



# Periprocedural Patient Care<sup>1</sup>

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**Abbreviations:** aPTT = activated partial thromboplastin time, ASA = American Society of Anesthesiologists, INR = international normalized ratio

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## SA-CME LEARNING OBJECTIVES

After completing this journal-based SA-CME activity, participants will be able to:

- Identify the key components of patient identifiers, informed consent, and universal time-out policies.
- Discuss the various stages of sedation and the common reversal agents.
- Describe the periprocedural management of patients with hypertension, coagulopathy, and diabetes.

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Periprocedural care of patients who undergo image-guided interventions is a task of monumental importance. As physicians who perform procedures, radiologists rely on their noninterpretive skills to optimize patient care. At the center of periprocedural care is proper patient identification. It is imperative to perform the indicated procedure for the correct patient. It is also of great importance to discuss with the patient the nature of the procedure. This conversation should include the indications, risks, benefits, alternatives, and potential complications of the procedure. Once the patient agrees to the procedure and grants informed consent, it is imperative to stop and confirm that the correct procedure is being performed on the correct patient. This universal time-out policy helps decrease errors and improves patient care. To optimize our interpretative and procedural skills, it may be necessary to provide the patient with sedation or anesthesia. However, it is important to understand the continuum of sedation and be able to appropriately monitor the patient and manage the sedation in these patients. To minimize the risks of infection, periprocedural care of patients relies on aseptic or, at times, sterile techniques. Before the procedure, it is important to evaluate the patient's coagulation parameters and bleeding risks and correct the coagulopathy, if needed. During the procedure, the patient's blood pressure and at times the patient's glucose levels will also require monitoring and management. After the procedure, patients must be observed in a recovery unit and deemed safe for discharge. The fundamental components of periprocedural care necessary to enhance patient safety, satisfaction, and care are reviewed to familiarize the reader with the important noninterpretive skills necessary to optimize periprocedural care.

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## Introduction

In 2012, the Radiological Society of North America (RSNA) launched the “Radiology Cares: The Art of Patient-centered Practice” campaign. This initiative was designed to help radiologists optimize patients’ experiences throughout their radiologic care and highlight the important role radiologists play in the overall health care of patients.

Patient-centered care goes beyond reading rooms. It is no longer the standard of practice for diagnostic and interventional radiologists to perform procedures and leave the care of the patient to the referring team. Increasingly, radiologists are an integral component of the

## TEACHING POINTS

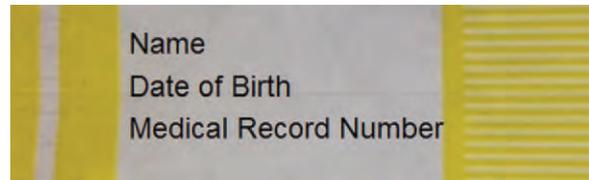
- As part of the hospital accreditation program, the Joint Commission updated the National Patient Safety Goals, effective as of January 2015. The recommendations are for the use of at least two patient identifiers when providing patient care and administering treatment, including performing procedures.
- Informed consent should be obtained for any procedure that exposes a patient to any substantial risk, including moderate sedation.
- All diagnostic imaging and interventional procedures require a time-out, which should adhere to the Joint Commission's universal protocol for preventing wrong site, wrong procedures, and wrong person surgery.
- While the Joint Commission and the American Society of Anesthesiologists (ASA) have described different levels of sedation, it is important to recognize that these "levels" are truly a therapeutic continuum, and a patient may quickly move between the different levels.
- Good aseptic technique is also a critical step in reducing procedure-related infections. Skin sites can be disinfected by using 2% chlorhexidine-based agents (preferred), tincture of iodine, or 70% alcohol and should be allowed to dry completely before starting the procedure. For most procedures, it is also appropriate to use either clean or sterile gloves or a sterile drape. For the placement or guidewire exchange of central venous catheters (including peripherally inserted central catheters), the Centers for Disease Control and Prevention guidelines require the use of maximal sterile barrier precautions, which mandate aseptic technique and the use of a cap, mask, sterile gown, sterile gloves, and sterile drape.

medical team, particularly those who perform image-guided interventions. Hence, knowledge of periprocedural care is paramount for building a successful patient-centered practice.

Periprocedural care with respect to image-guided intervention refers to the spectrum of patient care and management before, during, and after a procedure. In this article, we discuss the different components of periprocedural care with specific emphasis on patient safety and clinical management.

### Patient Identifiers

The importance of correct patient identification cannot be overstated. Historically, the emphasis on checking patient identification arose because of devastating medical errors, particularly with respect to surgery. Errors were related to patient misidentification, incorrect surgical site or location, or incorrect type of procedure performed. These same problems are applicable to radiology services. Failure to identify the correct patient and verify the intended radiologic study or intervention can result in errors involving the wrong patient, the wrong procedure, the wrong patient side, or the wrong anatomic site. Prevention of these errors requires well-developed, standardized safety policies and practices (1–4).



**Figure 1.** Example of a patient wristband, which includes patient identifiers such as name, date of birth, and medical record number.

These protocols should be clearly defined and available to all staff involved with the patient.

