images must document lateral and medial margins of the kidneys.
3. Transverse views of both kidneys must include labelled images of upper, mid, and lower poles.
4. Perform maximum measurements (minimum of 2) of renal length of both kidneys.
5. Compare renal echogenicity to that of the liver or spleen.
6. Record Color Power Doppler images when there is a clinical suspicion of pyelonephritis.
7. Use Color Doppler to exclude mild hydronephrosis vs. hilar vessels

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Connell, Chandler; Kvinlaug, Christine	Version #	3
Current Approval Date:	10/28/2021	Old Document ID:	
Date Procedure to go into Effect:	10/28/2021		
Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Cranial Imaging Procedure - Ultrasound - Radiology	Procedure ID	11185
Keywords	cranial, cranium, sonographer, sonologist, interpretation, images, ultrasound, us, studies		
Department	Ultrasound		

I. Purpose of Procedure

To describe how to perform cranial Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This applies to all Sonographers and Sonologists within the Ultrasound section of Dartmouth-Hitchcock-Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

This exam is performed on infants less than or equal to 6 months.

Scans are principally performed through the anterior fontanel to evaluate for intracranial hemorrhage or periventricular leukomalacia (PVL). Additional images may be obtained through the posterior fontanel, foramen magnum or temporal bone.

If extra-axial fluid is present, utilize a linear transducer to further differentiate between subdural or subarachnoid fluid. Document vessels crossing in the fluid space.

Coronal views – Minimum 5 evenly spaced images

- Frontal lobes and orbits
- Frontal horns of the lateral ventricles
- Body of the lateral ventricles
- Occipital horns of the lateral ventricles
- Occipital region
- Perform cine capture in the coronal plane through the entire brain

Right para sagittal views – Minimum 3 images each side

- Brain lateral to lateral ventricle beginning at Sylvian fissure
- Maximum size of the lateral ventricle
- Choroid plexus leading into the caudo-thalamic groove (CTG)
- Perform cine capture in the sagittal plane beginning at the Sylvian fissure and moving medial to the midline
- Using a linear transducer, obtain sagittal cine capture(s) of the parenchyma

Midline sagittal view - Document the following:

- Corpus callosum
- Third ventricle region
- Fourth ventricle
- Vermis of the cerebellum
- Cisterna magna

Left para sagittal views – Minimum 3 images each side.

- Brain lateral to lateral ventricle beginning at Sylvian fissure
- Maximum size of the lateral ventricle
- Choroid plexus leading into the caudo-thalamic groove (CTG)
- Perform cine capture in the sagittal plane beginning at the Sylvian fissure and moving medial to the midline
- Using a linear transducer, obtain sagittal cine capture(s) of the parenchyma

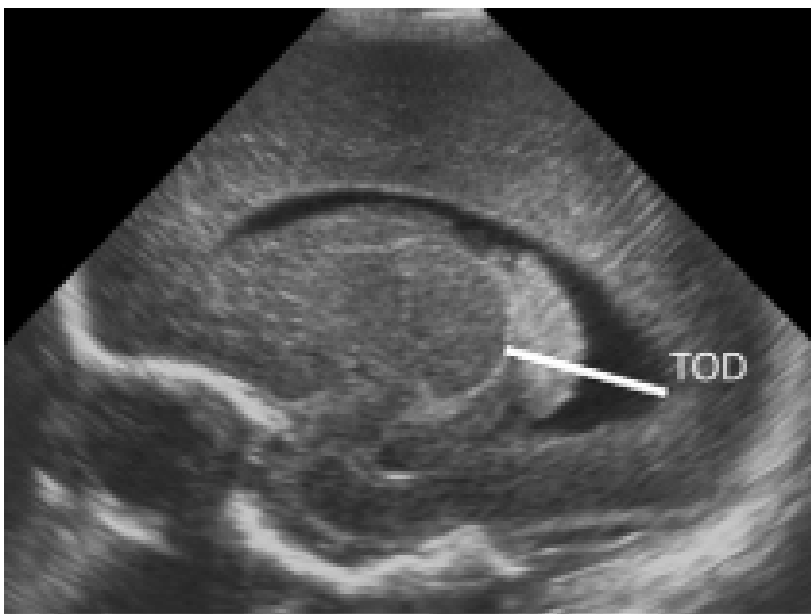
Posterior fossa views:

- Obtain images through the mastoid showing the cerebellum and posterior fossa structures.

Ventricular dilatation measurements (Inpatient studies only):

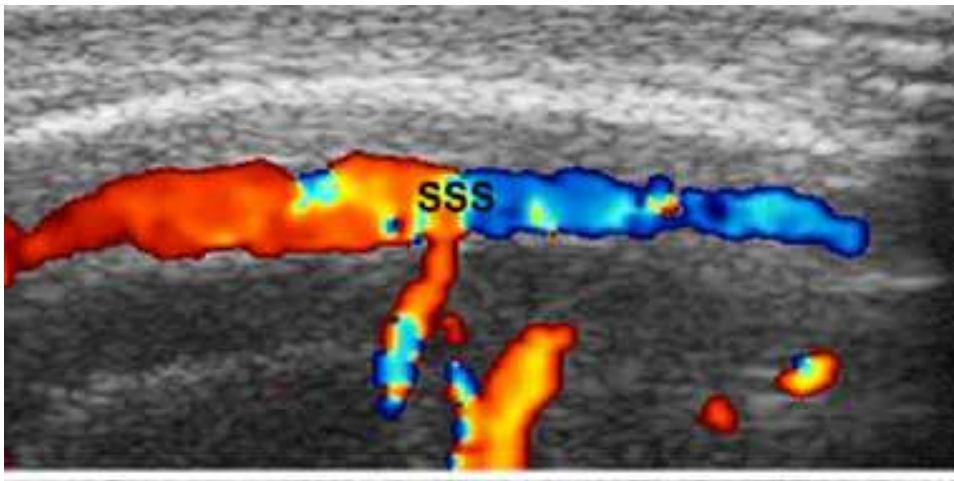
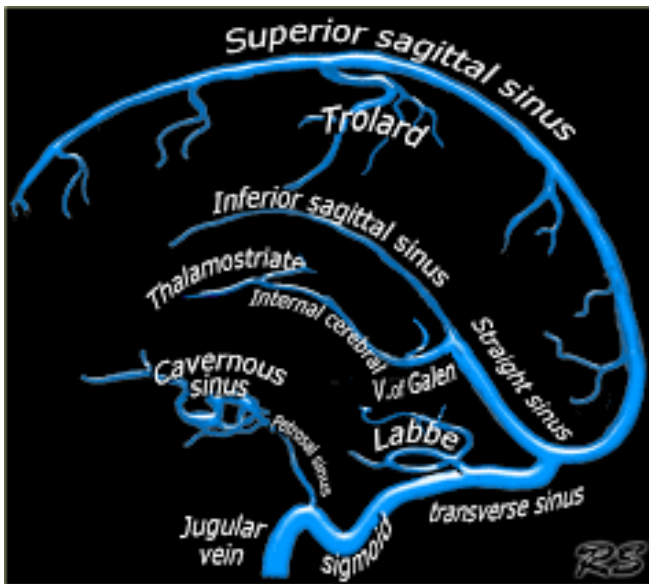
Obtain measurements and static images of the following:

- Ventricular index (VI)
- Anterior horn width (AHW)
- Thermo-occipital distance (TOD)



Additional imaging (Inpatient only):

- Applying very light pressure, obtain power Doppler static imaging of the superior sagittal sinus with a linear transducer in the coronal and sagittal planes.



VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine	Version #	3
Current Approval Date:	09/21/2020	Old Document ID:	
Date Procedure to go into Effect:	09/21/2020		
Related Policies & Procedures:			
Related Job Aids:			



Characterization of germinal matrix hemorrhage in extremely premature infants: recognition of posterior location and diagnostic pitfalls

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Abstract

Background Traditionally, descriptions of germinal matrix hemorrhage (GMH), derived from observations in preterm and very preterm infants, indicate its location at the caudothalamic grooves. However, before the germinal matrix begins to recede at approximately 28 weeks' gestational age (GA), it extends along the floor of the lateral ventricles far posterior to the caudothalamic grooves. Germinal matrix–intraventricular hemorrhage (GMH-IVH) can occur along any site from which the germinal matrix has not yet involuted. Therefore, as current advances in neonatology have allowed the routine survival of extremely preterm infants as young as 23 weeks' GA, postnatal GMH-IVH can occur in previously undescribed locations. Hemorrhage in the more posterior GMH on head ultrasound, if unrecognized, may lead to errors in diagnosis and mislocalization of this injury to the periventricular white matter or lateral walls of the lateral ventricles instead of to the subependyma, where it is in fact located.

Objective Our aim is to describe posterior GMH in extremely premature infants, including its characteristic imaging appearance and potential pitfalls in diagnosis.

Materials and methods Over a 5-year period, all consecutive extremely preterm infants of 27 weeks' GA or less who developed GMH-IVH of any grade were included. A consecutive group of 100 very preterm infants of 31 weeks' GA with a GMH-IVH of any grade served as controls.

Results In 106 extremely preterm neonates (mean GA: 25 weeks, range: 23.1–26.6 weeks) with 212 potential lateral ventricular germinal matrix bleeding sites, 159 sites had bleeds. In 70/159 (44%), the GMH-IVH was located posterior to the caudothalamic grooves and the foramina of Monroe, 52 (32.7%) were both anterior and posterior and 21 (13.2%) were exclusively anterior. In 16 ventricles with intraventricular hemorrhage, an origin site in the germinal matrix could not be determined. In the control population of very preterm infants, all hemorrhages were at the anterior caudothalamic grooves and 95% were grade I.

Conclusion Unlike the older very preterm and moderately preterm infants that form the basis of our GMH-IVH description and classification, the extremely preterm infants now routinely surviving have a more fetal pattern of germinal matrix distribution, which is reflected in a different distribution and size of germinal matrix injury. We report the postnatal occurrence of subependymal GMH-IVH in extremely preterm infants in these more primitive, posterior locations, its potential imaging pitfalls and sonographic findings.

Keywords Germinal matrix hemorrhage · Head · Infants · Intraparenchymal hemorrhage · Intraventricular hemorrhage · Prematurity · Ultrasound

Introduction

Preterm birth is a wide spectrum dependent on the gestational age (GA) of the infant at birth. Preterm birth, defined as birth before 37 weeks' gestation, affects an estimated 15 million infants worldwide and nearly 10% of births in the United States [1]. The World Health Organization defines moderate or late preterm as birth between 32 and 37 completed weeks of

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gestation, very preterm as birth between 28 and 32 weeks of gestation, and extremely preterm as birth at less than 28 weeks of gestation [2].

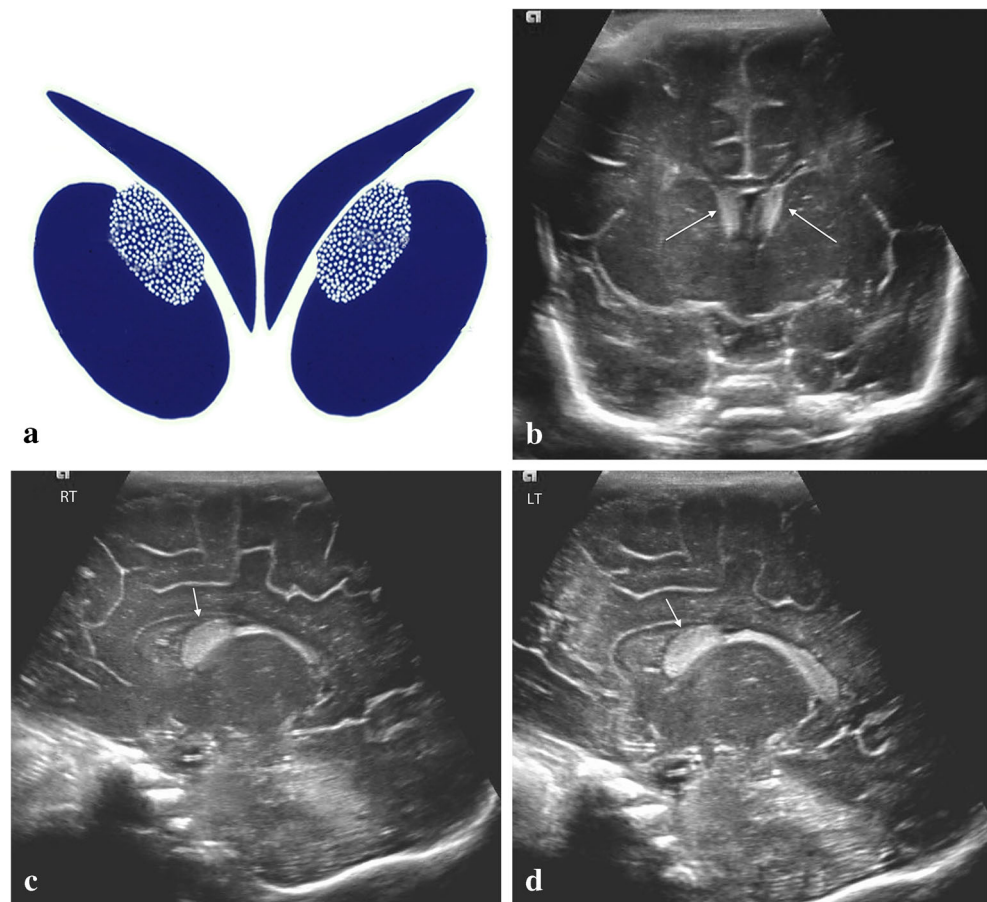
Germinal matrix–intraventricular hemorrhage (GMH-IVH) remains an important cause of morbidity and mortality in premature infants [3–5] despite advances in neonatal care, which have led to the survival of many extremely preterm infants who are at an increased risk for GMH-IVH [6, 7]. Thus, close to 10,000 extremely preterm infants survive with GMH-IVH each year in the United States [8].

GMH-IVH is traditionally stratified based on severity into grades I–IV, according to a grading system used for more than four decades, based initially on single-observation imaging findings described on computed tomography (CT) and subsequently on ultrasound in predominantly moderate preterm and very preterm infants because, at the time, extremely preterm infants approached the edges of viability and seldom survived [9–11]. In this more mature preterm population on which our concepts of GMH-IVH are still based, the residual germinal matrix is thinner and largely confined to the area anterior to the foramina of Monro under the frontal horns of the lateral ventricles at the caudate heads, described as the caudothalamic grooves (Fig. 1). However, as the limits of viability and routine resuscitation and survival have progressively extended to

extremely preterm infants, we have found that the location of the GMH-IVH has shifted to areas in which it is most abundant in this population, posterior to the traditional location. Further, advances in imaging, including magnetic resonance (MR) and fetal imaging and in ultrasound technology, allow for a more detailed evaluation of the neonatal brain. The routine extension of postnatal GMH-IVH posterior to the caudothalamic grooves, its appearance on head ultrasound and its potential imaging pitfalls to our knowledge have not been well-described in the imaging literature. The posterior location, despite being subependymal, can masquerade as a periventricular abnormality on posteriorly angled coronal/axial images, leading to a significant diagnostic pitfall in which the lesion mimics a periventricular hemorrhagic venous infarction or other isolated periventricular white matter injury, when it is not located in the white matter at all. The subependymal location of this abnormality can be confirmed on sagittal images (Figs. 2, 3 and 4; Online Supplementary Material 1).

Our purpose is to describe the posterior location of GMH-IVH in extremely preterm infants and its ultrasound appearance and differentiate this posterior subependymal injury from intraventricular and extraventricular parenchymal hemorrhages. A consecutive group of very preterm infants served as controls.

Fig. 1 An anterior caudothalamic germinal matrix hemorrhage (GMH; classic or traditional grade I hemorrhage). **a** A coronal schematic drawing shows the classic location of GMH in a very premature infant. **b–d** Coronal (**b**) and right- (**c**) and left- (**d**) angled parasagittal US images in a 31-week gestational age girl on day of life 7 show the classic grade I lesions (*arrows*) at the caudothalamic grooves



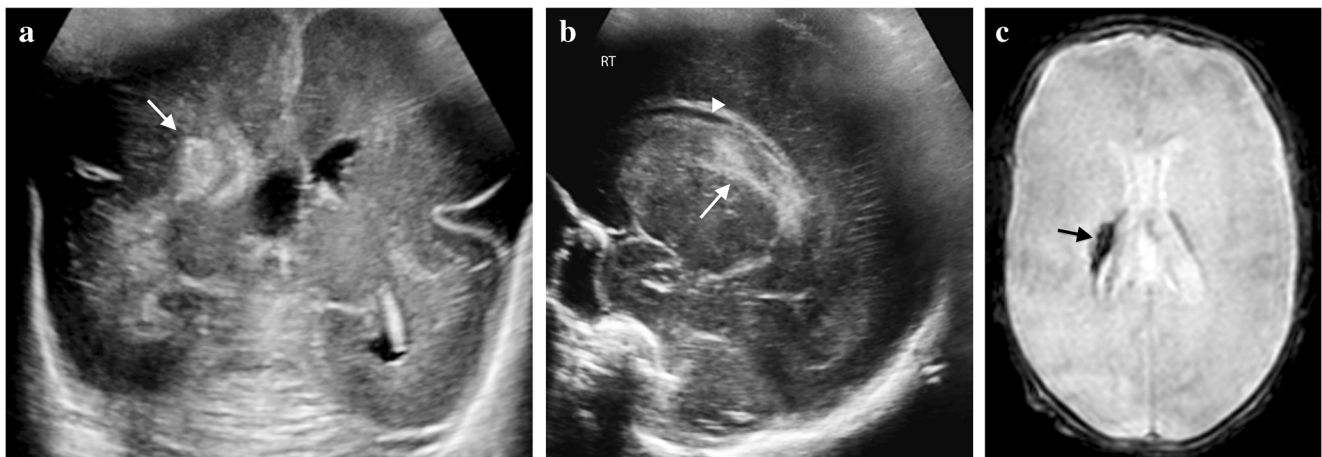


Fig. 2 A posterior subependymal grade I germinal matrix hemorrhage in a 25-week gestational age boy simulates a periventricular white matter hemorrhage. **a** A posteriorly angled coronal US image performed on day of life 7 shows a hyperechoic focus (*arrow*), seemingly in the periventricular white matter. **b** A right parasagittal US image shows that the hyperechoic focus (*arrow*) is located posterior to the caudothalamic groove, but along the floor of the lateral ventricle in the location of the posterior germinal matrix, and not in the periventricular white matter.

Materials and methods

This was an institutional review board (IRB)-approved retrospective observational study. Over a 5-year period from 2013 to 2018 all consecutive extremely preterm neonates with GA up to 27 weeks at birth with a GMH-IVH of any grade were included. Infants between 27 and 28 weeks were not included in order to obtain a distinct separation of the extremely preterm population from the very preterm population that begins at 28 weeks' GA. A consecutive group of 100 very preterm infants of 30–31 weeks' GA who had GMH-IVH of any grade served as controls. Infants transferred to our hospital without

This is clearly separated from the germinal matrix by the lateral ventricle, outlined by a cleft of cerebrospinal fluid (*arrowhead*) above the hemorrhage. The periventricular white matter is normal. **c** An axial T2-W fast field echo (FFE) MR image, performed at 3 months of age, confirms hemosiderin in the posterior germinal matrix (*arrow*). A small amount of hemosiderin also lines the posterior aspect of both lateral ventricles, and the posterior germinal matrix of the left lateral ventricle, not outlined on the sonographic images

initial examinations and infants with known underlying or preexisting conditions, such as congenital anomalies, were excluded.

All premature neonates at our institution receive a screening head ultrasound per institutional protocol on day of life 7, unless requested earlier based on the patient's clinical status. All head ultrasounds are performed by dedicated pediatric sonographers, who are required to pass pediatric sonography boards, including pediatric neurosonography, within 2 years of employment, and all head ultrasounds are reviewed and interpreted by fellowship-trained and experienced pediatric radiologists or pediatric neuroradiologists. Standard images

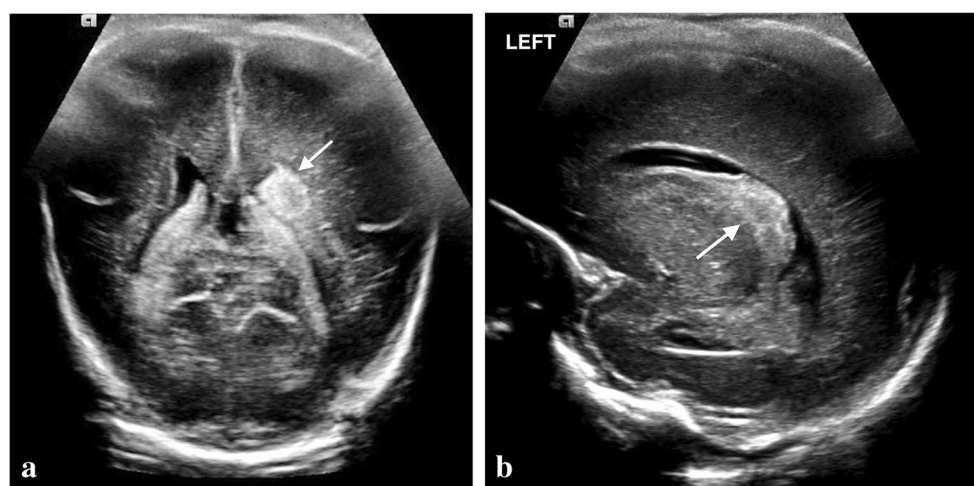


Fig. 3 A posterior germinal matrix hemorrhage in a 25-week gestational age boy, performed on day of life 7. **a** A posteriorly angled coronal US image shows a prominent hyperechoic focus along the lateral wall of the left ventricle (*arrow*), seemingly in the periventricular white matter. **b** A left parasagittal image shows the hemorrhage (*arrow*) to be posterior to

the caudothalamic grooves along the subependymal surface of the lateral ventricle, congruent with the posterior location of germinal matrix in this extremely preterm infant. Note that the periventricular white matter is normal, separated by a cleft of cerebrospinal fluid from the subependymal hemorrhage

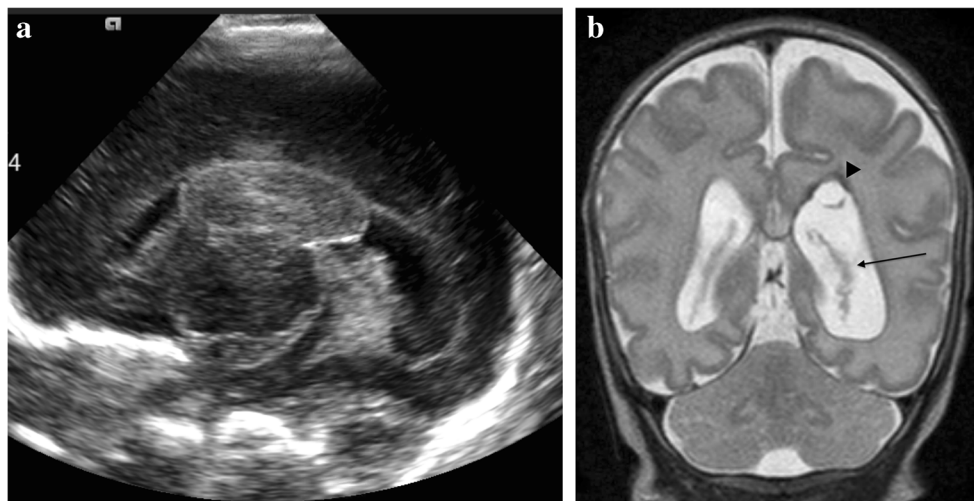


Fig. 4 A large posterior subependymal hemorrhage in a 24-week gestational age boy. **a** A left parasagittal US on day of life 7 shows a large posterior subependymal hemorrhage posterior to the caudothalamic groove and the foramina of Monro. **b** A coronal T2-W MR image at 11 weeks of age shows hemosiderin staining (arrowhead) along the

ependymal surfaces of the lateral ventricle posterior to the foramina of Monro. The choroid plexus of the left lateral ventricle appears normal in size and signal intensity (arrow) further distinguishing the large posterior subependymal bleed seen on the initial US from intraventricular choroid plexus hemorrhage

obtained during a routine head ultrasound include coronal and sagittal cine sweeps, including coronal left- and right-tilt angled sweeps, and coronal and sagittal still images through the anterior fontanelle using sector and linear transducers operating at 7–10 MHz. Additional images of the lateral ventricular atria and posterior fossa are acquired through the mastoid fontanelles.

All head ultrasounds of extremely preterm patients and very preterm controls were reviewed by two pediatric radiologists (M.H.-S. and E.J.S.) with 30 years and 2 years of experience, respectively, and by one pediatric neuroradiologist (S.P.) with 14 years of experience, blinded to the original report. Any discrepancy was resolved by consensus. For practical purposes in this report, we have defined anterior GMH-IVH as confined to the caudothalamic grooves over the heads of the caudate nuclei, anterior to the foramina of Monro, traditionally known as grade I GMH. Similarly, we have defined posterior hemorrhage as extending beyond the caudothalamic grooves, posterior to the foramina of Monro and posteriorly along the ependymal surface of the lateral ventricles, areas known to be occupied by germinal matrix at the gestational age of the extremely preterm infants [12]. Hemorrhage in the posterior germinal matrix mimicking periventricular white matter injury on coronal images was differentiated on parasagittal images. We subsequently reviewed the original reports, which had been generated over a time period before and after our awareness of these lesions, by dedicated fellowship-trained and certificate of added qualification (CAQ)-certified pediatric radiologists and pediatric neuroradiologists, including the authors of this manuscript.

Demographic data extracted from medical records included gestational age, sex, birth weight and APGAR (appearance,

pulse, grimace, activity and respiration) scores. We reported categorical data as counts and percentages, continuous variables as a mean and standard deviation, and APGAR scores as a median with interquartile range. All data were recorded using Excel (Microsoft, Redmond, WA).

Results

One hundred and six extremely preterm neonates were included in the study (Table 1). The average GA was 25 weeks (range: 23.1–26.6 weeks) and the average birth weight was 747.6 g (range: 457–1,300 g). The median APGAR scores at 1 min and 5 min were 3 (interquartile range [IQR]: 1–5) and 5 (IQR: 3–7), respectively. Sixty-three (58.5%) infants were boys.

There were 159 hemorrhages out of 212 potential sides in the 106 extremely preterm infants. The locations of the hemorrhagic sites were posterior (Figs. 2, 3 and 4; Online Supplementary Material 1) in 70/159 sites (44.0%), and

Table 1 Demographics of extremely preterm infants ($n=106$)

Demographic	
Mean gestational age in weeks (range)	25 (23 1/7 to 26 6/7)
Male sex (%)	63 (58.5%)
Birth weight in grams (range)	747.6 (457–1,300)
Median APGAR score at 1 min (IQR)	3 (1–5)

APGAR appearance, pulse, grimace, activity and respiration, IQR interquartile range

anterior and posterior (Fig. 5) in 52 sites (32.7%). In some of the posterior hemorrhages, if not recognized to be entirely subependymal, the size of the subependymal component was large enough to be classified as a grade III lesion by size criteria according to the Papile classification because it was larger than the diameter of a normal ventricle (Fig. 6). The hemorrhage was exclusively anterior in only 21 sites (13.2%). In 38/106 infants, there were bilateral hemorrhages involving the posterior germinal matrix. In one infant, the hemorrhage was in the occipital portion of the right germinal matrix (Fig. 7) and in the temporal portion in another. In 13/106 infants (12.3%), the GMH-IVH was extensive and associated with a large periventricular parenchymal hemorrhagic infarction (grade IV; Fig. 8). In 16 sites, intraventricular hemorrhage was seen, but the site of origin could not be determined.

The original reports reflected our realization of this new manifestation of posterior subependymal hemorrhage and its

differentiation from white matter injury during the study period. Therefore, the grade of GMH-IVH over the entire study period was misclassified in approximately half of the infants with posterior subependymal bleeds: as periventricular hemorrhagic infarction in approximately half and as other nonspecific white matter abnormality in the remainder.

The control population of 100 very preterm infants had a GA of 30–31 weeks. Of the hemorrhages in these infants, 95% were grade I, only 5% were grade II, and none was of a higher grade. All were in the typical location at the anterior caudothalamic grooves (Fig. 1).

Discussion

The germinal matrix is a fetal zone below the floor of the lateral ventricles paralleling the caudate nuclei. Between 10

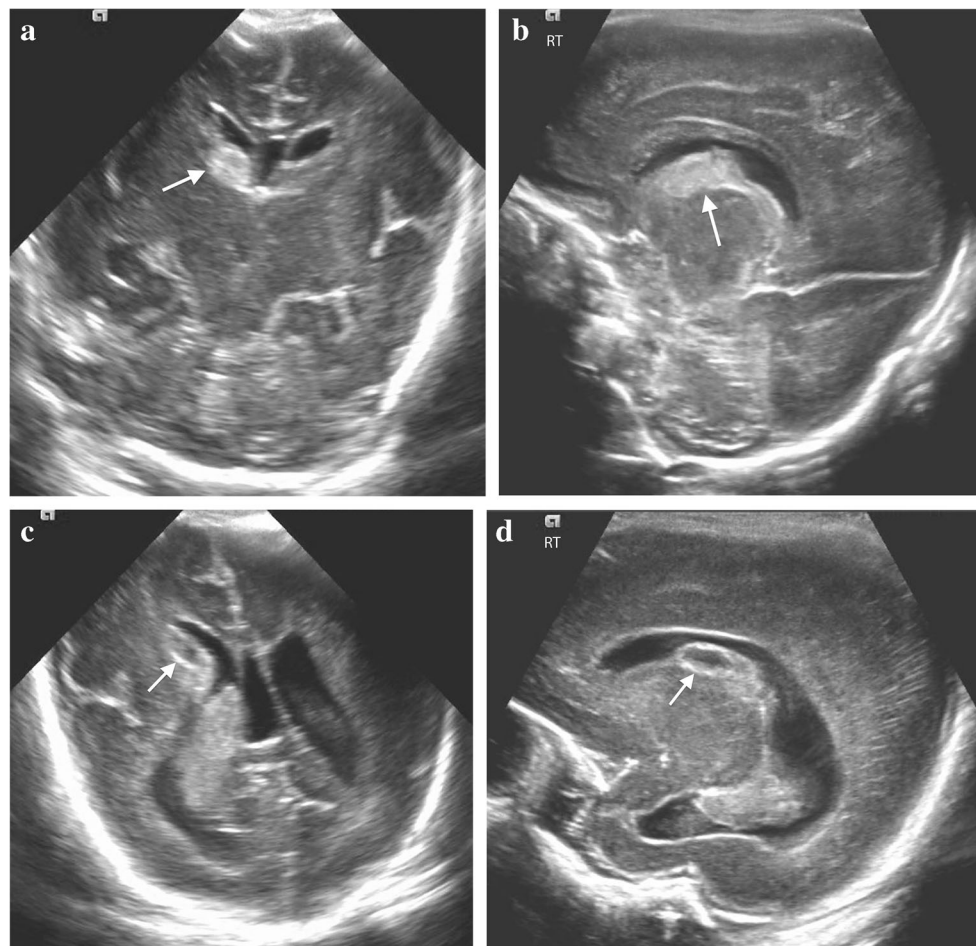


Fig. 5 Anterior and posterior subependymal hemorrhage in a 25-week gestational age male infant. **a** A coronal US image shows a hyperechoic hemorrhage in the right anterior caudothalamic groove (arrow). **b** A right parasagittal image shows the hyperechoic hemorrhage in the anterior caudothalamic groove (arrow). **c** A more posteriorly angled coronal image, tilted toward the right, shows a hypoechoic hemorrhage in the right posterior germinal matrix, simulating a right periventricular white matter injury (arrow). **d** A right parasagittal image with slightly more

lateral and posterior angulation shows the hypoechoic lesion to be located along the more posterior germinal matrix (arrow), not in the periventricular white matter as erroneously suggested on the coronal image. If this is not understood and appreciated, the more posterior lesion could easily be thought to represent an intraventricular hemorrhage–periventricular hemorrhagic infarction lesion. Cine images of this case can also be seen in Online Supplementary Material 1

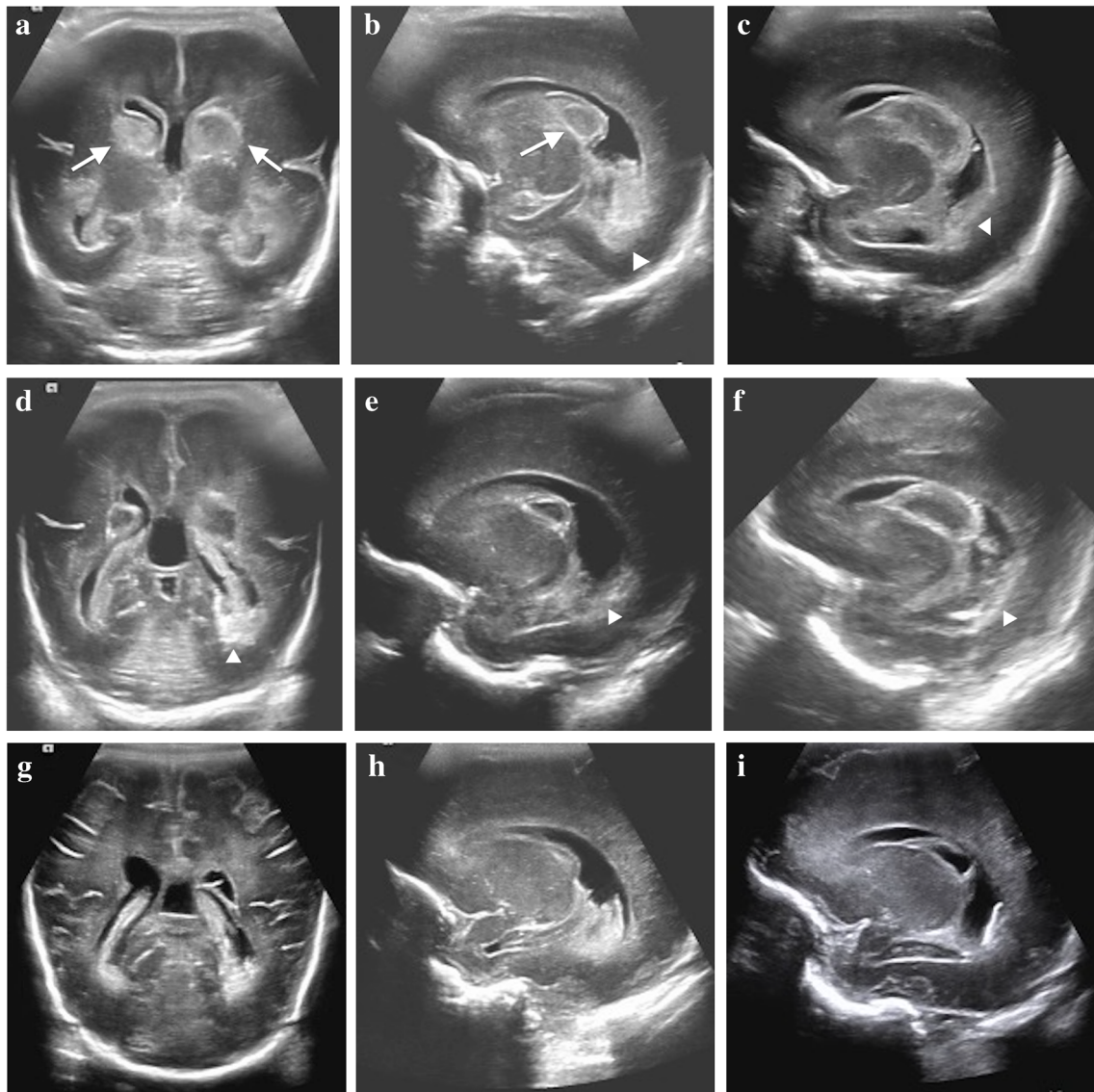


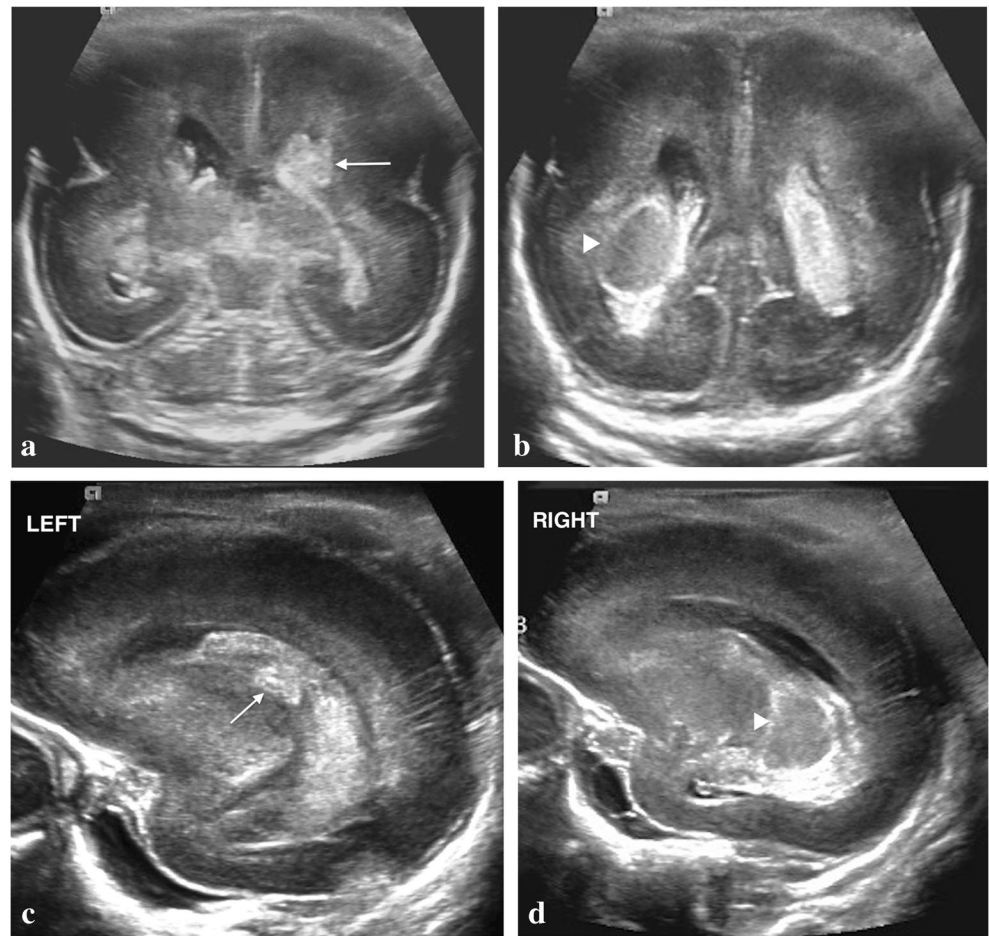
Fig. 6 Large posterior subependymal hemorrhages in a 23-week gestational age boy. **a** A coronal US image on day of life 10 shows very large subependymal hyperechoic hemorrhages adjacent to the lateral ventricles (*arrows*). **b** A right parasagittal US image shows the hemorrhage (*arrow*) extending into the area of the caudate nucleus, separate from the intraventricular thrombus layering dependently in the occipital horn (*arrowhead*). **c** A left parasagittal US image shows the larger left-side hemorrhage and the extension into the region of the caudate and separation from the posteriorly layering thrombus in the occipital horn (*arrowhead*). These subependymal lesions would be categorized as grade I according to the Papile classification based on location. However, based on volume, they would be classified as grade III. **d–f** Evolution of hemorrhages in the same infant at 4 weeks of age. A coronal image (**d**) shows the now hypoechoic bilateral subependymal hemorrhagic lesions, projecting laterally to the bodies of the lateral ventricles. A posteriorly layering thrombus in the occipital horn is again

seen (*arrowhead*). A right parasagittal image (**e**) shows the evolution of the subependymal lesion since the previous study, without change in location or shape. A posteriorly layering thrombus in the occipital horn is again seen (*arrowhead*). A left parasagittal image (**f**) shows the similar evolution of the larger, left-side subependymal lesion. A posteriorly layering thrombus in the occipital horn is again seen (*arrowhead*). **g–i** Evolution of hemorrhages in the same infant at 2 months of age. A coronal image (**g**) shows the now nearly resolved right subependymal lesion, and the cystic evolution of the larger left-side lesion; the coronal image erroneously suggests a periventricular white matter cyst. A right parasagittal image (**h**) confirms the near-total resolution of the right subependymal lesion. A left parasagittal image (**i**) shows continued liquefaction and volume loss of the larger left-side lesion in the same posterior subependymal location. This case illustrates the need for the paradigm change in our understanding of germinal matrix hemorrhage in the extremely preterm population

and 20 weeks of gestation it serves as the source of cerebral excitatory neurons and generates precursors of oligodendroglia and astrocytes as well as late-migrating gamma-aminobutyric acid-ergic (GABAergic) neurons that will go

on to populate both cerebral cortex and thalamus [8, 13]. As has been well described in the neurology literature, the germinal matrix undergoes extensive cellular proliferation during early fetal life and is thickest at 20–26 weeks of gestation

Fig. 7 Left posterior and right occipital subependymal germinal matrix hemorrhages in a 23-week gestational age boy on day of life 1. **a** A coronal US image shows a focus of hemorrhage along the left posterior germinal matrix projecting over the periventricular white matter (*arrow*), with some intraventricular blood in the left frontal horn. **b** A more posteriorly angled image shows a large hypoechoic hemorrhage (*arrowhead*) along the lateral wall of the posterior right ventricle. **c** A left parasagittal image shows the left focus of hemorrhage (*arrow*) at the level of the caudate nucleus but posterior to the caudothalamic groove, below the intraventricular blood. **d** A right parasagittal image shows the right hemorrhage to be contained and along the curvature of the thalamus (*arrowhead*), suggesting a location within the very posterior germinal matrix. There is also abundant intraventricular blood of differing echogenicity to this well contained focus



