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## Physical Diagnosis Section

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Advanced Pulmonary Exam

Preparation for this session:
1. Review Pulmonary DVD
2. Syllabus – Physical Diagnosis pp. 43-61, Advanced Pulmonary and Cardiovascular Exams
3. Swartz – The Chest, Chapter 12
4. Swartz – Cardiac and Peripheral Vascular Exam, Chapters 12-13
5. Swartz – Pediatric Cardiac and Chest Exam, pp. 694-695

Learning Objectives (in addition to those listed for year 1 pulmonary exam)
Be able to:
1. Recognize and know the differential diagnosis of clubbing.
2. Identify adventitious sounds and their significance in clinical scenarios.
3. List and recognize the characteristic lung findings seen in emphysema, pneumonia, pleural effusion, pneumothorax and congestive heart failure.

Equipment: Stethoscope, blood pressure cuff

Dress: Shorts, bathing suit, sports bra.
Dress to allow for removal of all clothing from the waist up.
Legs and feet will need to be exposed for the peripheral vascular exam, so avoid stockings.
Your fingernails must be short in order to avoid mutilating your classmate while practicing the physical exam

A. Review of Vital Signs: This is included for your review but will not be discussed during today’s session. Learn appropriate technique for measuring and recording vital signs.

1. Temperature — Discuss methods of recording temperature and indications for each method (e.g. oral, rectal, axillary, tympanic membrane). This technique will not be practiced in the group. Normal temperature is 37°C or 98.6°F. (Pediatric—Use rectal or tympanic thermometers. Infancy – early childhood, 87.2°C or 99°F.

2. Pulse Rate — Take the pulse over the radial artery using the pads of your index and middle fingers. Count it for 15 seconds and multiply by four to get the number of beats per minute. If the pulse is irregular, count it for a full minute. Then compare radial pulses simultaneously. Take the pulse immediately after exercise and then two minutes after exercise. The normal pulse rate in adults is 60 to 100 beats per minute. Check for a pulse deficit by listening to the heart with your stethoscope while you simultaneously palpate the radial pulse.

The average pulse for infants and children at rest are as follows:

<table>
<thead>
<tr>
<th>Age</th>
<th>(Two Standard Deviations)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth</td>
<td></td>
<td>90-190</td>
</tr>
<tr>
<td>1- 6 months</td>
<td></td>
<td>80-180</td>
</tr>
<tr>
<td>6-12 months</td>
<td></td>
<td>75-155</td>
</tr>
<tr>
<td>1-2 years</td>
<td></td>
<td>70-150</td>
</tr>
<tr>
<td>2-6 years</td>
<td></td>
<td>68-138</td>
</tr>
<tr>
<td>6-10 years</td>
<td></td>
<td>65-125</td>
</tr>
<tr>
<td>10-14 years</td>
<td></td>
<td>55-115</td>
</tr>
</tbody>
</table>
3. Respiratory Rate — Count the respiratory rate by observing respiratory movements. Make your observations unobtrusively, with your fingers still on the radial pulse, so that the patient will not focus attention on his or her respiration. The normal respiratory rate in adults is 8 to 16 breaths per minute. The normal respiratory rate for pediatrics is as follows: Newborn—30-60, early childhood—20-40, late childhood—15-25, 15 years—8-16. Observe for the presence or absence of the use of accessory muscles of respiration. Look for retractions in the intercostal and supraclavicular areas.

4. Blood Pressure — To measure blood pressure, place the cuff bladder over the medial side of the upper arm and securely wrap the cuff. Determine the location of the brachial pulse. Securely place the bell of the stethoscope over the brachial artery at the elbow and hold the arm at the level of the heart. In adults, raise the manometer to 200 mm Hg, and release pressure at 10 mm/3 seconds. Record the first appearance of sound as the systolic blood pressure. Record the disappearance of all sounds as the diastolic blood pressure. (In some patients, the sounds continue all the way to zero for reasons not understood. In this case, record the muffling of sounds as the diastolic pressure). Determine the systolic pressure by the palpatory method. Determine both systolic and diastolic pressure by this method. Systolic pressure is the pressure at which two consecutive sounds are heard. Diastolic pressures is the pressure at which the sounds are no longer heard. Record the pressure to the nearest 2 mm Hg mark. Record it in both arms. Specify the patient’s position, i.e. sitting, standing, or lying.