As part of the hospital accreditation program, the Joint Commission updated the National Patient Safety Goals, effective as of January 2015. The recommendations are for the use of at least two patient identifiers when providing patient care and administering treatment, including performing procedures. Although the Joint Commission does not require wristbands (Fig 1), if wristbands are used as an identifier, they must be attached to the patient at all times and cannot be removed. Nursing staff and physicians must use two identifiers before each procedure. These typically include the patient's name, medical record number, date of birth, and social security number. If the patient does not have the capacity to self-identify, the patient's relative, guardian, or domestic partner may identify the patient. Manual entry of information can also lead to misidentification. As such, the correct patient information should be verified on the imaging monitor before any procedure.

## Informed Consent

### Procedure and Documentation

Informed consent should be obtained for any procedure that exposes a patient to any substantial risk, including moderate sedation. Informed consent guidelines are state issued, not federal, and vary from state to state. The informed consent process requires a face-to-face conversation (5). Topics to discuss during the informed consent process may include the purpose and nature of the procedure, the method of performing the procedure, the procedural risks and potential complications, the expected benefits and effects, the risks of not performing the procedure, reasonable alternatives and likely risks and benefits, and the right to refuse the procedure.

Once the patient expresses understanding of the procedure, the informed consent is considered complete and should be appropriately documented—most commonly by the patient signing the consent form. Since the patient must be able to fully understand the consent process, the consent should be obtained before any sedation is administered.

**Final Verification Timeout Checklist - Led by Proceduralist**

- Other activities suspended.
- Any team member may express concerns.
- Interaction must include all team members.
- Procedure not started until all concerns are resolved.

**STOP** Except in emergencies, no procedure can begin until both checklists (above and below) have been filled out and signed.

Yes	N/A	Checklist may be filled out by any team member (✓ Check appropriate box)
<input type="checkbox"/>		1. Verify patient identity
<input type="checkbox"/>		2. Verify procedure
<input type="checkbox"/>		3. Verify consent(s)
<input type="checkbox"/>	<input type="checkbox"/>	4. Verify surgical site and side
<input type="checkbox"/>	<input type="checkbox"/>	5. Verify site marking
<input type="checkbox"/>	<input type="checkbox"/>	6. Verify correct patient position
<input type="checkbox"/>	<input type="checkbox"/>	7. Verify that images and other results are correctly labeled and displayed
<input type="checkbox"/>	<input type="checkbox"/>	8. Verify that prophylactic antibiotics have been given
<input type="checkbox"/>	<input type="checkbox"/>	9. Verify that correct irrigation fluids are present
<input type="checkbox"/>		10. Review safety precautions based on patient history or medications

Signature of person completing this section of the form \_\_\_\_\_ Date: \_\_\_\_\_ Time: \_\_\_\_\_

\*Licensed independent practitioner or other provider who is privileged or permitted by the hospital to perform the intended procedure.

**UNIVERSAL PROTOCOL VERIFICATION FORM**

Figure 2. Screenshot of a preprocedural time-out form.

The name of the health care provider who is performing the procedure or his or her designee must appear on the consent form before the signature of the patient. A copy of the consent form should be placed in the patient's medical record. Consent via telephone may be obtained from a patient's health care representative in circumstances where a patient cannot sign for him- or herself. In these situations, a witness in the form of a second hospital staff member may be necessary.

### Emergency Procedures

In emergency situations, an exception to the informed consent requirement may be made to prevent any serious injury or death or to alleviate suffering. This is only if a patient cannot provide consent and the legally authorized representative is unavailable. The need for any immediate intervention must be documented in the patient's medical record, including situational details, the need for immediate intervention, the magnitude of the situation, and the reason for not obtaining consent.

### Radiation

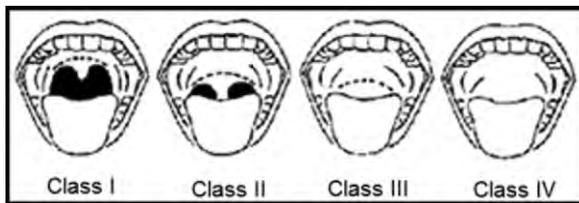
If an intervention has a potential for higher levels of radiation, the risks of radiation-induced injuries should be included during the consent process (6,7). The medical record should note the estimated radiation dose received, and the patient should be advised of any potential radiation-related injuries with follow-up instructions (8,9).

### Time-out

All diagnostic imaging and interventional procedures require a time-out, which should adhere to the Joint Commission's universal protocol for preventing wrong site, wrong procedure, and

wrong person surgery (10). The "preoperative verification process" is part of this universal protocol, which involves cessation of all activity before any invasive procedure to identify the patient by name and medical record number, located on the patient's wristband and/or in the patient's chart. Before initiating the time-out, anatomic site marking should be performed such that it can be verified during the time-out process. The radiologist must define a skin-marking site to prevent wrong anatomic site errors. These include procedures that involve right and left distinction, as well as multiple structures or levels. Mistakes can also occur because of incorrect patient positioning or imaging orientation, particularly with regard to the prone position. The procedure site must be marked by the person who will be present for the procedure and who will ultimately be accountable for the procedure. Clear communication and collaboration are imperative among the team members.

When possible, the patient should be involved in and aware of the site-marking process. At times, exact site marking cannot be performed. For example, if a computed tomography (CT)-guided drainage of an abdominal fluid collection is intended, the initial CT scan will help determine whether to approach the collection from the right or the left side of the abdomen. The radiologist who performs the procedure may state that the site of entry is not marked but will be determined after initial imaging. The procedure cannot begin until the time-out is completed and documented on a form (Fig 2). There can be no starting of the procedure until this is performed unless there are extenuating circumstances, such as an emergency or life-threatening situation where the procedure is deemed appropriate by the attending physician.