[12, 14]. During the period of extensive proliferation, the germinal matrix reaches a width of 2.5 mm at 23 weeks' GA, which decreases to 1.4 mm at 32 weeks, and is nearly

completely involuted by 36 weeks, being most prominent along the anterior caudothalamic groove between 28 and 32 weeks of gestation [8, 13–15] (Fig. 9). Fetal MRI literature

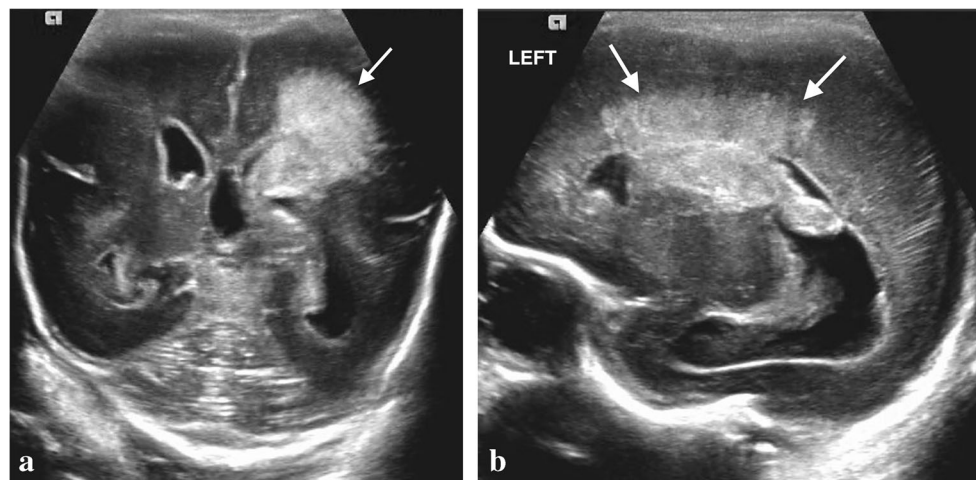


Fig. 8 Parenchymal hemorrhagic venous infarction in a 26-week gestational age boy on day of life 7. **a** A coronal US image shows a large left intraventricular hemorrhage and a large hyperechoic area in the left frontoparietal white matter (*arrow*), consistent with a periventricular hemorrhagic infarction. **b** A left parasagittal US image shows an intraventricular hemorrhage, which is confluent with and

difficult to distinguish from the posterior germinal matrix. However, the image confirms that the parenchymal component (*arrows*) is located above the lateral ventricle consistent with a germinal matrix hemorrhage–intraventricular hemorrhage associated with a periventricular hemorrhagic infarction

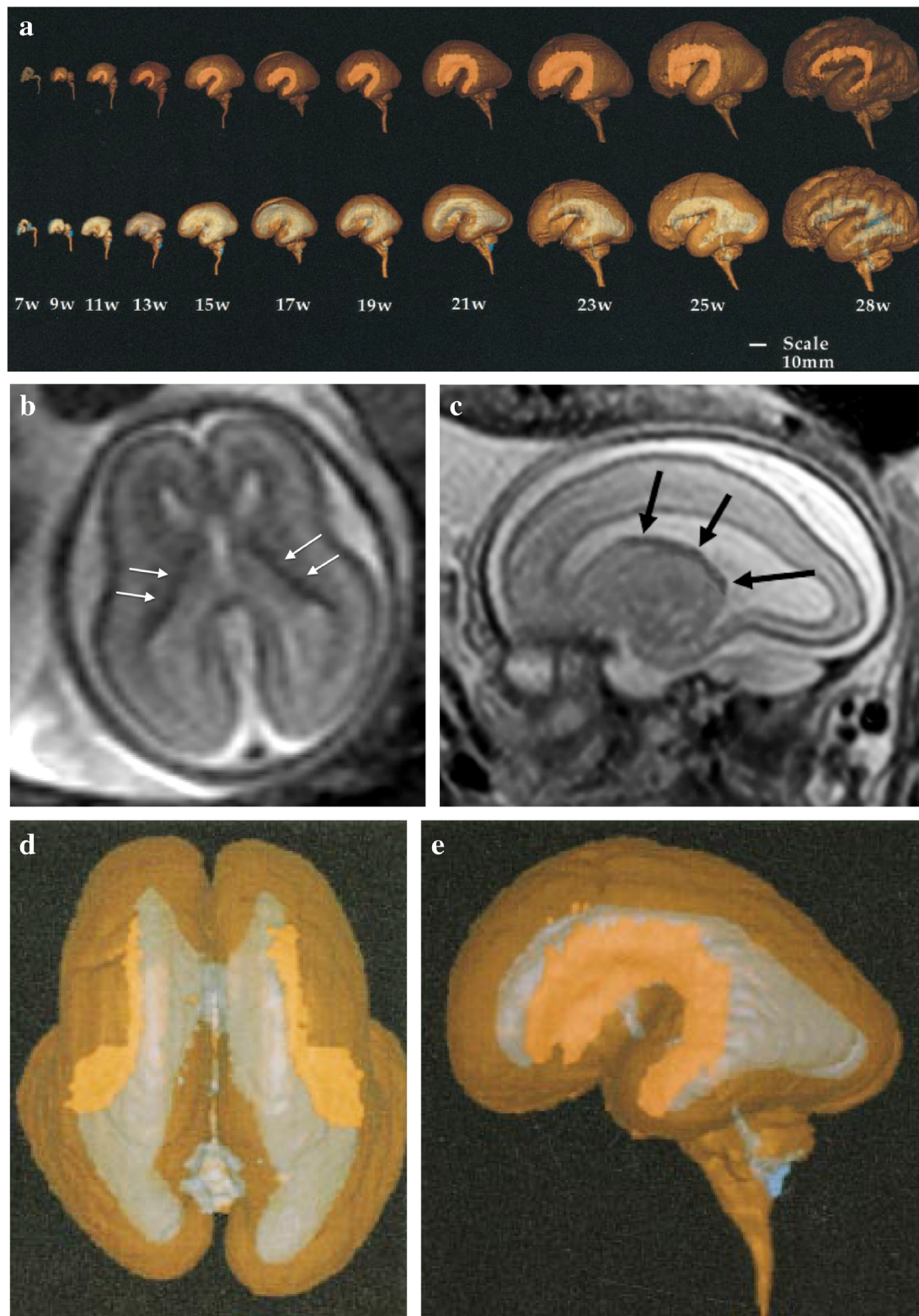


Fig. 9 Development of the germinal matrix. **a** Sequential images show concurrent developmental changes of the germinal matrix (*orange overlay*, top row) and ventricular systems (*light gray overlay*, bottom row) between 7 weeks' and 28 weeks' gestation. Note how the volume of the germinal matrix increases until 23 weeks of gestational age and is followed by a rapid decrease by 28 weeks. Reproduced with permission from [15]. **b, c** Axial (**b**) and parasagittal (**c**) prenatal MR images in a

21 weeks' gestation fetus obtained in our institution shows the posterior extent of the germinal matrix (*arrows*) far beyond the caudothalamic grooves at this gestational age. **d, e** Axial (**d**) and sagittal (**e**) sections show the ventricles (*light gray overlay*) and germinal matrix (*orange overlay*) over the surface-rendered brain of a 21 weeks' gestational age fetus. Reproduced with permission from [15]

also shows that, in fetuses younger than 28 weeks' gestation, a large volume of the germinal matrix extends along the entire length of the interface of the caudate nuclei with the ventrolateral floor of the lateral ventricles [12]. Extremely preterm infants, therefore, have a different distribution and volume of germinal matrix than their older counterparts on whom our current concepts and grading systems are largely based [9]. Although hemorrhage has been described in the posterior germinal matrix in fetal and neonatal MRI studies [16, 17], to our knowledge neither its appearance on ultrasound nor the potential for mislocalization of a germinal matrix injury to the periventricular white matter or within the lateral ventricles has.

The description of GMH-IVH with which most of us are familiar stems from the grading system of GMH-IVH adapted from Papile et al. [9] in general use today, with modifications by Volpe et al. [8]. GMH-IVH is traditionally stratified according to severity into grade I, confined to the subependyma, typically small and located at the caudothalamic grooves; grade II, extending into the ventricles without dilatation by blood products; and grade III, sufficient to dilate the ventricles with a larger intraventricular hemorrhagic burden. GMH-IVH with a periventricular hemorrhagic infarction, which has been considered a grade IV injury, is not strictly part of the continuum although it is typically associated with germinal matrix and intraventricular hemorrhage [8, 13]. In the Papile-based system, in use for more than four decades, a grade I lesion is defined as a lesion located in the subependyma and is typically small, and the classification implies an incremental rise in the severity of the lesion along grades I–IV.

Our study highlights the fact that the frequent survival of extremely preterm infants dictates new injury patterns that should be recognized, particularly with the potential for the erroneous resemblance to white matter injury on coronal imaging (Figs. 2, 3, 4, 5, 6 and 7; Online Supplementary Material 1). The differentiation is best delineated in parasagittal images, in which the hemorrhage is seen along the floor of the ventricles paralleling the caudate nuclei, and not above the ventricles in the periventricular white matter region (Figs. 2, 3, 4, 5, 6 and 7; Online Supplementary Material 1). Typically, when the ventricles are sufficiently distended with cerebrospinal fluid (CSF), the subependymal component can be further distinguished from the periventricular white matter by a band or cleft of CSF that delineates the edge of the ventricle below the periventricular white matter.

Similarly, we found that the size of the subependymal component in these posterior hemorrhages was often much larger than the anterior subependymal lesions that occur in the older very premature infant population (Fig. 6). We postulate that it is the larger volume of the germinal matrix in the extremely preterm infants [14, 15] (Fig. 9) that allows the subependymal component in the posterior lesions to be large, blurring the traditional volumetric distinction between grade I and grade

III injuries (Figs. 1 and 6). Thus, in the Papile [9] classification, the size of the subependymal, extraventricular lesion is moot and is always classified as a grade I lesion. However, in this different population in whom the germinal matrix is larger, the size of the lesion can sometimes blur the volumetric distinction between grades I and III lesions. Thus, the sometimes much larger size and the earlier gestational age at which it occurs conflict with the spectrum of severity implied in the Papile [9] classification. We therefore suggest that posterior subependymal GMH may be a more accurate description than grade I, with further description of location, size and extent.

Although we did not follow up on the infants' neurological and clinical status and did not investigate the clinical consequences of these lesions, our findings raise questions regarding their prognostic significance. Even subependymal lesions, as we have described, can be extensive and, at this stage in fetal development, affect a large volume of these germinal matrix cellular precursors of oligodendroglia and GABAergic neurons, as well as their subsequent migration and differentiation, potentially impairing myelination and cortical neuronal development [8, 17], thus heavily influencing the prognostic significance of a subependymal grade I lesion. As we follow these children into later life, this information should be taken into consideration in their follow-up and subsequent care, and inform the basis of future research, clearly beyond the scope of our initial report.

Limitations of this study include its retrospective nature and consensus readings. In addition, in some cases of large bleeds, hemorrhages adherent to the choroid and subependymal blood can appear confluent and difficult to compartmentalize to the site of origin with complete certainty. These issues may have affected the frequency of specific findings. In most of the cases, however, there was a large subependymal component clearly demarcated from the intraventricular hemorrhage, which could be followed to resolution (Fig. 2). Further, intraventricular blood does not masquerade as a periventricular white matter lesion on coronal images, as is the case with the posterior GMH. Confirmatory MRI is clearly difficult to perform contemporaneously in these fragile infants unless available in the neonatal intensive care unit, and follow-up images for clinical concerns when the infants are stable may no longer demonstrate the findings as clearly as during the acute event, although some of our patients did have follow-up imaging confirming the location of the hemorrhage (Fig. 2).

Conclusion

Germinal matrix–intraventricular hemorrhage in extremely premature infants frequently involves the posterior germinal

matrix, an area from which it has involuted in the more mature premature population and can simulate a periventricular hemorrhagic venous infarction (grade IV lesion) or other white matter lesion on posteriorly angled coronal (axial) ultrasound images. Knowledge of the typical involution patterns of the germinal matrix, its location in the extremely preterm population and the typical ultrasound appearance of posterior GMH is essential for accurate interpretation of head ultrasound studies. Given the stage of brain development at which they occur and the potential size of these lesions, we believe they should be described as posterior subependymal germinal matrix hemorrhages, and their potential prognostic implications explored by future research.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s00247-021-05189-3>.

Declarations

Conflicts of interest None

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Job Aid	Endometrial Biopsy Setup Job Aid - Ultrasound - Radiology	ID:	11355
Keywords	u/s, us, bx, ultrasound, biopsy, endometrial		
Department	Ultrasound, Radiology		

I. Purpose

To provide a list of necessary supplies for Ultrasound endometrial biopsy procedures.

- Speculum – (have all sizes available)
- Cotton Balls/Betadine Prep
- Surgical gloves (appropriate for physician)
- Long Curved Kelley
- Endometrial Biopsy Curette – 3 choices- have all available
- 10% Neutral Buffered Formalin
- Dilators – Tenaculum
- Surgical pathology request created in eD-H (created by MD)
- Patient Labels
- Specimen transport bag]
- Lidocaine (appropriate for physician)

Billing/ Supplies:

- Guidance only all charges included. No supplies required

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents, Jean Bolger	Version #	2
Current Approval Date:	10/15/2018	Old Document ID:	NEW
Date Policy to go into Effect:	10/15/2018		
Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Gynecologic Imaging Procedure - Ultrasound - Radiology	Procedure ID	11222
Keywords	gynecologic, imaging, ultrasound, study, studies		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographers and sonologist performing gynecologic Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Scheduling

1. Make every attempt to schedule examinations between cycle day 4 and 12.
 - In most cases transvaginal scanning is the preferred method of imaging.
 - Transabdominal approach should only be used if the patient is not a candidate for placement of a transvaginal probe, i.e., is not sexually active, has not yet had a gynecologic exam with a speculum, has been sexually abused, or refuses the endovaginal approach.

B. Ultrasound Imaging

- Annotate the plane of the scan, laterality, and structure(s) being imaged.
- High level decontamination is necessary after each use and the transducer used needs to be identified. Enter the transducer number (located on the connector) into the structured reporting package.
- Once the procedure is completed, the protective cover should be removed and discarded. The transducer should then be washed, placed in plastic bag and biohazard sticker attached. The transducer should then be transported to the decontamination room and processed according to Central Sterile and Reprocessing (CSR) decontamination guidelines.

C. Uterus

- Obtain representative images longitudinally and transversely of the uterus.
- Measurements of the uterine length from the fundus to the cervix and AP diameter perpendicular to the length should be documented.
- The uterine contour and any abnormalities should be documented.

- The double layer endometrial echo should also be analyzed for thickness and or focal abnormality.
- Color Doppler imaging should be performed to evaluate the endometrium.
 - If the entire uterine volume cannot be obtained transvaginally, measurements should be obtained transabdominally.

D. Ovaries & Adnexae

- Both ovaries should be measured in three dimensions and the volume recorded.
- Any abnormalities, size, echogenicity, characteristics (cystic, solid, complex) should be documented and measured.
- Color and spectral Doppler should be used to evaluate ovarian vascularity in the clinical setting when the suspicion of torsion or adnexal masses is suspected.
- Cysts which contain mural nodules/masses should have the size of them measured and images obtained. The presence or absence of vascularity within any mural nodule should be documented.

E. Cul de Sac

- Image and evaluated for the presence of free fluid or masses.

F. 3D & Cine Image Capture

- Obtain representative image of the endometrium to document contour and any questionable abnormalities.
- Also, perform a grey scale cine clip capture in sagittal and transverse planes when where the endometrial stripe appears thick on static images.
- A color cine capture should also be performed preferably in the sagittal plane.

G. Sonohysterogram (SHG)

- A pregnancy test must be performed prior to the study for women of reproductive age who have sexual relations with a male partner, and all of those patients undergoing treatment for infertility.
- This task is performed in the OB/GYN clinic prior to the Ultrasound appointment and documented in the electronic medical record.
- Perform a preliminary transvaginal ultrasound exam following the above guidelines. The ordering provider will request a comprehensive exam in the order.
- Follow Sonohysterogram (SHG) job aid for supplies and setup for this procedure.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s): email	Pamela Mazurek
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine	Version #	4
Current Approval Date:	03/29/2021	Old Document ID:	
Date Procedure to go into Effect:	03/29/2021		
Related Policies & Procedures:	Infertility Imaging Procedure - Ultrasound - Radiology		
Related Job Aids:	Sonohysterogram (SHG) Setup Job Aid - Ultrasound - Radiology		

Dept. Procedure Title	Hypertrophic Pyloric Stenosis (HPS) Imaging Procedure - Ultrasound - Radiology	Procedure ID	11470
Keywords	us, ultrasound, sonographers, sonologists, interpretation, studies, hypertrophic, pyloric stenosis, HPS		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographers and sonologists performing Hypertrophic Pyloric Stenosis Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Standard Images Required for Interpretation

- Using a linear high frequency transducer, image the pylorus in the right upper quadrant (RUQ) location.
 - Sonographic features: The suspicious area appears as a uniformly thickened, hypoechoic mass surrounding a hyperechoic center.
- Obtain measurements of the pyloric channel length (normal length <15mm length).
- Obtain transverse measurement of the single wall thickness (normal thickness <3mm).
- Obtain a cine image capture through suspicious area.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine	Version #	3
Current Approval Date:	11/04/2021	Old Document ID:	
Date Procedure to go into Effect:	11/04/2021		
Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Infertility Imaging Procedure - Ultrasound - Radiology	Procedure ID	11187
Keywords	studies, us, ultrasound, interpretation, images, imaging, infertility		
Department	Ultrasound		

I. Purpose of Procedure

To describe guidelines for performing infertility-specific Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all Sonographers and Sonologists within the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Ovulation Induction: (OI)

- Obtain the following images for Day 3, baseline or endometrial lining check:
 1. Obtain double layer endometrial echo measurement in the longitudinal axis.
 2. Obtain 3 measurements of both ovaries to determine ovarian volume.
 3. Evaluate for antral follicles of both ovaries (follicles less than 1.0 cm). Count all follicles less than 1.0 cm and record number for each ovary. The automated GE – SONOAVC option will not identify follicles under 10 mm.
 4. Measure all follicles greater than 1.0 cm – may use specific ultrasound unit enabled with follicular monitoring to evaluate (perform appropriate post-image acquisition processing).
 5. Obtain images of the cul-de-sac to assess for free fluid.
 6. Make note and record any adnexal masses seen.
- For subsequent studies, Day 7 and beyond:
 1. Obtain a longitudinal image of the uterus with an endometrial echo measurement.
 2. Use specific Ultrasound unit enabled with follicular monitoring capability.
 3. Review all sectional planes to include or exclude measurement error.
 4. **Best clinical judgement should always be used prior to saving the follicular volume and data.
 5. Obtain three orthogonal measurements of the 3 lead follicles on each ovary.
 6. Obtain images of the cul-de-sac to assess for free fluid.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Connell, Chandler; Kvinlaug, Christine	Version #	3
Current Approval Date:	10/28/2021	Old Document ID:	
Date Procedure to go into Effect:	10/28/2021		
Related Policies & Procedures:	Gynecologic Imaging Procedure - Ultrasound - Radiology		
Related Job Aids:			

Job Aid	Inter procedural Specific Laboratory Orders Verbal with Read Back Job Aid - Radiology - Ultrasound	ID	26696
Keywords	Inter procedural, Inter-procedural, Interprocedural, Laboratory, Orders, Verbal, Read, Back, Radiology, Biopsy, Biopsies, US, Ultrasound, Guided		
Department	Radiology - Ultrasound (US)		

I. Purpose

To safely care for patients scheduled for Ultrasound (US) guided elective procedures and provide direction to personnel who prescribe and implement medical orders for the provision of patient care.

- Inter procedural laboratory studies can be ordered by the Sonographer working in Mary Hitchcock Memorial Hospital when Ultrasound guided biopsies, i.e., Prostate, Native, Transplant and Musculoskeletal biopsies are performed.
- The Sonographer places procedural lab orders as specified in the attached documentation, using verbal with read back order mode in eD-H. Order(s) are placed on the scheduled procedure day after procedure consent and bedside ‘time out’ have been obtained.
- After the procedure has been completed, all orders are to be signed by attending provider (Urology, Nephrology, Transplant, or Musculoskeletal) specified as the Ordering Provider and/or Associate Provider.

Responsible Owner:	Radiology - Ultrasound	Contact:	Dennis Seguin
Approved By:	Office of Policy Support (OPS), Chandler Connell	Version #	1
Current Approval Date:	01/26/2022	Old Document ID:	
Date Policy to go into Effect:	01/26/2022		
Related Policies & Procedures:	Managing Medical Orders Policy		
Related Job Aids:			

Dept. Procedure Title	Intussusception Imaging Procedure - Ultrasound - Radiology	Procedure ID	11225
Keywords	intussusception, us, ultrasound, sonographers, sonologists, interpretation, studies		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographers and sonologists performing Intussusception Specific Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

1. Using a linear high frequency transducer, sweep from the right lower quadrant (RLQ) to the right upper quadrant (RUQ) and then across transverse colon to the left upper quadrant (LUQ) then down to the left lower quadrant (LLQ) in transverse and sagittal planes evaluating for a sonographic “bullseye” or target-like lesion.
2. Document static images in all locations.
3. Sonographic features: The suspicious area appears as a mass of concentric hyperechoic (mucosa) and hypoechoic (muscularis) layers (target appearance).
4. Obtain a cine image capture through suspicious areas.
5. If positive, obtain an image with color Doppler.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine	Version #	3
Current Approval Date:	10/26/2021	Old Document ID:	
Date Procedure to go into Effect:	10/26/2021		
Related Policies & Procedures:			
Related Job Aids:			

Job Aid	Intrauterine Device (IUD) Removal Setup Job Aid - Ultrasound - Radiology	ID:	11378
Keywords	u/s, IUD, ultrasound		
Department	Radiology, Ultrasound		

I. Purpose

To provide necessary supplies for Intrauterine device (IUD) removal procedures.

- Speculum – (have all sizes available)
- Betadine Prep
- Surgical gloves (appropriate for physician)
- Long Curved Kelley
- IUD Retriever (obtain from gynecology nurses as needed)
- Os finder
- Tenaculum
- Lidocaine Kit (local anesthesia)

Billing/ Supplies:

- Guidance only. No supplies

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents, Jean Bolger	Version #	2
Current Approval Date:	10/15/2018	Old Document ID:	NEW
Date Policy to go into Effect:	10/15/2018		
Related Policies & Procedures:			
Related Job Aids:			

Job Aid	Intrauterine Device (IUD) Placement Setup Job Aid - Ultrasound - Radiology	ID:	11377
Keywords	u/s, placement, iud		
Department	Ultrasound		

I. Purpose

To provide a list of necessary supplies for Intrauterine device placement (IUD) procedures.

- Pregnancy test if indicated
- Cotton Balls/Betadine Prep
- Surgical gloves (appropriate size for physician)
- Lidocaine Kit (local anesthesia)
- IUD sterile tray – (ask Gynecology nurse)
 - Gynecology nurse brings all necessary supplies to the exam room
- IUD – (ask Gynecology nurse for item)
- Tenaculum
- Os Finders
- Dilators
- Endometrial Biopsy Curette

Billing/ Supplies:

- Guidance only. No supplies required

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents, Jean Bolger	Version #	2
Current Approval Date:	10/15/2018	Old Document ID:	NEW
Date Policy to go into Effect:	10/15/2018		
Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Doppler Imaging of the Liver Scheduling and Imaging Procedure - Ultrasound - Radiology	Procedure ID	11380
Keywords	Doppler, liver, sonographer, sinologist, interpretation, images, studies, ultrasound, us, hepatology, protocol		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographers and sonologists performing Liver Doppler studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Scheduling

1. Requests for liver Doppler are to be performed for the clinical indications of hepatitis, cirrhosis, “liver disease,” or portal vein thrombosis.
2. Requests to evaluate TIPS patency should be scheduled \geq 10-14 days post procedure.

Abdomen Limited With Vascular - Hepatology Imaging Protocol

- (Imaging of the spleen may also be requested. Check order for clarification)

1. Liver

- Perform examination imaging per AIUM guidelines.
- Perform longitudinal and transverse views to assess the liver parenchyma for focal or diffuse abnormalities. Compare the liver echogenicity to that of the right kidney.
- Obtain images to include hepatic lobes (right, left, and caudate), inferior vena cava (IVC) and right hemidiaphragm.
- Perform measurement of the liver length in a sagittal plane at the level of the right kidney (anterior axillary line).
- Perform a minimum of (2) longitudinal and (2) transverse plane cine captures of the liver for all clinical indications of liver disease.
- Cine captures should include sagittal right and left lobes and transverse right and left lobes.

2. Gallbladder and Biliary System

- Perform examination imaging per AIUM guidelines.
- Obtain longitudinal and transverse images of the gallbladder in the supine and decubitus positions.
- Measure the gallbladder wall.
- Assess for a sonographic “Murphy’s sign.
- Evaluate for the presence or absence of intrahepatic and extrahepatic bile duct dilatation.
- Obtain measurement of the bile duct preferably over the right hepatic artery in the portal hepatitis.
- Additional imaging in the upright position may be helpful in finding small stones in the gallbladder neck.

3. Spleen

(Imaging as requested; check order for clarification).

- Perform examination imaging per AIUM guidelines.
- Obtain representative images of the spleen in the longitudinal and transverse planes.
- Perform longitudinal and transverse measurements of the spleen.
- Compare the splenic echogenicity to that of the left kidney.

4. Liver Doppler

- Perform examination imaging per AIUM guidelines.
- Perform color Doppler imaging of the main, left & right portal veins.
- Obtain color Doppler and a minimum of one (1) spectral waveform (angle corrected less than 60 degrees) in the main portal vein.
- Sample and measure the mean peak systolic velocity in the MPV and enter the value into the structured reporting package.
- Obtain 4-quadrant imaging to assess for ascites.

Abdomen Vascular Limited TIPS - Hepatology Imaging Protocol

○ **(Imaging of the spleen may also be requested; check order for clarification).**

- Perform examination imaging per AIUM guidelines.
- Imaging includes Liver, GB, CBD (spleen if requested) and Doppler interrogation.
- Perform color Doppler of the right, middle, & left hepatic veins.
- Perform color Doppler imaging of the main, left & right portal veins.
- Obtain a minimum of (1) spectral waveform (angle corrected less than 60 degrees) from the main portal vein.
- Measure and add the mean peak systolic velocity value into the structured reporting package.
- Obtain color Doppler images of the stent
- Obtain color and spectral Doppler imaging sampling at a minimum of three (3) different intervals (labeled as portal, mid, IVC end) along the stent using an angle of < 60 degrees.
- Measure and add the mean peak systolic velocity value at each level into the structured reporting package.
- Obtain 4-quadrant imaging to assess for ascites.

Abdomen Limited with Vascular - Non Hepatology Imaging Protocol - Limited RUQ Ultrasound
exam including Doppler evaluation.

- Perform examination imaging per AIUM guidelines.
- Exam includes, Liver, IVC, GB, CBD, Right Kidney, Pancreas and Doppler interrogation of the main, left & right portal veins (aorta, spleen, left kidney are excluded).
- Obtain 4-quadrant imaging to assess for ascites.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine	Version #	5
Current Approval Date:	07/28/2020	Old Document ID:	
Date Procedure to go into Effect:	07/28/2020		
Related Policies & Procedures:			
Related Job Aids:			



Hepatic Elastography Interpretation

Katy Lantz MD
Anne Silas MD

References/Resources

- Update to the Society of Radiologists in Ultrasound Liver Elastography Consensus Statement

<https://pubs.rsna.org/doi/full/10.1148/radiol.2020192437>

- Elastography Assessment of Liver Fibrosis: Society of Radiologists in Ultrasound Consensus Conference Statement

<https://pubs.rsna.org/doi/full/10.1148/radiol.2015150619>

****The following slides serve as a summary of key points****

How to perform

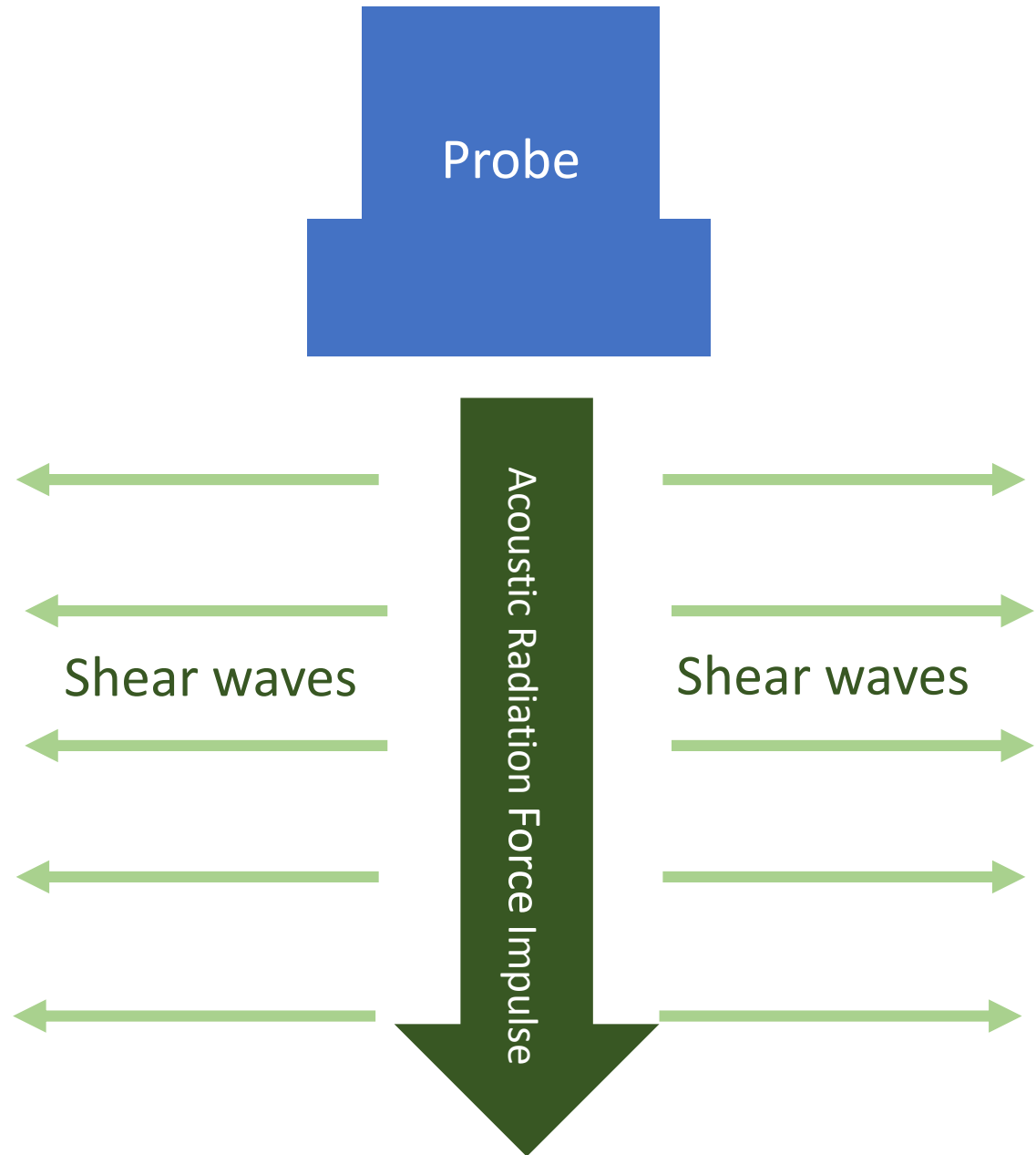
- 4hr fast
- Supine or <30 degrees left lateral decubitus
- Right arm over head
- Probe between ribs, perpendicular to liver capsule and color box
- Color box 1.5-2 cm below the capsule
 - Mitigate reverberation artifact
 - Max pulse at 4-4.5 cm, and attenuated by 6-7cm

How it works

- The probe sends out an Acoustic Radiation Force Impulse (ARFI) at 1-10 m/s.
- Shear waves spread perpendicular to the ARFI and deform the tissue
- The machine monitors the speed of the shear wave deformation.
- The machine uses Young's modulus to calculate the tissue stiffness in kPa or m/s.

$$E = 3\rho c_s^2$$

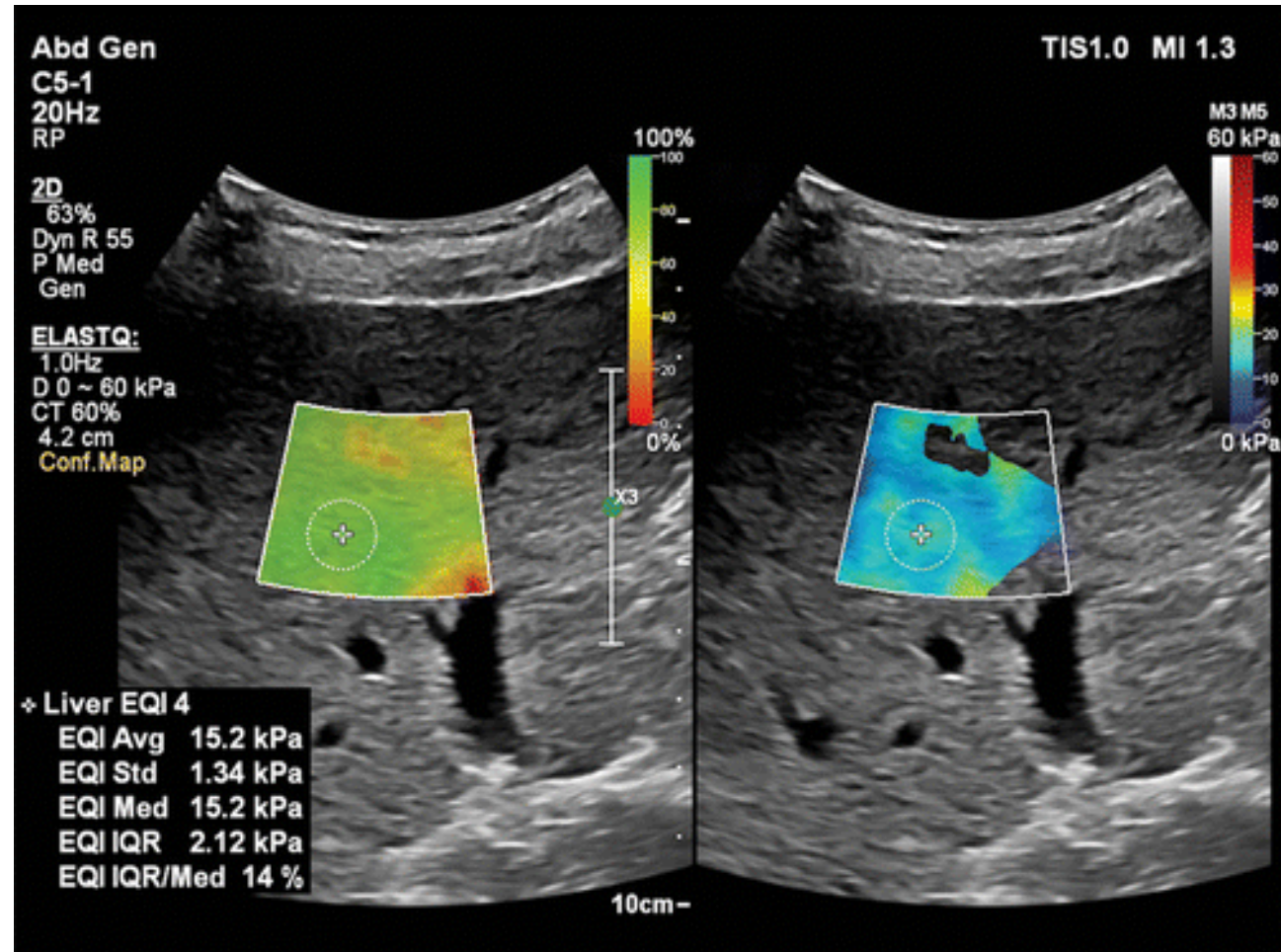
How it works



How it works

- Point shear wave elastography point shear wave (pSWE) sends one AFRI
 - The machine take the median of 10 values
- 2D sends multiple AFRI at a time
 - The machine takes the median of 5 values

Image example



IQR-to-median

- Interquartile range to median value ratio indicates quality/reliability of the study.
- You want the number to be low.
 - For kPa it should be <30%
 - For m/s it should be <15%

Rule of four for interpretation

Compensated advanced chronic liver disease (cACLD)

- Liver stiffness less than or equal to 5 kPa (1.3 m/sec) has high probability of being normal
- Liver stiffness less than 9 kPa (1.7 m/sec), in the absence of other known clinical signs, rules out cACLDV
- Values greater than 13 kPa (2.1 m/sec) are highly suggestive of cACLD

Result interpretation (rule of 4 wording)

Table 2: Recommendation for Interpretation of Liver Stiffness Values Obtained with ARFI Techniques in Patients with Viral Hepatitis and NAFLD

Liver Stiffness Value	Recommendation
≤ 5 kPa (1.3 m/sec)	High probability of being normal
< 9 kPa (1.7 m/sec)	In the absence of other known clinical signs, rules out cACLD. If there are known clinical signs, may need further test for confirmation
9–13 kPa (1.7–2.1 m/sec)	Suggestive of cACLD but need further test for confirmation
> 13 kPa (2.1 m/sec)	Rules in cACLD
> 17 kPa (2.4 m/sec)	Suggestive of CSPH

Note.—ARFI = acoustic radiation force impulse, cACLD = compensated advanced chronic liver disease, CSPH = clinically significant portal hypertension, NAFLD = non-alcoholic fatty liver disease.

**** Note if the liver is grossly cirrhotic on B-mode images than these results do not add anything.**

What can go wrong

Confounders

- ALT/AST 5x normal
- Obstructive cholestasis
- Eating recently
- Hepatic congestion
- Acute hepatitis
- Infiltrative diseases

** all falsely increase the result

Artifacts

- Reverberation from capsule
- Nearby blood vessels or bile ducts
- Not perpendicular to the liver capsule

** check B mode images for artifacts

Template report

1. Liver stiffness measurements were obtained on a [vendor, machine] following the SRU guidelines.
2. [#] valid measurements were obtained using a [point SWE or 2D SWE method].
3. The IQR-to median ratio was [#] suggesting a [quality data set or poor-quality data set].
4. The liver stiffness value was [X] suggesting [rule of 4 recommended wording]

Template report

Consider adding the following sentence(s) if appropriate

1. In the setting of [elevated liver function tests, non-fasting, vascular congestion etc] the stage of liver fibrosis may be overestimated.
2. In some patients with NAFLD, the cut-off values for cACLD may be lower (7-9 kPa)
3. In causes other than viral hepatitis and NAFLD, the cut-off values are not well established.

Departmental Policy Title	Liver Elastography Scheduling and Imaging Procedure - Radiology	Policy ID	25902
Keywords	schedule, scheduling, liver, elastography, us, ultrasound		
Department	Radiology - Ultrasound		

I. Purpose of Policy

To describe the procedures for scheduling and performing Liver Elastography Ultrasound studies. The following standard images are required for interpretation

II. Policy Scope

This scope applies to all Sonographers and Sonologists within the Ultrasound section of Dartmouth-Hitchcock – Lebanon

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Scheduling

1. Requires pre-approval from Triage before scheduling.
2. Schedule exams on the Philips EPIQ Ultrasound unit, preferably Room 2.
3. Evaluation of the liver echotexture and parenchyma (Abdomen limited exam) cannot be performed on the same day due to billing and coding guidelines.

B. Standard Images Required for Interpretation

- Position the transducer in the right intercostal space and aligned with the ribs.
- Image should avoid lung and narrow the field of view (FOV) if necessary.
- Image the liver keeping the liver capsule parallel to the transducer surface.
- Position the ROI (region of interest) box in the center of the image 1.5 - 2.0 cm below the liver capsule.
- Do not place the ROI near any liver vessels, near rib shadow, or the liver capsule.
- Ask the patient to pause breathing. Do not have them take a deep breath.

- Wait for stable image.
- Acquire a minimum of 10 samples, adding them to the scanner measurement report package.
- Print the calculations pages sending entire study to PACS.

Table 2: Recommendation for Interpretation of Liver Stiffness Values Obtained with ARFI Techniques in Patients with Viral Hepatitis and NAFLD

Liver Stiffness Value	Recommendation
≤5 kPa (1.3 m/sec)	High probability of being normal
<9 kPa (1.7 m/sec)	In the absence of other known clinical signs, rules out cACLD. If there are known clinical signs, may need further test for confirmation
9–13 kPa (1.7–2.1 m/sec)	Suggestive of cACLD but need further test for confirmation
>13 kPa (2.1 m/sec)	Rules in cACLD
>17 kPa (2.4 m/sec)	Suggestive of CSPH

Note.—ARFI = acoustic radiation force impulse, cACLD = compensated advanced chronic liver disease, CSPH = clinically significant portal hypertension, NAFLD = non-alcoholic fatty liver disease.

Liver Fibrosis Staging

Liver Fibrosis Staging	Metavir Score	kPa	m/s
Normal – Mild	F1	5.48 kPa – 8.29 kPa	1.35 m/s – 1.66 m/s
Mild – Moderate	F2	8.29 kPa – 9.40 kPa	1.66 m/s – 1.77 m/s
Moderate – Severe	F3	9.40 kPa – 11.9 kPa	1.77 m/s – 1.99 m/s
Cirrhosis	F4	> 11.9 kPa	> 1.99 m/s

V. References N/A

Responsible Owner:	Radiology - Ultrasound	Contact:	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine; Nystrom, Heidi	Version #	1
Current Approval Date:	11/22/2021	Old Document ID:	
Date Policy to go into Effect:	11/22/2021		
Related Policies & Procedures:			
Related Job Aids:			

Update to the Society of Radiologists in Ultrasound Liver Elastography Consensus Statement

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From the Department of Radiology, Northeastern Ohio Medical University, Rootstown, Ohio (R.G.B.); Department of Radiology, University of Calgary, Calgary, Canada (S.R.W.); Departments of Imaging Science, Oncology, and Biomedical Engineering, University of Rochester Medical Center, Rochester, NY (D.R.); Section of Digestive Diseases, Department of Medicine, Yale University, New Haven, Conn (G.G.T.); and Ultrasound Unit, Department of Clinical Sciences and Infectious Diseases, Fondazione IRCCS Policlinico San Matteo, University of Pavia, Pavia, Italy (G.F.). Received October 31, 2019; revision requested December 11; revision received April 2, 2020; accepted April 23. **Address correspondence to** R.G.B., Southwoods Imaging, 7623 Market St, Youngstown, OH 44512 (e-mail: rgbarr525@gmail.com).