Check for the presence or absence of pulsus paradoxus by listening to Korotkoff sounds at systolic pressure level during both inspiration and expiration. If the patient has a large arm, whether due to fat or muscle, a larger cuff must be used to avoid recording a falsely elevated blood pressure (the standard adult blood pressure cuff is appropriate for an arm up to 27 centimeters). Normal blood pressure is less than 140/90; normal pulse is between 60 and 100 beats per minute. A pulse of less than 60 is bradycardia, greater than 100 is tachycardia.

a. Pediatrics —
   i. Measuring the blood pressure in infants and children is often omitted because it has erroneously been judged to be too difficult to do with an active child. When the procedure is explained and demonstrated before hand, however, most children 3 years of age and older are fascinated by sphygmomanometer and are very cooperative. Obtaining the blood pressure measurement should be part of the physical examination of every child over 2 years of age, and of any younger child whose history or physical examination suggests that the blood pressure may be high or low (rare).

   ii. Use the sphygmomanometer to determine blood pressures in children as you would in adults. The inflatable rubber bag cuff should be long enough to encircle the upper arm or the thigh completely, with or without overlap. It should be wide enough to cover approximately 75% of the upper arm or the thigh. A narrower cuff elevates the pressure reading, while a wider cuff lowers it and interferes with proper placement of the stethoscope’s bell over the artery as it traverses the antecubital space or the popliteal space.

   iii. The level of systolic blood pressure increases gradually throughout infancy and childhood. Measured in mm Hg, normal systolic pressure in males is in the vicinity of 70 mm Hg at birth, 85 at 1 month, 90 at 6 months, 95 at 5 years, 100 at 8 years, 110 at 13 years, and 120 at 18 years. The diastolic pressure reaches about 55 mm Hg at 1 year of age and gradually increases throughout childhood and adolescence to approximately 70 mm Hg at age 18. Normal systolic and diastolic pressures in females are approximately 5 mm Hg lower than those in males at all these age levels, except during the first year of life.
B. Pulmonary Exam:
The examiner begins by standing in front of the seated patient who is typically wearing a gown with the opening in the back. Have the male patient drop their gown to the lap to examine the anterior chest. To examine the anterior chest in the female patient, you can either lift the gown and drape it over her shoulder or let it drop to the waist to expose the chest, rather than removing it completely. Remember that there is no part of the physical exam that should be done through clothes or a johnny.

1. Inspection — Note the shape, deformities, asymmetry, and any abnormal retraction of interspaces during inspiration (these are most apparent in lower interspaces); impairment in respiratory movement on one or both sides or unilateral lag (which suggests disease of underlying lung or pleura)
   a. Inspect the chest, observing the rate, rhythm, and effort of breathing. Note the shape of the chest and the way it which it moves.
   b. Identify external landmarks on the chest, including the suprasternal notch, the sternal angle, the 2nd, 3rd, 4th, 5th, and 6th ribs, the intercostal spaces, the costal margin, the xiphoid process. The inferior wing of the scapula lies at the level of T7.
   c. Identify the following imaginary lines: mid-clavicular, anterior axillary, midaxillary, and posterior axillary, scapular, and vertebral. These lines are used for localization of findings.
   d. Outline the positions of the lobes of the lungs on the chest. Trace the oblique fissure which extends from the sixth rib anteriorly at the midclavicular line, and extends laterally upward to the 5th rib in the midaxillary line, ending at the spinous process of T3 posteriorly.
   e. Clubbing of the digits (see Swartz p. 101 for diagram) – the earliest finding is an increase in the normal angle (normal is less than 160 degrees) between the nail and the terminal phalanx to greater than 180 degrees. This is associated with congenital heart disease, cystic fibrosis and bronchogenic carcinoma. Clubbing does not occur on the basis of chronic obstructive pulmonary disease.

2. Palpation — 4 uses
   a. Identification of tender areas.
   b. Assessment of observed abnormalities such as sinus tracts.
   c. Further assessment of respiratory expansion – a) put thumbs at level of 10th ribs; slide medially to raise loose skin folds between thumbs and spine; b) ask patient to inhale and watch divergence of your thumbs. Causes of unilateral diminution of or delay in chest expansion include chronic fibrotic disease of underlying lung or pleura, pleural effusion, lobar pneumonia, pleural pain with associated splinting and unilateral bronchial obstruction.
   d. Assessment of tactile fremitus - refers to the palpable vibrations transmitted through the bronchopulmonary tree to chest wall when the patient speaks. Ask patient to repeat “99”. Fremitus is decreased or absent when voice is soft or when transmission of vibrations from larynx to surface of chest is impeded. Fremitus is increased when transmission of sound is increased i.e. through consolidated lung of lobar pneumonia. Causes include obstructed bronchus; COPD; separation of pleural surfaces by fluid, fibrosis, air or infiltrating tumor; also thick chest wall.