**Figure 3.** Mallampati scoring system diagram. Class I anatomy consists of full visibility of the tonsils, uvula, and soft palate. Class II includes visibility of the hard and soft palate, the upper portion of the tonsils, and the uvula. Class III includes visualization of the soft and hard palate and the base of the uvula. Class IV includes visualization of only the hard palate.

## Conscious Sedation

### Levels of Sedation

Patients undergoing diagnostic imaging or interventional procedures may experience pain and anxiety (11). By relieving anxiety, pain, and discomfort, sedation and analgesia allow patients to tolerate procedures, but safe administration and proper patient monitoring are critical for the periprocedural care of the patient (12–14).

While the Joint Commission and the American Society of Anesthesiologists (ASA) have described different levels of sedation, it is important to recognize that these “levels” are truly a therapeutic continuum, and a patient may quickly move between the different levels (15). The four described levels of sedation include minimal, moderate, deep, and general. In minimal sedation, the airway, spontaneous ventilation, and cardiovascular function are unaffected, and the patient is able to demonstrate normal response to verbal stimulation. With moderate sedation, spontaneous ventilation is adequate, the airway does not require protection or intervention, and cardiovascular function is usually maintained, but the patient demonstrates purposeful response to verbal or tactile stimulation. In deep sedation, the airway may require protection or intervention, spontaneous ventilation may be adequate, and cardiovascular function is usually maintained, but purposeful response from the patient is generated after repeated or painful stimulation. In the case of general anesthesia, the airway often requires protection or intervention, spontaneous ventilation is frequently inadequate, cardiovascular function may be impaired, and the patient is unarousable even with painful stimulus (14).

Mild and moderate sedation can be provided by physicians with moderate sedation training and privileges. Since intentional induction of deep sedation may result in a state of general anesthesia, providers must be able to recognize that the patient has entered a state of general anesthesia and be able to maintain the patient’s

vital functions until he or she has returned to the appropriate level of sedation. Therefore, routine induction of deep sedation by nonanesthesiologists is discouraged because of the potential challenge of airway and respiratory compromise. General anesthesia is administered by anesthesiologists and nurse anesthetists.

### Pre-sedation Patient Evaluation

Before the administration of sedation, a patient must be assessed and approved for sedation. This evaluation includes discussion of the risks and benefits of sedation, in addition to acquiring a focused history and physical examination to determine the patient’s ASA physical status classification score (13). The ASA physical status classification is as follows: class I, normal healthy patient; class II, patient with mild systemic disease; class III, patient with severe systemic disease; class IV, patient with severe systemic disease that is a constant threat to life; class V, moribund patient who is not expected to survive without the procedure; and class VI, patient declared brain dead and undergoing organ removal for donor purposes.

Patients who are in ASA classes I and II typically qualify for moderate sedation. Patients in classes III and IV or those who have other clinically significant risk factors may require additional consideration, including a possible consultation with an anesthesiologist or undergoing sedation that is administered by an anesthesiologist or anesthetist. Patients in class V should not be sedated by nonanesthesiologists.

The patient’s airway must also be examined to assess the anatomy and ease of intubation. Several classification systems and bone landmarks are used to predict the difficulty of intubation. A commonly used example is the Mallampati classification, which is used to assess and score a patient’s airway as the patient opens his or her mouth and protrudes the tongue (Fig 3). It should be noted that the combination of classification systems and/or bone landmarks, such as the thyromental distance, increases the chance of predicting difficult airway intubations.

Finally, preprocedural fasting may decrease the risk of aspiration of gastric contents, a rare but potentially fatal complication of deep sedation and general anesthesia. Although the duration of fasting required before administration of sedation remains controversial (16,17), the ASA has recommended 6 hours of no oral intake for solids and 2 hours for clear liquids. Clear liquids include water, clear tea, fruit juices without pulp, carbonated beverages, and black coffee. Infant formula, nonhuman milk, and light meals, such as toast and clear liquids, are considered solids and require a 6-hour fasting time. Breast milk is not considered a clear

**Figure 4.** Photograph of a patient monitor screen, as viewed during sedation. During moderate sedation, the patient's blood pressure (purple numbers), heart rate (green rhythmic pattern), oxygen saturation (blue waveform), end tidal carbon dioxide partial pressure (orange waveform), and respiration rate (white waveform) are monitored.



**Table 1: Commonly Used Sedation and Analgesic Agents**

Drug Class and Drug	Effects	Starting Dose	Onset of Action	Duration of Action
<b>Hypnotics</b>				
Propofol	Sedation, anesthesia	25–75- $\mu\text{g}/\text{kg}/\text{min}$ infusion	60 sec	3–5 min
Midazolam	Sedation, anxiolytic effects, amnesia	1 mg	2 min	45–60 min
Ketamine	Analgesia, amnesia, dissociation	5–10 mg	1–2 min	60 min
Diazepam	Sedation, anxiolytic effects	1–2 mg	2–3 min	6 h
<b>Analgesics</b>				
Remifentanyl	Analgesia	0.1–0.2 $\mu\text{g}/\text{kg}/\text{min}$	3–5 min	5–7 min
Sufentanyl	Analgesia	2 $\mu\text{g}$ per dose	2–3 min	15 min
Fentanyl	Analgesia	25 $\mu\text{g}$ per dose	2–3 min	30–60 min
Morphine	Analgesia	2 mg per dose	3–10 min	3–4 h
<b>Other</b>				
Nitrous oxide	Sedation, anxiolytic effects, analgesia, amnesia	...	1–2 min	<5 min
<b>Reversal agents</b>				
Naloxone	Opioid reversal	40- $\mu\text{g}$ dose, repeat every 2 minutes for a maximum of 3 mg	2 min	20–40 min
Flumazenil	Benzodiazepine antagonist	200- $\mu\text{g}$ dose, repeat every 1 minute for a maximum of 1 mg	1–2 min	30–60 min