Conflicts of interest are listed at the end of this article.

Radiology 2020; 296:263–274 • <https://doi.org/10.1148/radiol.2020192437> • Content codes: **GI** **US**

This multidisciplinary update of the Society of Radiologists in Ultrasound consensus statement on liver elastography incorporates the large volume of new information available in the literature since the initial publication. The recommended procedure for acquiring stiffness measurements is reviewed. There has been substantial improvement in the acoustic radiation force impulse (ARFI) technology—most notably the addition of a quality assessment of the shear wave propagation. Due to the efforts of the Quantitative Imaging Biomarkers Alliance, or QIBA, the variability of liver stiffness measurements between systems had decreased. There are now effective treatments for hepatitis B and hepatitis C, and follow-up after effective treatment should be based on the use of the delta change of the value obtained at viral eradication or suppression. Because the detection of compensated advanced chronic liver disease (cACLD) is very important, the new guidelines are made based on the probability of cACLD for given stiffness values. The panel recommends a vendor-neutral rule of four for interpretation for ARFI techniques. This new method simplifies interpretation of liver stiffness results and is more clinically relevant.

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This statement is an update produced by the Society of Radiologists in Ultrasound (SRU). Authors include the clinical members of the original statement and comprise society representatives and hepatologists with expertise in liver elastography in the United States and the European Union. The revision process involved identifying a panel leader (R.G.B.), who then selected relevant previous panelists to participate in the update. The panel chair and co-chair (G.F.) created a preliminary draft with recommended updates, which were reviewed by the panel. Consensus was obtained iteratively after successive reviews and revisions and finalized after review by the SRU Executive Board.

The use of shear-wave elastography (SWE) for the non-invasive assessment of liver fibrosis has grown rapidly, and substantial new information regarding disease-specific liver stiffness is available since the publication of the consensus statement of the SRU in September 2015 (1,2). Vibration-controlled transient elastography has been available for almost 20 years and has a large body of literature (3–5). Acoustic radiation force impulse (ARFI) techniques, both point SWE (pSWE) and two-dimensional (2D) SWE have been available for almost 10 years. Currently, several vendors implement ARFI technology (both pSWE and 2D SWE, which are described in detail elsewhere [2,6]) in their US equipment and provide suggestions for optimal technique and assessment of data quality. Since publication of the previous guidelines, several additional vendors have introduced ARFI techniques, and the development of quality or confidence maps have led to the ability to assess the quality of the results. With excellent, less-expensive treatments for both hepatitis C and hepatitis B, these patients are being treated regardless of the liver stiffness value.

This led to a need to update the SRU recommendations on the use of ARFI SWE for the assessment of fibrosis in patients with diffuse liver disease, as a guide for performing and interpreting the examination, taking into account the interim technology advances and published studies.

Chronic liver disease is a world-wide problem. It can be due to a wide range of inciting factors. Its major consequence is increasing deposition of fibrous tissue within the liver leading to the development of cirrhosis, which in turn may give rise to portal hypertension, hepatic insufficiency, and hepatocellular carcinoma. The stage of liver fibrosis is important to determine the prognosis, for surveillance, for prioritization for treatment, and even to determine the potential for reversibility (1,2,7–9). The spectrum of fibrosis is a continuum, and patients with a higher stage of liver fibrosis (stage F3–F4) are at risk for clinical complications (eg, ascites, variceal hemorrhage, hepatic encephalopathy). For patients with severe fibrosis or liver cirrhosis who are asymptomatic, the term “compensated advanced chronic liver disease” (cACLD) has been proposed (10,11). In patients with cACLD, the degree of portal hypertension is predictive of decompensation and/or death (10,11). A portal pressure (as assessed by means of the hepatic venous pressure gradient) of 10 mm Hg or higher (normal, 3–5 mm Hg)—a threshold that is designated “clinically significant portal hypertension” (CSPH)—has been associated with an almost four-fold higher risk of decompensation compared with lower pressures (12).

Many clinical guidelines recommend the use of non-invasive tests for the detection and staging of liver fibrosis (3,5,13,14). Although biopsy is historically the reference standard for staging fibrosis, it is imperfect, with

Abbreviations

ARFI = acoustic radiation force impulse, cACLD = compensated advanced chronic liver disease, CSPH = clinically significant portal hypertension, IQR = interquartile range, NAFLD = non-alcoholic fatty liver disease, pSWE = point SWE, SRU = Society of Radiologists in Ultrasound, SWE = shear wave elastography, 2D = two-dimensional

Summary

To follow-up patients, the consensus suggests using the delta changes of liver stiffness over time instead of the absolute values, using as a baseline value in case of viral hepatitis that obtained after viral eradication or suppression.

Key Results

- The variability between consecutive liver stiffness acquisitions, assessed by means of the interquartile range-to-median ratio, is the most important quality criterion; when this ratio is higher than 30% for measurements given in kilopascals or higher than 15% for measurements given in meters per second, the accuracy of the technique is reduced.
- Given the large overlap of stiffness values for mild-to-moderate fibrosis, the Society of Radiologists in Ultrasound continues to recommend a low cutoff value below which there is a high probability of no or mild fibrosis and recommends a high cut-off value above which there is a high probability of compensated advanced chronic liver disease (cACLD).
- Because the overlap of liver stiffness values between METAVIR scores is as large if not larger than the difference between vendors, separate cut-off values for each vendor are not required.
- The panel recommends a vendor-neutral “rule of four” for the acoustic radiation force impulse techniques in the viral causes and non-alcoholic fatty liver disease (NAFLD): Liver stiffness less than or equal to 5 kPa (1.3 m/sec) has high probability of being normal, liver stiffness less than 9 kPa (1.7 m/sec), in the absence of other known clinical signs, rules out cACLD, and values greater than 13 kPa (2.1 m/sec) are highly suggestive of cACLD; in some patients with NAFLD, the cut-off values for cACLD may be lower and follow-up or additional testing in those with values between 7 and 9 kPa is recommended.
- For pediatric patients with liver disease or congenital heart disease with Fontan surgery, it is expert opinion that each patient becomes his or her own control, and the stiffness delta changes over time should be used to evaluate the efficacy of the treatment or the progression of disease.

considerable interobserver variability and κ values varying from 0.5 to 0.9 in the literature (15,16). It should be emphasized, however, that histologic examination of liver specimens does provide information on inflammation that is not yet possible to evaluate with US. Despite this benefit, the use of noninvasive tests is favored due to the need for longitudinal monitoring and to safely extend screening to larger populations.

There are many different causes of chronic liver disease worldwide. Chronic viral hepatitis (hepatitis C in the West, hepatitis B in the East) remains a major risk factor. Although the incidence of cACLD may be lower because of the advent of highly effective interferon-free antiviral therapies, staging of liver fibrosis is still necessary before treatment because patients with cACLD require continued surveillance for hepatocellular carcinoma and/or varices even after the clearance of the virus (17,18).

A rising cause of chronic liver disease worldwide is nonalcoholic fatty liver disease (NAFLD). NAFLD is currently the most common liver disease in the United States, with a worldwide

prevalence of 25% with imaging estimation (19). NAFLD ranges from simple steatosis to nonalcoholic steatohepatitis, which may progress to liver fibrosis and cirrhosis with its complications. Although there is no specific therapy for nonalcoholic steatohepatitis, lifestyle modifications have been associated with a decrease in fibrosis and portal hypertension (20,21), and identification of cACLD allows for screening and surveillance of varices and hepatocellular carcinoma. Therefore, the availability of non-invasive tools to exclude or diagnose cACLD in these patients is of the utmost importance.

Protocol for ARFI SWE Acquisition

The patient preparation, imaging technique, and measurement recommendations for ARFI SWE (both pSWE and 2D SWE) are the same, and the recommended protocol in the original SRU consensus is unchanged and similar to the European Federation of Societies for Ultrasound in Medicine and Biology and World Federation for Ultrasound in Medicine and Biology guidelines (3,5). The protocol includes obtaining measurements between the ribs in the right upper quadrant, instructing the patient to fast for at least 4 hours, imaging the patient in a supine or slight left lateral decubitus position (not more than 30°) with their right hand above their head, obtaining measurements in a neutral breath hold, placing the transducer perpendicular to the liver capsule and the measurement box parallel to the liver capsule, and taking measurements 1.5–2.0 cm from the liver capsule to avoid reverberation artifact. A brief outline of how to perform the examination is included in Table 1.

Because B-mode is used to track the shear waves, high-quality B-mode imaging is required. Images should be free of artifacts. Several studies have shown that operators require only a short period of training to perform reliable liver stiffness measurements; however, the reproducibility of liver stiffness measurements over time is higher for expert operators than for novice operators (22–24).

Quality Criteria

The recommended quality criteria include the number of required acquisitions and the interquartile range (IQR)-to-median ratio (subsequently referred to as IQR/M). Furthermore, some vendors provide a quality or confidence factor for measurements obtained with 2D SWE. Some vendors also provide an assessment of the quality of each measurement for pSWE. Each vendor has recommendations for use of their quality criteria.

Obtaining Measurements

Measurements should be obtained in areas of high quality, which is determined by a high amplitude of the shear waves, a normal shear-wave propagation, and a linear slope of the time of the peak and distance from ARFI pulse of the displacement curves. Each vendor provides a confidence or quality number or map that combines these factors into one number for clinical use. Figure 1 demonstrates various methods used to assess the quality of an image. If the quality is poor in most of the image, a measurement should not be obtained from that image.

Table 1: Recommendations for Performing Liver Stiffness Measurements with the ARFI Technique

Recommendations

1. Patients should fast at least 4 hours before the examination
2. Measurement should be taken at an intercostal space with the patient in the supine or slight lateral decubitus (30°) position with right arm in extension
3. Measurements should be taken at neutral breathing during a breath hold
4. Measurement should be taken at least 15–20 mm below liver capsule in pSWE
5. The 2D SWE region of interest can be positioned closer to the liver capsule, if reverberation artifacts are avoided; however, the measurement box should be positioned at least 15–20 mm below the liver capsule
6. Results can be reported in meters per second or in kilopascals
7. In most systems, the maximum ARFI push pulse is at 4–4.5 cm from the transducer, which is the optimal location for obtaining measurements. In most systems, the ARFI push pulse is attenuated by 6–7 cm, limiting adequate shear wave generation
8. Major potential confounding factors include liver severe inflammation indicated by AST and/or ALT elevation greater than five times upper normal limits, obstructive cholestasis, liver congestion, acute hepatitis, and infiltrative liver disease (these all lead to overestimation of the stage of fibrosis)
9. Ten measurements should be obtained with pSWE, and the final result should be expressed as the median together with the IQR/M
10. Fewer than 10 measurements with pSWE can be obtained (at least five); however, the IQR/M should be within the recommended range
11. For 2D SWE, five measurements should be obtained when the manufacturer's quality criteria are available, and the final result should be expressed as the median together with the IQR/M
12. The most important reliability criterion is an IQR/M of $\leq 30\%$ of the 10 measurements (pSWE) or five measurements (2D SWE) for kilopascals and $\leq 15\%$ for measurements in velocity (in meters per second)
13. Adequate B-mode liver imaging is a prerequisite for point and 2D SWE as shear waves are tracked with B-mode

Note.—ALT = alanine aminotransferase, ARFI = acoustic radiation force impulse, AST = aspartate aminotransaminase, IQR/M = interquartile range-to-median ratio, pSWE = point SWE, SWE = shear-wave elastography, 2D = two-dimensional.

Number of Measurements

pSWE.—Ten measurements are still recommended; however, studies have shown that there is no loss in accuracy with five measurements when the quality criterion of IQR/M is fulfilled (25–28). In the study by Fang et al (25), six measurements were recommended; however, when only the values obtained with a high reliability (IQR/M, $\leq 30\%$) were considered, there was no difference between five and six measurements.

Two-dimensional SWE.—The measurement area is larger than that with pSWE, and thus each value is an average of several measurements. Hence, five measurements are adequate if a quality assessment is provided by the manufacturer. If a quality assessment is not available, 10 measurements are recommended.

IQR/M Values

Studies have shown that the level of variability between consecutive acquisitions, assessed by means of the IQR/M, is the most important quality criterion. When this ratio is higher than 30% (for measurements given in kilopascals), the accuracy of the technique is reduced (3,25,27). It is important to note that the IQR/M for measurements reported in kilopascals should be 30% or less, whereas that for measurements reported in meters per second (shear wave speed) should be 15% or less as the conversion of meters per second to kilopascals is nonlinear. If the IQR/M values are greater than 30% in kilopascals or 15% in meters per second, the measurement of liver stiffness should be judged as unreliable.

Cut-off Values

Cut-off values for fibrosis staging vary across US systems from different vendors; however, the variance has decreased due to the efforts of the Quantitative Image Biomarker Alliance, or QIBA (29,30). QIBA (an RSNA organization with vendors, scientists, members of the U.S. Food and Drug Administration, and clinicians) developed standardized phantoms that the vendors have used to standardize their measurements. The difference between various system measurements increases as liver stiffness increases. The difference in cut-off values is greatest as patients exceed the threshold of cACLD (31).

Given the large overlap of stiffness values for mild-to-moderate fibrosis, the SRU continues to recommend a low cut-off value below which there is a high probability of no or mild fibrosis and recommends a high cut-off value above which there is a high probability of cACLD. In this update, a new cut-off value to rule out CSPH has been added on the basis of some recent studies (32–35). The consensus panel also divides the liver stiffness values between no or minimal disease and cACLD into two categories. For these middle liver stiffness values, confirmation with an additional test may be needed to rule in or rule out cACLD. From a clinical perspective, it is more important to rule in or rule out significant disease than it is to provide an exact stage by using the METAVIR scoring system. Because of the large liver stiffness value overlap of METAVIR scores (1), which is greater than the measurement variability between vendors (31), separate cut-off values for each vendor are not required. Based on some published studies and mirroring the Baveno VI consensus conference (10,11), that is, the so-called “rule of five” (5, 10, 15, 20 kPa)

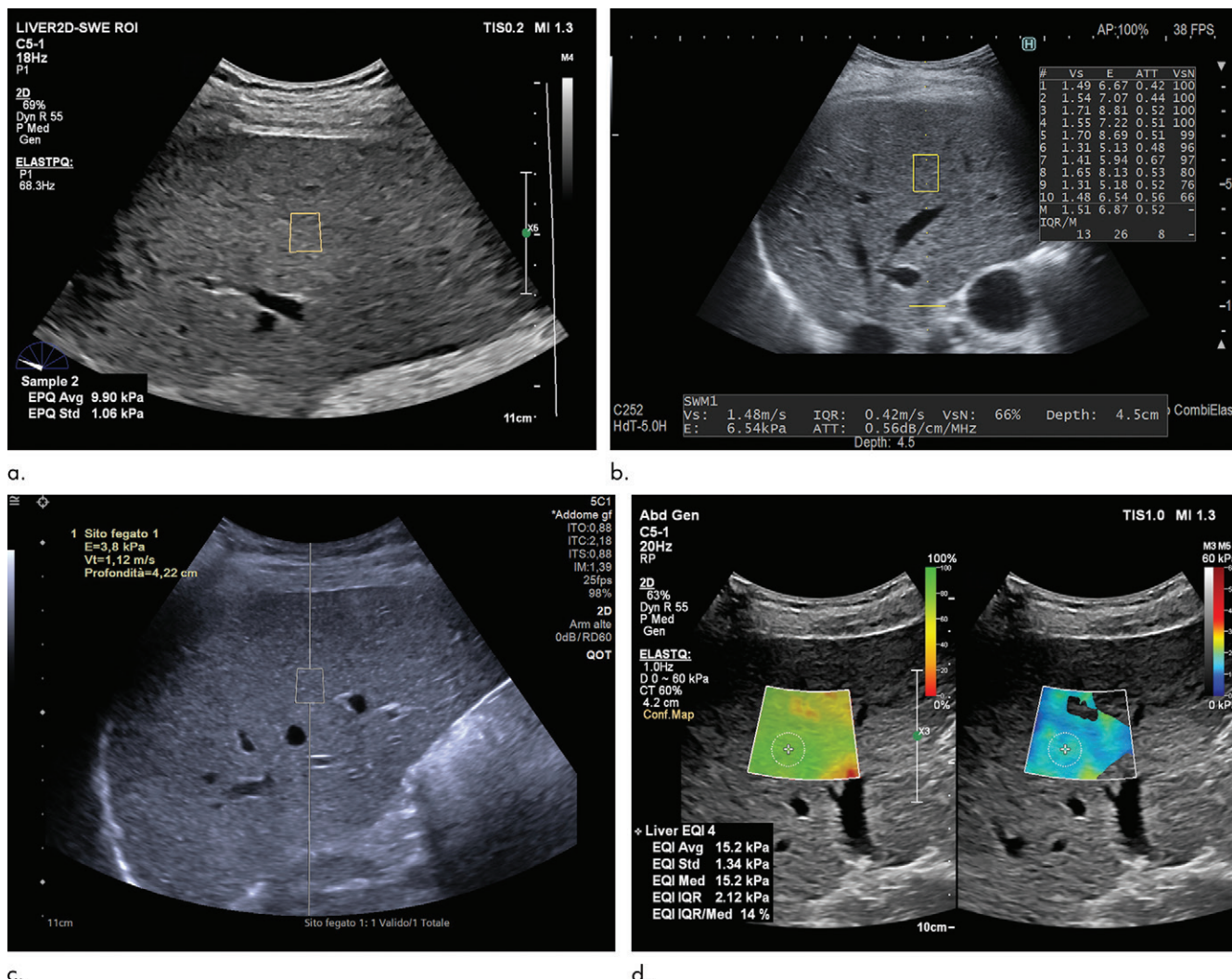


Figure 1: (a) Image obtained with point shear-wave elastography (pSWE) system (ElastPQ; Philips, Bothell, Wash). A standard deviation (Std) of 30% or less of the mean value is indicative of an acquisition of good quality. In this case, the standard deviation is 1.06/9.90 or 10.7%. When the signal-to-noise ratio of an acquisition is very low, the mean value is not shown. (b) Image obtained with pSWE (SWM; Hitachi, Tokyo, Japan). "VsN" is a reliability index that indicates the percentage of effective push-track sequences. When the signal-to-noise ratio of an acquisition is very low, the mean value is not shown. A good acquisition has a VsN of at least 50%. In this case, the VsN measurements are all above 66%. (c) Image obtained with pSWE (VTQ; Siemens, Mountain View, Calif). The system automatically filters out the measurements that are not good. In these cases, the numeric value of shear-wave speed is replaced by an "XXX" sequence. (d) Images obtained with two-dimensional (2D) shear-wave elastography (SWE) (EQI, Philips). The color-coded confidence map (left) is an evaluation of the quality of the acquired signals. The confidence threshold (CT) is set at 60%: Areas of low quality (red) are filtered out and left blank on the color-coded image of liver stiffness assessment (right); the yellow color on the confidence map is a warning, that is, it indicates that the acquisition in that area is not the highest quality (Fig 1 continues).

for the staging of liver fibrosis with vibration-controlled transient elastography, the consensus panel proposes a vendor-neutral "rule of four" (5, 9, 13, 17 kPa) for the ARFI techniques for viral etiologies and NAFLD: Liver stiffness of 5 kPa (1.3 m/sec) or less has high probability of being normal; liver stiffness less than 9 kPa (1.7 m/sec), in the absence of other known clinical signs, rules out cACLD; values between 9 kPa (1.7 m/sec) and 13 kPa (2.1 m/sec) are suggestive of cACLD but may need further test for confirmation; and values greater than 13 kPa (2.1 m/sec) are highly suggestive of cACLD. There is a probability of CSPH with liver stiffness values greater than 17 kPa (2.4 m/sec), but additional patient testing may be required. In some patients with NAFLD, the cut-off values for cACLD may be lower and follow-up or additional testing in those with values between 7 and 9 kPa is recommended.

For other causes such as alcoholic hepatitis, primary biliary cirrhosis, Wilson disease, autoimmune hepatitis, sclerosing cholangitis, and drug-induced liver disease, there is insufficient data to make a conclusion.

Table 2 summarizes these cut-off value recommendations and provides them in both kilopascals and meters per second. For those who would like a value to rule out significant fibrosis, most studies that used ARFI (pSWE and 2D SWE) suggest that a liver stiffness value of less than 7 kPa (1.5 m/sec) can help rule out significant fibrosis.

With vibration-controlled transient elastography, the alanine aminotransferase-adapted cut-off values of liver stiffness reportedly improved the staging of liver fibrosis in patients with chronic hepatitis B in a single study (36). The consensus

Top Image Data:

Q-Box Liver	
Nb Q-Box =	9
Average	8.6 kPa
Average	1.7 m/s
Median	8.6 kPa
Median	1.7 m/s
SD	0.8 kPa
SD ₀	0.1 m/s
IQR	0.9 kPa
IQR	0.1 m/s

Bottom Image Data:

+Q-Box Liver 9	
Mean	8.9 kPa
SD	0.4 kPa
Mean	1.7 m/s
SD	0.0 m/s
Depth	4.0 cm
Diam	15.00 mm
SI	96%

Figure 1 (continued): **(e)** Images obtained with 2D SWE (STE; Mindray, Shenzhen, China). Two quality criteria are provided: the motion stability (M-STB) index, which is indicated by stars (with the highest stability shown with five green stars), and the reliability (RLB) map, which goes from purple to green—with the latter indicating the highest reliability. The stars are an indicator of motion during the acquisition. When there are fewer than four stars, there is significant motion during the acquisition and that frame should not be used for liver stiffness measurement. **(f)** Images obtained with 2D SWE (Aplio; Canon, Tochigi, Japan). The system filters out values with a low signal-to-noise ratio, and these areas are left blank. The proprietary quality parameter is the propagation map (right). A proper propagation map is displayed with parallel lines, with the intervals between the lines constant. The propagation map is used to guide placement of the measurement box. Image on left is velocity map. **(g)** Images obtained with 2D SWE (SSI; SuperSonic, Aix-en-Provence, France). Values with a low signal-to-noise ratio are filtered out. The stability index (SI) is an indicator of temporal stability, and it is displayed while positioning the measurement box (Q-Box). An acquisition of good quality should have a stability index greater than 90%. Top image is velocity map, and bottom image is B-mode image.

Liver Stiffness Value	Recommendation
≤5 kPa (1.3 m/sec)	High probability of being normal
<9 kPa (1.7 m/sec)	In the absence of other known clinical signs, rules out cACLD. If there are known clinical signs, may need further test for confirmation
9–13 kPa (1.7–2.1 m/sec)	Suggestive of cACLD but need further test for confirmation
>13 kPa (2.1 m/sec)	Rules in cACLD
>17 kPa (2.4 m/sec)	Suggestive of CSPH

panel therefore does not recommend alanine aminotransferase-adapted cut-offs until additional publications confirm its usefulness. The updated World Federation of Ultrasound in Medicine and Biology guidelines provide a detailed review of the literature for several of the causes that progress to chronic liver disease and associated confounding factors (3).

There are several clinical conditions in which an increase of liver stiffness unrelated to liver fibrosis can be observed

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Table 3: Recommendations for Performing Spleen Stiffness Measurements with the ARFI Technique

Recommendations

1. Patients should fast at least 4 hours before the examination (56)
2. Measurement should be taken at an intercostal space with the patient in supine position with left arm in extension
3. Measurements should be taken during breath hold at neutral breathing (57)
4. Measurement should be taken at least 15 mm below spleen capsule with pSWE and reverberation artifacts avoided with 2D SWE. The region of interest should be placed perpendicular to the splenic surface
5. Results can be reported in meters per second or kilopascals
6. In most systems, the maximum ARFI push pulse is at 4–4.5 cm from the transducer, which is the optimal location for obtaining measurements. In most systems, the ARFI push pulse is attenuated by 6–7 cm, limiting adequate shear wave generation
7. Ten measurements should be obtained with pSWE, and the final result should be expressed as the median together with the IQR/M
8. For 2D SWE, five measurements should be obtained, and the final result should be expressed as the median together with the IQR/M
9. The most important reliability criteria is a IQR/M of $\leq 30\%$ of the recommended measurements for kilopascals and $\leq 15\%$ for meters per second

Note.—ARFI = acoustic radiation force impulse, IQR/M = interquartile range-to-median ratio, pSWE = point SWE, SWE = shear-wave elastography, 2D = two-dimensional.

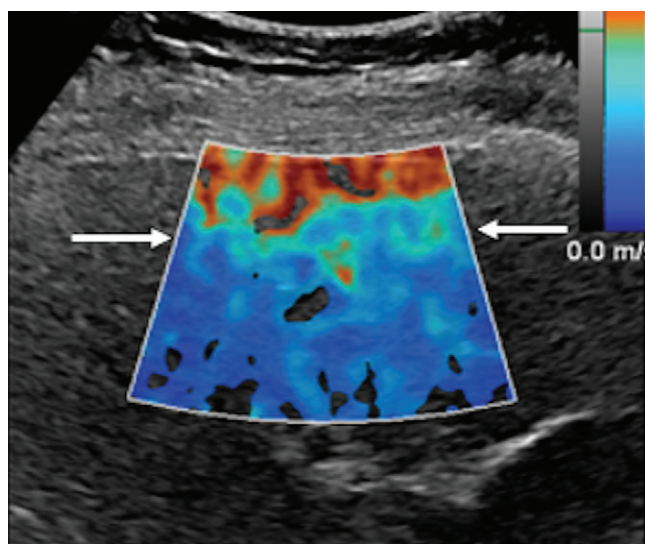


Figure 2: Image obtained with two-dimensional (2D) shear-wave elastography (SWE) demonstrates area of increased stiffness (red and teal, arrows) due to reverberation artifact. The reverberation artifact occurs below the liver capsule in both point SWE (pSWE) and 2D SWE. In pSWE, the artifact is not seen; therefore, it is important to obtain measurements at least 1.5 cm below the liver capsule to avoid the artifact. This area should be avoided when placing the measurement box for liver stiffness measurements.

Follow-up

In patients with chronic hepatitis B virus or hepatitis C virus who have been successfully treated with antiviral drugs, the cut-offs obtained in viremic patients should not be used because a rapid decline of stiffness values has been observed in these patients, likely due to the decrease of liver inflammation (3,5). When liver cirrhosis is evident with B-mode findings, elastography should not be used to rule out the disease because a value in the low range of liver stiffness may only indicate a successful response to antiviral treatment.

On the basis of results of both prospective and retrospective studies with more than 1000 patients (37–41), the delta change

of liver stiffness values over time should be used instead of the absolute values (37–40,42). Thus, every patient becomes his or her own control. Because there is an approximately 10% variability of the measurements within a vendor and between vendors (29,30), a clinically significant change should be considered when the delta change is greater than 10%. The panel recommends using the same equipment for follow-up studies. In patients with chronic viral hepatitis who are successfully treated, the baseline liver stiffness should be that obtained after viral eradication or suppression. Applying this rule, liver stiffness assessment can be suitable for evaluating all clinical conditions leading to an increase of liver stiffness, independent of the disease etiology including nonfibrotic causes of liver stiffness increase, such as congestive heart failure.

Spleen Stiffness

It has been reported that liver stiffness correlates with the severity of liver fibrosis up to the threshold of CSPH, defined as an increase in hepatic venous pressure gradient greater than 10 mm Hg (43). In patients with CSPH, the strength of the correlation between liver stiffness and fibrosis decreases, probably due to an increasing role played by extrahepatic factors, mainly the increase in portal venous inflow, as portal hypertension progresses (10,44). The acquisition technique is the same as that for liver, except the measurements are taken between the left ribs with the patient in a supine or slight right lateral position. It is the opinion of the expert panel that adequate studies have not been performed to provide cut-off values at this time. A review of the existing literature is provided below. In patients with chronic liver disease, splenic measurements should only be taken in patients with cACLD as significant portal pressures are not expected at lower levels of fibrosis.

CSPH is predictive of the development of complications of cirrhosis, including variceal rupture and death. However, it is also present in about 50%–60% of patients with compensated cirrhosis without gastroesophageal varices (12,45). It appears that spleen stiffness shows better correlation with portal pressure than does liver stiffness (46). Portal hypertension leads to splenic

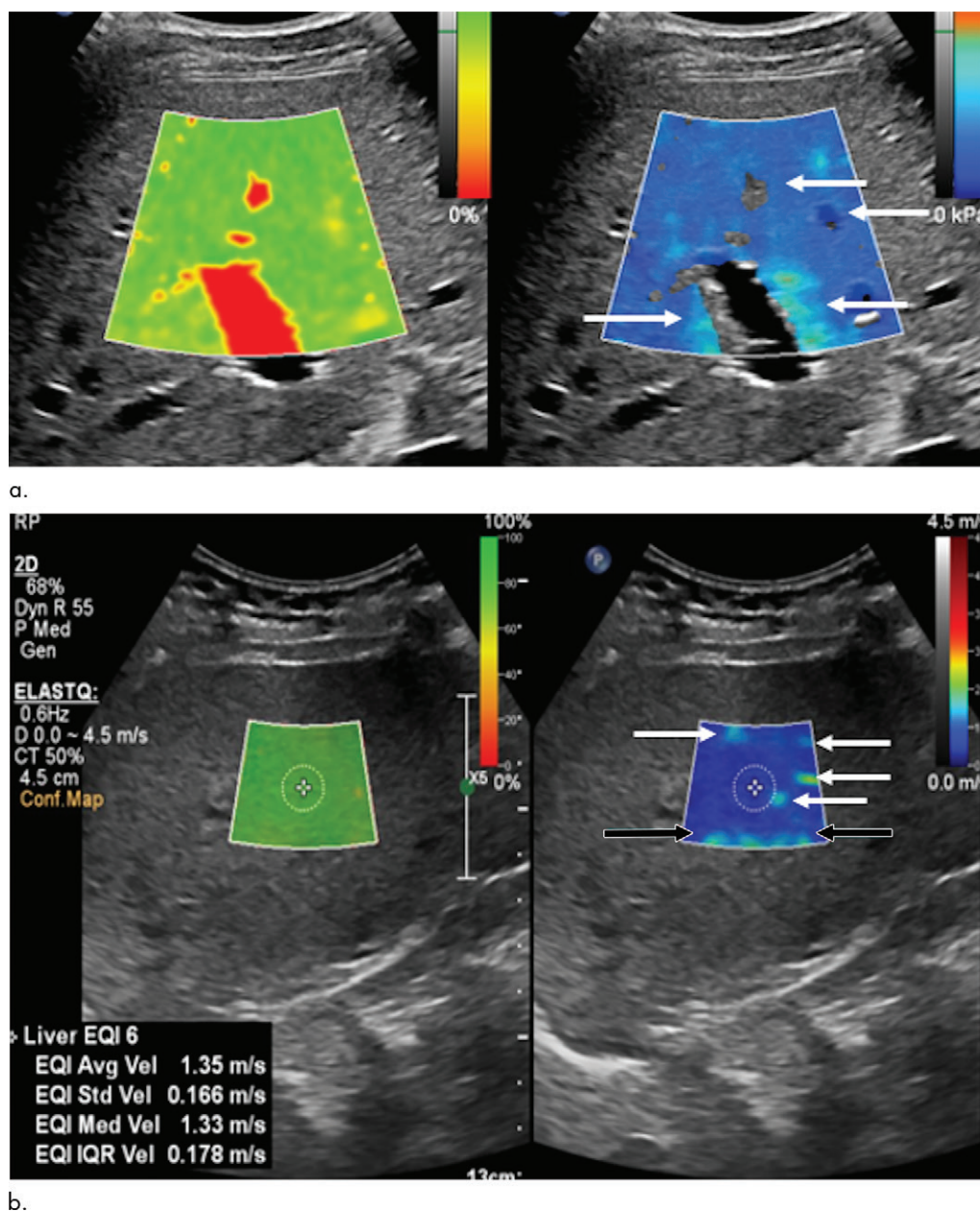


Figure 3: (a) Artifacts occur around large blood vessels and bile ducts. These artifacts are not seen in point shear-wave elastography (SWE), and therefore measurements should be obtained at least 5 mm from these structures. In two-dimensional SWE, these artifacts can be identified and avoided. Image on right is velocity map, and image on left is quality map. Arrows indicate artifacts. Depending on the vendor, artifacts may not be color-coded or appear as areas of increased stiffness (teal). These areas should be avoided when placing the measurement box. (b) Shear-wave propagation occurs in all directions perpendicular to the acoustic radiation force impulse (ARFI) pulse. Therefore, artifacts from a blood vessel just out of the image plane can also produce artifacts. Velocity image (right) shows artifacts in teal (white arrows). These artifacts are most likely from vessels just out of the image plane. The measurement box should not include these areas. Black arrows point to teal areas at the deep part of the image. These are artifacts from the ARFI pulse strength decreased due to attenuation, leading to weak shear waves that make it difficult to obtain accurate estimates of shear-wave speed. Note that the quality map (left) in this case suggests high quality throughout the field of view. The quality map does not identify all artifacts, and both the quality map and velocity map should be evaluated for artifacts.

congestion, increasing splenic stiffness. In fact, portal hypertension may cause splenic fibrosis (47).

In healthy individuals, the spleen is stiffer than the liver. Several studies, most of which were performed with vibration-controlled transient elastography, have shown that, in patients with portal hypertension, spleen stiffness is more reliable than liver stiffness for assessing the risk of CSPH and esophageal varices (46,48–50).

However, there are differences in cut-off values between studies, and the level of evidence is still too low to recommend spleen stiffness in the diagnostic work-up of patients with cirrhosis.

For ARFI-based techniques, limited studies suggest that abdominal wall thickness and splenic longitudinal diameter are independent predictors of successful spleen stiffness measurement (51,52). The feasibility of performing spleen

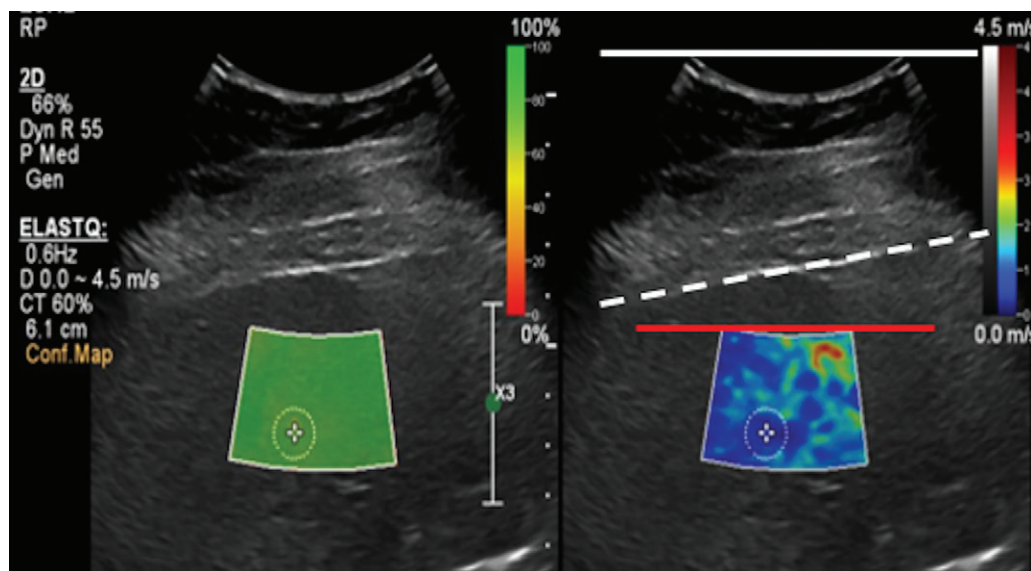


Figure 4: Images from two-dimensional shear-wave elastography. Image on left is confidence map, and image on right is velocity map. When the acoustic radiation force impulse pulse is not perpendicular to the liver capsule, artifacts occur. In this case, the liver capsule (dashed white line) is not parallel to the transducer (solid white line) or the field-of-view box (red line). The heterogeneous stiffness measurements in the field of view are due to artifacts occurring because the three lines are not parallel.

Suggested Reporting for Liver Stiffness Measurements

Liver stiffness measurements were obtained on a (list vendor and machine) using a (list probe) following the SRU guidelines. (# number of) valid measurements were obtained using a (point SWE or 2D SWE) method. The IQR-to-median ratio was (x), suggesting a (quality data set or poor-quality data set). The liver stiffness value was (X), suggesting (rule of 4 recommended wording). Consider adding the following sentence(s) if appropriate: In the setting of (elevated liver function tests, nonfasting, vascular congestion, etc), the stage of liver fibrosis may be overestimated; In some patients with NAFLD, the cut-off values for cACLD may be lower (7–9 kPa); In causes other than viral hepatitis and NAFLD, the cut-off values are not well established.

Figure 5: Suggested reporting format for liver stiffness measurements. cACLD = compensated advanced chronic liver disease, IQR = interquartile range, NAFLD = non-alcoholic fatty liver disease, SWE = shear wave elastography, SRU = Society of Radiologists in Ultrasound, 2D = two-dimensional.

stiffness measurement was evaluated by Procopet et al (53) in 88 patients undergoing hepatic venous pressure gradient measurement for portal hypertension. The overall success rate of obtaining an accurate measurement, defined as the system being able to estimate a stiffness value, was 66%. In that series, the patients with failure of spleen stiffness had higher body mass index (mean, $28.3 \text{ kg/m}^2 \pm 5.0$ vs $25.2 \text{ kg/m}^2 \pm 3.7$; $P = .002$) and smaller spleen (mean bipolar diameter, $11.8 \text{ cm} \pm 2.7$ vs $14.2 \text{ cm} \pm 4.0$; $P < .0001$). In a series composed of 313 consecutive patients who underwent liver stiffness and spleen stiffness measurements on the same day (52), the success rate of spleen stiffness measurement was 80% in patients with splenomegaly. Technical success of spleen stiffness measurements was 78% in another small series (54), including 54 patients with cirrhosis who either had low-grade esophageal varices or were without esophageal varices at upper endoscopy.

Normal values of spleen stiffness with ARFI-based techniques in published studies range from 20.5 kPa (2.6 m/sec) to 24.4 kPa (2.85 m/sec) (52,53,55). The suggested procedure

for performing spleen stiffness measurement is presented in Table 3.

With use of pSWE, investigators in one study reported a higher incidence of esophageal variceal bleeding in patients with a spleen stiffness value of at least 39 kPa (3.64 m/sec); no bleeding occurred in patients with spleen stiffness less than 36 kPa (3.48 m/sec) (58). With use of 2D SWE, other investigators showed that CPSH is unlikely in patients with spleen stiffness less than 26.6 kPa (3.0 m/sec) (35). Algorithms that combine liver stiffness and spleen stiffness, or platelets count, have been proposed (59).

In a multicenter study in which liver stiffness and spleen stiffness were available in 109 patients undergoing hepatic venous pressure gradient measurement, liver stiffness of 16.0 kPa (2.3 m/sec) or less and spleen stiffness of 21.7 kPa (2.7 m/sec) or less were able to help rule out CSPH, whereas liver stiffness values greater than 29.5 kPa (3.2 m/sec) and spleen stiffness values greater than 35.6 kPa (3.5 m/sec) were able to help rule in CSPH (specificity, $>92\%$). In patients with liver stiffness of 38.0 kPa (3.6 m/sec) or less, a splenic stiffness greater than 27.9 kPa (3.2 m/sec) ruled in CSPH. This algorithm had a sensitivity of 89.2% and a specificity of 91.4% to rule in CSPH (41). However, in a series of 191 patients (60), this algorithm has not been validated: Specificity and positive predictive value were 52% and 83%, respectively.

Interestingly, it has been reported that patients with hepatitis C virus hepatitis successfully treated with antiviral drugs show a rapid decline of liver stiffness but not of spleen stiffness because there is not an immediate effect on portal hypertension. Spleen stiffness is more accurate in assessing portal hypertension in this setting. Therefore, the risk of variceal hemorrhage remains in the short term (61).

Table 4: Summary of Recommendations

Protocol for acquisition: As reported in Table 1, the most important criterion is $IQR/M \leq 30\%$ for values in kilopascals and 15% for values in meters per second. In pediatric patients, the same protocol must be used

Protocol for 2D SWE acquisition in children who are unable to hold their breath: The consensus panel suggests recording a 2D SWE cine loop for up to 30 seconds if real-time 2D SWE is available, reviewing it, and choosing the image that demonstrates the most stable pattern for the stiffness measurement. No more than one image should be chosen in each recorded cine loop

Cut-off values: “rule of four” (5, 9, 13, 17 kPa) for the ARFI techniques for viral causes and NAFLD (Table 2)

NAFLD and rare diseases in pediatric patients: The number of published pediatric studies of NAFLD remains low, and the cutoff values for staging liver fibrosis varies between studies. It is expert opinion that each patient becomes his or her own control, using the stiffness delta changes over time to evaluate the efficacy of the treatment or the progression of disease—remembering that the measurement reflects stiffness and not fibrosis

Follow-up: The use the delta changes of LS values over time should be used instead of the absolute values. In patients with chronic viral hepatitis who are successfully treated, the baseline LS stiffness should be that obtained after viral eradication or suppression. A clinically significant change should be considered when the delta change is greater than 10%. Applying this rule, LS assessment can be suitable for evaluating all clinical conditions leading to an increase of LS, independent of the disease cause including nonfibrotic causes of LS increase (eg, congestive heart failure)

Spleen stiffness: It appears that spleen stiffness is better correlated with portal pressure than LS. However, there are differences in cut-off values between studies and the level of evidence is still low to recommend spleen stiffness in the diagnostic work-up of patients with cirrhosis

Reporting: The report should include the system vendor name, the SWE technique (pSWE or 2D SWE), the probe used, the number of acquisitions, the IQR/M , and conclusions (Fig 5)

Note.—ARFI = acoustic radiation force impulse, IQR/M = interquartile range-to-median ratio, LS = liver stiffness, NAFLD = non-alcohol-related fatty liver disease, pSWE = point SWE, SWE = shear-wave elastography, 2D = two-dimensional.