liquid or a solid and requires a 4-hour fasting time. In addition, fatty foods or meat may prolong the gastric emptying time and may require prolonged fasting time (for example, 8 hours or more) in certain cases. In emergent circumstances when preprocedural fasting is not practical, care should be taken to protect against aspiration by limiting the depth of sedation, delaying the procedure, or arranging for endotracheal intubation.

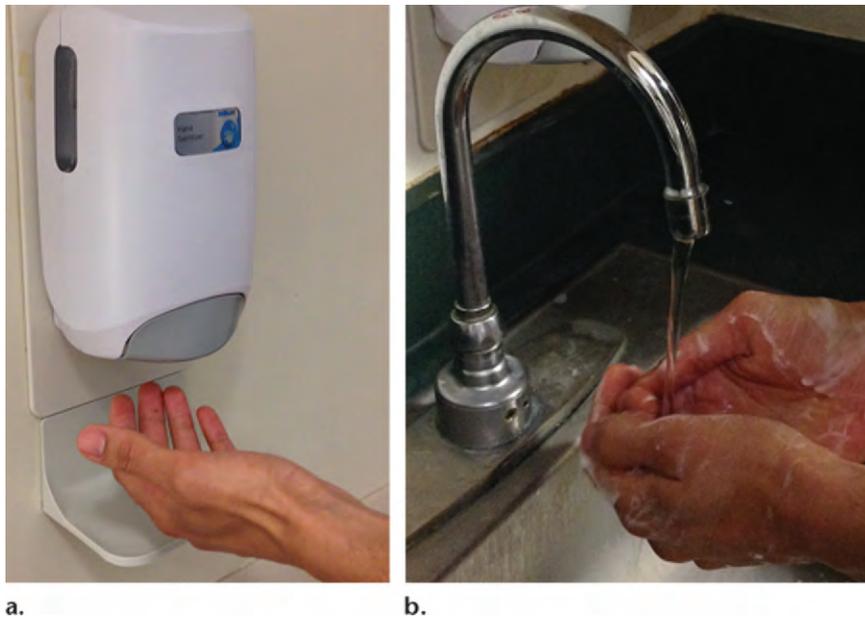
### Periprocedural Sedation Monitoring

In cases where sedation is performed under the supervision of a physician, a separate qualified health care professional must be present whose primary focus is the monitoring, medicating, and care of the patient. The patient must have functional intravenous access for drug administration. Continuous monitoring should include blood pressure, heart rate, cardiac rhythm, respiration rate, and pulse

oximetry (Fig 4). Electrocardiographic monitoring should be performed in all patients who undergo deep sedation and is recommended during moderate sedation for patients with clinically significant cardiovascular disease, elderly patients, and patients undergoing procedures where dysrhythmias are anticipated. Since sedation may result in the loss of protective reflexes, all sedated patients must be monitored, regardless of the intended level of sedation. Table 1 includes the common medications used for sedation and analgesia, with reversal agents (12).

### Postprocedural Sedation Recovery and Discharge

Postprocedural monitoring is needed in the recovery period after sedation. To safely discharge patients who have undergone sedation, the following conditions must be met: The patient has



**Figure 5.** Photographs show use of alcohol-based hand rub (a) and antimicrobial soap and water (b) for hand hygiene.

returned to a baseline level of consciousness; the patient has stable vital signs; if reversal agents were used, a sufficient time (as long as 2 hours) has elapsed to prevent repeat sedation after reversal agents have worn off; a responsible adult is present who will accompany the patient home; the patient is not permitted to drive; and patients and caregivers have been provided with written instructions regarding medications, activities, diet, and an appropriate phone number to call in case of emergency.

In compliance with the recommendations of the Joint Commission, before patient discharge, written instructions should be provided to the patient and the responsible adult who is accompanying the patient. The instructions may include a description of the procedure performed, postprocedural restrictions on activity and diet, and instruction on what to do in the event of a complication or an emergency.

## Hand Hygiene and Aseptic Technique

### Hand Hygiene

The importance of hand hygiene for reducing infection rates in health care environments was first described by Semmelweis and Holmes (18) in the mid-19th century. Achieving high rates of compliance among health care workers, however, has been an ongoing battle (19,20). Since radiologists and especially interventional radiologists perform so many procedures as part of daily practice, it is crucial to understand the current guidelines for both hand hygiene and sterile technique for procedures, especially central venous catheter placement. Hand hygiene, as

defined by the 2002 Centers for Disease Control and Prevention Guideline for Hand Hygiene in Health-Care Settings (21), requires decontamination of hands by using either an alcohol-based hand rub (recommended as a first-line method) (Fig 5a) or hand washing with antimicrobial soap (preferred) or plain soap (acceptable) and water (Fig 5b). Indications for hand hygiene include the following: Hands should be washed before direct patient contact and before handling wound dressings, body fluids, or mucous membranes; if moving from a contaminated body site to a clean body site during patient care; before donning sterile gloves when inserting central venous catheters; before inserting indwelling urinary catheters, peripheral vascular catheters, or other devices that do not require a surgical procedure; after removing gloves (wearing gloves can promote bacterial proliferation on the covered skin); after contact with objects in the immediate vicinity of a patient; before eating; and after using a restroom.

Alcohol-based hand rubs typically contain additional antibacterial agents, such as chlorhexidine or triclosan. They are preferable to soap and water, since they reduce bacterial counts more effectively, as well as provide some degree of longer-acting antibacterial activity after their use (22,23). Most preparations also contain emollients to minimize skin irritation and are better tolerated in repeated application than soap-based hand washing (23). However, hand rubs are not recommended when hands are visibly dirty or contaminated with blood or body fluids or after suspected exposure to spore-forming organisms, such as *Clostridium difficile* or *Bacillus anthracis*.



**Figure 6.** Photographs show use of aseptic technique with maximal sterile barriers for central venous catheter placement. Note the use of a cap, mask, sterile gown, and sterile gloves (a) and a sterile drape (b).

### Aseptic Technique

Good aseptic technique is also a critical step in reducing procedure-related infections. Skin sites can be disinfected by using 2% chlorhexidine-based agents (preferred), tincture of iodine, or 70% alcohol and should be allowed to dry completely before starting the procedure. For most procedures, it is also appropriate to use either clean or sterile gloves or a sterile drape. For the placement or guidewire exchange of central venous catheters (including peripherally inserted central catheters), the Centers for Disease Control and Prevention guidelines require the use of maximal sterile barrier precautions, which mandate aseptic technique and the use of a cap, mask, sterile gown, sterile gloves (Fig 6a), and sterile drape (Fig 6b) (24).

### Coagulation Status and Hemorrhage Risk

#### Bleeding Risks

Hemorrhage should be listed as a potential complication of essentially all image-guided procedures. The risk of bleeding depends on the nature of the planned procedure, the patient's underlying health, and any ongoing antiplatelet or anticoagulant therapy. The risks of bleeding after image-guided procedures can be divided into three categories, as follows (25). The low bleeding risk category includes procedures such as dialysis access, venography, nontunneled central line placement or removal, inferior vena cava filter placement or removal, drainage tube exchange, thoracentesis, paracentesis,

and superficial aspiration, biopsy, and abscess drainage. The moderate bleeding risk category includes angiography, arterial intervention, embolization, tunneled central line placement or removal, venous or pulmonary artery intervention, transjugular liver biopsy, percutaneous gastrostomy tube placement, percutaneous cholecystostomy tube placement, thermal ablation, spine procedures, and deep biopsy, aspiration, or drainage (except the kidney and spleen). The high bleeding risk category includes a transjugular intrahepatic portosystemic shunt procedure, percutaneous transhepatic cholangiography with or without biliary drainage, percutaneous nephrostomy tube placement, and biopsy of the kidney or spleen.

The recommendations for laboratory testing and management of coagulation status depend on the bleeding risk with the procedure, the patient's underlying health, and any ongoing antiplatelet or anticoagulant therapy (25). For procedures that have a low risk of bleeding, knowledge of the preprocedural value of the international normalized ratio (INR) for prothrombin time is recommended if the patient is taking warfarin or has liver disease. If the patient is receiving intravenous heparin, activated partial thromboplastin time (aPTT) should be measured. Platelet count and hematocrit levels do not need to be checked before the procedure. If the procedure has a moderate risk of bleeding, the preprocedural INR level or aPTT (if the patient is receiving intravenous heparin) should be evaluated. With procedures that incur a high risk of bleeding, it

is recommended that the INR level or the aPTT (if the patient is receiving intravenous heparin) be checked and also that the platelet count and hematocrit level be checked.

For all procedures, regardless of the risk of bleeding, the patient's platelet count should be at least  $50 \times 10^9/L$ . For procedures with low bleeding risks, the INR should be corrected if it is greater than 2. For procedures that have a moderate or high risk of bleeding, the INR should be corrected if it is greater than 1.5 (25).

### Management of Anticoagulant Therapies

Withholding oral anticoagulant and antiplatelet therapy should be discussed with the prescribing physician in advance of the procedure. Guidelines exist for patients who receive commonly used antiplatelet agents and anticoagulants, including aspirin, clopidogrel, and low-molecular-weight heparin but are based on limited data that pertain to imaging-guided procedures (25). Intravenous heparin infusion should be stopped or reversed for aPTT values that are greater than 1.5 times normal values. For procedures that have a low or moderate risk of bleeding, one dose of low-molecular-weight heparin should be withheld. For procedures with high risk of bleeding, low-molecular-weight heparin should not be administered for 24 hours before the procedure.