Pediatric Patients

The use of a noninvasive technique for staging liver fibrosis is of great interest because it may avoid liver biopsy, which, in addition to its well-known complications, is particularly stressful for pediatric patients. In the pediatric age group, NAFLD is the most common cause of chronic liver disease. A 2015 meta-analysis (62) determined that the pooled mean prevalence of NAFLD in the United States was 7.6% in the general U.S. pediatric population and that it reached 34.2% in obese children. In one study of 347 children suspected of having NAFLD who were identified through screening in primary care and referral to pediatric gastroenterology, advanced fibrosis was present in 17% of 193 children diagnosed with NAFLD at liver biopsy. Conversely, in 242 consecutive adolescents undergoing bariatric surgery, the prevalence of NAFLD was 58.8%, and 6% of the cohort had definite nonalcoholic steatohepatitis. Fibrosis was mild: 81% had none, while 18% had stage 1 or 2 fibrosis (63,64).

The use of noninvasive techniques in this population is particularly appealing. However, the number of published pediatric studies of NAFLD to date remains low and the cut-off values for staging liver fibrosis vary between studies (65).

For liver stiffness assessment, the procedure used for adults should be adopted. In children who are unable to hold their breath, the consensus panel suggests recording a 2D SWE cine loop for up to 30 seconds if real-time 2D SWE is available, reviewing it, and choosing the image demonstrating the most stable pattern for the stiffness measurement. No more than one image should be chosen in each recorded cine loop.

For ARFI-based techniques, most published studies have shown that age has no significant influence on liver stiffness values (66–68). However, there is not enough literature at this time for the panel to recommend the rule of four for NAFLD in pediatric patients.

The mean normal shear-wave velocity value ranges from 1.07 to 1.16 m/sec (66–68).

For liver disease associated with cystic fibrosis, autoimmune hepatitis, biliary atresia and the Kasai procedure, or congenital heart disease with Fontan surgery or even NAFLD or viral hepatitis, it is expert opinion that each patient becomes his or her own control, using the stiffness delta changes over time to evaluate the efficacy of the treatment or the progression of disease—remembering that the measurement reflects stiffness and not fibrosis. Results must always be interpreted considering transaminase values and clinical condition.

Steatosis Assessment

Liver fat content has also been evaluated by using US-based methods. Several studies have demonstrated proof of concept. Although there is insufficient evidence at this time to provide recommendations regarding the use of US-based methods in this setting, early work suggests that these methods will be clinically useful (69–73).

Artifacts

Artifacts are common in ARFI-based techniques and can significantly change the liver stiffness value. It is important to recognize and avoid these artifacts (eg, liver capsule reverberation artifact [Fig 2], ARFI push artifacts, artifacts from blood vessels [Fig 3], and the artifact that occurs when the transducer is not parallel to the liver capsule [Fig 4]). Most systems now have a confidence map or quality map that helps identify most artifacts. However, none of the confidence maps or quality maps depict all artifacts and knowledge of artifacts is crucial for obtaining accurate liver stiffness values. Although a detailed discussion of artifacts is beyond the scope of this article, it is available elsewhere (74–77).

Reporting

The report should include the system vendor name, the SWE technique (pSWE or 2D SWE), the probe used, the number of acquisitions, the IQR/M, and conclusions. Conclusions should use the rule of four detailed earlier (Table 2). An example of a report is shown in Figure 5. A summary of recommendations is given in Table 4.

Future Directions

The development of new US techniques that will provide a measurement of liver steatosis and dispersion imaging (ie, evaluating the change in stiffness values by varying the ARFI frequency) are also being evaluated as a method to assess inflammation. This is extremely important to differentiate simple steatosis, a benign condition, from nonalcoholic steatohepatitis. However, evidence available for these techniques is not yet at a level where recommendations can be given. Other US techniques that do not use vibration-controlled transient elastography or ARFI technology techniques are being evaluated for liver stiffness evaluation (78).

Future Research Questions

Basic Questions

1. What are the sources of variability between commercial SWE systems? In particular, how does the ARFI frequency component affect measures of stiffness?
2. Should we measure in more than one location?
3. What are appropriate tissue-mimicking phantom materials for the liver?
4. Will liver dispersion be helpful in evaluating inflammation and/or steatosis?

Clinical Questions

1. How different are cut-offs depending on the cause of chronic liver disease?
2. How can US elastography complement hepatic venous pressure measurements in the assessment of portal hypertension and in the assessment of changes in portal venous pressure in patients with liver disease?
3. Inflammation and congestion are important processes to document in the evolution of liver disease. Histologic assessment of biopsy specimens can only be used to identify the cellular component of inflammation and is essentially blind to the fluid component. Quantitative elastography, conversely, seems to be sensitive to the effects of the fluid component of inflammation. How can this capability be exploited for diagnostic purposes?
4. Can we use elastography and measures of loss modulus to differentiate nonalcoholic or alcoholic steatohepatitis from simple steatosis?

Follow-up of Patients

1. What is a minimal clinically important difference in stiffness measurements over time? How often should these measures be obtained?

2. How should the use of elastography change the screening interval in patients at risk for hepatocellular carcinoma?

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Dept. Procedure Title:	Lymph Node Imaging Procedure - Ultrasound - Radiology	Procedure ID:	12483
Keywords	lymph, node, us, ultrasound, image, imaging, study		
Department:	Radiology, Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographers and sonologist performing lymph node Ultrasound studies.
The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock-Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Imaging: Lymph Node Imaging

1. Place the patient in a position that allows the best access to the area to be investigated for adenopathy.
2. Obtain images documenting the following:
 - i. Perform longitudinal and transverse images of the lymph nodes visualized.
 - ii. Measure each lymph node in the longest dimension with the AP diameter also recorded on that image.
3. Once representative longitudinal and transverse images have been obtained, use the split screen functionality on the scanner to measure and number the three (3) largest abnormal appearing lymph nodes so that measurements can be easily compared.
4. Perform Color Doppler imaging to evaluate for vascularity in each lymph node and record immediately after the split screen recording.
5. Repeat this for each site if more than one.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact:	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine	Version #	1
Current Approval Date:	09/21/2016	Old Document ID:	NEW
Date Procedure to go into Effect:	09/21/2016		
Related Policies & Procedures:			
Related Job Aids:			

Job Aid	Ultrasound Musculoskeletal (msk) Biopsy Setup Job Aid - Radiology	ID	23662
Keywords	radiology, ultrasound, musculoskeletal, msk, biopsy		
Department	Radiology - Ultrasound		

I. Purpose

To provide a list of supplies and discharge instructions (see attachments) necessary for ultrasound guided Musculoskeletal (msk) biopsy procedures.

• Equipment

- Sterile drape (4)
- Sterile OR towels
- Sterile transducer cover
- Sterile surgical gown
- Sterile gloves (physician preference)
- Telfa pad (physician preference)
- Sterile microscope slide (physician preference)
- Achieve or Bard disposable core biopsy needle (physician preference)
- Lidocaine 1% 10mL
- Sodium Chloride 0.9% – 10 mL
- 10 mL syringe (2)
- 25g needle (2)
- 18g needle (2)
- Kerlix gauze sponges (2 pkgs.)
- Chloraprep stick (2)
- Band-Aid
- Tegaderm (2)
- Alcohol prep pads (5)
- Formalin container
- # 11 scalpel
- Specimen transport bag
- Patient belonging bag
- PPE – 2 surgical masks, 2 hats, 2 non sterile gowns

Responsible Owner:	Radiology - Ultrasound	Contact:	Dennis Seguin
Approved By:	Office of Policy Support (OPS), Michael Patrick	Version #	1
Current Approval Date:	08/25/2020	Old Document ID:	
Date Policy to go into Effect:	08/25/2020		
Related Policies & Procedures:			
Related Job Aids:			

Job Aid	Ultrasound Musculoskeletal (msk) Injection / Aspiration Setup Job Aid - Radiology	ID	23659
Keywords	radiology, ultrasound, musculoskeletal, msk		
Department	Radiology - Ultrasound		

I. Purpose

To provide a list of supplies and discharge instructions (see attachments) necessary for ultrasound guided Musculoskeletal (msk) injection or aspiration procedures.

• Equipment

- Sterile drape (4)
- Sterile OR towels (1 pkg.)
- Steri-drape
- Sterile transducer cover
- Sterile gloves (physician preference)
- 10 mL syringe (2)
- 3 mL syringe
- *Lidocaine 1% - 10mL
- Sodium Chloride 0.9% - 10mL
- *Nesacaine MPF 2% (*if the patient has an allergy to lidocaine)
- Triamcinolone 40mg/mL – 1 mL vial (large joints or deep injections)
- Depo-Medrol vial 40mg – 1 mL vial (small joints or superficial injections)
- Ropivacaine 0.5% – 30 mL vial
- 20g needle (1.5” physician preference)
- 20g needle (3.5” physician preference)
- 22g needle (1.5” physician preference)
- 22g needle (3.5” physician preference)
- 25g needle
- 18g needle (2)
- Kerlix gauze sponges (1 pkg.)
- Chloraprep stick (2)
- Band-Aid
- Teraderm (2)
- Alcohol preps (5)
- PPE – 2 surgical masks, 2 hats, 2 non sterile gowns

Responsible Owner:	Radiology - Ultrasound	Contact:	Dennis Seguin
Approved By:	Office of Policy Support (OPS), Michael Patrick	Version #	1
Current Approval Date:	08/25/2020	Old Document ID:	
Date Policy to go into Effect:	08/25/2020		
Related Policies & Procedures:			
Related Job Aids:			

Job Aid	Ultrasound Native Renal Kidney and Transplant Biopsy Setup Job Aid - Radiology	ID	11356
Keywords	ultrasound, guided, renal, biopsy, biopsies		
Department	Ultrasound, Radiology		

I. Purpose

To provide a list of supplies and discharge instructions (see attachments) necessary for ultrasound guided renal biopsy procedures.

• Equipment

- 18 g needle (2)
- 25 g needle
- 10 mL syringe (2)
- Lidocaine 1%
- Sodium Chloride (2)
- Chloraprep stick
- Kerlix sponges
- Sterile drape (6)
- Sterile gloves (physician preference)
- Formalin bottle
- Sterile culture bottle
- Gluteraldehyde - (physician brings this)
- Standard Biopsy guide clip
- Sterile biopsy guide kit
- Sterile transducer cover
- 18 g or 16 g biopsy needle (physician preference - have both available)
- 20 g 6-inch spinal needle
- # 11 Scalpel
- Q-tips
- Tongue depressor
- Band-Aid
- Specimen transport bag
- PPE - (3) surgical hats, (3) surgical masks, (3) non sterile gowns
- Patient belongings bag
- Stretcher to transport the patient to the recovery room once procedure is complete

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents, Michael Patrick	Version #	3
Current Approval Date:	08/24/2020	Old Document ID:	
Date Policy to go into Effect:	08/24/2020		
Related Polices & Procedures:	Native and Transplant Kidney Biopsy Imaging Procedure - Ultrasound - Radiology		
Related Job Aids:			

Dept. Procedure Title:	Native and Transplant Kidney Biopsy Imaging Procedure - Ultrasound - Radiology	Procedure ID:	11471
Keywords	ultrasound guided, bx, sono, native, transplant, kidney, biopsy		
Department:	Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographer and sonologist performing Native and Transplant Kidney Biopsies under Ultrasound guidance.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions –

SDP – Same Day Program

IV. Equipment - N/A

V. Procedure

A. Required Kidney Images

The following standard images are required for interpretation.

1. Imaging: Native Kidneys – Scout imaging:
 - i. Obtain a longitudinal and transverse scout image of both native kidneys confirming location.
 - ii. Measure the renal length and record in the structured reporting package.
2. Imaging: Native Kidneys – Full study:
 - i. Obtain representative images in the longitudinal and transverse planes of both kidneys.
 - ii. Document longitudinal images that contain lateral and medial margins of the kidneys.
 - iii. Transverse views of both kidneys must include images of upper, mid, and lower poles.
 - iv. Perform maximum measurements (minimum of 2) of renal length of both kidneys.
 - v. Compare renal echogenicity to that of the liver or spleen.
 - vi. Obtain longitudinal and transverse images of the urinary bladder.
3. Imaging: Transplant Kidney – Scout Imaging:
 - i. Obtain longitudinal and transverse scout images of the transplant kidney.
 - ii. Measure the renal length and record in the structured reporting package.

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Reference ID #11471, Version #3

Approval Date: 10/15/2018

4. Imaging: Transplant Kidney – Full Study:
 - i. Obtain representative images documenting the following.
 - ii. Longitudinal measurements (2-3) of the maximum transplant kidney length.
 - iii. Transverse images through upper, mid, and lower poles.
 - iv. Assess for peri-renal fluid collections (urinomas, lymphoceles, etc.).
 - v. Assess for collecting system dilatation.
 - vi. Obtain longitudinal and transverse images of the urinary bladder.
 - vii. Color/Power images of the transplant kidney (adjust color scale and gain to visualize slow/venous flow).
 - viii. Obtain representative spectral Doppler tracings (2 per section) of arcuate vessels at the cortico-medullary junction at the upper, mid and lower renal poles.
 - ix. Obtain color and spectral Doppler tracing (2 per section) of the main renal artery (MRA) and main renal vein (MRV) at the renal hilum and proximal to the anastomosis.
5. Bedside timeout performed in eD-H with all procedural staff verifying pre-procedure questions.
6. Post Biopsy
 - i. Obtain post biopsy images (grey scale and color Doppler) to exclude retroperitoneal bleeding.
7. Lab specimens
 - i. Create a pathology request in eD-H (lab3175) for renal biopsy specimens.
 - ii. Specimens source label and corresponding form should state:
 - A. Formalyn
 - B. Saline
 - C. Glutaraldehyde
8. Paperwork- Discharge Instructions
 - i. Provide nursing recovery with after care instruction sheet (native or transplant).
 - ii. Post biopsy report must be given by the attending physician to the SDP nursing unit.
 - iii. SDP will assign the post procedure room location.
 - iv. Create transportation “hand off” document/checklist in eD-H for transportation. Request “Stat” transport to SDP.

VI. References - N/A

Responsible Owner:	Department of Radiology	Contact(s): email	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Bolger, Jean	Version #	3
Current Approval Date:	10/15/2018	Old Document ID:	RAD.0058
Date Procedure to go into Effect:	10/15/2018		
Related Policies & Procedures:			
Related Job Aids:	Ultrasound Native Renal Kidney and Transplant Biopsy Setup Job Aid - Radiology		

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Reference ID #11471, Version #3

Approval Date: 10/15/2018

Dept. Procedure Title	Ultrasound Neonatal Spine Scheduling and Imaging Procedure - Radiology	Procedure ID	11463
Keywords	ultrasound, us, neonate, neonatal, spine, study		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for Sonographers and Sonologists performing Neonatal spine Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all Sonographers and Sonologists within the Ultrasound section of Dartmouth-Hitchcock.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Scheduling

- This exam is to be performed on infants (less than) < 3 months of age.
- Any variations need to be approved by the Radiologist.

B. Spine

1. Obtain representative images of the entire spine through the sacrum in longitudinal and transverse planes.
2. Include longitudinal and transverse images of the conus and a longitudinal image from the conus to the sacrum.
3. Identify the conus.
 - a. The conus usually lies at or above the L2-L3 interspace.
4. Perform a cine capture if technically possible of the lumbar spine in a longitudinal projection demonstrating the normal motion of the nerve roots of the cauda equine.
 - a. It is helpful to label the lumbar vertebral bodies by identifying the last rib (T12).
5. Identify and measure the filum terminale (normal < 2mm).
6. If indication for scan is sacral dimple, pit, pigmented lesion, etc., scan the sacrum over the skin abnormality looking for communication into the spinal canal.
7. Obtain representative longitudinal image of each kidney

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine; Nystrom, Heidi	Version #	3
Current Approval Date:	11/08/2021	Old Document ID:	
Date Procedure to go into Effect:	11/08/2021		
Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Ultrasound Obstetrical Imaging Procedure - Radiology	Procedure ID	11223
Keywords	obstetrical, ultrasound, image, imaging, us, ob		
Department	Radiology, Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographers and sonologists performing Obstetrical Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions

AIUM – American Institute of Ultrasound in Medicine

MVP – Maximum Vertical Pocket

AFI – Amniotic Fluid Index

LVOT – Left Ventricular Outflow Tract

RVOT – Right Ventricular Outflow Tract

CRL – Crown-Rump Length

IV. Equipment N/A

V. Procedure

A. Special Considerations

- Procedure listed below are per AIUM Standards.
- Measurements are only obtained when the electronic order confirms the request (e.g., growth requested).
- Clarification of limited exam imaging components.
- Exam details may be amended based upon initial findings, which is within the clinical scope of practice or both sonographers and sonologists.

B. Dating

- Dating assessment is established by **best clinical judgment**. Suggested guidelines listed below:

Table 1. Guidelines for Redating Based on Ultrasonography

Gestational Age Range*	Method of Measurement	Discrepancy Between Ultrasound Dating and LMP Dating That Supports Redating
≤ 13 6/7 wk • ≤ 8 6/7 wk • 9 0/7 wk to 13 6/7 wk	CRL	More than 5 d More than 7 d
14 0/7 wk to 15 6/7 wk	BPD, HC, AC, FL	More than 7 d
16 0/7 wk to 21 6/7 wk	BPD, HC, AC, FL	More than 10 d
22 0/7 wk to 27 6/7 wk	BPD, HC, AC, FL	More than 14 d
[†] 28 0/7 wk and beyond	BPD, HC, AC, FL	More than 21 d

Abbreviations: AC, abdominal circumference; BPD, biparietal diameter; CRL, crown-rump length; FL, femur length; HC, head circumference; LMP, last menstrual period.

*Based on LMP

[†]Because of the risk of redating a small fetus that may be growth restricted, management decisions based on third-trimester ultrasonography alone are especially problematic and need to be guided by careful consideration of the entire clinical picture and close surveillance.

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C. Amniotic Fluid

- Amniotic fluid evaluation:
 - Quantitative measurement or assessed subjectively at all obstetrical ultrasound examinations.
 - Maximal vertical pocket is the preferred method.
 - Early gestation: Subjective assessment.
 - Late second and third trimester: Either amniotic fluid index (AFI) or maximal vertical pocket (MVP).
 - Width of any measured fluid pocket must be 1 cm and exclude umbilical cord or fetal parts.
- Definitions (both singleton and multiple gestations):
 - Oligohydramnios:** MVP less than 2 cm
 - Hydramnios:** MVP greater than 8 cm or AFI greater than or equal to 24 cm.

D. Screening Morphology and Detailed Morphology Fetal Assessment

1. Obtain representative images documenting the following:

Table 2. Components of CPT 76811 (Basic and Detailed Examinations)

Component	Basic	Detailed
Head and neck	Lateral cerebral ventricles Choroid plexus Midline falx Cavum septi pellucidi Cerebellum Cisterna magna	3rd ventricle ^{A,36} 4th ventricle ^{A,36} Lateral ventricles ^{A,36} Cerebellar lobes, vermis, and cisterna magna ^{A,37} Corpus callosum ^{A,38} Integrity and shape of cranial vault ¹⁹ Brain parenchyma ²⁰ Neck ^{21,22} Profile ²³⁻²⁵ Coronal face (nose/lips/lens*) ²³ Palate,* maxilla, mandible, and tongue ^{A,26,27} Ear position and size ⁸ Orbits ⁸
Face	Upper lip	Aortic arch Superior and inferior venae cavae ^{28,29} 3-vessel view ²⁹ 3-vessel and trachea view ³⁰ Lungs ^{31,32} Integrity of diaphragm ³³ Ribs ^{A,34,35}
Chest Heart and thorax	Cardiac activity 4-chamber view Left ventricular outflow tract Right ventricular outflow tract	Small and large bowel ^{A,36-38} Adrenal glands ^{A,39} Gallbladder ^{A,40,41} Liver ^{38,42} Renal arteries ^{A,43} Spleen ^{A,42} Integrity of abdominal wall ^{A,44} Integrity of spine and overlying soft tissue ^{A,45,46} Shape and curvature ^{45,46}
Abdomen	Stomach (presence, size, and situs) Kidneys Urinary bladder Cord insertion site into fetal abdomen Umbilical cord vessel number	Number, architecture and position ⁴⁹⁻⁵¹ Hands ⁵²⁻⁵³ Feet ⁵³⁻⁵⁴ Digits; number and position ^{A,51,52} Sex ^{A,55}
Spine	Cervical Thoracic Lumbar Sacral spine	
Extremities	Legs Arms	
Genitalia	In multiple gestations When medically indicated	
Placenta	Location Relationship to internal os Appearance Placental cord insertion (when possible)	Masses ^{54,57} Placental cord insertion ⁵⁸ Accessory/succenturiate lobe with location of connecting vascular supply to primary placenta ^{A,59,60}
Standard evaluation	Fetal number Presentation Qualitative or semiquantitative estimate of amniotic fluid	
Maternal anatomy	Cervix (transvaginal when indicated) Uterus Adnexa	
Biometry	Biparietal diameter Head circumference Femur length Abdominal circumference Fetal weight estimate	Cerebellum ^{A,61} Inner and outer orbital diameters ^{A,62} Nuchal thickness (16–20 wk) ⁶³⁻⁶⁵ Nasal bone measurement (15–22 wk) ⁶³⁻⁶⁶ Humerus ^{A,63-65} Ulna/radius ⁸ Tibia/fibula ⁸

*Performed when medically indicated.

⁸Also included in the basic obstetric examination.

E. Follow-up for Growth-Amniotic Fluid

1. Only obtain measurements when the electronic order verifies the request (i.e., growth requested).
2. Perform fetal assessment to include fetal anatomy appropriate for gestational age.
3. Clinical Ultrasound findings should determine the necessity (if something new is seen, for example; previously appeared normal, now appears abnormal).
4. Obtain representative images documenting the following:
 - Longitudinal image documenting the bladder and cervix
 - Fetal position
 - Placenta location
 - Placental cord origin images in grey scale and color Doppler
 - Amniotic fluid – 4-quadrant measurement if greater than 28 weeks (adhere to amniotic fluid guidelines)
 - Intra-cranial anatomy
 - 4-chamber heart & cine loop capture
 - LVOT – cine loop capture if feasible
 - RVOT– cine loop capture if feasible
 - M-mode tracing with heart rate measurement
 - Diaphragm
 - Stomach
 - Kidneys
 - Bladder
 - Fetal cord insertion
 - Adnexal structures

F. Morphology Limited Follow-up

1. Fetal assessment re-check for a prior incomplete morphology assessment.
2. Clinical Ultrasound findings should determine the necessity (if something new is seen, for example; previously appeared normal, now appears abnormal) and should include the following:
 - Longitudinal image documenting the bladder and cervix
 - Fetal position
 - Placenta location
 - Amniotic fluid – 4-quadrant measurement if greater than 28 weeks (adhere to amniotic fluid guidelines)
 - 4-chamber heart & cine loop capture if feasible
 - M-mode tracing with heart rate measurement

G. OB Limited > 14 Weeks

1. Clinical Ultrasound findings should determine the necessity (if something new is seen, for example; previously appeared normal, now appears abnormal) and should include the following:
 - Longitudinal image documenting the bladder and cervix
 - Fetal position
 - Placenta location
 - Amniotic fluid – 4-quadrant measurement if greater than 28 weeks (adhere to amniotic fluid guidelines)

- 4-chamber heart & cine loop capture if feasible
- M-mode tracing with heart rate measurement

H. Viability

1. Obtain representative images documenting the following:
 - Sagittal wide field of view to include the entire uterus, cervix to fundus
 - CRL measurement
 - Placental location (> than 15 weeks)
 - Amniotic fluid
 - Gestational Sac
 - Identify and document yolk sac
 - Adnexal structures
 - M-mode tracing with heart rate measurements
 - Cine loop capture documenting the presence or absence of fetal cardiac activity
 - In the clinical setting of a prior C-section, obtain sagittal wide field of view to include the entire uterus, cervix to fundus to ascertain location/implantation of the gestational sac.

I. Nuchal Translucency

1. Obtain representative images documenting the following:
 - NT measurement
 - CRL length
 - Placental location
 - Amniotic fluid
 - Gestational Sac
 - Adnexal structures
 - M-mode tracing with heart rate measurement
 - Cine loop capture if feasible

J. Cervical Length

1. Obtain representative images documenting the following:
 - Position
 - Cervical length with & without fundal pressure or valsalva
 - Observe cervix for three minutes after applying fundal pressure
 - Placental location
 - Adnexal structures
 - M-mode tracing with heart rate measurement
 - Cine loop capture if feasible

K. Amniotic Fluid (AFV) – Post Dates

1. Obtain representative images documenting the following:
 - Presentation
 - Placenta location
 - Amniotic fluid – 4-quadrant measurement (adhere to amniotic fluid guidelines).
 - M-mode tracing with heart rate measurement
 - Cine loop capture if feasible

- For Twins/ multiples – Measure and report the deepest vertical pocket in each gestational sac.

L. Position Only

1. Obtain representative images documenting the following:
 - Position
 - Amniotic fluid – 4-quadrant measurement (adhere to amniotic fluid guidelines).
 - M-mode tracing with heart rate measurement
 - Cine loop capture if feasible

M. Biophysical Profile (BPP)

1. Obtain representative images documenting the following:
 - BPP parameters – Use the grading score parameters (2-8) in the structured reporting system
 - Do not use NST section.
 - Presentation
 - Amniotic fluid – 4-quadrant measurement (adhere to amniotic fluid guidelines).
 - Placenta location
 - M-mode tracing with heart rate measurement
 - Cine loop capture if feasible

N. Fetal mechanical PR Interval

1. GE unit is required for these studies.
2. Obtain representative images documenting the following:
 - Presentation
 - Placenta location
 - Amniotic fluid – 4-quadrant measurement (adhere to amniotic fluid guidelines).
 - M-mode tracing with heart rate measurement.
 - PR interval (5 chamber view) – See enclosed document in attachments.
 - Measure time from the onset of mitral valve A wave to Aortic valve opening.

O. Middle Cerebral Artery (MCA) Doppler

Obtain representative images documenting the following

- MCA Doppler assessment with measurements entered into appropriate boxes
- Report Peak Systolic (PSV), S/D Ratio and multiple of the mean (MoM)
- SV gate size should be set to 1.0 mm
- Position
- Placenta location
- Amniotic fluid – 4-quadrant measurement (adhere to amniotic fluid guidelines).
- Assessment for hydrops
- M-mode tracing with heart rate measurement
- Cine loop capture if feasible

P. Umbilical Artery (UA) Doppler

1. Indications:
 - AC less than 10%
 - EFW less than 10%
 - Oligohydramnios
 - Multiple gestation: discordant growth or twin-twin transfusion syndrome
2. Obtain representative images documenting the following:
 - S/D ratio & RI
 - Position
 - Placenta location
 - Amniotic fluid – 4-quadrant measurement (adhere to amniotic fluid guidelines)
 - M-mode tracing with heart rate measurement

Q. Ultrasound Guided Procedures

Amniocentesis

1. Obtain representative images documenting the following:
 - Position
 - Placenta location
 - Amniotic fluid – 4-quadrant measurement if greater than 28 weeks (adhere to amniotic fluid guidelines)
 - M-Mode tracing with heart rate measurement pre and post procedure
 - Cine loop capture if feasible

Therapeutic

1. Obtain representative images documenting the following:
 - Position
 - Amniotic fluid – 4-quadrant measurement (adhere to amniotic fluid guidelines)
 - M-Mode tracing with heart rate measurement pre & post procedure
 - Cine loop capture if feasible

Note: To access attachments, click on the notification (bell) icon located in the upper right hand corner of the document.

VI. References

- 76811 Task Force. Consensus Report on the Detailed Fetal Anatomic Ultrasound Examination. Journal Ultrasound Med 2014; 33:189-195. 0278-4297. www.aium.org
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Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine; Nystrom, Heidi	Version #	4
Current Approval Date:	11/30/2021	Old Document ID:	
Date Procedure to go into Effect:	11/30/2021		
Related Policies & Procedures:			
Related Job Aids:			

Obstetrical Imaging Guidelines

Purpose:

To establish guidelines for sonographers/ sonologists performing selected Ultrasound examinations.

Dating:

Dating assessment is established by **best clinical judgment**. The following are guidelines only.

General guidelines:

1st Trimester:

Use the LMP if the difference between Ultrasound dating and LMP date is ≤ 7 days to establish the EDD.

If difference is > 7 days use the Ultrasound dating to establish the EDD.

2nd Trimester:

Use the LMP if the difference between Ultrasound dating and LMP date is $\leq 10-14$ days to establish the EDD.

If the difference is $> 10-14$ days use the Ultrasound dating to establish the EDD.

Oligohydramnios is an overall sum of the 4 quadrants that is ≤ 8 cm

Procedure Guidelines listed below are per AIUM Standards

OBS- MORPHOLOGY:

Obtain representative images documenting the following:

- Longitudinal image documenting the bladder and cervix
- Fetal position
- Placenta location (if low lying perform trans vaginal study)
- Placental cord insertion images in grey scale and color Doppler
- AFV if specific to gestational age
- Adnexal structures
- Lateral ventricle measurement
- Cerebellar hemispheres

- Cisterna magna measurement
- Cavum septi pellucidum
- Nuchal fold measurement
- Nasal bone measurement
- Face and upper lip
- Fetal profile
- Fetal orbits documenting lens
- 4-chamber heart & cine loop capture
- LVOT – cine loop capture if feasible
- RVOT – cine loop capture if feasible
- M-mode tracing with heart rate measurement
- Stomach
- Fetal cord insertion
- Kidneys
- Bladder
- Color Doppler umbilical vessels surrounding fetal bladder
- Fetal limbs – documenting feet at 90 degrees and open hands
- Longitudinal and transverse images of fetal spine
- Cine image capture of the entire spine in transverse section
- Adnexal structures
- Measurements specific to gestational age

OB FOLLOW-UP/ EFW:

Obtain representative images documenting the following:

- Perform fetal assessment to include fetal anatomy appropriate for gestational age.
- Document areas NOT well seen on prior scan. If for example, the fetal spine was well seen at 18 weeks, a full re-assessment is not necessary.
- Re-check are of prior documented abnormality.

- If it has been more than 2 weeks from the last scan, measurements should be considered. Clinical Ultrasound findings should determine the necessity.
- Longitudinal image documenting the bladder and cervix
- Fetal position
- Placenta location
- Placental cord insertion images in grey scale and color Doppler
- AFI- 4 quadrant measurement if ≥ 28 weeks
- Intra-cranial anatomy
- 4-chamber heart & cine loop capture
- LVOT – cine loop capture if feasible
- RVOT– cine loop capture if feasible
- M-mode tracing with heart rate measurement
- Stomach
- Kidneys
- Bladder
- Fetal cord insertion
- Longitudinal and transverse images of fetal spine
- Adnexal structures

VIABILITY:

Obtain representative images documenting the following:

- CRL measurement
- Placental location
- Amniotic fluid
- Gestational Sac
- Identify and document yolk sac
- Adnexal structures
- M-mode tracing with heart rate measurements
- Cine loop capture documenting the presence or absence of fetal cardiac activity

NUCHAL TRANSLUCENCY:

Obtain representative images documenting the following:

- NT measurement
- CRL length
- Placental location
- Amniotic fluid
- Gestational Sac
- Adnexal structures
- M-mode tracing with heart rate measurement

CERVICAL LENGTH:

Obtain representative images documenting the following:

- Position
- Cervical length with & without fundal pressure
- Observe cervix for three minutes after applying fundal pressure
- Adnexal structures
- M-mode tracing with heart rate measurement

AFV- POST DATES:

Obtain representative images documenting the following:

- Presentation
- Placenta location
- AFI- 4 quadrant measurement
- M-mode tracing with heart rate measurement
- ** For Twins/ multiples**
- Measure and report the deepest vertical pocket in each gestational sac

POSITION ONLY:

Obtain representative images documenting the following:

- Position
- AFI- 4 quadrant measurement
- M-mode tracing with heart rate measurement

BIOPHYSICAL PROFILE

Obtain representative images documenting the following:

- BPP parameters – Use the grading score parameters (2-8) in AS- Ob-Gyn
- Do not use NST section.
- Presentation
- AFI- 4 quadrant measurement
- Placenta location
- M-mode tracing with heart rate measurement

MCA DOPPLER:

Obtain representative images documenting the following:

- MCA Doppler assessment with measurements entered into appropriate boxes
- Report Peak Systolic Velocity (PSV) & S/D Ratio
- SV gate size should be set to 1.0mm
- Position
- Placenta location
- AFI - 4 quadrant measurement
- Assessment for hydrops
- M-mode tracing with heart rate measurement

UA DOPPLER:

Indications:

AC < 10%

EFW < 10%

AFV < 10%

If the individual AC percentile falls $< 10\%$ a UA Doppler should be performed

HC/ AC ratio $>$ the upper limits of normal for GA

(Example: small abdominal circumference, relatively large head)

Significant drop off the growth curve

Obtain representative images documenting the following:

S/D ratio & RI

Position

Placenta location

AFI- 4 quadrant measurement

M-mode tracing with heart rate measurement

AMNIOCENTESIS:

Obtain representative images documenting the following:

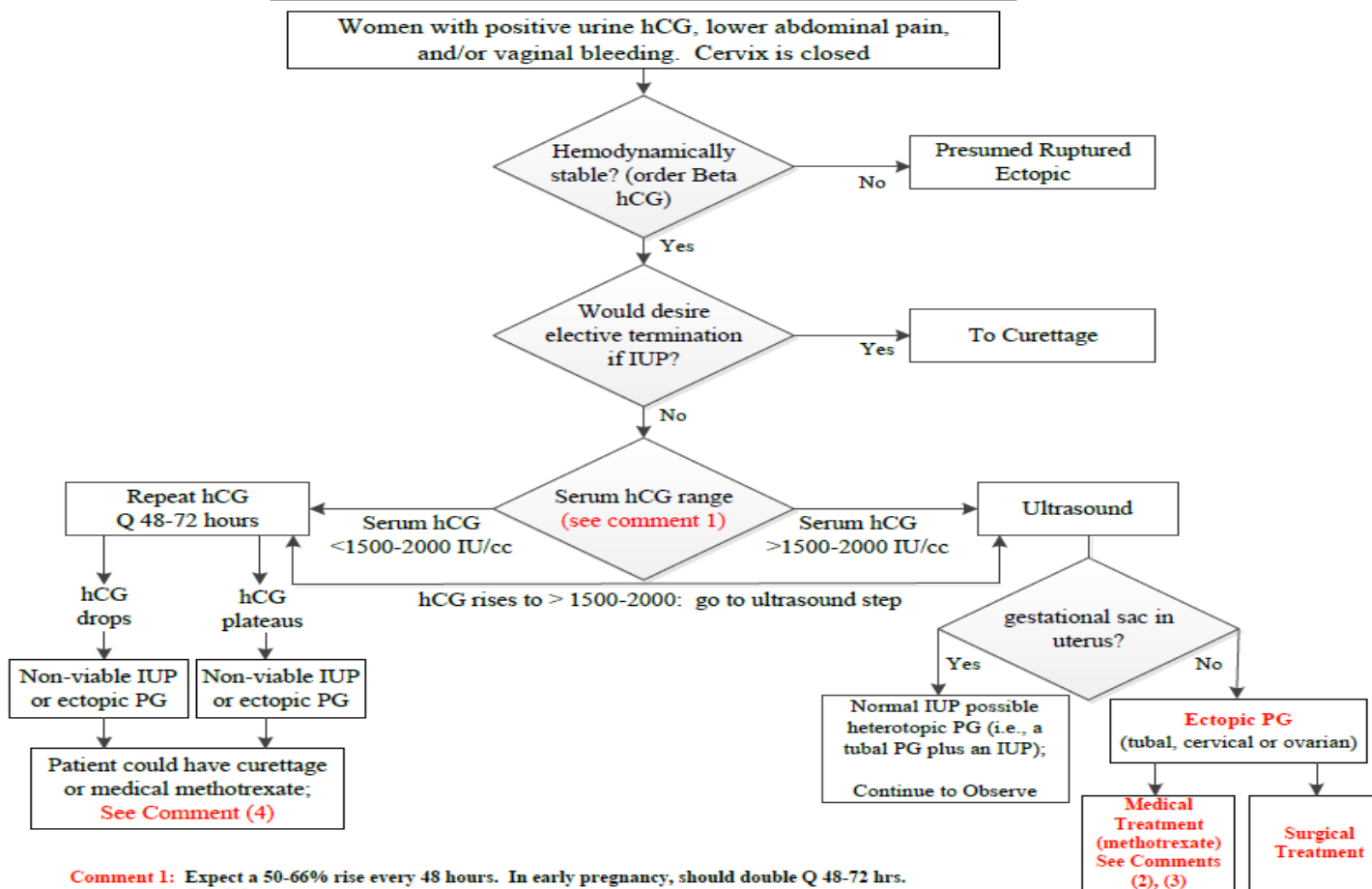
- Position
- Placenta location
- AFI- 4 quadrant measurement if ≥ 28 weeks
- M- Mode tracing with heart rate measurement pre and post procedure

KCL Procedure:

Obtain representative images documenting the following:

- Position
- AFI- 4 quadrant measurement
- M- Mode tracing with heart rate measurement pre & post procedure

Suspected Ectopic Presents to ER (Protocol)



Comment 1: Expect a 50-66% rise every 48 hours. In early pregnancy, should double Q 48-72 hrs.

Comment 2: Candidates:

- a. Hemodynamically stable
- b. hCG < 5000 IU (*)
- c. Compliant
- d. Adnexal mass, 3cm, no cardiac activity (*)

* Relative contra-indication

Comment 3: Need to call pharmacy to call in a qualified pharmacist. Need methotrexate (chemotherapy form) in ER. Can be administered by ER Nurse or inpatient Hem-Onc Nurse. Dosage 50 mg/M2 (sq. meters of body surface area). Baseline Labs: (CBC, LFTs, Rh, hCG).

Repeat labs in 7 days; expect 25% drop in hCG; then weekly hCG until undetectable (less than 100 days)

Comment 4: Curettage if villi present, from viable IUP. Observe. If patient refuses curettage, should suggest methotrexate protocol.

Dept. Procedure Title	Pediatric Hip Scheduling and Imaging Procedure - Ultrasound - Radiology	Procedure ID	11464
Keywords	pediatric, hip, study, studies, us, ultrasound, images, interpretation, sonographers, sonologists		
Department	Ultrasound		

I. Purpose

To describe guidelines for performing pediatric hip Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock.

III. Definitions N/A

IV. Equipment N/A

V. Procedure imaging:

A. Scheduling:

1. Evaluation of infants suspected of hip dysplasia.
 - Infants should be at least 4 weeks of age (preferably 6 weeks) and NOT older than 6 months of age.
 - Infants younger than 4 weeks old may be scanned if clinically suspected of hip dislocation.
 - Prior approval required from attending Radiologist.
 - Scans should not be performed for rule out development dysplasia of the hip (DDH) after 6 months of age.
 - Examinations may be performed at any age to rule out joint effusion.

B. Scanning Procedure:

The following standard images are required for interpretation.

1. Scan both hips with a linear transducer.
2. Obtain images in a flexed position.
3. Obtain the following images:
 - a. Coronal view of hip (2-3 measurements to obtain “alpha” hip angle).
 - Determine the degree of coverage.
 - Report alpha angle into designated structured reporting system.
 - b. Transverse view of the hip to show the femoral head in relation to the triradiate cartilage.