Warfarin should be discontinued 4 days before elective intermediate and high-risk procedures, and INR levels should be checked on the day of the procedure (26). Clopidogrel should be withheld for at least 5 days before a procedure. Aspirin should be withheld for 5 days only for procedures that have a high risk of bleeding. The prescribing physician who is managing the patient's anticoagulant therapy should be contacted to determine whether a periprocedural heparin "bridge" is required (27). In certain circumstances, a patient may receive a fresh frozen plasma transfusion or recombinant factor VII to temporarily correct the coagulopathy. Novel oral anticoagulants (eg, rivaroxaban, apixaban, edoxaban, and dabigatran) should be stopped at least 1 day before elective procedures. Longer drug holidays (3–5 days) are needed for patients with renal dysfunction who receive dabigatran and for patients with hepatic dysfunction who are treated with apixaban (28).

### Management of Antiplatelet Agents

Antiplatelet effects of ticlopidine, clopidogrel, prasugrel, and ticagrelor continue through the life of the platelet, which can be 5–9 days (29). Therefore, these agents should be stopped 5–7

days before elective procedures (30). Glycoprotein IIb/IIIa receptor antagonists prevent platelet binding to fibrinogen and include abciximab, eptifibatid, and tirofiban. Reversing the effects of these agents can be achieved by means of discontinuation and allowing time for clearance. Abciximab has an approximate 12-hour pharmacological effective half-life, whereas the other agents are shorter acting (2–4 hours). In theory, their effect can be overcome by the transfusion of unaffected platelets (31).

### Periprocedural Hypertension

Preexisting hypertension is the most common cause of periprocedural hypertension (32). Most patients with hypertension have essential hypertension or secondary causes, such as primary aldosteronism, renovascular disease, or chronic kidney disease. Other conditions that can less commonly cause elevated blood pressure include bladder distention, hypoxemia, and catecholamine release.

### Analgesia and Anxiolytics

Pain is commonly overlooked as a cause of hypertension. Additionally, tolerance to frequent dosing or continuous infusions of short-acting opioid analgesics and benzodiazepines may result in underdosing of analgesics during procedures (33).

### Antihypertensive Pharmacotherapy

The decision to treat with antihypertensive medications should only be made after consideration of the patient's preprocedural baseline blood pressure. Adrenergic receptor antagonists lower blood pressure by blocking norepinephrine and epinephrine effects at either  $\beta$ - or  $\alpha$ -receptors. Direct vasodilators act by relaxing vascular smooth muscle and should be used with caution because they can abruptly lower blood pressure and may result in rebound tachycardia (34). Table 2 lists the common periprocedural antihypertensive agents (35).

### Pheochromocytoma

Consultation with colleagues in endocrinology and/or anesthesiology should be performed when a suspected pheochromocytoma is biopsied or ablated because a surge in catecholamines can result in a hypertensive crisis. Premedication with an oral  $\alpha$ -adrenergic blocker is used for 1–3 weeks before the procedure. If  $\beta$ -blockers are used, it is paramount to initiate this after  $\beta$ -blockade.  $\beta$ -blockade impedes catecholamine-induced vasodilation, resulting in unopposed  $\alpha$ -receptor-induced vasoconstriction. Intraprocedural nitroprusside is also often used to manage a hypertensive crisis in this setting (36).

**Table 2: Common Periprocedural Antihypertensive Agents**

Medication	Dose and Method of Administration	Onset of Action	Duration of Action
Hydralazine	10–20-mg intravenous administration every 4–6 hours, up to a 40-mg dose	5–20 min	1–4 h
Labetalol	10–20-mg intravenous bolus once, 40–80 mg at 10-minute intervals up to a 300-mg total dose	2–5 min	2–18 h
Metoprolol	5–10-mg intravenous bolus, up to 15 mg	20 min	5–8 h
Nitroglycerin	Sublingual dose of 0.4 mg administered, with paste applied over 1/2 to 2 inches topically	Sublingual dose, 1–3 min; paste, 15–60 min	Sublingual dose, 30–60 min; paste, 2–12 h
Phentolamine	5–20-mg intravenous administration	Immediate	15–30 min
Phenoxybenzamine	10–20-mg per oral administration two times daily, 1–3 weeks before pheochromocytoma intervention	...	...

## Periprocedural Blood Glucose Level Management

### Patients with Type I and Type II Diabetes

The requirement to fast for sedation or anesthesia disrupts the diabetic patient's routine for controlling blood glucose levels. Inappropriate management of a diabetic patient's medications in the periprocedural period can potentially lead to dangerously low or high blood glucose levels in the periprocedural and intraprocedural periods, the symptoms of which may be masked by sedation. Table 3 illustrates the symptoms and acute treatment of hypoglycemia and hyperglycemia (37,38).

Historically, there has been little guidance in the literature on the periprocedural glycemic management in patients undergoing ambulatory surgery. To address this, the Society for Ambulatory Anesthesia developed a consensus statement in 2010, the recommendations of which provide a useful guide to the management of patients undergoing minimally invasive image-guided interventions (39).

It is not necessary for patients with type II diabetes to withhold their oral antidiabetic medications and noninsulin injectable antidiabetic medications the day before the procedure. However, to avoid hypoglycemia, which can be dangerous for even brief periods, patients should withhold their oral antidiabetic medications and noninsulin injectables on the morning of the procedure and should not restart them until they resume normal food intake. Resumption of metformin should be managed with particular care because of the risk of metformin-associated lactic acidosis, which is rare (0–0.084 cases per 1000 patient years) but results in death in half of reported cases (40). Metformin should not be restarted for 48 hours in patients with multiple comorbidities, such as

liver dysfunction, alcohol abuse, cardiac failure, myocardial or peripheral muscle ischemia, sepsis, or severe infection. In those patients, metformin should be restarted only when clinical or laboratory evidence supports normal renal function.

Periprocedural blood glucose level management is more challenging in patients with type I diabetes. If a marked disruption in feeding schedule is anticipated owing to the procedure start time or length of the procedure, doses of short-acting and rapid-acting insulin (regular insulin, lispro insulin, insulin aspart, and insulin glulisine) should be withheld the morning of the procedure. Patients who usually receive morning doses of intermediate-acting insulin (neutral protamine Hagedorn insulin, zinc insulin, and extended zinc insulin) should reduce that dose to 50%–75%, to be administered on arrival to the preoperative area; if they usually receive intermediate-acting insulin in the evening, that dose should be reduced to 75% the evening before the procedure. Patients who require long-acting insulin (insulin glargine or insulin detemir) in the morning can take 75%–100% of their usual morning dose, to be administered on arrival to the preoperative area. Patients who require long-acting insulin do not need to modify their regimen the day before surgery unless they typically receive an evening dose and are prone to nocturnal or morning hypoglycemia; in that case, they can also reduce their evening dose the day before surgery. Patients with insulin pumps do not need to change their regimen the day before surgery or the day of surgery but should adjust their basal rates to “sick day” or “sleep” mode (39).

### Blood Glucose Level Monitoring

Blood glucose levels should be tested on arrival to the preoperative area and the recovery room. A range of 140–200 mg/dL (7.77–11.1 mmol/L) would be an acceptable target. Patients at risk for

**Table 3: Symptoms and Acute Treatment of Hypoglycemia and Hyperglycemia**

Condition and Symptom Type or Treatment	Details
<b>Hypoglycemia</b>	
Neurogenic symptoms	Tremulousness, palpitations, anxiety and/or arousal, sweating, hunger, paresthesias
Neuroglycopenic symptoms	Warmth, weakness, fatigue, difficulty thinking, confusion, behavior changes that mimic inebriation, emotional lability, seizures, loss of consciousness, brain damage, death
Treatment (blood glucose level < 70 mg/dL)	If the patient is able to eat, administer 20 g of fast-acting carbohydrate orally (glucose tablet, juice, soft drink, milk, or crackers), repeated in 15–20 minutes if blood glucose level is still low; if the patient is unable to eat, administer 25 g of dextrose 50% intravenously
<b>Hyperglycemia</b>	
Diabetic ketoacidosis	Rapid development (<24 hours), polyuria, polydipsia, weight loss, nausea and vomiting, abdominal pain (occasional in adults, common in children), Kussmaul breathing, signs of dehydration, mental status range from alert to lethargic
Hyperglycemic hyperosmolar state (plasma glucose level > 600 mg/dL)	Usually slow to develop (several days), polyuria, polydipsia, weight loss, dehydration, mental status changes, lethargy, obtundation or coma, focal neurologic signs (hemiparesis, hemianopsia), seizures
Hyperglycemic crisis treatment	1 L of 0.9% NaCl bolus administered in 1 hour, followed by 0.5–1 L per hour of 0.45% or 0.9% NaCl for the next 2 hours; medical management with intravenous insulin, potassium replacement, bicarbonate as needed, and conversion of intravenous fluids to 5% dextrose when serum glucose level reaches 250 mg/dL

Note.—To convert milligrams per deciliter to millimoles per liter, multiply by 0.0555.

glycemic complications—such as patients with type I diabetes or patients who arrive with unusually high or low blood glucose measurements—should be tested hourly before, during, and after the procedure until a stable feeding regimen is resumed (41). High blood glucose level readings can be treated with a mild sliding scale of short-acting insulin, while low blood glucose level readings (<70 mg/dL [ $<3.9$  mmol/L]) can be treated with 10–25 g of dextrose 50% intravenously or, if the patient can eat, 10–25 g of glucose via sugary drinks, such as 4 oz of apple juice. If there is a delay before patients can resume eating, intravenous fluids that contain 5% dextrose can be given at 75–125 mL per hour to maintain blood glucose levels (37,38).

### Periprocedural Use of Antibiotics

Administration of prophylactic antibiotics before image-guided interventions has become standard clinical practice for selected procedures. However, supporting data remain incomplete, owing to a dearth of randomized controlled trials specific to these interventions. The use of perioperative prophylactic antibiotics to reduce the incidence of wound infection has been well studied, validated, and reported in the surgical

literature (42). Some of the principles described in the literature are relevant to image-guided procedures. Historically, surgical wounds have been categorized into the following four classes associated with different risks of infection (43): (a) Clean wounds have no entry of the gastrointestinal, genitourinary, or respiratory tract. No inflammation is evident, and there is no break in aseptic technique. Diagnostic angiography would be an example of this wound type. (b) In clean-contaminated wounds, the gastrointestinal, biliary, or genitourinary tract has been entered. No inflammation is evident, and there has been no break in aseptic technique. Percutaneous nephrostomy tube placement in a patient with sterile urine would create a clean-contaminated wound. (c) In contaminated wounds, entry into an inflamed or colonized gastrointestinal or genitourinary tract has occurred, without frank pus or a major break in aseptic technique. An example would be percutaneous biliary drainage in a patient with cholangitis. (d) In a dirty wound, entry has occurred into an infected, purulent site, such as in percutaneous abscess drainage.