- c. Obtain a D:D ratio measurement for each hip to determine the degree of femoral head coverage. Enter this value into the structured reporting package.
- d. Stress views of both hips (if not in harness) in transverse view.
- e. Image both hips for comparison.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine; Silas, Anne	Version #	3
Current Approval Date:	02/18/2020	Old Document ID:	
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Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title:	Pediatric Kidney Procedure - Ultrasound - Radiology	Procedure ID:	11475
Keywords	pediatric, kidney, us, ultrasound, images, interpretation, studies		
Department:	Ultrasound		

I. Purpose of Procedure

To describe guidelines for sonographers and sonologists performing Pediatric Kidney Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Scheduling

- Infants must be at least 2 days old.
- Exceptions must be approved by the Attending Radiologist

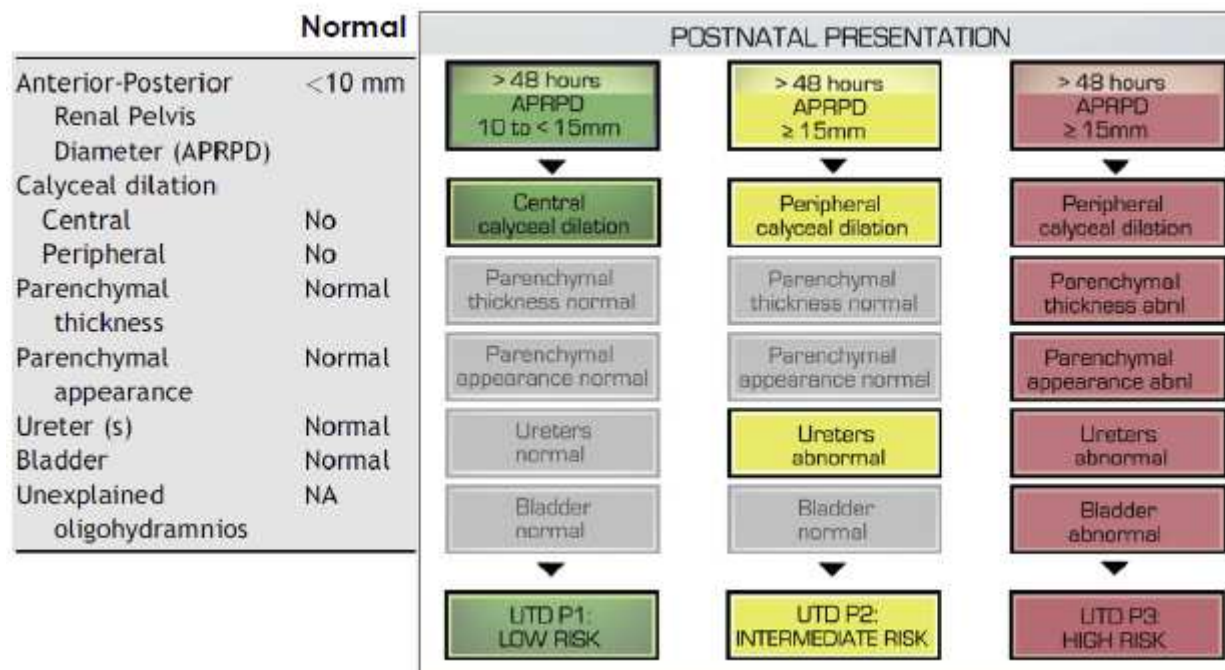
B. Kidney Imaging

- Obtain representative images in the longitudinal and transverse planes of both kidneys.
- Document longitudinal images of the lateral and medial margins of the kidneys.
- Include labeled images of the transverse views of upper, mid, and lower poles of both kidneys.
- Perform maximum measurements (minimum of 2) of renal length of both kidneys.
- Compare renal echogenicity to that of the liver or spleen.
- Obtain measurements in the longitudinal and transverse planes of the urinary bladder adding these to the structured reporting package.
- Use Color Doppler to document urinary jets when hydronephrosis is present.
 - Record Color or Power Doppler images when there is a clinical suspicion of pyelonephritis.
 - Use Color Doppler to exclude mild hydronephrosis vs. hilar vessels when the gray scale images are equivocal.
- Obtain cine captures through both kidneys when hydronephrosis is present.

C. Pediatric Nephrology Doppler Imaging

- Obtain representative images of both kidneys per section B above.
- Perform Color Doppler and Spectral Waveforms (2 per section) of the intra-renal arteries.
- Calculate measurements of the Resistive Index (RI).

Urinary Tract Dilatation (UTD)



Journal of Pediatric Urology (2014) 10, 982-999

VI. References

Nguyen, H., Benson, C., Bromley, B., Campbell, J., Chow, J., Coleman, B., . . . Stein, D. (2014). Multidisciplinary consensus on the classification of prenatal and postnatal urinary tract dilatation (UTD classification system). Journal of Pediatric Urology, 10, 982-998.

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Date Procedure to go into Effect:	02/21/2020		
Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Prostate Scheduling and Imaging Procedure - Radiology	Procedure ID	11469
Keywords	prostate, schedule, scheduling, sonographer, sinologist, us, ultrasound, scan, image, studies, interpretation		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for Sonographers and Sonologists performing Prostate Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This applies to all Sonographers and Sonologists within the Ultrasound section of Dartmouth-Hitchcock-Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Scheduling

- Prostate biopsies (fusion directed and regular) are performed in conjunction with the Urology service.
- Prostate imaging (non-biopsy) can be scheduled into specific Radiant exam resources with adherence to prep instructions.
- All other requests must be approved by Triage.

B. Standard Images Required for Interpretation.

- Obtain axial images equally spaced from the seminal vesicles, to the apex of the gland. Targeted images should be obtained from the right, mid and left. Note and measure any focal abnormalities.
- In the mid axial plane, measure the prostate at the widest portion in two (2) dimensions, and add to the calculation package. Note any cystic changes or calcifications.
 - In the setting of infertility evaluation, identify and measure the ejaculatory ducts at the level of the verumontanum.
- Obtain longitudinal images of the right gland to include the seminal vesicle, right base, mid and apex. Note and measure any focal abnormalities.
- Obtain longitudinal image of the mid gland identifying the bladder and prostatic urethra if possible. Measure the prostate size and add to the calculation package. Note any cystic changes or calcifications.

- Obtain longitudinal images of the left gland to include the seminal vesicle, left base, mid and apex. Note and measure any focal abnormalities.
- Import measurements obtained including the transducer # into the structured reporting package.
- Complete the bedside “time out” checklist prior to beginning the procedure.

C. Standard Imaging for Prostate Size Only

- Obtain a cine capture from the seminal vesicles to the apex of the gland.
- In the mid-axial plane, measure the prostate at the widest portion in two (2) dimensions, and add to the calculation package.
- Obtain a cine capture to include the right base, mid and apex
- Obtain longitudinal image of the mid gland identifying the bladder and prostatic urethra if possible.
- Measure the prostate size and add to the calculation package.
- Obtain a cine capture to include the left base, mid, and apex.
- Import measurements obtained including the transducer # into the structured reporting package.

D. Prostate Biopsy - Pathology specimen order (fusion and regular)

- Generate a pathology request in eD-H (lab3175) per Radiology Per Protocol guidelines for the prostate biopsy specimens.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine; Nystrom, Heidi	Version #	3
Current Approval Date:	11/22/2021	Old Document ID:	
Date Procedure to go into Effect:	11/22/2021		
Related Policies & Procedures:			
Related Job Aids:			

Job Aid	Ultrasound Prostate Biopsy Setup Job Aid - Radiology	ID	20248
Keywords	supply list, bx, us, guided, ultrasound, prostate, biopsy		
Department	Radiology - Ultrasound		

I. Purpose

To provide a list of supplies needed and specimen bottle setup/labeling for ultrasound guided prostate biopsy procedures.

Supplies

- 10cc syringe
- 18g hypodermic needle
- Bottle of 1% Lidocaine
- 22g, 15cm spinal needle
- 18g, 20cm biopsy needle
- 2 large specimen transport bags
- Large transducer cover
- Disposable prostate needle guide (institution standard)
- Disposable bracket for fusion biopsies only (institution standard)
- 4 packets sterile Surgilube
- Double ID on each specimen container (MD and sonographer initials)
- Non sterile latex free gloves (have S, M, L available)

Specimen Bottle Setup/Labeling

Right lateral base (A)	Right base (D)
Right lateral mid (B)	Right mid (E)
Right lateral apex (C)	Right apex (F)
Left lateral base (G)	Left base (J)
Left lateral mid (h)	Left mid (K)
Left lateral apex (I)	Left apex (L)
Label additional bottles beginning with (M)	

Responsible Owner:	Radiology - Ultrasound	Contact:	Dennis Seguin
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Date Policy to go into Effect:	01/17/2022		
Related Policies & Procedures:	Prostate Scheduling and Imaging Procedure - Radiology		
Related Job Aids:			

Job Aid	Sonohysterogram (SHG) Setup Job Aid - Ultrasound - Radiology	ID:	11357
Keywords	sonohysterogram, SHG, setup, us, ultrasound		
Department	Ultrasound, Radiology		

I. Purpose

To provide necessary supplies for Sonohysterogram (SHG) procedures.

- Pregnancy test if indicated
- Speculum - (have all sizes available)
- Betadine swab sticks
- SHG catheter
- 20 mL syringe
- Sterile Saline
- Surgical gloves (appropriate for physician)
- Os finder
- Dilators
- Tenaculum

Billing / Supplies:

- Catheter already added. Add additional supplies as needed

Responsible Owner:	Department of Radiology	Contact(s): email	Dennis Seguin
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Current Approval Date:	01/04/2018	Old Document ID:	RAD.0053
Date Policy to go into Effect:	01/04/2018		
Related Polices & Procedures:			
Related Job Aids:			

Society for Maternal-Fetal Medicine Consult Series #52: Diagnosis and management of fetal growth restriction



(Replaces Clinical Guideline Number 3, April 2012)

Society for Maternal-Fetal Medicine (SMFM); Juliana Gevaerd Martins, MD; Joseph R. Biggio, MD, MS; Alfred Abuhamad, MD

The American Institute of Ultrasound in Medicine (AIUM) supports this document review of the subject matter and believes it contributes to our understanding of the topic.

Fetal growth restriction can result from a variety of maternal, fetal, and placental conditions. It occurs in up to 10% of pregnancies and is a leading cause of infant morbidity and mortality. This complex obstetrical problem has disparate published diagnostic criteria, relatively low detection rates, and limited preventative and treatment options. The purpose of this Consult is to outline an evidence-based, standardized approach for the prenatal diagnosis and management of fetal growth restriction. The recommendations of the Society for Maternal-Fetal Medicine are as follows: (1) we recommend that fetal growth restriction be defined as an ultrasonographic estimated fetal weight or abdominal circumference below the 10th percentile for gestational age (GRADE 1B); (2) we recommend the use of population-based fetal growth references (such as Hadlock) in determining fetal weight percentiles (GRADE 1B); (3) we recommend against the use of low-molecular-weight heparin for the sole indication of prevention of recurrent fetal growth restriction (GRADE 1B); (4) we recommend against the use of sildenafil or activity restriction for in utero treatment of fetal growth restriction (GRADE 1B); (5) we recommend that a detailed obstetrical ultrasound examination (current procedural terminology code 76811) be performed with early-onset fetal growth restriction (<32 weeks of gestation) (GRADE 1B); (6) we recommend that women be offered fetal diagnostic testing, including chromosomal microarray analysis, when fetal growth restriction is detected and a fetal malformation, polyhydramnios, or both are also present regardless of gestational age (GRADE 1B); (7) we recommend that pregnant women be offered prenatal diagnostic testing with chromosomal microarray analysis when unexplained isolated fetal growth restriction is diagnosed at <32 weeks of gestation (GRADE 1C); (8) we recommend against screening for toxoplasmosis, rubella, or herpes in pregnancies with fetal growth restriction in the absence of other risk factors and recommend polymerase chain reaction for cytomegalovirus in women with unexplained fetal growth restriction who elect diagnostic testing with amniocentesis (GRADE 1C); (9) we recommend that once fetal growth restriction is diagnosed, serial umbilical artery Doppler assessment should be performed to assess for deterioration (GRADE 1C); (10) with decreased end-diastolic velocity (ie, flow ratios greater than the 95th percentile) or in pregnancies with severe fetal growth restriction (estimated fetal weight less than the third percentile), we suggest weekly umbilical artery Doppler evaluation (GRADE 2C); (11) we recommend Doppler assessment up to 2–3 times per week when umbilical artery absent end-diastolic velocity is detected (GRADE 1C); (12) in the setting of reversed end-diastolic velocity, we suggest hospitalization, administration of antenatal corticosteroids, heightened surveillance with cardiotocography at least 1–2 times per day, and consideration of delivery depending on the entire clinical picture and results of additional evaluation of fetal well-being (GRADE 2C); (13) we suggest that Doppler assessment of the ductus venosus, middle cerebral artery, or uterine artery not be used for routine clinical management of early- or late-onset fetal growth restriction (GRADE 2B); (14) we suggest weekly cardiotocography testing after viability for fetal growth restriction without absent/reversed end-diastolic velocity and that the frequency be increased when fetal growth restriction is complicated by absent/reversed end-diastolic velocity or other comorbidities or risk factors (GRADE 2C); (15) we recommend delivery at 37 weeks of gestation in pregnancies with fetal growth restriction and an umbilical artery Doppler waveform with decreased diastolic flow but without absent/reversed end-diastolic velocity or with severe fetal growth restriction with estimated fetal weight less than the third percentile (GRADE 1B); (16) we recommend delivery at 33–34 weeks of gestation for pregnancies with fetal growth restriction and absent end-diastolic velocity (GRADE 1B); (17) we recommend delivery at 30–32 weeks of gestation for pregnancies with fetal growth restriction and reversed end-diastolic velocity (GRADE 1B); (18) we suggest delivery at 38–39 weeks of gestation with fetal growth restriction when the estimated fetal weight is between the 3rd and 10th percentile and the umbilical artery Doppler is normal (GRADE 2C); (19) we suggest that for pregnancies with fetal growth restriction complicated by absent/reversed end-diastolic velocity, cesarean delivery should be considered based on the entire clinical scenario (GRADE 2C); (20) we recommend the use of antenatal corticosteroids if delivery is anticipated before 33 6/7 weeks of gestation or for pregnancies between 34 0/7 and 36 6/7 weeks of gestation in women without contraindications who are at risk of preterm delivery within 7 days and who have not received a prior course of antenatal corticosteroids (GRADE 1A); and (21) we recommend intrapartum magnesium sulfate for fetal and neonatal neuroprotection for women with pregnancies that are <32 weeks of gestation (GRADE 1A).

Key words: cardiotocography, Doppler, fetal growth restriction, fetal weight, umbilical artery

Introduction

Fetal growth restriction (FGR) can result from a variety of maternal, fetal, and placental conditions.¹ Although the primary underlying mechanisms for FGR are varied, they often share the same final common pathway of **suboptimal fetal nutrition and uteroplacental perfusion**.^{1,2} Chromosomal disorders and congenital malformations are responsible for approximately 20% of FGR cases.^{2,3} **Suboptimal perfusion of the maternal placental circulation is the most common cause of FGR and accounts for 25–30% of all cases.**^{2,3}

FGR occurs in up to 10% of pregnancies and is a leading cause of infant morbidity and mortality.^{1,4,5} **In fetuses at all gestational ages with weights below the 10th percentile, the stillbirth rate is approximately 1.5%, which is twice the rate in fetuses with normal growth.** With fetal weights below the fifth percentile, the stillbirth rate can be as high as 2.5%.^{6,7} Furthermore, infants with birthweights below the 10th percentile are more likely to have severe acidosis at birth, low 5-minute Apgar scores, and neonatal intensive care unit admissions.⁸ Prematurity further compounds the risk of adverse outcomes in FGR.⁹ **Studies report a 2- to 5-fold increased rate of perinatal death among preterm FGR fetuses compared with term FGR fetuses.**⁹ **Perinatal outcomes are largely dependent on the severity of FGR, with the worst outcomes noted in fetuses with estimated fetal weights (EFWs) at less than the third percentile or in association with fetal Doppler abnormalities.**^{5,10}

In addition to its significant perinatal impact, FGR also has an impact on long-term health outcomes. It has been associated with metabolic programming that increases the risk of future development of metabolic syndrome and consequent cardiovascular and endocrine diseases.^{11,12} It also can contribute to cardiac remodeling, leading to cardiovascular dysfunction that can persist into childhood and adolescence.^{13,14} In addition, studies have shown an association between FGR and long-term neurologic impairment,^{15–20} with rates of cognitive and learning disabilities as high as 20%–40% by school age.²¹

FGR remains a complex obstetrical problem with disparate published diagnostic criteria, relatively low detection rates, and limited preventative and treatment options.^{22–25} Antenatal care of FGR is often complicated by the presence of maternal disease, such as hypertension, and optimal management involves balancing maternal, fetal, and neonatal risks. The purpose of this document is to outline an evidence-based, standardized approach for the prenatal diagnosis and management of FGR.

Terminology and diagnostic criteria

FGR and small for gestational age (SGA) are terms sometimes used interchangeably in the literature and clinical

practice. The term FGR has been used to describe a fetus with an EFW below the 10th percentile and SGA to describe a newborn whose birthweight is less than the 10th percentile for gestational age.²⁶ The use of the term intrauterine growth restriction (IUGR) should be abandoned in favor of FGR.

Fetuses with FGR are not always SGA at birth, and SGA neonates have often not been diagnosed as growth restricted on prenatal ultrasound.²⁷ **Of fetuses diagnosed with FGR, approximately 18%–22% will be constitutionally small but healthy at birth with a normal outcome.**²⁴ A significant challenge in the prenatal management of FGR is **differentiating the constitutionally small fetus from one who is pathologically growth restricted and at risk for postnatal complications.**

FGR is commonly defined as an ultrasonographic EFW below the 10th percentile for gestational age. A review of national guidelines for the diagnostic criteria for FGR from 6 countries (United States, United Kingdom, France, Ireland, Canada, and New Zealand) reveals a broad consensus on this definition of FGR.²⁴ However, there is significant variation in the diagnostic criteria used for FGR. Some diagnostic criteria are limited to fetal biometric measurements, whereas others incorporate abnormal Doppler findings.²⁸ Moreover, the biometric component of the FGR diagnostic criteria differs according to the choice of population vs customized reference growth standards, whether EFW is used alone or together with abdominal circumference (AC), and which cutoff is used to define abnormal growth.^{24,29,30} For example, 3 of the 6 countries also include AC as a diagnostic criterion, with the United Kingdom and Canada using an AC cutoff of less than the 10th percentile and New Zealand using an AC cutoff of less than the 5th percentile.²⁴

Evidence supports the use of AC as a diagnostic criterion for FGR. In a prospective study in 1000 low-risk pregnancies, an AC of less than the 10th percentile was found to have diagnostic accuracy similar to EFW less than the 10th percentile for the prediction of SGA.³¹ In a meta-analysis published in 2017, an AC of less than the 10th percentile predicted SGA as well as ultrasonographic EFW less than the 10th percentile, with comparable sensitivity and specificity. Compared with other cutoffs, an AC of less than the fifth percentile has significantly lower sensitivity but higher specificity in predicting SGA.³² Another systematic review and meta-analysis reported that AC and EFW performed similarly, and for a 10% fixed false-positive rate, AC had higher sensitivity.³³

An alternative approach to the diagnosis of FGR includes the determination of fetal growth trajectory, generated from multiple ultrasound examinations, and the identification of the fetus that drops off its own growth trajectory. Theoretically, this approach takes into consideration the dynamic aspect of growth and the individualized growth potential of each fetus.³⁴ However, this approach requires multiple ultrasound examinations, and prospective studies fail to demonstrate the superiority of this approach in improving clinical outcomes.³⁵ **We recommend that FGR be defined as an**

ultrasonographic EFW or AC below the 10th percentile for gestational age (GRADE 1B).

Ultrasonographic estimation of fetal weight

Accurate pregnancy dating is an important prerequisite for diagnosing FGR. Parameters for assigning gestational age by ultrasound have been recently updated.³⁶ Pregnancy dating is best established when first-trimester crown-rump length is used to either confirm menstrual dates or assign new dates.³⁶ Ultrasonographic fetal weight estimation is generated by the use of regression equations that combine biometric measurements of the fetal biparietal diameter, head circumference (HC), AC, and femur length; a multi-society task force has recently standardized criteria for these images obtained for fetal biometry.³⁷ The ultrasonographic EFW is then compared with a reference chart to generate a weight percentile.

The first ultrasonographic equation used to estimate fetal weight was published by Warsof et al in 1977, and since then, many others have been developed.³⁸ Considerable variation in accuracy was noted in a retrospective review of 26 formulas for ultrasonographic fetal weight estimation. For birthweights in the range of 1000–4500 g, formulas based on 3 or 4 fetal biometric indices were significantly more accurate in estimating fetal weights than formulas based on 1 or 2 indices.³⁹ In a review of the literature relating to methods and sources of inaccuracies in the estimation of fetal weight, the authors concluded that averaging of multiple measurements, improvements in image quality, uniform calibration of equipment, and regular audits may help to improve fetal weight estimation and reduce errors.⁴⁰

Fetal growth nomograms generally represent either unadjusted population standards or customized standards that adjust for constitutional or physiological variations of fetal size based on sex and race.^{35,41–44} The most widely used method for estimating fetal weight and calculating weight percentile in the United States is based on the Hadlock formula, which was generated from a study involving 392 pregnancies in predominantly white, middle-class women conducted at a single institution in Texas.⁴¹ In some studies, the use of customized growth standards has been shown to improve the ability to distinguish growth-restricted fetuses from constitutionally small fetuses.^{45–47}

Whether the use of customized growth standards translates to improved pregnancy outcomes was the subject of several recent studies: the INTERGROWTH-21st standard,⁴⁴ the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) standards,⁴⁸ and the World Health Organization (WHO) standard.^{49,50} The INTERGROWTH-21st study included healthy pregnant women with no maternal or fetal risk factors from 8 countries and created a single universal standard for fetal growth without adjusting for ethnic variation.⁴⁴ The NICHD study, performed at 12 sites in the United States, developed racial/ethnic-specific standards of fetal growth.⁴⁸ Finally,

the WHO study developed an overall growth standard based on data collected from 10 countries.^{49,50}

Although both the NICHD and WHO studies identified racial/ethnic differences in fetal growth, evidence to date indicates that the use of these new formulas in clinical practice does not improve the detection and outcome of FGR.^{51–53} In a preterm population in France, the INTERGROWTH-21st formula was associated with a higher mean percentage error and a higher underestimation of birthweight at >28 weeks of gestation when compared with Hadlock. The Hadlock formula classified more infants within 10% of actual birthweight and was more accurate than the INTERGROWTH-21st in the overall estimation of weight for fetuses delivered between 22 and 34 weeks of gestation.⁵³ The diagnostic accuracy for estimating fetal weight and the prediction of neonatal morbidity was compared using the NICHD standard and Hadlock in 1514 pregnant women with different ethnicities. The Hadlock formula better predicted SGA and composite neonatal morbidity at birth and had a lower ultrasound-to-birthweight percentile discrepancy than the NICHD growth standard. Fetuses classified as growth restricted by Hadlock, but not by the NICHD growth standard, had significantly higher composite morbidity than fetuses of normal growth.⁵¹ In view of these findings, we recommend the use of population-based fetal growth references (such as Hadlock) in determining fetal weight percentiles (GRADE 1B).

Classification of fetal growth restriction

Timing of diagnosis

FGR has been categorized as early or late onset based on gestational age at prenatal ultrasound diagnosis, with early-onset FGR diagnosed before 32 weeks of gestation and late-onset FGR diagnosed at or after 32 weeks of gestation. In a cohort of 656 pregnancies with FGR, a gestational age of 32 weeks at diagnosis was identified as the optimal cutoff to maximize the differences in associated comorbidities and pregnancy outcomes between early- and late-onset FGR.⁵⁴ The clinical spectrum of early- and late-onset FGR also differs; early-onset FGR is typically more severe, tends to follow an established Doppler pattern of fetal deterioration, is more commonly associated with maternal hypertensive disorders of pregnancy, and shows more significant placental dysfunction than late-onset FGR.^{23,28,54–56} Fetuses with genetic abnormalities can also present with early-onset FGR, commonly in association with fetal and amniotic fluid abnormalities.³ Late-onset FGR represents approximately 70%–80% of FGR cases and is typically milder in presentation.^{55,56} Unlike early-onset FGR, late-onset FGR is less likely to be associated with maternal hypertensive disorders and typically has less extensive placental histopathologic findings of underperfusion.^{57–59} In early-onset FGR, the pattern of Doppler deterioration progresses from abnormalities in the umbilical arteries and the ductus venosus to abnormal biophysical parameters.^{55,56} In contrast, cardiovascular adaptation of late-onset FGR is

typically limited to the cerebral circulation and is commonly associated with normal Doppler of the umbilical arteries.^{57,60,61}

Severity of fetal growth restriction

Studies have reviewed various ultrasonographic parameters to better identify growth-restricted fetuses at increased risk for perinatal morbidity and mortality.²⁸ The presence of abnormal umbilical artery Doppler indices has been found to predict adverse perinatal outcomes.⁶² An EFW below the third percentile has also been associated with an increased risk of adverse perinatal outcome irrespective of umbilical and middle cerebral artery Doppler indices.¹⁰ In a large retrospective cohort of more than 3 million singleton pregnancies, the risk of stillbirth at birthweights of less than the 3rd percentile was increased approximately 3-fold over the 3rd to 5th percentile group at nearly all gestational ages, and there was an increased risk of 4-fold to 7-fold over the 5th to 10th percentile group.⁶³ These results are consistent with neonatal data showing a significantly increased risk of morbidity and mortality in infants born at term with birthweights below the third percentile.⁶⁴ Therefore, an EFW below the third percentile has been found to represent a more severe form of FGR.

Symmetric and asymmetric fetal growth restriction

FGR has been classified as symmetric or asymmetric based on the ratio between the head circumference and the abdominal circumference (HC/AC). In the past, such classification was thought to provide valuable information about the timing of pregnancy insult and the etiology and prognosis of FGR.⁶⁵ More recently, growth and developmental delay have been evaluated from birth to the age of 4 years and shown to be similar in symmetric and asymmetric growth-restricted preterm newborns.⁶⁶ Furthermore, HC/AC was not found to be an independent predictor of adverse pregnancy outcomes.⁶⁷

Management of fetal growth restriction

General considerations

There are currently no preventative strategies or treatments for FGR that have been proven to be effective. There is no consistent evidence that nutritional and dietary supplements or bed rest prevents FGR or reduces the incidence of SGA births.^{68–71} The use of prophylactic low-dose aspirin was shown to provide a modest risk reduction in FGR and SGA in 2 meta-analyses.^{72,73} However, this finding was not confirmed in the Aspirin for Evidence-Based Preeclampsia Prevention (ASPRE) trial, which was primarily designed for preterm preeclampsia prevention.^{74,75} Due to the conflicting evidence on the role of low-dose aspirin in the prevention of recurrent FGR in otherwise low-risk women, the American College of Obstetricians and Gynecologists recommends against the use of low-dose aspirin for the sole indication of FGR

prevention.⁷⁶ Furthermore, the use of low-molecular-weight heparin has not been shown to reduce the risk of recurrent placenta-mediated pregnancy complications in at-risk women.^{75,77,78} At present, there is no evidence that therapeutic interventions, including sildenafil to augment uteroplacental perfusion through vasodilation, improve placental perfusion and outcome in pregnancies with FGR.^{75,79} **We recommend against the use of low-molecular-weight heparin for the sole indication of prevention of recurrent FGR (GRADE 1B). We also recommend against sildenafil or activity restriction for in utero treatment of FGR (GRADE 1B).**

Management of FGR is based on early diagnosis, optimal fetal surveillance, and timely delivery that reduces perinatal mortality and minimizes short- and long-term morbidity. In pregnancies with FGR, delivery decisions require balancing the risk of prematurity against that of stillbirth. The decision to deliver is typically guided by maternal factors, such as the presence of maternal hypertension, and by fetal comorbidities, such as the degree of growth restriction and the severity of abnormal fetal surveillance results. There is currently no consensus on the best approach to the management of FGR, despite a large body of literature on the subject. This lack of agreement is primarily due to the paucity of randomized trials and the heterogeneity of study populations.

Despite these limitations, accumulating evidence suggests a benefit to the use of umbilical artery Doppler in the surveillance of FGR. Furthermore, the presence of a standardized protocol for diagnosis and management appears to be associated with more favorable outcomes, as evidenced in the better-than-expected perinatal morbidity and mortality in the Trial of Randomized Umbilical and Fetal Flow in Europe (TRUFFLE).⁸⁰ Results of this trial, which standardized the approach to care and criteria for delivery, are in contrast to those of the Growth Restriction Intervention Trial (GRIT),^{81,82} which left management to the discretion of the managing providers. **The single most important prognostic factor in preterm fetuses with growth restriction is the gestational age at delivery.**^{80,83} A large longitudinal cohort study on FGR showed an increase of 1%–2% in intact survival for every additional day spent in utero up until 32 weeks of gestation.⁸³ An algorithm for the diagnosis and management of FGR is provided in Figure 1.

Maternal hypertensive disease is common in early-onset FGR and plays an important role in pregnancy outcomes. In TRUFFLE, maternal hypertension was present in 50% of pregnancies during the study and 70% of pregnancies at the time of delivery. The presence of maternal hypertension was one of the most important independent determinants of poor outcomes.^{16,80} Pregnant women with hypertension had a significantly shorter median interval from study enrollment to delivery, and newborns of mothers with hypertension were delivered at an earlier gestational age and had lower birthweights.⁸⁰ Women with early-onset FGR should be closely monitored for the development of hypertensive disorders of pregnancy.

Summary of recommendations

Number	Recommendations	Grade
1	We recommend that FGR be defined as an ultrasonographic EFW or AC below the 10th percentile for gestational age.	1B Strong recommendation, moderate-quality evidence
2	We recommend the use of population-based fetal growth references (such as Hadlock) in determining fetal weight percentiles.	1B Strong recommendation, moderate-quality evidence
3	We recommend against the use of low-molecular-weight heparin for the sole indication of prevention of recurrent FGR.	1B Strong recommendation, moderate-quality evidence
4	We recommend against the use of sildenafil or activity restriction for in utero treatment of FGR.	1B Strong recommendation, moderate-quality evidence
5	We recommend that a detailed obstetrical ultrasound examination (CPT code 76811) be performed with early-onset FGR (<32 weeks of gestation) because up to 20% of cases are associated with fetal or chromosomal abnormalities.	1B Strong recommendation, moderate-quality evidence
6	We recommend that women be offered fetal diagnostic testing, including CMA, when FGR is detected and a fetal malformation, polyhydramnios, or both are also present regardless of gestational age.	1B Strong recommendation, moderate-quality evidence
7	We recommend that pregnant women be offered prenatal diagnostic testing with CMA when unexplained isolated FGR is diagnosed at <32 weeks of gestation.	1C Strong recommendation, low-quality evidence
8	We recommend against screening for toxoplasmosis, rubella, or herpes in pregnancies with FGR in the absence of other risk factors and recommend PCR for CMV in women with unexplained FGR who elect diagnostic testing with amniocentesis.	1C Strong recommendation, low-quality evidence
9	We recommend that once FGR is diagnosed, serial umbilical artery Doppler assessment should be performed to assess for deterioration.	1C Strong recommendation, low-quality evidence
10	With decreased end-diastolic velocity (ie, flow ratios greater than the 95th percentile) or in pregnancies with severe FGR (EFW less than the 3rd percentile), we suggest weekly umbilical artery Doppler evaluation.	2C Weak recommendation, low-quality evidence
11	We recommend Doppler assessment up to 2–3 times per week when umbilical AEDV is detected because of the potential for deterioration and development of REDV.	1C Strong recommendation, low-quality evidence
12	In the setting of REDV, we suggest hospitalization, administration of antenatal corticosteroids, heightened surveillance with CTG at least 1–2 times per day, and consideration of delivery depending on the entire clinical picture and results of additional evaluation of fetal well-being.	2C Weak recommendation, low-quality evidence
13	We suggest that Doppler assessment of the ductus venosus, middle cerebral artery, or uterine artery not be used for routine clinical management of early- or late-onset FGR.	2B Weak recommendation, moderate-quality evidence
14	We suggest weekly CTG testing after viability for FGR without AEDV/REDV and that the frequency be increased when FGR is complicated by AEDV/REDV or other comorbidities or risk factors.	2C Weak recommendation, low-quality evidence
15	We recommend delivery at 37 weeks of gestation in pregnancies with FGR and an umbilical artery Doppler waveform with decreased diastolic flow but without AEDV/REDV or with severe FGR with EFW less than the third percentile.	1B Strong recommendation, moderate-quality evidence
16	We recommend delivery at 33–34 weeks of gestation for pregnancies with FGR and AEDV.	1B Strong recommendation, moderate-quality evidence
17	We recommend delivery at 30–32 weeks of gestation for pregnancies with FGR and REDV.	1B Strong recommendation, moderate-quality evidence
18	We suggest delivery at 38–39 weeks of gestation with FGR when the EFW is between the 3rd and 10th percentile and the umbilical artery Doppler is normal.	2C Weak recommendation, low-quality evidence

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(continued)

Summary of recommendations *(continued)*

Number	Recommendations	Grade
19	We suggest that for pregnancies with FGR complicated by AEDV/REDV, cesarean delivery should be considered based on the entire clinical scenario.	2C Weak recommendation, low-quality evidence
20	We recommend the use of antenatal corticosteroids if delivery is anticipated before 33 6/7 weeks of gestation or for pregnancies between 34 0/7 and 36 6/7 weeks of gestation in women without contraindications who are at risk of preterm delivery within 7 days and who have not received a previous course of antenatal corticosteroids.	1A Strong recommendation, high-quality evidence
21	We recommend intrapartum magnesium sulfate for fetal and neonatal neuroprotection for women with pregnancies that are <32 weeks of gestation.	1A Strong recommendation, high-quality evidence

AC, abdominal circumference; AEDV, artery absent end-diastolic velocity; CMA, chromosomal microarray analysis; CMV, cytomegalovirus; CPT, current procedural terminology; CTG, cardiotocography; EFW, estimated fetal weight; FGR, fetal growth restriction; PCR, polymerase chain reaction; REDV, reversed end-diastolic velocity.

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Initial diagnosis

With the initial diagnosis of FGR and if not previously performed, **we recommend that a detailed obstetrical ultrasound examination (current procedural terminology code 76811) be performed with early-onset FGR because up to 20% of cases are associated with fetal or chromosomal abnormalities^{2,3,84,85} (GRADE 1B).** The combination of FGR with a fetal malformation or polyhydramnios should prompt genetic counseling and consideration of prenatal diagnostic testing.⁸⁶ **We recommend that women be offered fetal diagnostic testing, including chromosomal microarray analysis (CMA), when FGR is detected and a fetal malformation, polyhydramnios, or both are also present regardless of gestational age (GRADE 1B).**

Although chromosome abnormalities are more frequent in pregnancies with structural anomalies and FGR, in a systematic review that included fetuses with no structural malformations, the mean rate of chromosomal abnormalities was 6.4%. Only a fraction of the studies included women in the third trimester with apparently isolated FGR, but no karyotype abnormalities were identified in those women. Due to substantial heterogeneity of the selected studies in the systemic review, meta-analytic methods, such as calculating the effect estimates, could not be applied.⁸⁷ More recent studies have evaluated the role of CMA in fetuses with early-onset growth restriction and no structural malformations; such studies have identified a 4%–10% incremental yield of CMA over karyotype.^{88–90}

We recommend that pregnant women be offered prenatal diagnostic testing with CMA when unexplained isolated FGR is diagnosed at <32 weeks of gestation (GRADE 1C).

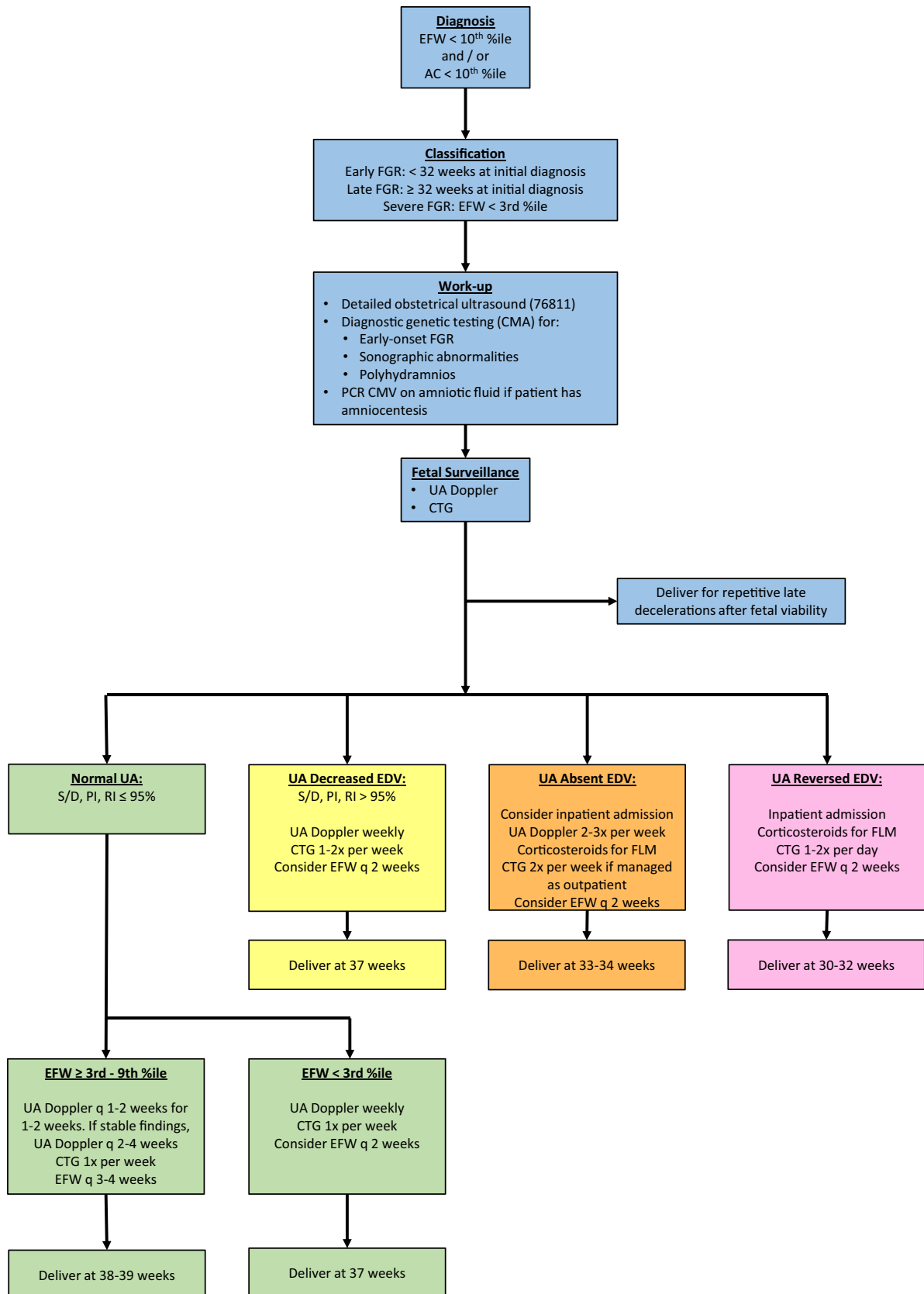
The association of maternal infections with FGR was recently evaluated in a study that included 319 pregnancies. No cases of maternal or congenital infection with toxoplasma, rubella, or herpes were found, whereas 6 (1.8%) fetuses were diagnosed as having congenital cytomegalovirus (CMV). Two (0.6%) of the fetuses with congenital CMV had no ultrasonographic findings other than FGR.⁹¹ In

another prospective cohort study of 48 pregnancies with FGR, 1 newborn (2.1%) was diagnosed with congenital CMV.⁹² **We recommend against screening for toxoplasmosis, rubella, or herpes in pregnancies with FGR in the absence of other risk factors and recommend polymerase chain reaction (PCR) for CMV in women with unexplained FGR who elect diagnostic testing with amniocentesis (GRADE 1C).** However, given the low incidence of CMV in cases of FGR, the lack of effective antenatal interventions, and the limited utility of serologic testing for CMV in the third trimester, routine infectious serologies may not be warranted in the absence of risk factors or ultrasonographic markers of fetal infection.^{91–94} PCR is the preferred testing approach for CMV and should be performed in women with unexplained FGR who undergo diagnostic testing with amniocentesis.

Umbilical artery Doppler

Umbilical artery Doppler assesses the impedance to blood flow along the fetal component of the placental unit. As early as 14 weeks of gestation, low impedance of the fetal placental circulation permits continuous forward flow in the umbilical artery throughout the cardiac cycle.⁹⁵ Doppler waveforms of the umbilical artery can be obtained from any segment along the umbilical cord. Waveforms obtained near the placental end of the cord reflect downstream impedance and show higher end-diastolic blood flow velocity than waveforms obtained near the fetal cord insertion.⁹⁵ In general, this variation in umbilical artery Doppler end-diastolic flow along the umbilical cord is minimal and not significant enough to affect clinical decision-making.