The choice of antibiotic should be tailored for effectiveness against anticipated pathogens, when possible. Administration of antimicrobial prophylaxis before incision has been shown to reduce

the risk of perioperative wound infection, compared with postoperative administration. The Society of Interventional Radiology has developed a procedure-specific set of guidelines for adult antibiotic prophylaxis during vascular and interventional radiology procedures (44). The guidelines recommend that intravenous antimicrobial prophylaxis be administered within 1 hour before incision, with 2 hours allowed for the administration of vancomycin and fluoroquinolones and with discontinuation within 24 hours after the intervention, unless clinical circumstances warrant continuation of antibiotics as therapy (44).

The recommendations and summary of the Society of Interventional Radiology guidelines provided here constitute a starting point for decisions regarding antibiotic prophylaxis. While these are rationally constructed and reasonable, in most cases they are not supported by findings of randomized controlled trials. The risks of antibiotics should also be considered. These risks include alteration of normal gastrointestinal flora and predisposition to *Clostridium difficile* colitis and the selection of antimicrobial-resistant organisms, such as methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant *Enterococcus*, in individual patients and the community. The decision to administer prophylactics is ultimately left to the physician who is performing the procedure. Finally, it is important to remember that antimicrobial prophylactics must be accompanied by strict adherence to aseptic technique to prevent periprocedural infection.

### Procedure-related Complications

Occasional procedure-related complications are to be expected when performing medical procedures. Complications are typically classified into two categories: minor and major. Minor complications either result in no additional therapy or consequence to the patient or may result in nominal therapy without consequences, such as an overnight hospital admission for observation. Major complications may require minor hospitalization (<48 hours), additional therapies, unplanned increase in the level of care (such as an intensive care unit admission), or prolonged hospitalization (>48 hours). Major complications may also result in permanent adverse consequences or death (45).

A thorough discussion of image-guided procedural complications is beyond the scope of this article. In brief, however, complications of image-guided procedures can be divided into the following categories: (a) vascular complications, involving access site hematoma, hemorrhage, and arterial injury, including pseudoaneurysm, dis-

section, arteriovenous malformation, thrombosis, and embolism; (b) nonvascular complications, involving pain, infection, catheter- or drain-related complications (occlusion and/or leakage around the catheter), air embolism, pneumothorax, ischemia and/or necrosis, nerve injury, and skin injury; and (c) oversedation.

The management of such complications may depend on the patient's clinical status and the perioperative risk factors. Some complications, such as hematomas with small access sites, may require no additional intervention, compared with retroperitoneal hemorrhage, which may necessitate surgery and prolonged hospitalization. Therefore, it is important to be familiar with the common complications associated with the planned intervention and to ensure that the benefits of the planned procedure outweigh the risks to the patient. Last, as discussed previously, familiarity with the common reversal agents (Table 1) is important to ensure patient safety when administering moderate sedation or analgesia.

### Transition of Care

The process of passing critical information about a patient from one caregiver to the next or "signing a patient out" has been a source of struggle for health care organizations. According to the Joint Commission, substandard patient "sign-outs" may result in delay in treatment, inappropriate treatment, adverse events, omission of care, increased costs, and inefficiency from redundant communications and activities (46). The Agency for Healthcare Research and Quality has highlighted the components of a safe and effective patient sign-out by using the acronym "ANTICIPATE" (47): administrative data (eg, a patient's name, medical record number, and location) must be accurate, new clinical information must be updated, tasks to be performed by the covering provider must be clearly explained, illness severity must be communicated, and contingency plans for changes in clinical status must be outlined to assist cross-coverage in managing the patient overnight.

In case of image-guided interventions, the patient sign-out will depend on whether the patient is to be discharged home or will remain in the hospital. For ambulatory procedures, patients are routinely observed in a recovery area. The patient sign-out in this case would include a discussion between the physician or the nurse who is caring for the patient and the recovery room nurse regarding the procedure that was performed, the medication the patient received during the procedure, and the expected recovery course. The physician should indicate how long the patient should be monitored, particularly if sedation was used, whether the patient may ambulate or eat,

and whether he or she needs to see the patient before discharge.

For inpatient procedures, the physician must communicate with the referring team about the procedural findings, possible complications, and expected results. While the postprocedural note can be used to outline the findings and interventions performed, the management of the patient after the procedure should be communicated directly to the referring team.

### Specimen Labeling and Delivery

Two patient identifiers must be used for specimen labeling to ensure accurate linkage of the patient, the specimen, and the test results. In addition, labeling the specimen container in the presence of the patient has been shown to reduce errors involving wrong patient information (48). Specimen labels may also include the time and date of collection and the initials of the physician who performed the intervention, on the basis of the specific laboratory protocol. Once specimens are collected and labeled, they should be delivered to the intended laboratory division in a timely fashion. It is important for the physician who performs the procedure to be aware of the time sensitivity of the diagnosis and make every effort to deliver the specimen to the destination in a fashion that optimizes patient diagnosis and resultant care.

### Conclusion

Over the past several years, technological advancements in the field of radiology have resulted in its monumental growth in clinical applications, use, and interventions. As health care undergoes fundamental changes in the upcoming years, patient-centered care will be the focus of our future. We must rely on our noninterpretive skills to ensure that patient care is optimized. Being familiar with the different aspects of periprocedural care is an incredibly important responsibility of a radiologist who performs image-guided interventions, to ensure safe and effective patient-centered care.

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