The pulsatility index (PI), resistance index (RI), or systolic-to-diastolic (S/D) ratio can be used for quantification of the Doppler waveform in the umbilical artery, although recent studies have generally used either the PI or RI.^{5,16,28,30,80,83} An abnormal umbilical artery Doppler is defined as a PI, RI, or S/D ratio greater than the 95th percentile for gestational age or an absent or reversed end-diastolic velocity (AEDV or

FIGURE 1
Algorithm for the diagnosis and management of fetal growth restriction


REDV). The progression from an abnormal umbilical artery Doppler with a decreased diastolic flow to AEDV/REDV can take several days to weeks, especially in the absence of maternal disease. In a large study on FGR, the mean time-to-delivery interval for umbilical artery PI greater than the 95th percentile, AEDV, and REDV was 26, 13, and 4 days, respectively.⁶²

An abnormal umbilical artery Doppler waveform reflects the presence of placental insufficiency and can help differentiate the growth-restricted fetus from the constitutionally small fetus. Incorporation of umbilical artery Doppler evaluation in the management of high-risk pregnancies has been shown to significantly reduce the risk of perinatal death, induction of labor, and cesarean delivery. As such, it is an essential component of fetal surveillance in FGR.^{96,97} In contrast, a systematic review of 5 trials found no evidence of maternal or neonatal benefit from the routine use of umbilical artery Doppler in low-risk pregnancies.⁹⁸

AEDV/REDV in the umbilical artery reflects the presence of significant placental deterioration and is associated with high perinatal mortality. The finding of AEDV/REDV of the umbilical artery can be intermittent; this likely represents the continuum of Doppler deterioration that occurs before the absent or reversed flow becomes persistent.⁹⁹ A meta-analysis of 31 studies on the risk of fetal death in FGR before 34 weeks of gestation reported odds ratios for fetal death of 3.59 (95% confidence interval [CI], 2.3–5.6) and 7.27 (95% CI, 4.6–11.4) for AEDV and REDV, respectively. Pooled data from this meta-analysis also revealed a risk of stillbirth of 6.8% for AEDV and 19% for REDV in the umbilical artery or ductus venosus.¹⁰⁰ These risks of stillbirth are higher than the risk of infant mortality or severe morbidity at 33–34 weeks for AEDV and at 30–32 weeks for REDV as reported in TRUFFLE.⁸⁰

Evidence suggests that umbilical artery Doppler does not reliably predict adverse pregnancy outcome in late-onset FGR.¹⁰¹ This result is probably related to the lower frequency of placental pathologic findings in late-onset FGR when compared with early-onset FGR.^{102–104} Experimental modeling suggests that a threshold of placental vascular obliteration is required before umbilical artery Doppler abnormalities are seen; therefore, the presence of a normal umbilical artery Doppler in late-onset FGR does not rule out placental disease.^{105,106}

There are currently no randomized trials with adequate sample size to inform recommendations regarding the optimal frequency of umbilical artery Doppler for FGR surveillance.¹⁰⁷ Protocols vary from weekly umbilical artery Doppler to a 2- to 4-week interval.^{24,108} A prospective observational study of the progression of Doppler

abnormalities in FGR suggests that rapid progression, if it is going to occur, is typically noted within the first 2 weeks after diagnosis.^{24,108} **We recommend that once FGR is diagnosed, serial umbilical artery Doppler assessment should be performed to assess for deterioration (GRADE 1C).** This assessment should initially occur every 1–2 weeks. If the umbilical artery Doppler remains normal after this initial assessment, a less frequent interval of umbilical artery Doppler testing (eg, every 2–4 weeks) may be considered.¹⁰⁸

With decreased end-diastolic velocity (ie, flow ratios greater than the 95th percentile) or in pregnancies with severe FGR (EFW less than the 3rd percentile), we suggest weekly umbilical artery Doppler evaluation^{24,95} (GRADE 2C). We recommend Doppler assessment up to 2–3 times per week when umbilical artery AEDV is detected due to the potential for deterioration and development of REDV (GRADE 1C). In the setting of REDV, we suggest hospitalization, administration of antenatal corticosteroids, heightened surveillance with cardiotocography (CTG) at least 1–2 times per day, and consideration of delivery depending on the entire clinical picture and results of additional evaluation of fetal well-being (GRADE 2C). Hospital admission should be considered if fetal surveillance of more often than 3 times per week is deemed necessary. Once FGR is diagnosed, assessment of fetal growth and weight should be performed at least every 3–4 weeks; consideration can be given for a 2-week interval in cases of severe FGR or with abnormal umbilical artery Doppler.¹⁰⁹

Ductus venosus Doppler

Longitudinal studies have shown that Doppler abnormalities of the ductus venosus in FGR reflect an advanced stage of fetal compromise, associated with increased perinatal morbidity and mortality.^{2,23,55,110–117} A meta-analysis of FGR at <34 weeks of gestation reported odds ratios for stillbirth of 11.16 (95% CI, 6.31–19.73) for absent or reversed A-wave of the ductus venosus and a frequency of stillbirth of 20%; the risk of stillbirth with a reversed A-wave was 46%.¹⁰⁰ In FGR, Doppler abnormalities of the ductus venosus primarily reflect increased central venous pressure, resulting from increased right ventricular end-diastolic pressure and decreased cardiac muscle compliance.^{110,118} Reversed A-wave of the ductus venosus in FGR signifies more significant fetal cardiac compromise.¹¹⁹ Doppler abnormalities of the ductus venosus in the setting of a normal umbilical artery Doppler indicate an alternative pathophysiological etiology, possibly related to the presence of fetal cardiac, vascular, or genetic abnormalities, and thus are most often not reflective of significant placental disease.

TRUFFLE compared ductus venosus Doppler and computer-generated short-term fetal heart rate variability (cSTV)

AC, abdominal circumference; CMA, chromosomal microarray analysis; CMV, cytomegalovirus; CTG, cardiotocography; EDV, end-diastolic velocity; EFW, estimated fetal weight; FGR, fetal growth restriction; FLM, fetal lung maturity; PCR, polymerase chain reaction; PI, pulsatility index; RI, resistance index; S/D, systolic-to-diastolic ratio; UA, umbilical artery.

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in the monitoring and timing of delivery in early-onset FGR. After correction for prematurity, survival without neurologic impairment was found to be significantly higher in the group delivered according to late ductus venosus changes (95%) compared with cSTV (85%).¹⁶ However, caution is urged when extrapolating the findings of TRUFFLE to practice in the United States. TRUFFLE compared cSTV with ductus venosus Doppler, and results cannot be generalized to the visual interpretation of CTG. Furthermore, absent or reversed A-wave of the ductus venosus represents an advanced stage of fetal compromise and is uncommon. Even in pregnancies with AEDV/REDV of the umbilical artery, late Doppler abnormalities of the ductus venosus are noted in only about 41% of fetuses.¹¹⁷ After 32 weeks of gestation, abnormal CTG findings will almost invariably precede Doppler abnormalities of the ductus venosus.¹¹¹ In TRUFFLE, delivery decisions guided by ductus venosus Doppler findings only accounted for about 11% of pregnancies allocated to the late ductus venosus findings group because most delivered due to other fetal or maternal indications.^{115,120,121} Prospective research is needed to further elucidate the role of ductus venosus Doppler in pregnancies with early-onset FGR before its use in routine surveillance of pregnancies with FGR can be recommended.

Middle cerebral artery Doppler

The middle cerebral artery is the largest vessel of the fetal cerebral circulation and carries about 80% of cerebral blood flow.¹²² Fetal hypoxemia associated with growth restriction results in cerebral vasodilation, an early adaptive mechanism termed the brain-sparing effect. Measurement of flow through the middle cerebral artery using Doppler can identify cerebral vasodilation, which can be quantified using PI or the cerebroplacental ratio (CPR). CPR is calculated by dividing the middle cerebral artery PI by the umbilical artery PI.^{123–126} The role of middle cerebral artery Doppler in the management of early-onset FGR has been evaluated in several studies.^{127–129} In a meta-analysis of 35 studies, abnormal middle cerebral artery Doppler had a low likelihood ratio (LR) for prediction of perinatal mortality (LR 1.36 [1.10–1.67]) and adverse perinatal outcome (LR 2.77 [1.93–3.96]).¹³⁰ Similarly, in a secondary analysis of data from TRUFFLE, middle cerebral artery Doppler did not add useful information beyond umbilical artery and ductus venosus Doppler assessments for optimizing the timing of delivery.¹³¹

Studies have found that 15%–20% of late-onset growth-restricted fetuses with normal umbilical blood flow have middle cerebral artery Doppler findings of cerebral vasodilation, and CPR has also been studied for its utility in predicting adverse outcomes and guiding the timing of delivery in late-onset cases.^{101,115,132–137} The Prospective Observational Trial to Optimize Pediatric Health in IUGR (PORTO) study evaluated the optimal management of fetuses with FGR at 24 0/7 to 36 6/7 weeks of gestation, including

multivessel Doppler measurement and CPR. Data from this study showed that CPR evaluation had a sensitivity of 66% and specificity of 85% for the prediction of adverse outcomes.¹³⁸ However, a large systematic review and meta-analysis on the prognostic accuracy of CPR and middle cerebral artery Doppler for adverse perinatal outcomes in FGR revealed few high-quality studies and reported large variations in sensitivity and specificity.¹³⁹ The available evidence does not indicate improved accuracy of CPR over umbilical artery Doppler, and clinical trials are needed to evaluate the effectiveness of CPR in guiding clinical management, especially in late-onset FGR, before its use in routine surveillance of pregnancies with FGR can be recommended.¹³⁹

Uterine artery Doppler

Uterine artery Doppler assesses the maternal component of placental blood flow and is a marker of remodeling of the spiral arteries by trophoblastic cellular invasion. In normal pregnancies, spiral artery remodeling results in a low-impedance circulation, which is reflected in the uterine arteries by the presence of high velocity and continuous forward flow in diastole.¹⁴⁰ This pregnancy adaptation optimizes the intervillous placental blood flow and delivery of oxygen and nutrients to the fetus. Severe early-onset FGR is characterized by failure of trophoblastic invasion of the myometrial spiral arteries, resulting in reduced uteroplacental perfusion.¹⁴⁰

Abnormal uterine artery Doppler, defined as a PI greater than the 95th percentile for gestational age or the presence of a diastolic notch, has been associated with adverse pregnancy outcomes, including preeclampsia, FGR, and perinatal mortality.^{137,141–147} However, uterine artery Doppler has limited diagnostic accuracy and clinical utility in predicting FGR, SGA birth, and perinatal mortality.^{148,149} Although FGR detection rates >90% have been reported in first- and second-trimester prediction models that combine maternal factors, biochemical markers, and uterine artery Doppler, lack of external validation or demonstration of improved pregnancy outcomes limits their clinical applicability.^{145,150,151} Based on the available evidence, uterine artery Doppler does not add clinically valuable information for diagnosis or management. **We suggest that Doppler assessment of the ductus venosus, middle cerebral artery, or uterine artery not be used for routine clinical management of early- or late-onset FGR (GRADE 2B).**

Cardiotocography

CTG is currently accepted as the primary method for fetal surveillance in high-risk pregnancies in the United States. Despite the absence of large prospective studies on the role of CTG in the management of FGR, a normal CTG in pregnancies with FGR is more likely to be associated with a normal perinatal outcome, and the presence of spontaneous repetitive late decelerations is accepted as an indication for delivery in viable pregnancies with FGR, irrespective of Doppler findings.¹²¹ Although there is limited

evidence to support the frequency of CTG in pregnancies with FGR, it is reasonable to initiate testing at diagnosis after viability, or at a gestational age at which an abnormal finding would trigger intervention.²⁴ **We suggest weekly CTG testing after viability for FGR without AEDV/REDV and that the frequency be increased when FGR is complicated by AEDV/REDV or other comorbidities or risk factors (GRADE 2C).**

Biophysical profile

Observational studies have indicated that an abnormal biophysical profile (BPP) is a late manifestation of placental disease that appears to become abnormal 48–72 hours after ductus venosus Doppler abnormalities in 90% of cases.¹⁵² More recent studies have questioned the value of BPP in fetal surveillance of high-risk pregnancies, including early-onset severe FGR, because of a high prevalence of false-positive and false-negative results. A Cochrane review concluded that available evidence from randomized controlled trials does not support the use of BPP as a test of fetal well-being in high-risk pregnancies.^{153,154} Although fetal deterioration has been reported to be independently reflected by Doppler and BPP testing, further studies are required to prove the usefulness of BPP or of combining these testing modalities.¹⁵⁵

Amniotic fluid volume

Oligohydramnios is defined as a single deepest vertical pocket of amniotic fluid of less than 2 cm. The PORTO study, which included more than 1100 pregnancies with FGR, noted that amniotic fluid volume abnormalities did not independently increase the risk for adverse outcomes in FGR.³⁰ There is currently a paucity of data on the role of amniotic fluid volume measurement in FGR management and delivery.³⁰ However, current guidelines on medically indicated late-preterm and early-term deliveries suggest delivery at 34 0/7 to 37 6/7 weeks of gestation for FGR associated with oligohydramnios.¹⁵⁶

Neonatal outcomes and delivery timing

The decision for delivery in FGR is driven by fetal and maternal factors. Fetal factors include EFW, gestational age, and findings on fetal surveillance. Maternal factors include the presence of comorbidities, such as hypertension. In the periviable period, the decision for delivery may be challenging because the rates of perinatal death, neurodevelopmental impairment, and other adverse outcomes are high in this gestational age window.^{157–159}

Survival of very preterm neonates gradually decreases with decreasing weight percentiles.^{160–163} Neonatal mortality in SGA infants born between 24 and 29 weeks of gestation is increased 2-fold to 4-fold when compared with appropriately grown neonates.^{4,164–166} In a large European study, birthweights between the 10th and 25th percentiles were associated with a 2-fold increase in mortality when compared with the 50th to 75th percentile weight group.¹⁶⁷ In early-onset FGR associated with abnormal Doppler

studies, neonatal survival increased from 13% at 24 weeks to 43% at 25 weeks and 58%–76% at 26 weeks of gestation. Intact survival was 0% at 24 weeks, 13% at 25 weeks, and 6%–31% at 26 weeks of gestation.¹⁵⁹ Given the high rate of adverse outcomes, thresholds of 26 weeks of gestation, 500 g, or both have been suggested for the delivery of pregnancies with severe early-onset FGR.^{55,80,83,159} With recent advances in neonatal care and survival of fetuses at the limits of viability, the decision for delivery before 26 weeks of gestation or at 500 g should include coordination of care between maternal-fetal medicine and neonatology services, along with comprehensive patient counseling on neonatal morbidity and mortality and shared decision-making regarding pregnancy management.

The evidence supporting the timing of delivery in pregnancies with FGR and abnormal umbilical artery Doppler but without AEDV/REDV is limited.¹⁶⁸ In a retrospective cohort study of pregnancies with FGR, no difference in composite neonatal outcome was seen between delivery at 39 weeks of gestation in fetuses with normal umbilical artery Doppler and delivery at 37 weeks of gestation in fetuses with elevated umbilical artery S/D ratio.¹⁶⁸ A large US cohort study reported that delivery at 37 weeks of gestation results in a decrease in the stillbirth rate in the presence of risk factors, such as FGR.¹⁶⁹ **We recommend delivery at 37 weeks of gestation in pregnancies with FGR and an umbilical artery Doppler waveform with decreased diastolic flow (S/D, RI, or PI greater than the 95th percentile) but without AEDV/REDV or with severe FGR with EFW less than the 3rd percentile (GRADE 1B).**

As discussed previously, neonatal morbidity and mortality rates associated with AEDV are higher than rates of complications of prematurity at 33–34 weeks of gestation.¹⁰⁰ **Therefore, we recommend delivery at 33–34 weeks of gestation for pregnancies with FGR and AEDV (GRADE 1B).** In the presence of REDV, neonatal morbidity and mortality rates are higher than complications of prematurity at 30–32 weeks of gestation.¹⁰⁰ **Therefore, we recommend delivery at 30–32 weeks of gestation for pregnancies with FGR and REDV (GRADE 1B).** **We suggest delivery at 38–39 weeks of gestation with FGR when the EFW is between the 3rd and 10th percentile and the umbilical artery Doppler is normal (GRADE 2C).**

There are limited data to inform recommendations regarding the mode of delivery in pregnancies complicated by FGR. Growth-restricted fetuses, particularly those with AEDV/REDV, are at an increased risk for decelerations in labor, emergency cesarean delivery, and metabolic acidemia at delivery.^{170,171} Older studies reported rates of intrapartum fetal heart rate decelerations requiring cesarean delivery in 75%–95% of pregnancies with FGR and AEDV/REDV.^{172,173} National guidelines from 4 countries recommend cesarean delivery when FGR is complicated by AEDV/REDV of the umbilical artery.²⁴ In recent studies that reported outcomes of pregnancies complicated by FGR with AEDV/REDV, the mode of delivery was primarily by cesarean, thus rendering it impossible to determine the likelihood of adverse outcomes associated with

The Society for Maternal-Fetal Medicine grading system: grading of recommendations assessment, development, and evaluation¹⁷⁶

Grade of recommendation	Clarity of risk and benefit	Quality of supporting evidence	Implications
1A. Strong recommendation, high-quality evidence	Benefits clearly outweigh risks and burdens or vice versa.	Consistent evidence from well-performed, randomized controlled trials or overwhelming evidence of some other form. Further research is unlikely to change confidence in the estimate of benefit and risk.	Strong recommendation that can apply to most patients in most circumstances without reservation. Clinicians should follow a strong recommendation unless a clear and compelling rationale for an alternative approach is present.
1B. Strong recommendation, moderate-quality evidence	Benefits clearly outweigh risks and burdens or vice versa.	Evidence from randomized controlled trials with important limitations (inconsistent results, methodologic flaws, indirect or imprecise) or very strong evidence of some other research design. Further research (if performed) is likely to have an impact on confidence in the estimate of benefit and risk and may change the estimate.	Strong recommendation that applies to most patients. Clinicians should follow a strong recommendation unless a clear and compelling rationale for an alternative approach is present.
1C. Strong recommendation, low-quality evidence	Benefits seem to outweigh risks and burdens or vice versa.	Evidence from observational studies, unsystematic clinical experience, or randomized controlled trials with serious flaws. Any estimate of effect is uncertain.	Strong recommendation that applies to most patients. Some of the evidence base supporting the recommendation is, however, of low quality.
2A. Weak recommendation, high-quality evidence	Benefits closely balanced with risks and burdens.	Consistent evidence from well-performed randomized controlled trials or overwhelming evidence of some other form. Further research is unlikely to change confidence in the estimate of benefit and risk.	Weak recommendation; best action may differ depending on circumstances or patients or societal values.
2B. Weak recommendation, moderate-quality evidence	Benefits closely balanced with risks and burdens; some uncertainty in the estimates of benefits, risks, and burdens.	Evidence from randomized controlled trials with important limitations (inconsistent results, methodologic flaws, indirect or imprecise), or very strong evidence of some other research design. Further research (if performed) is likely to have an effect on confidence in the estimate of benefit and risk and may change the estimate.	Weak recommendation; alternative approaches likely to be better for some patients under some circumstances.
2C. Weak recommendation, low-quality evidence	Uncertainty in the estimates of benefits, risks, and burdens; benefits may be closely balanced with risks and burdens.	Evidence from observational studies, unsystematic clinical experience, or randomized controlled trials with serious flaws. Any estimate of effect is uncertain.	Very weak recommendation; other alternatives may be equally reasonable.
Best practice	Recommendation in which either (1) there is an enormous amount of indirect evidence that clearly justifies strong recommendation (direct evidence would be challenging, and inefficient use of time and resources, to bring together and carefully summarize) or (2) recommendation to the contrary would be unethical.	—	—

Adapted from Guyatt et al.¹⁷⁷

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spontaneous or induced vaginal delivery.⁸⁶ Given these data and outcomes, we suggest that for pregnancies with FGR complicated by AEDV/REDV, cesarean delivery should be considered based on the entire clinical scenario (GRADE 2C).

In accordance with other guidelines,¹⁷⁴ we recommend the use of antenatal corticosteroids if delivery is anticipated before 33 6/7 weeks of gestation or for pregnancies between 34 0/7 and 36 6/7 weeks of gestation in women without contraindications who

are at risk of preterm delivery within 7 days and who have not received a previous course of antenatal corticosteroids¹⁷⁵ (GRADE 1A). We also recommend intrapartum magnesium sulfate for fetal and neonatal neuroprotection for women with pregnancies that are less than 32 weeks of gestation (GRADE 1A). ■

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Multidisciplinary consensus on the classification of prenatal and postnatal urinary tract dilation (UTD classification system)

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Abstract *Objective:* Urinary tract (UT) dilation is sonographically identified in 1–2% of fetuses and reflects a spectrum of possible uropathies. There is significant variability in the clinical management of individuals with prenatal UT dilation that stems from a paucity of evidence-based information correlating the severity of prenatal UT dilation to postnatal urological pathologies. The lack of correlation between prenatal and postnatal US findings and final urologic diagnosis has been problematic, in large measure because of a lack of consensus and uniformity in defining and classifying UT dilation. Consequently, there is a need for a unified classification system with an accepted standard terminology for the diagnosis and management of prenatal and postnatal UT dilation.

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Methods: A consensus meeting was convened on March 14–15, 2014, in Linthicum, Maryland, USA to propose: 1) a unified description of UT dilation that could be applied both prenatally and postnatally; and 2) a standardized scheme for the perinatal evaluation of these patients based on sonographic criteria (i.e. the classification system). The participating societies included American College of Radiology, the American Institute of Ultrasound in Medicine, the American Society of Pediatric Nephrology, the Society for Fetal Urology, the Society for Maternal-Fetal Medicine, the Society for Pediatric Urology, the Society for Pediatric Radiology and the Society of Radiologists in Ultrasounds.

Results: The recommendations proposed in this consensus statement are based on a detailed analysis of the current literature and expert opinion representing common clinical practice. The proposed UTD Classification System (and hence the severity of the UT dilation) is based on six categories in US findings: 1) anterior-posterior renal pelvic diameter (APRPD); 2) calyceal dilation; 3) renal parenchymal thickness; 4) renal parenchymal appearance; 5) bladder abnormalities; and 6) ureteral abnormalities. The classification system is stratified based on gestational age and whether the UT dilation is detected prenatally or postnatally. The panel also proposed a follow-up scheme based on the UTD classification.

Conclusion: The proposed grading classification system will require extensive evaluation to assess its utility in predicting clinical outcomes. Currently, the grading system is correlated with the risk of postnatal uropathies. Future research will help to further refine the classification system to one that correlates with other clinical outcomes such as the need for surgical intervention or renal function.

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Introduction

Prenatal diagnosis of urinary tract (UT) dilation occurs in 1–2% of all pregnancies. Based on an estimated birth rate in the United States of 4 million per year [1], approximately 40–80,000 children are diagnosed annually with this condition. The prenatal sonographic identification of UT dilation reflects a spectrum of potential etiologies and uropathies. The rationale of prenatal detection is to identify pathology prior to the development of complications such as urinary tract infection (UTI), urinary stone formation, and renal dysfunction. In the majority of the cases, the prenatal finding of UT dilation is transient or physiologic and has no clinical significance. In other cases, it represents obstructive conditions such as posterior urethral valves (PUV) that have significant morbidities and even mortalities (Table 1). In many of the cases, the etiology of UT dilation is unable to be determined before birth and is diagnosed postnatally with additional imaging including ultrasound (US) and voiding cystourethrogram (VCUG).

Clinical practice patterns vary considerably regarding recommendation for the follow-up evaluation of fetuses and children who have been diagnosed with prenatal UT dilation. This stems from the challenge of predicting which children will have a clinically significant uropathy and would benefit from postnatal imaging. Evaluating every child with prenatal UT dilation results in the expenditure of significant healthcare resources and could cost over \$90 million annually (1–3 prenatal US scans at \$500; antibiotics at \$25; 1–3 postnatal US scans at \$400; 1 VCUG at \$1200 per child). This does not factor in the cost associated with travel, time off from work for the parents, unnecessary parental anxiety, childhood radiation, and antibiotic

exposure. Alternatively, not evaluating any child with prenatal UT dilation could avoid these initial costs but might delay the diagnosis of significant uropathies such as PUV and consequently, incur higher long-term health and financial costs.

Evidence correlating the severity of prenatal UT dilation with postnatal urological pathologies is lacking for several reasons. First, there is no uniformity on how to define, classify, and grade UT dilation both within and between the prenatal and postnatal periods. As a result, several different classification systems have evolved, leading to varying nomenclature. Second, different terminologies with overlapping meanings are used to describe UT dilation, and different clinicians may use the terms to mean different things. This causes misunderstanding, which further leads to confusion as to the specific US findings identified. For example, the term hydronephrosis is often used by imagers to describe even mild degrees of UT dilation, while clinicians (especially among primary care providers) consider the term hydronephrosis to mean distension of the renal pelvis and calyces from obstruction of urine flow that, if left untreated, results in progressive renal deterioration. Thus, the communication of the findings, which is transmitted between the imager and the clinician, may be misinterpreted. Third, UT dilation is a dynamic process, which can fluctuate over time and with varying conditions. The distension of the renal pelvis and calyces may vary depending on factors such as hydration status, degree of bladder filling, and patient position. Finally, uropathies present in a spectrum of severity. As an example, not all cases of PUV present with a severe UT dilation. Therefore, minimal UT dilation does not necessarily exclude the diagnosis of PUV. Given the lack of

Table 1 Etiology of urinary tract dilation detected on antenatal ultrasound.

Etiology	Incidence (%)
Transient/physiologic	50–70
Ureteropelvic junction obstruction	10–30
Vesicoureteral reflux	10–40
Ureterovesical junction obstruction/megaureter	5–15
Multicystic dysplastic kidney disease	2–5
Posterior urethral valves	1–5
Ureterocele, ectopic ureter, duplex system, urethral atresia, Prune belly syndrome, polycystic kidney diseases, l cysts	Uncommon

Adapted from Nguyen et al. 2010 [16].

uniformity in the description of the sonographic findings and paucity of evidence on which to base clinical management, our goal is to develop a unified classification system with an accepted standard terminology for the diagnosis and management of prenatal and postnatal UT dilation.

Methods and conference preparations

Eight societies with a special interest in the diagnosis and management of fetuses and children with UT dilation (The American College of Radiology (ACR), the American Institute of Ultrasound in Medicine (AIUM), the American Society of Pediatric Nephrology (ASPN), the Society for Fetal Urology (SFU), the Society for Maternal-Fetal Medicine (SMFM), the Society for Pediatric Urology (SPU), the Society for Pediatric Radiology (SPR), and the Society of Radiologists in Ultrasound (SRU)) agreed to collaborate on the development of a unified grading system for perinatal UT dilation and propose a standardize scheme for follow-up evaluation.

The panel consisted of a director (HTN) and 12 panelists who each have specialized clinical and research experience with the perinatal diagnosis of UT dilation. The panel members were appointed by their respective societies and were representative of several medical disciplines including obstetrics (maternal fetal medicine, MFM), radiology, pediatric radiology, pediatric urology, and pediatric nephrology. Prior to the conference, specific aspects of prenatal and postnatal diagnosis of UT dilation were assigned to society representatives, based on his/her area of expertise. The current literature was reviewed and summarized for presentation (see References).

The consensus conference took place on March 14–15, 2014, in Linthicum, MD. An audience consisting of clinicians and researchers from the various specialties observed the proceedings in person or via webinar. The first day of the conference was devoted to presentations and discussion regarding the current classification systems for prenatal and postnatal UT dilation, correlation of prenatal US findings with postnatal outcomes, current recommendations for postnatal evaluation and follow-up, and long-term renal

outcomes in children with prenatal UT dilation. At the end of the first day, the panelists spent the evening drafting a consensus statement. The following day, this statement was presented to the audience and discussed until the entire group arrived at a consensus.

Background and summary of the literature

Correlation between prenatal and postnatal US findings and the ultimate urological diagnosis has been problematic, partly because of the lack of uniformity in defining and grading urinary tract (UT) dilation. Currently, there are several grading systems utilized. Some are descriptive (e.g. mild-moderate-severe [2]); others are quantitative (e.g. numeric value of the anterior-posterior renal pelvic diameter (APRPD) [3]) or semi-quantitative (e.g. SFU [4], European Society of Pediatric Radiology (ESPR), Uroradiology Task Force [5], and Onen grading system [6]). Certain grading systems are preferentially used in prenatal evaluation while others are preferred for postnatal evaluation. Based on a survey regarding prenatal diagnosis, MFM physicians overwhelmingly preferred using the APRPD, while pediatric urologists were equally divided between using the APRPD and the SFU grading system [7]. Pediatric radiologists were not included in the survey study results because most who were surveyed did not perform prenatal evaluation. For postnatal evaluation, pediatric radiologists preferred using the descriptive grading system, while urologists preferred using the quantitative (APRPD) or semi-quantitative (SFU) grading system [7]. Moreover, Swenson et al. (publication in progress) demonstrated that even when the same grading system was utilized, there was significant inter-rater variability as to which grade a specific sonographic image represented. All the current grading systems have less than ideal inter-observer reproducibility (kappa ranging from 0.2 to 0.6 [5,8,9]), and there are no defined correlations between grading systems.

A single grading system that can be used across the prenatal and postnatal time period to describe UT dilation would be beneficial to promote communication between different specialists. In the majority of the cases, oral communication or the report of the findings is not dependable. Although providing the actual US images would be optimal, non-imagers may not be familiar with interpreting gray-scale images, and, in practice, actual images are often not available. Developing a common grading system would allow for information transfer without the ambiguities of interpretation by different providers. Additionally, by having a consistent grading system utilized in both the prenatal and postnatal evaluation, more rigorous outcomes research could be performed to correlate the prenatal sonographic findings to specific consequences such as resolution of renal dilation, specific uropathies, risks for urinary tract infection, surgery, or renal dysfunction.

Prenatal imaging

In the United States, US evaluation is routinely performed during pregnancy with an average of two scans for low-risk

patients and four scans for high-risk patients [10]. National practice guidelines for obstetrical imaging include evaluation of the fetal kidneys and bladder as a required component of a complete survey [11]. The kidneys and bladder can be reliably seen on US by the end of the first trimester [12]. The incidence of detecting UT dilation prenatally after the first trimester is 1–2%, but is reported to be as high as 5% in some studies [13]. The majority of MFM specialists (91%) favor measuring the APRPD to characterize the severity of the renal dilation [7]. Several studies have evaluated the APRPD of the renal pelvis in normal fetuses as a function of gestational age to establish normative data [13,14]. The threshold used for diagnosing UT dilation based on APRPD typically varies depending on the gestational age of the fetus. The gestational age ranges used for various cut-off values were not consistent across studies, such that the number of gestational age groups and what cut-off values are applied to each group, is highly variable and erratic. The most common clinical practice is to use two gestational age groups, with the first typically starting in the second trimester (16–20 weeks) and the second in the third trimester (28–32 weeks). An APRPD of ≥ 4 mm is the most common threshold for diagnosing UT dilation in the earlier gestational age range, and ≥ 7 mm in the older age range [13,14].

Additional US findings that are important for defining the severity and clinical significance of the prenatal UT dilation include: laterality, extent of calyceal dilation, parenchymal abnormalities, bladder and ureteral abnormalities, gender, amniotic fluid volume (AFV), and other organ system abnormalities. Dilation of the calyces is an important predictor of clinically significant UT dilation [15]; consequently, some grading systems incorporate the degree of dilation of the calyces in characterizing the severity of UT dilation. Grignon et al. [3] proposed five grades of UT dilation that take into account the measurement of the APRPD, the degree of calyceal dilation, and parenchymal thickness. The SFU grading system [4] is composed of five grades that subjectively evaluate the dilation of the renal pelvis, distinguish between central (major) and peripheral (minor) calyceal dilation, and assess parenchymal thickness with different diagnostic criteria for second trimester and again for third trimester findings [16]. During the second trimester, the SFU system defined APRPD as mild for 4 to <7 mm, moderate 7 to ≤ 10 mm, and severe >10 mm. During the third trimester, mild is defined as APRPD of 7 to <9 mm, moderate as 9 to ≤ 15 mm, and severe as >15 mm.

Correlation with outcomes

Several studies have assessed outcome based on prenatal APRPD measurements, and most have found that the larger the APRPD, the more likely it is to be caused by obstructive uropathies [17–19], the greater the risk of requiring surgery postnatally [18,20–22], and the lower the spontaneous resolution rate [18,23]. However, it should be noted that these studies varied widely, applying different APRPD cut-offs, different gestational age ranges, and different outcome measures. Looking at the SFU grading system, a meta-analysis of the literature found that the severity of UT dilation based on the SFU criteria correlated with urological pathologies, except for vesicoureteral reflux (VUR)

[19,24]. Postnatal pathology (including VUR) was detected in only 12% of children with isolated second trimester UT dilation, but in 40% of those with dilation observed in both the second and third trimester [25]. Progressive UT dilation observed during pregnancy, rather than lack of progression or regression, is more often associated with uropathies [26]. In the diagnosis of lower urinary tract obstruction (such as from PUVs), oligohydramnios, renal cortical abnormalities, and early gestational age at diagnosis (e.g. <24 weeks) were found to be independent predictors of poor postnatal renal function [27].

Follow-up fetal imaging

In evaluating the need for follow-up US evaluation, it has been observed that prenatal UT dilation can resolve during pregnancy, remain stable, or may progress. The likelihood of resolution is related to the severity of the APRPD at initial diagnosis. Prenatal resolution occurred in approximately 80% of the cases when APRPD was between 4 and 7–8 mm during the second trimester [28–30], but less than 15% when APRPD was greater than 9 mm at that stage [28]. Consequently, follow-up US during the third trimester to assess interval change is usually recommended. For fetuses in which the UT dilation is mild (4–6 mm prior to 28 weeks gestation and 7–9 mm after 28 weeks onward), follow-up US during the third trimester detects those in which resolution has occurred and hence, those that do not require further prenatal or postnatal evaluation. In cases of moderate UT dilation (7–10 mm prior to 28 weeks and 10–15 mm 28 weeks onward) and severe cases (>10 mm prior to 28 weeks and >15 mm 28 weeks onward), US is warranted to evaluate for progression of UT dilation [16,28,30,31]. For the vast majority of cases, follow-up prenatal US evaluation is sufficient. In a few unique situations, prenatal MRI may provide additional information in diagnosis of UT dilation [32–34].

Fetal pyelectasis on mid-trimester US is associated with an increased risk of trisomy 21 [35–39]. The sonographic finding should prompt a targeted anatomic evaluation of the fetus, and as an isolated finding, carries a likelihood ratio of 1.5–1.6 for Down syndrome [36]. The finding of isolated fetal pyelectasis must be interpreted in the context of the *a priori* risk of trisomy 21 based on an accepted screening protocol. In addition, there are monogenic syndromes with congenital renal anomalies, some of which are associated with UT dilation [40].

Postnatal imaging

In current clinical practice, it is common that the prenatal US findings are not available to the physicians taking care of infants postnatally. Often, it is only mentioned that there is a history of prenatal kidney problems, without any additional details characterizing the extent and severity of the UT dilation. Postnatally, US is often the first imaging modality to evaluate these patients. In a recent survey of 284 pediatric radiologists with experience in interpreting postnatal US of UT dilation, 66% utilize the mild-moderate-severe grading system, while others routinely measure the APRPD or use the SFU grading system to characterize the

severity of the UT dilation (Swenson et al., publication accepted *Pediatric Radiology*) Based on intravenous pyelogram (IVP) [41] and magnetic resonance imaging (MRI) measurements (Swenson et al., publication accepted *Pediatric Radiology*), the normal APRPD in children is commonly considered to be 3 mm at 1 year of age and 6 mm at 18 years with the 99th percentile for children <5 years of age being <10 mm. It is important to recognize that these normative values are based on MRI, while most postnatal studies are performed with US. Furthermore, the distension of the urinary tract can be affected by the degree of bladder distension, hydration, and the position of the patient in which the US is performed. Furthermore, the accuracy of these measurements may be dependent on the US image resolution, the site of measurement, the technical skill of the sonographer, and the supervising physician.

It has been long recognized that the timing of the first postnatal US is important. Up to 48 h after birth, there is a tendency to underestimate the severity of hydronephrosis, in part because of dehydration [41,42]. It is generally recommended that the first postnatal US be delayed for at least 48 h after birth, except for cases of oligohydramnios, urethral obstruction, bilateral high-grade dilation, and concerns about patient compliance with postnatal evaluation [43]. Hydration can increase the size of a normal renal pelvis by increasing the volume of excreted fluid and also by affecting the bladder volume [44–48]. Consequently, it is recommended that in the presence of UT dilation, the patient should be rescanned after bladder emptying to accurately assess the severity of UT dilation. Patient position can also affect the accurate measurement of UT dilation, as in many cases the APRPD decreases when measured in the prone position [49]. As there are pros and cons to imaging the kidneys in either the prone or supine position, the current recommendation is that the same position be used in the same patient during each follow-up measurement to make for more accurate comparisons.

Multiple methods of grading UT dilation postnatally have been utilized. The descriptive grading system assesses the degree of renal pelvis dilation, calyceal dilation, and parenchymal thickness, categorizing variations as mild, moderate, or severe. This grading system was developed by correlating US with IVP grading [2]. The SFU grading system emphasizes the importance of intrarenal calyceal dilatation rather than the size of renal pelvis [4]. Consequently in this grading system, the APRPD is not measured. The intra-rater reliability is good and the inter-rater reliability is modest using this grading system [8,50]. A meta-analysis of the literature indicated that the SFU grading system is the most widely used with the best consistency (11/25 studies) [51]. In an attempt to improve further the accuracy of the grading system, ESPR proposed a modification of the SFU grading system in which APRPD was incorporated [5]. Onen proposed an alternative grading system in which Grade 1 represents pelvic dilation alone, Grade 2 with calyceal dilation, Grade 3 with less than 50% loss of the renal parenchyma, and Grade 4 with severe loss of renal parenchyma [6]. Compared with the SFU grading system, the Onen system has increased intra-rater reliability but decreased inter-rater reliability [9].

Alternative US parameters used to evaluate the severity of the UT dilation include pelvicalyceal area [52],

hydronephrosis index (parenchymal to pelvicalyceal area [53], calyx to parenchymal ratio [54], and pelvicalyceal volume using 3D US [55]. These methods are more complicated to perform and therefore less commonly used in routine clinical practice.

In addition to US, IVP and static MR urography (MRU) can provide additional information on morphology. Diuretic urosonography, radionuclide renography (NUC), and functional MR urography (MRU) can provide functional information. Diuretic urosonography is not widely used. The assessment of VUR can be performed by radionuclide cystography (RNC), voiding cystourethrography (VCUG), or contrast enhanced voiding urosonography (VUS).

Correlation with outcomes

Similar to APRPD measured on prenatal US, the APRPD measured on the first postnatal US correlates with the risk of uropathies [56]. Multivariate analysis demonstrated that the severity of renal pelvic dilation, ureteral dilation, parenchymal thinning, renal hyperechogenicity, and thickened bladder were independently predictive of uropathies. An APRPD >16 mm (sensitivity = 99.8%, specificity = 89.5%, and OR 106) has been correlated with the child undergoing pyeloplasty [21]. Recent studies have attempted to combine several grading systems to improve correlation with outcomes. Based on multivariate analysis, Longpre et al. observed that the larger initial APRPD and SFU Grade 4 both independently predicted lower likelihood of resolution [57].

Postnatal management

Follow-up US evaluation. An initial normal postnatal US may be misleading. Aksu et al. observed that 21–28% of children with prenatal UT dilation had a normal initial postnatal US [58]; 45% of these children with an initial normal first postnatal scan had an abnormal US at follow-up [58]. In another study, 5% of those requiring surgery for obstructive uropathies had a normal US at 1 week of age but an abnormal US at 1 month of age [26]. It has been reported that approximately 15% of children with prenatal UT dilation develop later worsening or recurrent hydronephrosis after an initial normal postnatal US [59]. Consequently, many advocate that, in children with prenatal UT dilation, a second postnatal US should be performed even if the first postnatal US is normal.

It is generally agreed that those with moderate and severe hydronephrosis (SFU Grade 3 and 4) require earlier and more frequent postnatal US evaluation than those with mild (SFU Grade 1 and 2) UT dilation [16]. In a meta-analysis, SFU Grade 2 resolved in 70% of the cases and SFU Grade 1 and 2 stabilized in 98% of the cases [51]. Sencan et al. observed in their study population of children with a history of prenatal UT dilation and mild (SFU Grade 1 and 2) hydronephrosis on the first postnatal US, that subsequent follow-up US demonstrated resolution of UT dilation in 67%, improvement in 13%, stabilization in 16%, and worsening in 3% [60].

Evaluation for vesicoureteral reflux. In children with a history of prenatal UT dilation, the incidence of reflux

ranges from 12% to 38% [24,56]. When UT dilation is observed on the postnatal US, approximately 40% of the children have VUR, compared with less than 5% when two postnatal US evaluations are normal [25]. Similarly, in children with SFU grade 1 and 2 (mild), the incidence of VUR was 3% [60]. Notably, VUR is the only uropathy in which the degree of UT dilation observed on the prenatal and postnatal US does not correlate with increasing risk of pathology. Moreover, there is poor correlation between VUR grade and severity of UT dilation [61–64]. Controversies remain over the management of VUR. This raises the question as to the utility of diagnostic evaluation for VUR in this population, but this was outside the scope of this consensus conference.

Functional imaging. It is generally recommended that children with mild hydronephrosis (SFU Grade 1 and 2) do not need any functional imaging studies such as nuclear renography. With moderate (SFU Grade 3), the risk for surgical intervention was greater in those with differential renal function (DRF) < 40% (33% vs. 3%) [65]. Most clinicians recommend that severe hydronephrosis (SFU Grade 4) be evaluated with functional studies.

Risk for UTI. Systematic review of the literature suggests benefit of selective use of prophylactic antibiotics in children with a prenatal diagnosis of UT dilation [66]. The incidence of UTI in children with SFU Grade 1–2 was approximately 5%, compared with 23% in those with SFU Grade 3–4 [60]. The risk of UTI with and without antibiotic prophylaxis in children with SFU Grade 1 and 2 or APRPD < 15 mm was similar (2.2% vs. 2.8%), but was significantly different in those with SFU Grade 3 and 4 or APRPD ≥ 15 mm (14.6% (95% CI: 9.3–22) vs. 28.9% (95% CI: 24.6–33.66), $p < 0.01$) [66]. The estimated number needed to treat to prevent one UTI in patients with SFU Grade 3 and 4 was seven. The risk for UTI is also significantly higher in those with ureteral dilation [67]. Several studies have suggested that circumcision appears to be an equally effective alternative to antibiotic prophylaxis in preventing UTI in children with UT dilation [66,68,69].

Long-term renal function. Many of the uropathies that manifest UT dilation prenatally (known collectively as the Congenital Abnormalities of the Kidney and Urinary Tract or CAKUT) have concomitant renal developmental anomalies. In fact, CAKUT is the most frequent cause of chronic kidney disease (CKD) and end stage renal disease (ESRD) in children [70]. How these uropathies affect long-term GFR is determined by: 1) the extent of renal developmental injury and its impact on nephrogenesis; 2) the integrity of the nephron mass that develops and its ability to maintain renal reserve in the face of normal glomerular obsolescence and any new insults that may adversely impact the reserve; and 3) the ability to decrease the tempo of loss of GFR over time by blunting any hyperfiltration injury that ensues from reduced renal reserve.

Nephron development begins early in fetal life and reaches completion by 35 weeks of gestation. With

morphologically normal kidneys, there are on average approximately 600 000–1,000,000 nephrons present at birth [71]. For most individuals, such a nephron endowment provides enough renal reserve to maintain renal function throughout life. Developmental or genetic abnormalities affecting nephron development or integrity, as well as acquired conditions or renal trauma or surgeries resulting in nephron loss, can lead to a reduced renal reserve with an ensuing increased risk of CKD or even ESRD. Children who are born with a reduced reserve, or who are left with a significantly reduced reserve early in life, are particularly at risk for manifesting renal functional abnormalities, as normal somatic growth places ever-increasing demands on their already compromised kidneys, in addition to the effect of hyperfiltration injury.

An individual's overall GFR reflects the sum of the filtration that occurs in all of that individual's functioning nephrons. As physiologically it is important to maintain GFR, a compensatory process termed hyperfiltration can occur when there is a reduced number of functioning nephrons. In hyperfiltration, the remaining nephrons try to maintain overall GFR by increasing their single nephron GFR, essentially increasing their filtration burden to take over for the absence or loss of normal nephron mass [72,73]. This process can accelerate normal obsolescence in these nephrons, leading to glomerular and tubular dysfunction and in many cases, the ultimate loss of enough overall function that effective GFR wanes.

As serum creatinine levels are maintained or even appear better than expected in the early phases of hyperfiltration, this process may initially present with what looks like a picture of functional renal adequacy. Over time, however, with ongoing nephron loss, there can be the development of proteinuria, hypertension, and renal insufficiency. In other words, although hyperfiltration may begin as a compensatory mechanism to maintain function in a variety of congenital or acquired conditions in which nephron mass is reduced, the accelerated glomerular obsolescence that ensues is often a final common pathway to advanced kidney disease.

In children with CAKUT, high grade obstructing lesions and diffuse anomalies in development such as hypoplasia and dysplasia are associated with earlier onset of CKD and progression to ESRD; however, any prenatally diagnosed CAKUT increases the risk of CKD substantially. In the general pediatric population, CKD is very rare, with a prevalence of about 75 cases/million children [74]. On the other hand, in children with any prenatally diagnosed CAKUT, up to 6% may manifest CKD by 10 years of age, an 800-fold increased risk over normal rates [75].

Minimizing new or ongoing insults to the kidney when there is already pre-existing CKD improves long-term renal survival and slows down progression to ESRD [76]. Importantly, recurrent UTI in children is associated with the risk of new renal scarring and accompanying nephron loss in children, from 10% with two UTIs to 60% after five UTIs [77]. In addition to addressing any necessary urologic issues such as obstruction or vesicoureteral reflux, medical management of associated sequelae of CKD may have significant implications for both renal survival and the child's overall long-term health. For example, in infants with prenatally diagnosed CAKUT, the incidence of hypertension increases

from <5% in children under 5 years of age to nearly 20% in older adolescents [75], and uncontrolled hypertension is certainly a co-factor for accelerating renal dysfunction. Along these same lines, high-grade proteinuria also portends poorer outcomes such as poorer blood pressure control [78].

The role of angiotensin blockade in dampening the progression of chronic kidney disease has been a focus of attention for many years, especially since the ready availability of angiotensin converting enzyme inhibitors or angiotensin receptor blockers. These therapies are well tolerated, making such intervention attractive to both clinicians and patients [79]. The beneficial role of angiotensin blockade in CKD is thought to stem not only from anti-hypertensive effect, but also by general renoprotection as a result of decreasing intraglomerular filtration pressure, proteinuria, and profibrogenic cytokines [80].

All of these factors are, in turn, thought to play a role in the development and progression of hyperfiltration injury and the loss of renal reserve in CAKUT and other clinical entities with CKD. There is indeed clinical evidence that in some populations angiotensin blockade can slow down the progression from hyperfiltration to albuminuria and can stabilize proteinuria once present [81].

Accordingly, angiotensin blockade serves at present as an important adjunctive therapy to blunt disease progression in children with CKD. As other therapies are developed to impede disease progression or even to induce disease regression, accurate risk stratification for children with abnormal renal development and abnormal urinary tracts will be of utmost importance to help determine potential efficacy.

Consensus discussion and statement

The goals of the Consensus Panel

The principal goals for the Consensus Panel were:

1. To propose a unified description of UT dilation that can be applied both prenatally and postnatally with consistent terminology. This grading system should be simple

but detailed enough to be meaningful for both clinical use and future research endeavors. It should also allow for communication of information between specialists who care for these patients, both as fetuses and children.

2. To propose a standardized scheme for the perinatal evaluation of these patients based on sonographic criteria; this is intended to be a starting point for observation and study and will likely require modification over time based on the accumulated evidence.

There are several important caveats that the Consensus Panel considered in developing the following recommendations. First, this grading system is not designed with the intent of developing a definitive final classification system for prenatal UT dilation. The proposed grading system is expected to be validated and/or modified with clinical experience and evidence-based research results. Second, it is based on the current available literature, which is inconsistent and limited. Third, the grading system is designed to be used in cases of isolated UT dilation and not to be applied to unique situations or anomalous kidneys such as solitary, ectopic, multicystic dysplastic kidneys (MCDK) or other cystic diseases of the kidney. Finally, while the grading system can be used for post-surgical evaluation, the proposed scheme for subsequent evaluation is not intended for application to patients who have undergone urinary tract surgery.

Recommendations

Recommendation #1: terminology

Because of the apparent confusion associated with the implied meanings of various terminologies for UT dilation, the Consensus Panel recommended avoiding the use of non-specific terms in describing UT dilation (e.g. hydronephrosis, pyelectasis, pelviectasis, uronephrosis, UT fullness or prominence, and pelvic fullness). The panel recommends the consistent use of the term "UT dilation." Further determination of the severity of UT dilation is characterized by specific sonographic findings, delineated by the UTD classification system below.

Table 2 US parameters included in the Urinary Tract Dilation Classification System.

US parameters	Measurement/findings	Note
Anterior-Posterior Renal Pelvic Diameter (APRPD)	(mm)	Measured on transverse image at the maximal diameter of intrarenal pelvis
Calyceal dilation	Central (major calyces) Peripheral (minor calyces)	Yes/No Yes/No
Parenchymal thickness	Normal/Abnormal	Subjective assessment
Parenchymal appearance	Normal/Abnormal	Evaluate echogenicity, corticomedullary differentiation, and for cortical cysts
Ureter	Normal/Abnormal	Dilation of ureter is considered abnormal; however, transient visualization of the ureter is considered normal postnatally
Bladder	Normal/Abnormal	Evaluate wall thickness, for the presence of ureterocele, and for a dilated posterior urethra

Table 3 Normal values for Urinary Tract Dilation Classification System.

Ultrasound findings	Time at presentation		
	16–27 weeks	≥28 weeks	Postnatal (>48 h)
Anterior-Posterior Renal Pelvis Diameter (APRPD)	<4 mm	<7 mm	<10 mm
Calyceal dilation			
Central	No	No	No
Peripheral	No	No	No
Parenchymal thickness	Normal	Normal	Normal
Parenchymal appearance	Normal	Normal	Normal
Ureter (s)	Normal	Normal	Normal
Bladder	Normal	Normal	Normal
Unexplained oligohydramnios	No	No	NA

Recommendation #2: consultation and communication of information

Communication of prenatal findings to physicians taking care of the infant postnatally is essential for clinical care as well as for future outcomes research. The sonographic findings should be described in accordance with the recommended grading system, and if feasible, representative images should be included with the final US report. The panel recommends that when it is feasible, the parents of fetuses with prenatal UT dilation and/or the eventual primary care provider should be provided with the actual US images. When this is not practical, the panel recommends providing the family and/or treating physician with the necessary US findings as delineated by the UTD classification system. When the prenatal findings are concerning enough for a potential need for surgical intervention or risk for renal compromise, the panel recommends that

consultation prior to delivery with a pediatric urologist and/or pediatric nephrologist be undertaken to help outline the care that the child may require postnatally.

Recommendation #3: classification system

The panel concluded that the following sonographic features are important factors in characterizing the severity of the UT dilation (Table 2). The ideal technique for APRPD measurement is based on images of the kidney obtained with the fetus or the child in an anterior-posterior plane. For optimal visualization of the fetal kidneys and measurement of the APRPD, the spine should be demonstrated at the 12 or 6 o'clock positions. In addition, the measurement should be taken at the maximal diameter of intrarenal pelvis dilation. In postnatal evaluation, imaging in the transverse plane at the hilum and in the prone position is encouraged, although consistency of position (prone or supine) at the time of measurement should take precedence in serial evaluations.

Additional sonographic features that should be evaluated include: 1) calyceal dilation, making a distinction between central and peripheral location (recognizing that this may be difficult to evaluate prenatally, especially before the third trimester); 2) parenchymal thickness (a subjective assessment); 3) parenchymal appearance with respect to echogenicity (subjectively determined by comparison with the adjacent liver or spleen), the presence or absence of cortical cysts and corticomedullary differentiation (the latter finding on postnatal imaging only); 4) ureteral dilation (transient visualization of the ureter is considered normal postnatally); 5) bladder abnormalities such as increased wall thickness, the presence of ureterocele or dilated posterior urethra; and 6) the presence of otherwise unexplained oligohydramnios on prenatal imaging. We acknowledge that ureteroceles are part of the ureter and not the bladder, but for simplicity we consider them as an abnormality in the bladder.

The threshold values for the diagnosis of UT dilation based on sonographic imaging are stratified based on gestational age at presentation (Table 3). The renal pelvis is considered not to be dilated (normal) when the APRPD



Figure 1 Ultrasound appearance of normal fetal kidneys at 32 weeks gestation. A: Imaging in the transverse plane demonstrates an anterior-posterior renal pelvis diameter (APRPD) measuring < 7 mm, which is within the normal range for this gestational age. The measurement is taken with the spine at the 12 o'clock position and the calipers are placed at the widest part of the intrarenal fluid collection. B: Imaging in the sagittal plan demonstrates normal appearing parenchyma and no peripheral calyceal dilation. This fetus has a normal appearing bladder (not shown) and the ureters are not visualized.

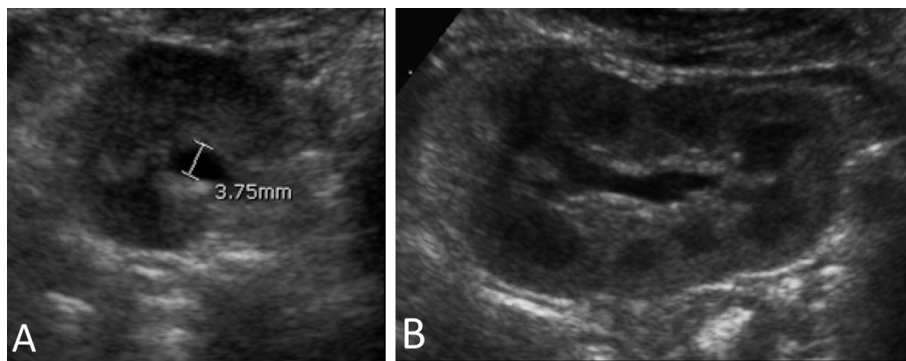
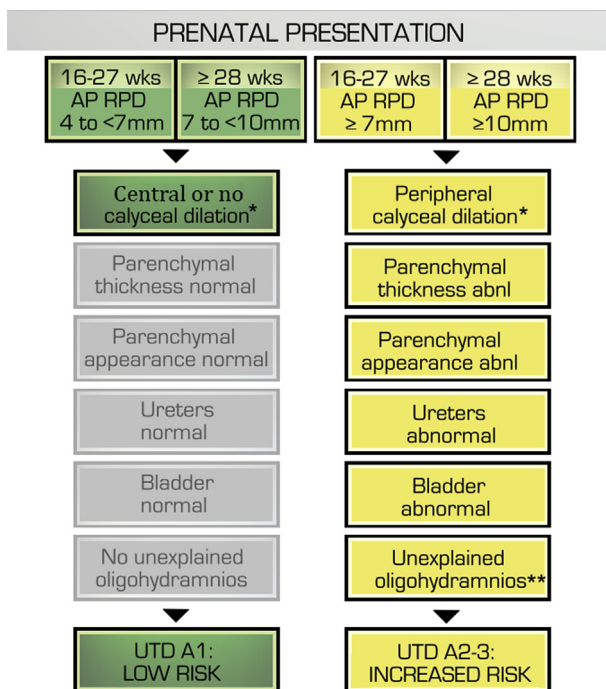


Figure 2 Appearance of normal kidneys on postnatal ultrasound. A: Imaging in the transverse plane demonstrates an anterior-posterior renal pelvis diameter (APRPD) < 10 mm, which is normal for age. Note that the APRPD is measured at the maximal diameter of intrarenal pelvis dilation rather than that of extrarenal pelvis dilation. B: Imaging in the sagittal plane demonstrates normal renal parenchyma without any calyceal dilation. The bladder is normal (not shown), and the ureters are not visualized.

measures <4 mm at <28 weeks gestation, <7 mm at ≥28 weeks (Fig. 1A and B), and <10 mm postnatally (Fig. 2A and B). In the normal fetus, calyceal dilation is absent, the renal parenchyma has normal thickness and appearance, the ureter is not seen, and the bladder is normal. Additionally, there is no unexplained oligohydramnios.



*Central and peripheral calyceal dilation may be difficult to evaluate early in gestation

**Oligohydramnios is suspected to result from a GU cause

Figure 3 Urinary Tract Dilation (UTD) Risk Stratification - Prenatal Presentation for UTD A1 (low risk) and UTD A2–3 (increased risk). Note: Classification is based on the presence of the most concerning feature. For example, a fetus with an anterior-posterior renal pelvis diameter (APRPD) within the UTD A1 range but with peripheral calyceal dilation would be classified as UTD A2–3 (as illustrated in Fig. 5C and D).

When the UT dilation is detected prenatally (denoted as A for antenatally), we suggest stratifying the findings into a low risk group (UTD A1) and an increased risk group (UTD A2–3) (Fig. 3). With UTD A1 the APRPD considered to be low risk for postnatal uropathies is 4 to <7 mm at <28 weeks (Fig. 4A and B), and 7 to <10 mm at ≥28 weeks (Fig. 4C and D). Fetuses in the low-risk category UTD A1 may also have central calyceal dilation but the presence of peripheral calyceal dilation is considered to increase risk. The renal parenchyma has normal thickness and appearance, the ureter is not seen, and the bladder is normal. There should not be unexplained oligohydramnios. Fetuses with UTD A2–3, are considered at increased risk for postnatal uropathy, based on an APRPD ≥7 mm at <28 weeks (Fig. 5A and B) and ≥10 mm at ≥28 weeks, or any one of the following findings: dilation of peripheral calyces (Fig. 5C and D); abnormal parenchymal thickness or appearance (Fig. 5E and F); visibly dilated ureter (Fig. 5G, H, and I); an abnormal bladder; or the presence of oligohydramnios suspected to be related to the urinary tract.

Initially, the panel intended to create low (A1), intermediate (A2), and high-risk (A3) groups to parallel the postnatal classification system, with the distinction between the intermediate and high-risk groups being dilation of the central versus the peripheral calyces. However, the panel noted that based on the literature and clinical experience, it was often difficult to distinguish between central and peripheral calyceal dilation on prenatal US. Consequently, the panel recommends combining the intermediate and high-risk groups to create one category of increased risk (A2–3).

When UT dilation is detected postnatally (denoted as P), we recommend stratification of risk into three groups: low risk (UTD P1); intermediate risk (UTD P2); and high-risk (UTD P3) groups (Fig. 6). With UTD P1, the APRPD considered to be low risk for postnatal uropathies is 10 to <15 mm (Fig. 7A and B). Again it should be emphasized that the first postnatal US should be done more than 48 h after birth to ensure it does not underestimate dilation, and be repeated once to ensure the appropriate management. In the low-risk group, central calyceal dilation may be present, but again, peripheral calyceal dilation is considered to increase

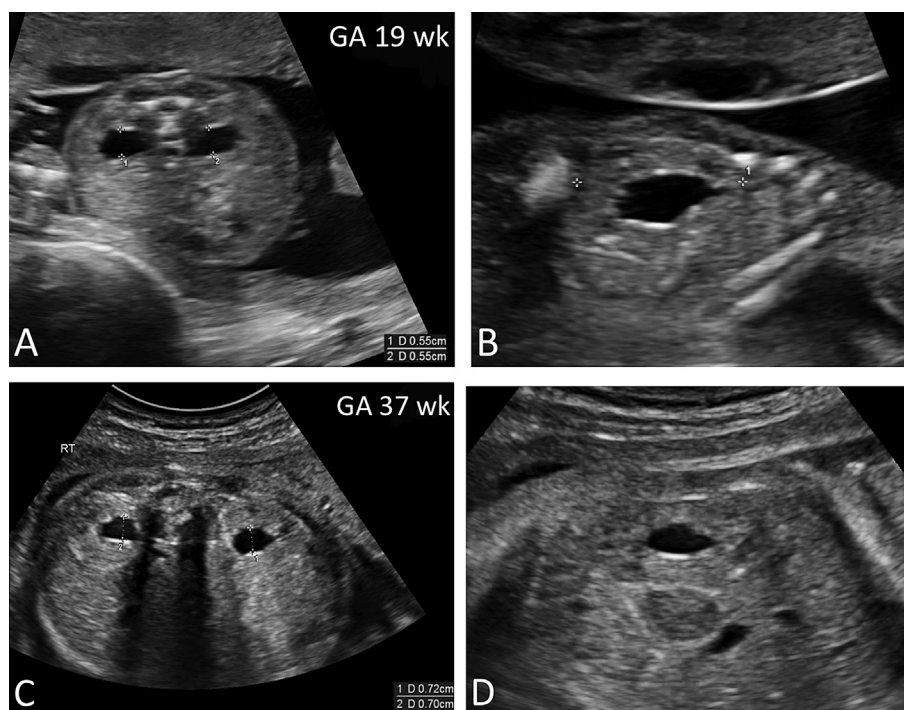


Figure 4 Ultrasound appearance of UTD A1. A and B: Fetal kidneys at 19 weeks gestation. A: Imaging in the transverse plane demonstrates an anterior-posterior renal pelvis diameter (APRPD) measuring less than 7 mm, which is within the UTD A1 range for this gestational age. B: Imaging in the sagittal plane demonstrates normal appearing parenchyma and no peripheral calyceal dilation. C and D: Fetal kidneys at 37 weeks gestation. C: Imaging the transverse plane demonstrates an APRPD measuring less than 10 mm, which is within the UTD A1 range for this gestational age. D: Imaging in the sagittal demonstrates normal appearing parenchyma and no peripheral calyceal dilation. In each case, the bladder is normal, and the ureters are not visualized (not illustrated).

risk. The renal parenchyma should have normal thickness and appearance, the ureter is not seen, and the bladder is normal. If there is central calyceal dilation but the APRPD is less than 10 mm, it is still considered UTD P1 (Fig. 7C and D). With UTD P2, which is considered to be intermediate risk for postnatal uropathies, the APRPD is ≥ 15 mm (Fig. 8A and B). The calyces may be dilated centrally and peripherally or a dilated ureter is visible. For this classification, the parenchymal thickness and appearance as well as the bladder are normal. Cases in which there is peripheral calyceal dilation but the APRPD is less than 15 mm are still classified as UTD P2 (Fig. 8C and D). Finally, with UTD P3, the sonographic findings for APRPD, calyceal dilation, and the ureter are the same as those in UTD P2. However, in UTD P3, the renal parenchyma is thinned, has increased echogenicity and/or has decreased corticomedullary differentiation, or the bladder is abnormal (wall thickening, ureterocele, posterior urethral dilation) (Fig. 9A and B). Cases in which there are parenchymal abnormalities but the APRPD is < 15 mm, are still classified as UTD P3.

Recommendation #4: proposed management scheme

Based on the suggested UTD classification system's risk stratification, the panel proposed a follow-up management scheme. For UTD A1 diagnosed before 32 weeks, a follow-up prenatal US is recommended at ≥ 32 weeks (Fig. 10). If the US at ≥ 32 weeks reveals resolution of the UT dilation

with normal renal parenchyma, bladder and ureters, no further prenatal or postnatal follow-up is necessary. If there is persistent UTD A1 or UTD A2–3 (Fig. 3), evaluation after birth is recommended. Postnatal evaluation should include two US evaluations: the first at > 48 h but less than 1 month after birth; and the second 1–6 months later. In fetuses considered at increased risk for postnatal uropathy (UTD A2–3), a follow-up prenatal US is recommended within 4–6 weeks of the initial diagnosis of UT dilation. Because of the variability of US findings on prenatal US in these cases, recommendations for subsequent interval assessment are at the discretion of the clinician. Prenatal consultation with a pediatric urologist and/or pediatric nephrologist is recommended in situations where there is substantial risk for surgery or renal dysfunction. After birth, a follow-up US is recommended at > 48 h of life but before 1 month. Follow-up should be performed sooner for obstructive uropathies, such as suspected PUV (as suggested by the finding of a thick-walled bladder with persistent dilation and a fusiform appearance and/or posterior urethral dilation on prenatal US) or for bilateral conditions.

For UTD P1, a follow-up US is recommended in 1–6 months (Fig. 11). As there is significant controversy regarding the clinical importance of diagnosing VUR and the effectiveness of prophylactic antibiotics, recommendations for evaluation with VCUG and the use of prophylactic

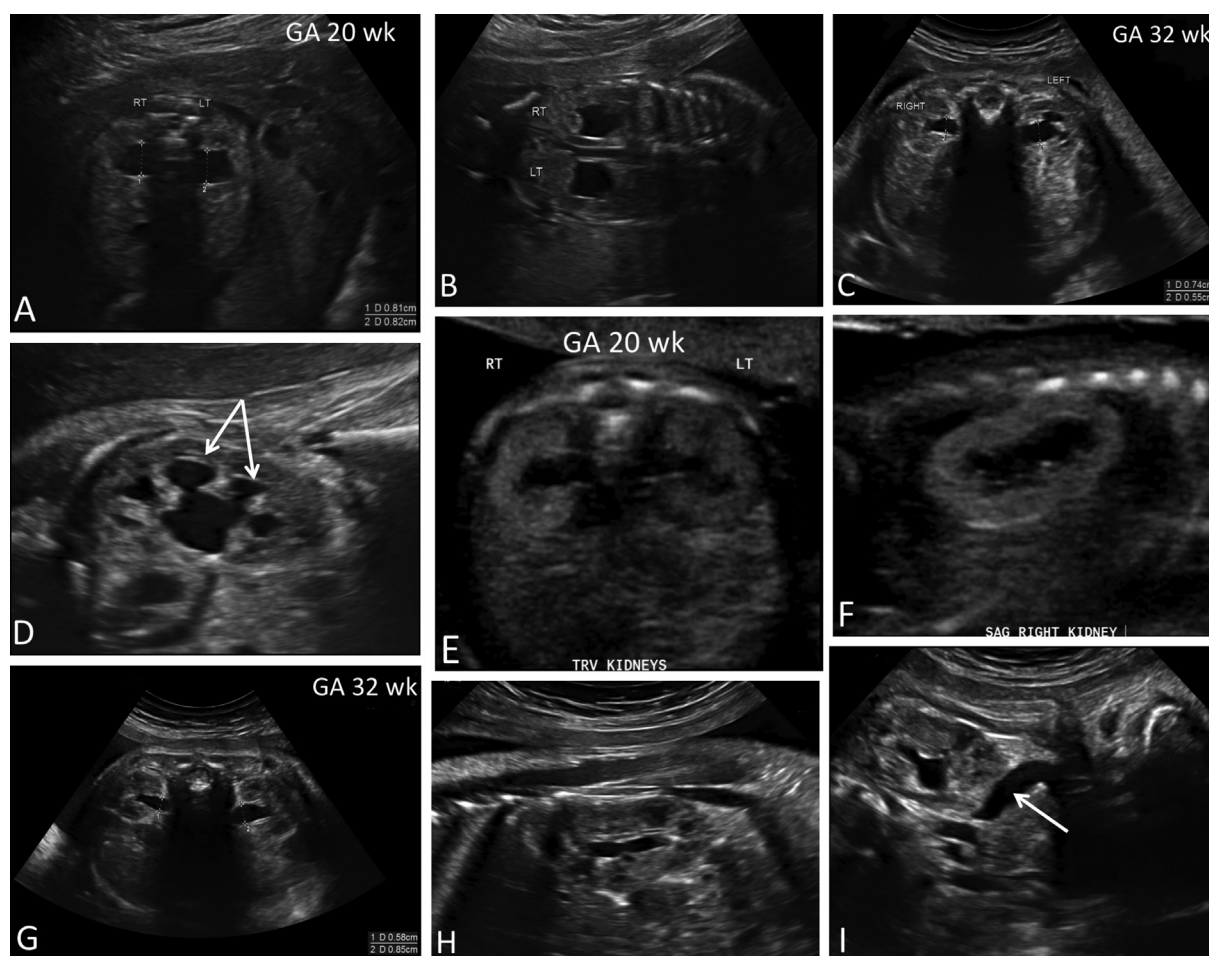


Figure 5 Ultrasound appearance of UTD A2–3. A and B: Fetal kidneys at 20 weeks gestation. A: Imaging in the transverse plane demonstrates an anterior-posterior renal pelvis diameter (APRPD) measuring greater than 7 mm, which is within the UTD A2–3 range for this gestational age. B: Imaging in the coronal plane demonstrates normal appearing parenchyma. C and D: Fetal kidneys at 32 weeks gestation. C: Imaging in the transverse plane demonstrates an APRPD measuring 7 mm, which is below the UTD A2–3 range for gestational age; however, note the presence of peripheral calyceal dilation. D: Imaging in the sagittal plane demonstrates normal appearing parenchyma but clear peripheral calyceal dilation leading to the classification as UTD A2–3. E and F: Fetal kidneys at 20 weeks gestation. E: Imaging in the transverse plane demonstrates fluid within the renal pelvis (not measured). F: Imaging in the sagittal plane demonstrates abnormal appearing parenchyma that is more echogenic than adjacent liver, prompting classification UTD A2–3. G, H, and I: Fetal kidneys at 32 weeks. G: Imaging in transverse plane demonstrates an APRPD of 8 mm, which is below the usual range for UTD A2–3 classification. H: Imaging in the sagittal plane demonstrates normal renal parenchyma and no calyceal dilation. I: However, imaging in the modified sagittal plane demonstrates a clear hypoechoic tubular structure that has peristalsis in real time, characteristic of a hydroureter. Consequently, the urinary tract classification in this case is UTD A2–3 based on the presence of a visualized ureter on prenatal US imaging.

antibiotics are left to the discretion of the clinician. For UTD P2, a follow-up US is recommended in 1–3 months. As with UTD 1, recommendations for evaluation with VCUG and the use of prophylactic antibiotics are left to the discretion of the clinician. There is significant variability in the practice of performing functional scans in children with SFU Grade 3. Consequently, recommendations for functional scans in patients with UTD P2 are left to the discretion of the clinician. For UTD P3, a follow-up US is recommended within 1 month. Evaluation with VCUG and the use of prophylactic antibiotics is recommended in this group, depending in part on the pathology suspected. As

with UTD P2, recommendation for functional scans in patients with UTD P3 is left to the discretion of the clinician.

Recommendation #5: modifiers of UTD classification system

Worsening findings on serial prenatal or postnatal US are associated with increased risk of genitourinary pathology. With regards to fetal gender, the panel feels there is insufficient evidence to suggest that the risk for postnatal uropathies is significantly different, the exception being the diagnosis of PUV in males. With regards to unilateral vs. bilateral UT dilation, there is insufficient evidence to

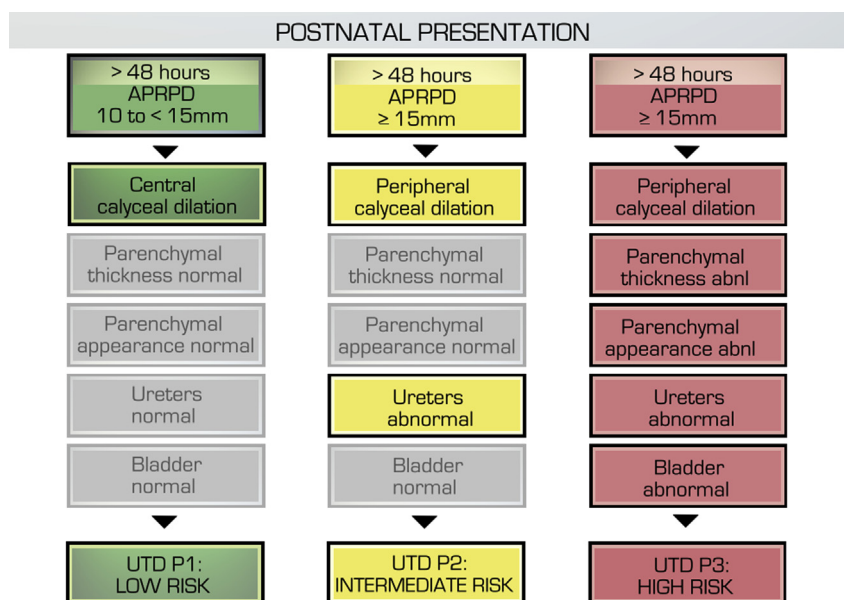


Figure 6 Urinary Tract Dilation (UTD) Risk Stratification – Postnatal Presentation for UTD P1 (low risk), UTD P2 (intermediate risk), and UTD P3 (high risk). Note: Stratification is based on the most concerning ultrasound finding. For example, if the anterior-posterior renal pelvis diameter (APRPD) is in the UTD P1 range, but there is peripheral calyceal dilation, the classification is UTD P2. Similarly, the presence of parenchymal abnormalities denotes UTD P3 classification, regardless of APRPD measurement.

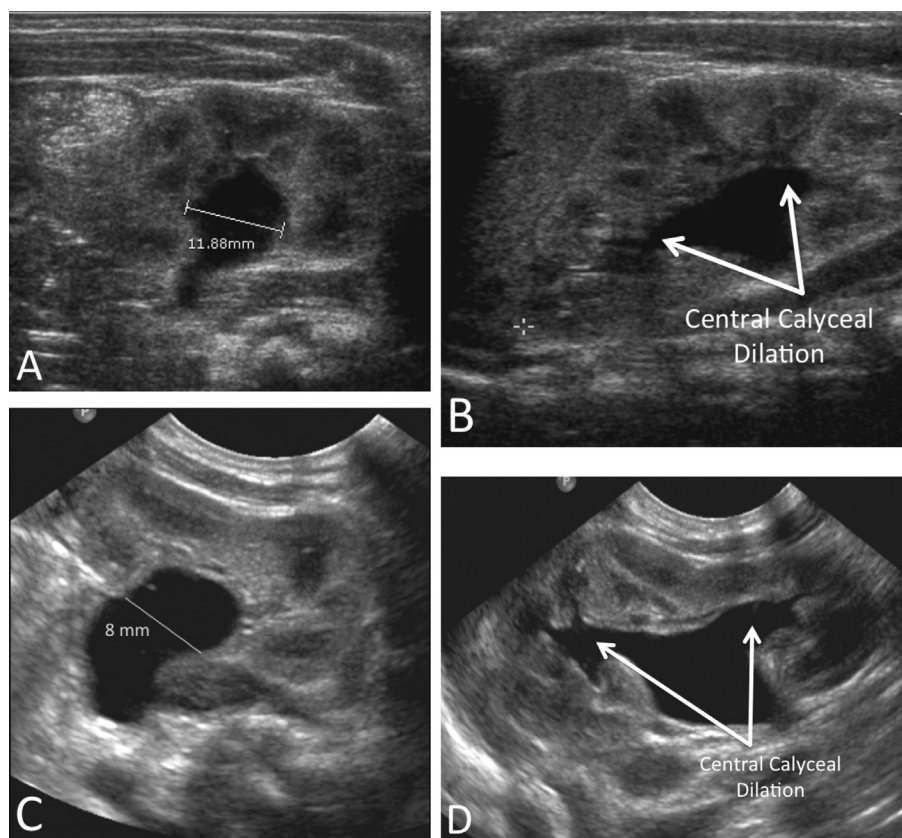


Figure 7 Appearance of UTD P1 on postnatal ultrasound. A: Imaging in the transverse plane demonstrates an anterior-posterior renal pelvis diameter (APRPD) 10 to <15 mm. B: Imaging in the sagittal plane demonstrates central but no peripheral calyceal dilation. The renal parenchyma is otherwise normal. The bladder is normal (not shown), and the ureters are not visualized. Another example of UTD P1 on postnatal US. C: Imaging in the transverse plane demonstrates an APRPD <10 mm. D: However, imaging in the sagittal plane demonstrates central calyceal dilation.

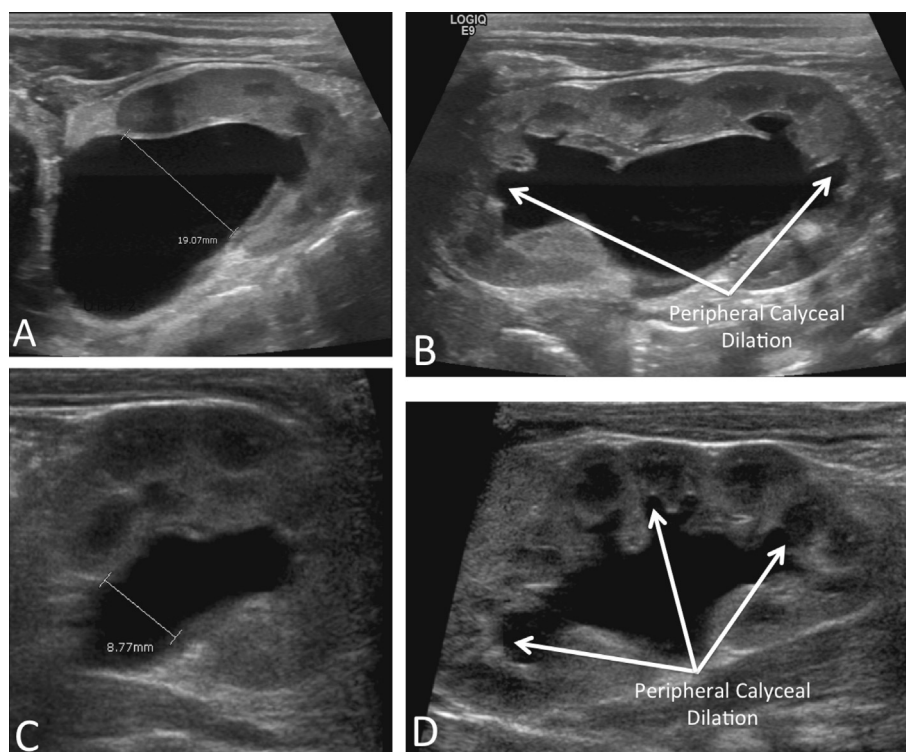


Figure 8 Appearance of UTD P2 on postnatal ultrasound. A: Imaging in the transverse plane demonstrates an anterior-posterior renal pelvis diameter (APRPD) ≥ 15 mm. B: Imaging in the sagittal plane demonstrates peripheral calyceal dilation but normal renal parenchymal thickness and appearance. In addition, there are no bladder abnormalities (not shown). Another example of UTD P2 on postnatal US. C: Imaging in the transverse plane demonstrates an APRPD < 10 mm. D: However, imaging in the sagittal plane demonstrates peripheral and central calyceal dilation.

suggest that the risks for postnatal uropathies are significantly different. The panel recommends that stratification of risk should be based on the grading of UT dilation in the most severely affected side.

Recommendation #6: reporting

When reporting UT dilation, the panel recommends that a description of the above seven imaging parameters (Table 3, Figs. 3 and 6) be reported in the written report. In the Impression section, the specific UTD category (Normal, UTD

A1, UTD A2–3, UTD P1, UTD P2, or UTD P3) should be reported along with the suggested management scheme. Ideally, representative images should be provided with the report.

Discussion

In this consensus statement, the panel integrated existing grading systems and recommendations and attempted to

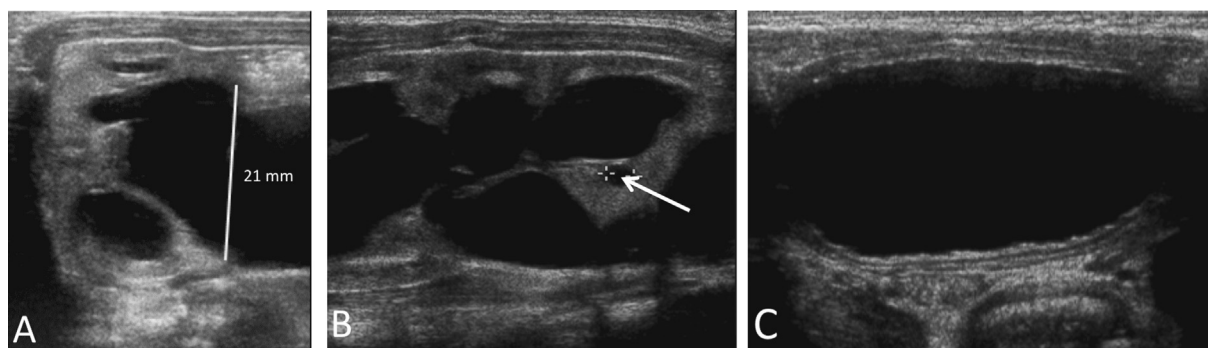


Figure 9 Appearance of UTD P3 on postnatal ultrasound. A: Imaging in the transverse plane demonstrates an anterior-posterior renal pelvis diameter (APRPD) ≥ 15 mm with peripheral calyceal dilation. B: Imaging in the sagittal plane demonstrates parenchymal thinning and cysts (arrow). C: Imaging of the bladder demonstrates increased wall thickness.

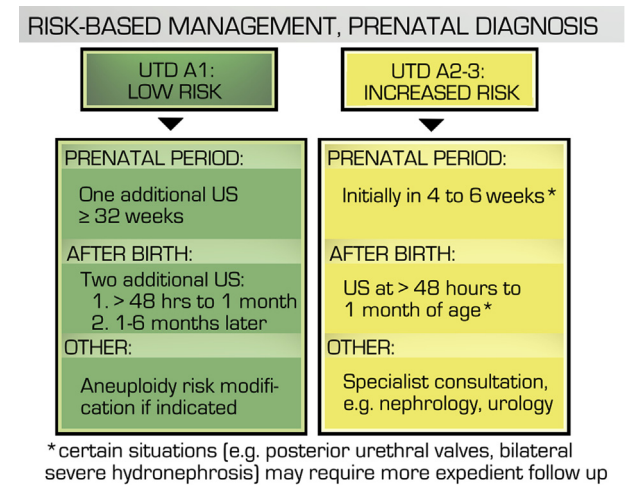


Figure 10 Management schema based on UTD classification system’s risk stratification of UTD A1 and UTD A2–3.

adapt them to current clinical care. The UTD classification system incorporates three broad categories of sonographic findings – degree of UT dilation, parenchymal quality, and associated anomalies. Specific aspects of the existing grading systems have been simplified and incorporated into a single unified system. Consequently, conversion from existing grading systems to the UTD classification system should be relatively uncomplicated. For example, SFU Grade 1–2 would be equivalent to UTD P1, SFU Grade 3 to UTD P2, and SFU Grade 4 to UTD P3.

In categorizing the severity of the UT dilation, the panel felt that it was appropriate to correlate the sonographic findings to postnatal urological pathology (not transient or physiologic hydronephrosis) because it was the most objective and best-characterized outcome identified in the literature. Further research will be needed to correlate the UTD classification system risk stratification to other specific clinical outcomes such as surgical intervention, renal function, urinary tract infection, and others.

In addition, the panel recognized that not all urinary tract dilation is associated with renal pelvic dilation as in some cases of primary megaureter or reflux where there is ureteral dilation, but there may be little to no pelvic or calyceal dilation. The classification system proposed is primarily for different degrees of renal pelvic dilation and is thus the main criteria for the UTD classification system with ureteral dilation as a modifier of renal pelvic dilation. The visualization of dilated ureter(s) categorizes the UT dilation as either UTD A2–3 or UTD P2, regardless of the APRPD measurements.

The panel recommendations are in agreement with the Executive Summary on Fetal Imaging by NICHD [82]. Specifically, an abnormal APRPD is defined as ≥ 4 mm in the second trimester and ≥ 7 mm at ≥ 32 wk. We concur with the Executive Summary that UT dilation is most often transient and carries an increased risk of Trisomy 21, warranting a detailed US and correlation with accepted aneuploidy-screening protocols. In addition, we agree that follow-up US evaluation should be performed at 32 weeks to rule out persistent UT dilation. If the APRPD is ≥ 7 mm at 32 weeks, we agree with the recommendation of postnatal radiological evaluation.

Future research directions

The Consensus Panel identified several important areas that require future research evaluation.

1. The proposed grading classification system will require extensive evaluation to assess its utility in predicting clinical outcomes. Currently, the grading system is correlated with the risk of postnatal uropathies. Future research will help to further refine the classification system to one that correlates with other clinical outcomes such as the need for surgical intervention or renal function.
2. The seven sonographic parameters utilized in the UTD classification system were selected based on the current

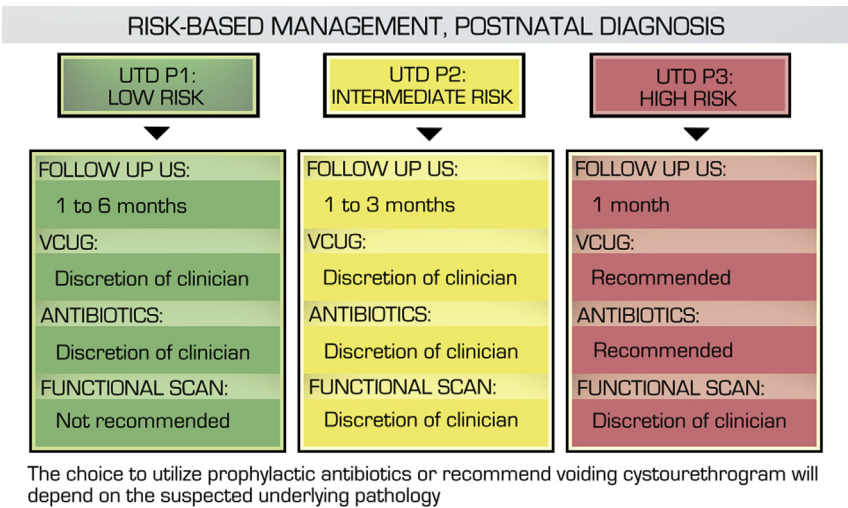


Figure 11 Management schema based on Urinary Tract Dilation (UTD) classification system risk stratification of UTD P1, UTD P2, and UTD P3.

literature. Further research may help to identify other US findings that may be more predictive of uropathies and clinical outcomes.

3. While it is beyond the scope of this consensus statement, the panel identified that the issue of UTI and the evaluation of VUR in children with prenatal UT dilation is controversial. Prospective studies in this area are needed to define the role of prophylactic antibiotic or circumcision and the clinical significance of identifying VUR in this patient population.

Conflict of interest

None.

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None.

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Commentary to 'Multidisciplinary consensus on the classification of prenatal and postnatal urinary tract dilation (UTD classification system)'



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Appropriate management of neonatal urinary tract dilation is a challenge to clinicians in various medical specialties. One initial obstacle to good care, or even to high-quality clinical evidence to guide care, is the lack of a widely accepted method of categorizing this problem. The development of standardized classification criteria for chronic kidney disease [1] and acute kidney injury [2,3] has allowed for large-scale studies [4,5] that have greatly advanced our understanding of these diseases. Currently, many classification schemes exist for neonatal urinary tract dilation, none of which are widely accepted by all medical specialties involved in the care of patients with this condition.

A new classification and management strategy for neonatal urinary tract dilation is proposed in this issue of the *Journal of Pediatric Urology*. It represents a multidisciplinary consensus among radiologists, urologists, maternal-fetal medicine practitioners, and nephrologists. This has great appeal. It allows for all clinicians caring for

neonates with urinary tract dilation to have a common language for communication. Representatives from all interested parties participated in the development of this document. There are explicit criteria for classification that are clear and (for the most part) objective. There are a small number of categories for classification, which lends itself to outcomes-oriented research as well as to communication with patients.

While this consensus statement is useful, it does not resolve all the obstacles to excellent care of patients with neonatal urinary tract dilation. It will be meaningful only if its classification system is widely adopted. As the authors acknowledge, management recommendations are vague. This reflects both the lack of conclusive evidence to guide management and the wide variability in current clinical practice. As with any guideline, there will be isolated clinical situations where application will not be appropriate.

Summary, UTD Grading Scale Postnatal US

Stephen Foster

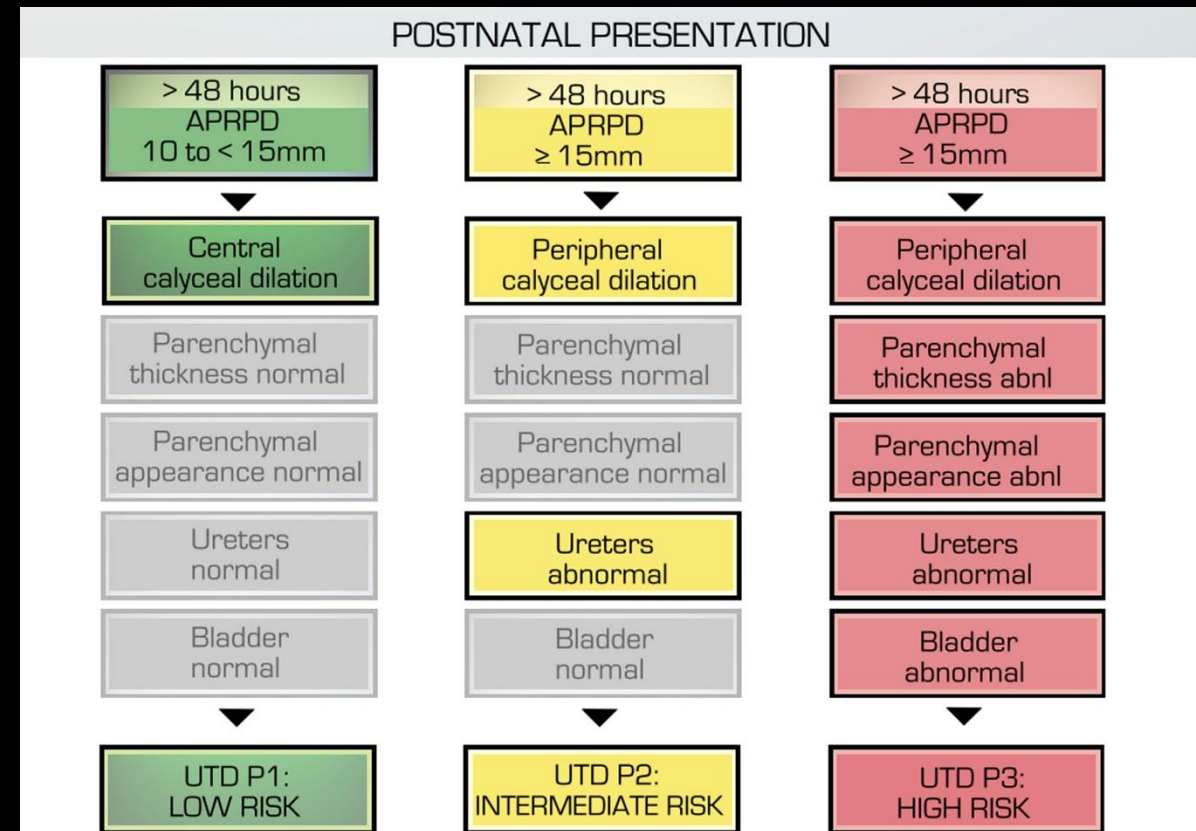
- The Urinary Tract Dilation (UTD) scale came about as an attempt to improve inter-observer variability when classifying Pediatric hydronephrosis
- It was released as a consensus statement in the Journal of Pediatric Urology in 2014 [https://www.jpurology.com/article/S1477-5131\(14\)00310-6/abstract#articleInformation](https://www.jpurology.com/article/S1477-5131(14)00310-6/abstract#articleInformation)
- It is now in general use in the Pediatrics community. They will know what you mean if you use the scale in an impression.
- There is pre-natal and post-natal. I will concentrate on Post-Natal here as OB has reclaimed the prenatal.
- All images are shamelessly stolen from the article referenced above under fair use for education rules. Plus I assume this is staying here in house.

Criteria

- AP diameter of renal pelvis. Measured on transverse images, at the level of the parenchymal margin
- Central calyceal dilation
- Peripheral Calyceal dilation
- Ureter normal or dilated
- Parenchymal thinning +/-
- Parenchymal echotexture abnormal
- Appearance of the bladder

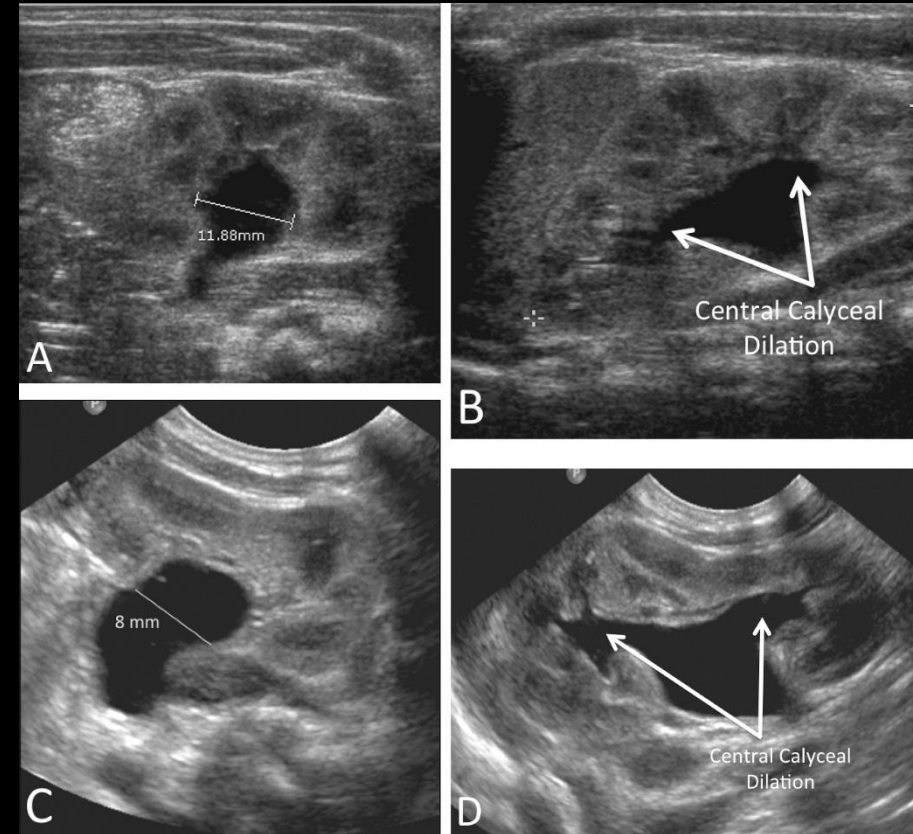
Whatever single item is the WORST will bump the scale to that level

- Central calyceal dilation with loss of corticomedullary differentiation = UTD P3



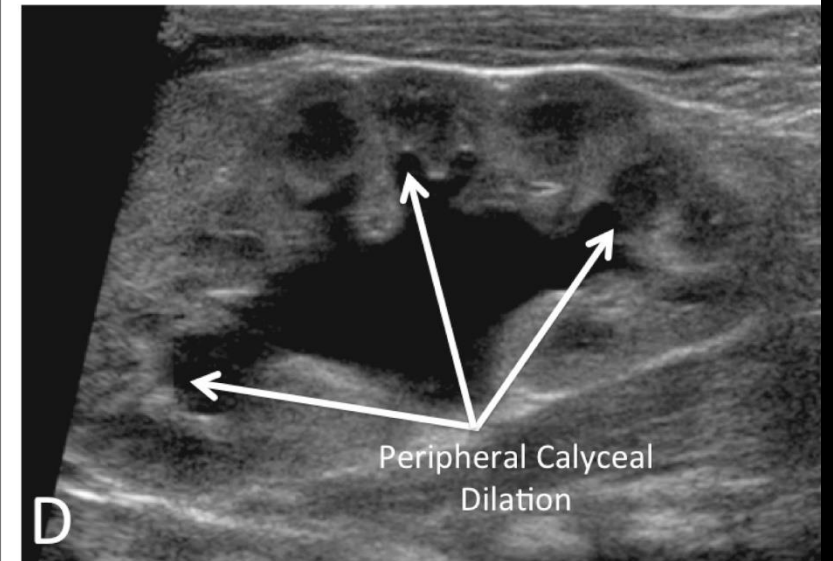
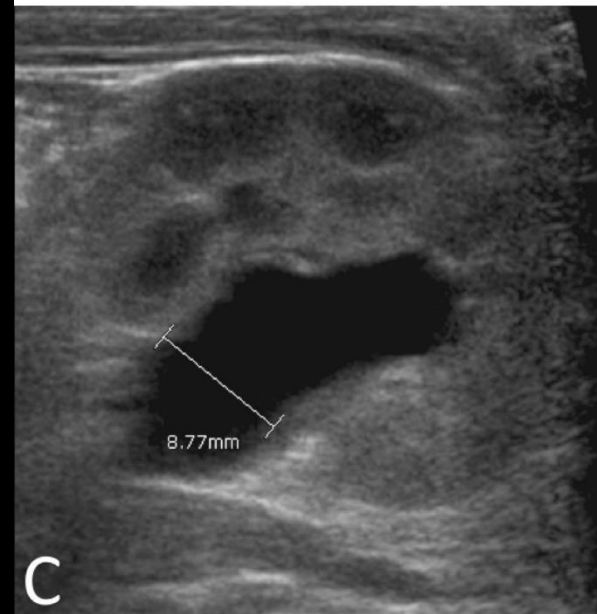
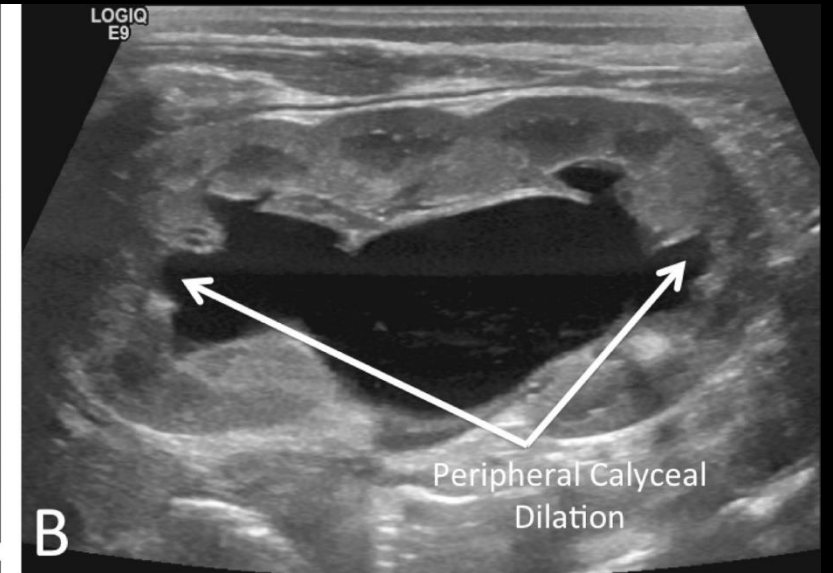
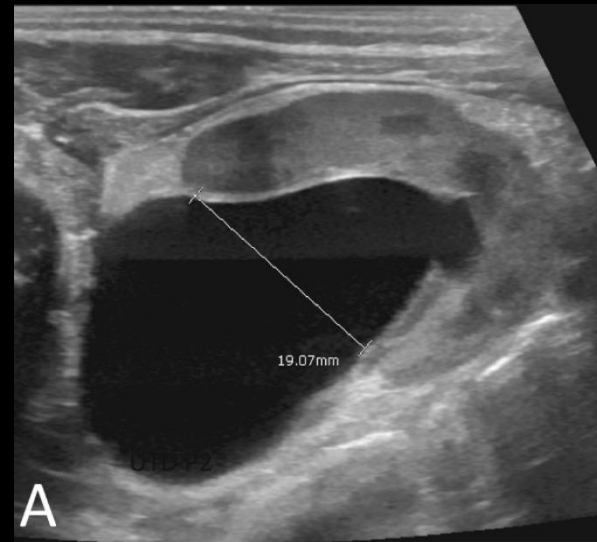
What's dilated?

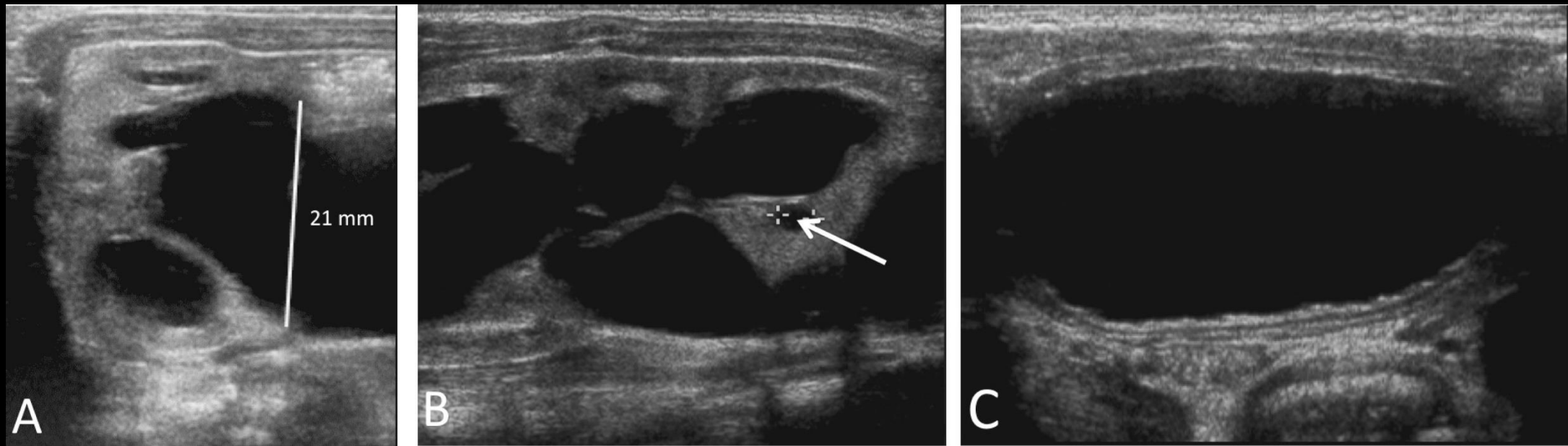
- Everyone is entitled to some minimal splitting of the renal pelvis (urine has to go somewhere)
- Central calyces as shown in B and D
- Location of measurement for the AP diameter of pelvis is pretty good in C. Not so great in A, and these are the images from the article
- Pelvis diameter IMO is the least reproducible and by far the least useful criteria. One can easily have a rather large pelvis and no central collecting system dilation (I call these normal), or a 4mm pelvis and completely blown out center.
- However, because it's a number, people will ask for it and persevere on it. I gave up fighting it, but just know it's not that helpful.



What's Dilated?

- B and D now show peripheral dilation
- Notice the difference between A and C for pelvis diameter. These kidneys end up the same UTD grade
- Given the wide range of variability in central collecting system dilation with visibility of the minor/peripheral calyces, people do use intermediate grades, i.e. UTD 1-2, or UTD 2-3 for a little more flexibility. I do it and have never had push back, though the original article does not specify this.
- An argument could be made that there is cortical thinning in B here.
- I would call D a UTD P2, and B a UTD 2-3 based on these single images.

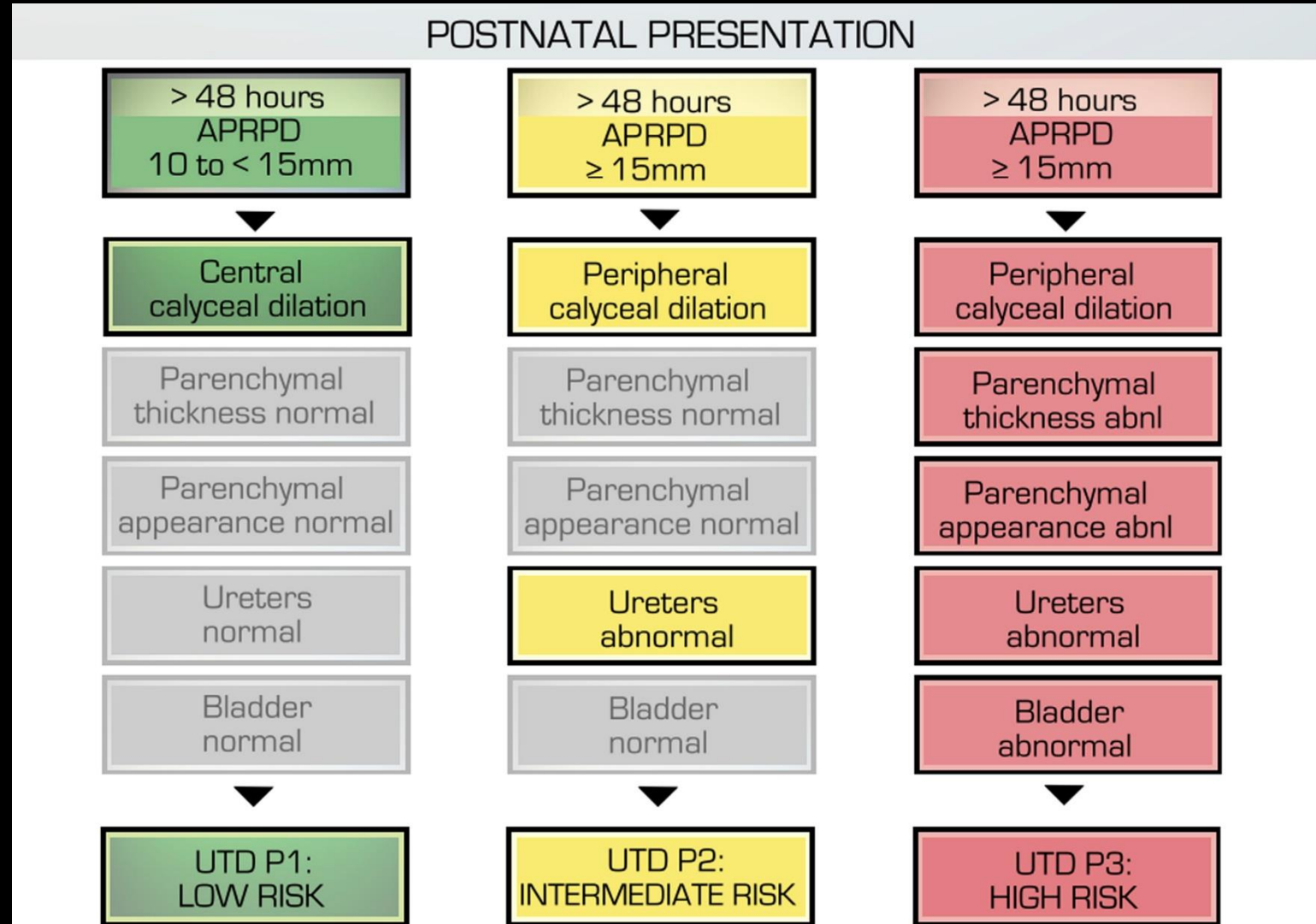




- In this case, we have parenchymal thinning and cystic change
- Gross dilation of the peripheral/minor calyces
- Dilation of the proximal ureter
- Abnormal bladder trabeculation
- Any 1 of these would elevate the case to a UTD P3

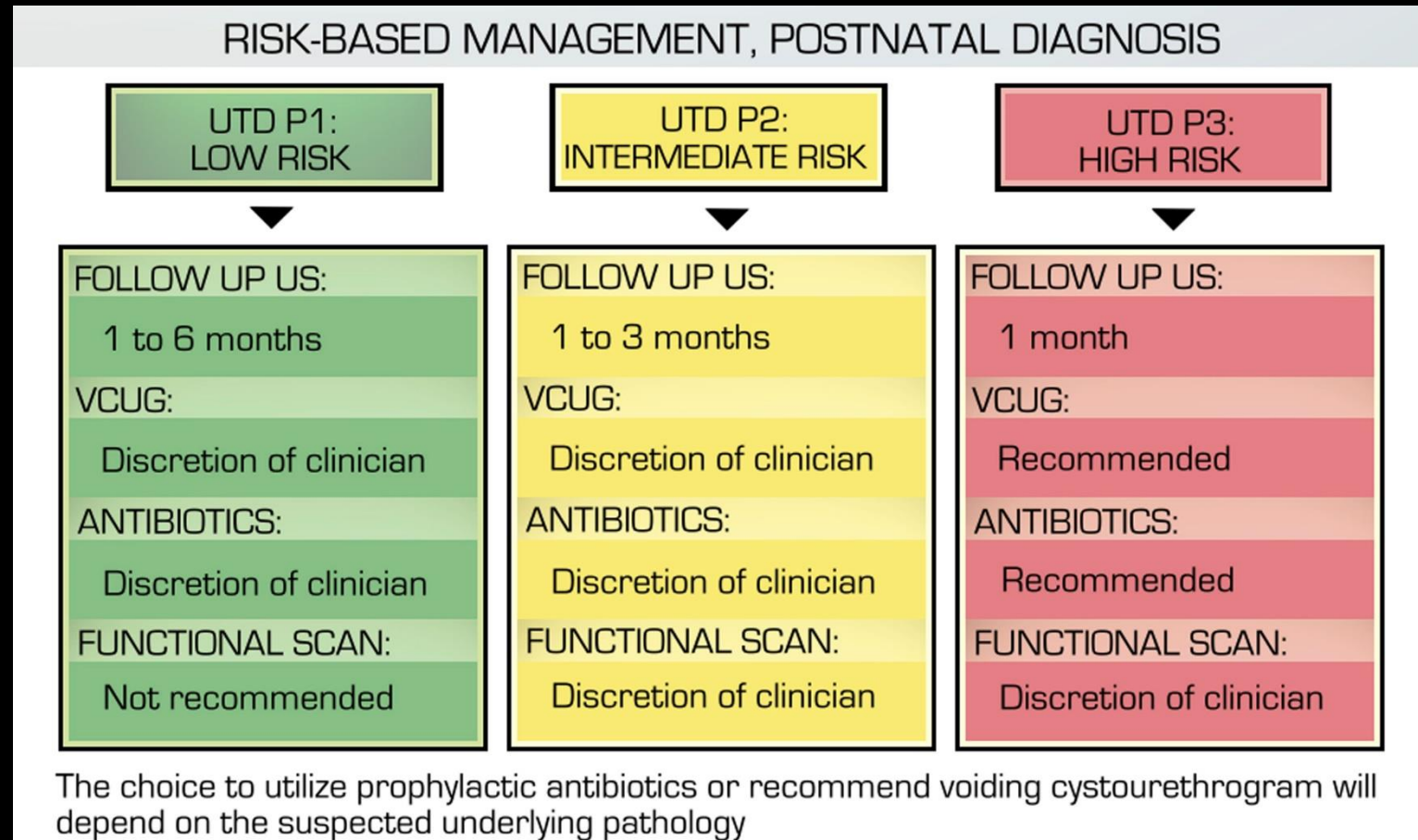
UTD Grading Helps drive management

- The world changing (for Peds Rads) article in the Journal Pediatrics in 2011, allowing clinicians to NOT do a VCUG on females with first UTIs, made my life and the lives of innumerable little girls better.
- But, now that everyone didn't get a full work up, how do we know who does?
- The UTD scale drives next steps, so it is very helpful for the Pediatricians if we use it widely.



Management

- UTD scaling via Ultrasound determines risk level, in conjunction with clinical information such as UTI number, male vs female, etc.
- Like most scales and clinical decision making, I rarely mention these recommendations specifically in a report. Definitely not for urology, possibly for the busy APRN with the 6 minute office visits.
- If I am calling an initial 2 or 3, I do recommend Pediatric Urology consultation be considered.
- In the end, this system isn't perfect and does leave some room for inter-observer variability. But, it is better than "mild, moderate, severe"



Thanks for Helping out the Little Ones



Dept. Procedure Title	Testicular Imaging Procedure - Ultrasound - Radiology	Procedure ID	11472
Keywords	us, ultrasound, testicle, testicular		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for Sonographers and Sonologists performing Testicular Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all Sonographers and Sonologists within the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

A. Standard Images for Interpretation

- Obtain representative images documenting each testicle separately
 - Longitudinal view of the head of epididymis and upper portion of testicle.
 - A minimum of 3 longitudinal views documenting the lateral, midline, and medial aspects of each testicle.
 - Longitudinal right and left epididymis.
 - Longitudinal tail of epididymis and lower portion of the testicle.
 - Transverse inferior to include epididymal tail.
 - Transverse lower, mid and upper portion of the testicle.
 - Transverse head of epididymis.
- Perform 3 measurements to estimate the testicular volume.
- Obtain appropriate measurements of any suspicious lesions.
- Transverse, grey scale, and color Doppler of both testicles on the same image to compare echogenicity and color Doppler blood flow.
- Color Doppler of the epididymal head and upper portion of each testicle for blood flow comparison relative to the testicle.
- Obtain (3) equally spaced color Doppler images of each testicle.

7. In the clinical setting of suspected torsion, obtain color and spectral Doppler waveforms of each testicle.
8. Perform Color Doppler and grey scale imaging of the spermatic cord structures with and without valsalva to document presence or absence of varicocele. A varicocele is a change in the internal spermatic vein > 3 mm.
9. If an isolated right sided varicocele is identified a limited bilateral renal ultrasound (uretrolim) exam is required. Perform representative longitudinal and transverse imaging and measurements to document the kidneys and the renal hilum to exclude a mass.
10. Evaluate the inguinal canals bilaterally for presence or absence of hernia.

VI. References N/A

Responsible Owner:	Ultrasound	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine; Nystrom, Heidi	Version #	3
Current Approval Date:	11/22/2021	Old Document ID:	
Date Procedure to go into Effect:	11/22/2021		
Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Thyroid Imaging Procedure - Ultrasound - Radiology	Procedure ID	11473
Keywords	thyroid, imaging		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for sonographers and sonologists performing thyroid Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all sonographers and sonologists within the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

1. Place patient in supine position with neck slightly hyperextended. If necessary, place a rolled up towel or pillow under the patient's neck.
2. Obtain representative images documenting the following:
 - i. Perform longitudinal and transverse images of both thyroid lobes including transverse images of the isthmus.
 - ii. Measure the size of the thyroid in 3 dimensions.
 - iii. Document and measure any abnormalities within the thyroid as well as adjacent structures (lymph nodes).
 - iv. Once the representative longitudinal and transverse images have been obtained, use the split screen functionality on the scanner to measure and number the two (2) largest nodules in each lobe so that measurements can be easily compared with prior and subsequent studies.
3. Perform color Doppler imaging to evaluate for vascularity in the thyroid and within any thyroid nodule.
4. In the presence of thyroidectomy, or if a thyroid nodule 1 centimeter (cm) or greater in size is seen, evaluate the cervical lymphatic chain, both anterior and posterior to sternocleidomastoid muscle, in longitudinal and transverse, to exclude enlarged lymph nodes.
5. Record, and number the two (2) largest lymph nodes seen on each side using the split screen function.
6. Measure each lymph node in its longest dimension with the AP diameter also recorded on that image.
7. Evaluate each lymph node with Color Doppler.
8. TiRads criteria will assigned to the structured report template by the attending Radiologist.

VI. References N/A

Responsible Owner:	Department of Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Patrick, Michael	Version #	5
Current Approval Date:	11/18/2020	Old Document ID:	
Date Procedure to go into Effect:	11/18/2020		
Related Policies & Procedures:			
Related Job Aids:			

Dept. Procedure Title	Transplant Kidney Imaging Procedure - Ultrasound - Radiology	Procedure ID	11474
Keywords	us, ultrasound, kidney, transplant		
Department	Ultrasound		

I. Purpose of Procedure

To describe the procedure for Sonographers and Sonologists performing transplant kidney Ultrasound studies. The following standard images are required for interpretation.

II. Procedure Scope

This scope applies to all Sonographers and Sonologists within the Ultrasound section of Dartmouth-Hitchcock Lebanon.

III. Definitions N/A

IV. Equipment N/A

V. Procedure

1. Obtain longitudinal measurements (minimum of 2) of the maximum transplant kidney length.
2. Obtain labeled transverse images through upper, mid, and lower poles.
3. Assess for peri-renal fluid collections (urinomas, lymphoceles, etc.).
4. Assess for collecting system dilatation.
5. Obtain longitudinal and transverse images of the urinary bladder.
6. Color/Power images of the transplant kidney (adjust color scale and gain to visualize slow/venous flow).
7. Obtain and label representative spectral Doppler tracings (2 per section) of intra-renal vessels at the cortico-medullary junction at the upper, mid, and lower renal poles.
 - a. Enter resistive index (RI) measurements into structured reporting package
8. Obtain color and spectral Doppler tracing (2 per section, mid and proximal to the anastomosis) of the main renal artery (MRA) and main renal vein (MRV).
 - a. Enter the peak systolic velocity (PSV), end diastolic velocity (EDV) and resistive index (RI) measurements into structured reporting package.

VI. References N/A

Responsible Owner:	Ultrasound	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents; Kvinlaug, Christine; Nystrom, Heidi	Version #	3
Current Approval Date:	11/08/2021	Old Document ID:	
Date Procedure to go into Effect:	11/08/2021		
Related Policies & Procedures:			
Related Job Aids:			

Trophon Guidelines

1. Non latex gloves and eye goggles will be used when a transducer is placed into and taken out of the Trophon unit. Purple nitrile gloves are not required for this activity.
2. The Sonex-HL cartridge must be changed in an area with immediate access to a plumbed eye wash station. Eye goggles and gloves will be worn when the SonoEX- HL cartridge is replaced. Recap the empty bottle of Sonex-HL before discarding in the trash.
3. The transducer will be wiped at the point of use to remove any excess gel from the transducer. Once completed, it will then be wiped with "grey top" Sani Wipe AF3 product (dwell 3 minutes). Any remaining AF3 product will be wiped with a lint free cloth (institution standard) prior to starting the Trophon disinfection cycle.
4. Plastic bags are not required over the 'cleaned' transducer once it is removed from the Trophon unit. The clean transducer must be stored in the dust free cabinet located in each exam room.
5. One (1) label will be generated from the Trophon printer and this will be attached to the transducer connector (specific location) prior to the transducer being placed into the dust free cabinet
6. Transducers used for all endocavitary exams are assigned a number based upon the DH asset ID #. Documentation of the transducer(s) used can be found within the Ultrasound report/EPIC imaging tab. All exams performed after normal business hours will also be documented in the same manner. Should an infection be discovered, the transducer used for the specific study can be easily identified.
7. Plastic bags will only be used for the following activities
 - Transport of a transducer(s) outside the department to an offsite clinic.
 - The 'transducer' will be placed in a plastic bag and into a dust cover bag, sealed, and placed into a rigid clean container for transport. Double bagging will reduce the chance of cross contamination (ie; cord touching the clean transducer tip)
 - Clean transducers returned back to the department will be placed into the dust free cabinet.
8. Exterior and interior cleaning of the Trophon unit will be performed weekly and documented in the Ultrasound 'I' drive for review as needed.
9. Each Trophon unit permanently stores 100,000 disinfection cycles. The data from the disinfection cycles from each unit (5) will be exported via encrypted USB devices every 6 months and stored electronically in the Ultrasound 'I' drive for CSR & TJC review as necessary.
10. The exported document(s) will include the DH asset ID# for ease of identification because the units are mobile. The export frequency will be will reviewed by CSR and changes made as needed.

Departmental Procedure Title	Trophon2 High Level Disinfection (HLD) Procedure - Ultrasound - Radiology	ID	26678
Keywords	Trophon, High, Level, Disinfection, HLD, Probe, CI		
Department	Radiology - Ultrasound		

I. Purpose

To safely and effectively perform igh level disinfection (HLD) of semi-critical items that touch mucous membranes or non-intact skin in accordance with the manufacturer's recommendations (IFU).

II. Procedure Scope

This applies to all ultrasound transducers utilized at Dartmouth-Hitchcock, Lebanon.

III. Definitions N/A

IV. Equipment

- trophon®2 high level disinfection (HLD) device
- Non-latex gloves
- Disinfecting wipes

V. Procedure

Transducer validation must be performed before any transducer is processed by trophon®2.

A complete list can be found at: <https://www.nanosonics.us/products/trophon-epr>

- Non-latex gloves must be worn during the cleaning process to protect against exposure to infectious agents and cross-contamination.
- Remove the protective cover from the transducer and wipe residual gel off the transducer with a clean dry towel.
- Pre-clean the transducer with a hospital approved low level disinfection (LLD) wipe and dried BEFORE the High Level Disinfection process can commence.
- Scan the medical instrument tag against the Acutrace reader.
- Load the clean, dry probe into the trophon®2 disinfection chamber ensuring that the probe is straight and not touching the walls or the bottom and that the tip of the probe is above the embossed line.
- Place a chemical indicator red side up at the base of the chamber door. A chemical indicator (CI) must be used for each disinfection cycle and can only be used once.
- Close the chamber door.
- The next screen message will confirm: *Is the probe clean and dry?*
- Respond YES if the probe has been pre-cleaned and dried.
- If NO, follow the trophon2 touch screen prompts.
- Scan your operator card.

- Press Start Disinfection on the touch screen to begin disinfection cycle.
- At the end of the 7-minute HLD cycle, the blue status bar at the top of the trophon2's touch screen states: Disinfection Finished.
- Perform proper hand hygiene and put on a new set of gloves before opening the chamber door and removing the probe.
- Open chamber door, verify the chemical indicator (CI) pass status using the color assessment chart on the chemical indicator packaging (**Note:** must be lighter than the MEC-orange on the fail-side of the color assessment chart) and then discard into the nearest trash receptacle.
 - **Important:** Both CI and trophon2 touch screen must indicate a successful cycle for the probe to be ready for use. If either the CI or trophon2 touch screen indicates a fail, the cycle **MUST** be repeated.
- Select chemical indicator result on the touch screen and then scan your operator card to confirm.
- Remove the probe after the cycle is complete. Wipe the probe with a dry, clean, single-use, lint-free cloth.
- Visually inspect the probe and remove any disinfectant residue.
- Store clean probe with the HLD label attached (on connector) and place in the Ultrasound probe storage cabinet.
- The Acutrace information recorded on the trophon2 printer label:
 - Date and time
 - Trophon serial number
 - Cycle number
 - Disinfectant lot number and expiration date
 - Chemical Indicator lot number and expiration date
 - Operator names
 - Trophon cycle status (pass or fail)
 - chemical indicator status (pass or fail)
 - Probe identification (including transducer number)

Chemical Indicators

- Chemical indicators should be stored at room temperature 59-86°F.
- Store in a dry, clean environment out of direct heat.
- Do not store near chemicals such as sterilizing agents, acids, bases, bleaches, and other disinfectants.

SONEX-HL Cartridge Storage

- Cartridge should be stored at temperatures between 59-77°F.
- Store cartridge in all original packaging in correct directional orientation until use.
- Keep away from excessive heat.

Removing and Installing the Disinfectant Cartridge

- The device will automatically prompt you to run a purge cycle if the cartridge has been in the device too long and has expired (30 days). Follow prompts on the LCD screen.
- Screen message will say: ***Replace the cartridge and close cartridge door.***
- Cartridge door opens automatically. Do **NOT** use excessive force to pull down the cartridge door.
- Wearing non-latex gloves and in a designated eye wash station location, lift the cartridge out by touching the areas exposed while the bottle is in the holder and avoid touching pierced areas.

- Recap the empty cartridge and dispose in the nearest waste receptacle.
- Verify the expiration date before inserting a new SONEX-HL cartridge.
- Once the cartridge is in place, close the cartridge door and the device is ready for use.

Contingency Plans

- USB encrypted device will be used to download trophon2 data (cleaning cycles, solution and chemical indicator expiration) every 6 months.
- An Excel document displaying all recorded data will be kept locally and sent to CSR as requested.
- **trophon2 service:**
 - 1-800-437-1171 option 1, option 1, option 5.
- Acceptable alternatives to the trophon2 process are as follows:
 - Temporarily suspend or postpone procedures.
 - Transport all transducers to Central Sterilization (CSR) for High Level Disinfection (HLD) processing
- Annual competencies (training video) will be completed by each staff member who uses the trophon2.
- Training certificate will be printed by the employee to verify successful completion of training course.
- A copy of the training certificate will be kept in the employee file

VI. References

User Manual & Transducer compatibility list

<https://www.nanosonics.us/products/trophon-epr>

Nanosonics / Trophon training website

<https://nanosonicsacademy.com/>

Responsible Owner:	Radiology - Ultrasound	Contact:	Dennis Seguin
Approved By:	Office of Policy Support (OPS), Christine Kvinlaug	Version #	1
Current Approval Date:	01/25/2022	Old Document ID:	
Date Policy to go into Effect:	01/25/2022		
Related Policies & Procedures:			
Related Job Aids:			

Job Aid	Ultrasound Prep Guide Job Aid - Radiology	ID	5592
Keywords	us, ultrasound, prep		
Department	Radiology, Radiology-Support Svcs, Radiology-Ultrasound		

I. Purpose

This guide is designed to provide a quick reference for patient preparation instructions and general information related to Ultrasound.

General Information

Ultrasound uses sound waves to reproduce the structure of organs and tissues in virtually all areas of the body. Ultrasound can produce precise images of the heart, blood vessels, uterus, bladder, kidneys, etc. and reveals internal motion such as heartbeat and blood flow. It is generally considered painless and safe. Sound waves do not damage tissue, even when used to examine a fetus.

A transducing gel is applied over the portion of the body to be examined. Patients may be aware of slight pressure with the movement of the transducer. It is important that patients remain still and relaxed during the examination. Some exams require specific preparation instructions. Most exams/procedures take approximately 30-60 minutes.

OB ultrasound serves patients with reproductive and perinatal needs where radiologists work closely with the gynecologists and obstetricians. Ultrasound also serves patients requiring sonography for various diagnostic and treatment needs. Some minimally invasive ultrasound guided biopsies are performed.

Prep Guidelines

Complete Abdomen, Right Upper Quadrant & Aorta

- Adult patients should be instructed to fast (NPO) for 8 hours prior to the exam.
- The above guideline pertains to inpatients on tube feedings as well.
- Infants should fast for a minimum of 4 hours prior to exam.

Renal

No Prep necessary.

NOTE: Infants must be at least 3 days old, unless approved by a staff radiologist.

Pelvis

- Every attempt should be made to schedule these examinations between cycle day 4 and 12. In most cases trans-vaginal scanning will be the preferred method of imaging. The patient may come with an empty urinary bladder.
- The trans-abdominal approach should only be used if the patient is under 18, not sexually active, has not yet had a gynecologic exam with a speculum, or has been sexually abused. These patients should arrive with a distended urinary bladder. Preferably the patient should consume 32 oz. of liquid 1 hour prior and be instructed not to void.

Obstetrical

- All outside physician requests should be accompanied by prior Ultrasound reports indicating measurements data. Patients scheduled for a nuchal translucency exam should arrive with a moderately distended urinary bladder. All other obstetrical patients may come with an empty urinary bladder.

Testicular & Thyroid, Musculoskeletal

- No special prep required.

Hips

- Infants must be between 4 weeks and 6 months of age. Infants younger than 4 weeks of age may be scanned if clinically suspected of hip dislocation. Prior approval required. Scans should not be performed for rule out DDH after 6 months of age. Examinations may be performed at any age to rule out joint effusion.

Infant Head-Cranial

- Infants for head ultrasound examinations need be less than 1 year old.

Spine

- Infants for spine ultrasound examination need to be no greater than 6 months of age. Requests for infants older than 6 months of age require prior approval.

Prostate Biopsy

- Prostate biopsies are scheduled through Urology.

Responsible Owner:	Radiology	Contact(s):	Dennis Seguin
Approved By:	Office of Policy Support - All Other Documents, Michael Patrick	Version #	3
Current Approval Date:	09/01/2020	Old Document ID:	
Date Policy to go into Effect:	09/01/2020		
Related Policies & Procedures:	Adult Minimal Sedation Procedure - Radiology		
Related Job Aids:	Scheduling and Prep Guide Job Aid- Introduction and Index - Radiology Ultrasound Scheduling Job Aid - Radiology		

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