3. Percussion — Useful to determine whether underlying tissues are air-filled, fluid-filled or solid but penetration is limited to 5-7 cm. into the chest.

In order to percuss, hyperextend the middle finger of your non-dominant hand (pleximeter finger). Press DIP firmly on surface to be percussed; avoid surface contact by any other part of hand since this would damp the vibrations. Strike with your middle finger – it should be relaxed; use quick, brisk stroke with relaxed wrist with the plexor (R middle finger).
Practice the technique of **percussion** on a tabletop, then over your partner’s thigh, liver, chest, and stomach. Train yourself to distinguish **flatness**, **dullness**, **resonance**, and **typanity**.

**Percussion Notes:**

<table>
<thead>
<tr>
<th></th>
<th>Intensity</th>
<th>Relative Pitch</th>
<th>Relative Duration</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td>Soft</td>
<td>High</td>
<td>Short</td>
<td>Thigh</td>
</tr>
<tr>
<td>Dullness</td>
<td>Medium</td>
<td>Med</td>
<td>Med</td>
<td>Liver</td>
</tr>
<tr>
<td>Resonance</td>
<td>Loud</td>
<td>Low</td>
<td>Long</td>
<td>NI Lung</td>
</tr>
<tr>
<td>Hyperresonant</td>
<td>V. Loud</td>
<td>Lower</td>
<td>Longer</td>
<td>Pneumothorax</td>
</tr>
<tr>
<td>Typanity</td>
<td>Loud</td>
<td>High</td>
<td></td>
<td>Gastric air bubble or puffed out cheek</td>
</tr>
</tbody>
</table>

Percuss chest symmetrically from bases to apices - moving from one side to the other. Dullness replaces resonance when fluid or solid tissue replaces air-containing lung or pleural space - for example with pneumonia, pleural effusion, blood, pus, fibrous tissue or tumor.

Hyperresonance is usually heard with COPD and asthma but this is not always present. If unilateral, hyperresonance suggests a pneumothorax or large air-filled bulla.

**Identify level of diaphragmatic dullness** Normal excursion is 5-6 cm. An abnormally high level suggests a pleural effusion or a paralyzed hemi-diaphragm.

4. **Breath Sounds** — Normal breath sounds are produced by the turbulent flow of air in the lobar and segmental bronchi. No sounds are produced by air moving in and out of the alveoli since the airflow here is slower and non-turbulent. There are four normal breath sounds:

   a. **Vesicular** - I>E; soft; relatively low pitch, heard over most of lungs. Inspiration is greater than expiration with expiration being very quiet.

   b. **Broncho-vesicular** - I=E; intermediate intensity; intermediate pitch. Inspiration and expiration are equal. Audible in two places: often in 1st and 2nd interspaces anteriorly and between the scapulæ.

   c. **Bronchial** - E>I; Loud intensity; relatively high pitch; locations over the manubrium if at all. Expiration is louder and longer than inspiration.

   d. **Tracheal** - I=E; very loud intensity; relatively high pitch and of harsh quality. Expiration is greater than inspiration. These are heard over the extrathoracic portion of the trachea.

5. **Adventitious Sounds** —

   a. **Crackles/rales** – discontinuous sounds are intermittent, non musical and brief, short, explosive, non musical. Due to the sudden opening of small airways. Have patient cough, if rales clear this suggests secretions or atelectasis were the cause.

   b. **Wheeze**s – A musical pulmonary sound. Produced by a bronchus narrowed to the point of closure, whose opposite wall oscillate between the closed and barely open position. High pitched, suggest narrowed airways as with asthma, COPD, bronchitis or tumor or F.B.

   c. **Rhonchi** – secretions in large airways. This term is no longer taught by pulmonary specialists; it is called wheezing.

   d. **Transmitted voice sounds** – if you hear broncho-vesicular sounds in an abnormal location, then assess the patient for transmitted voice sounds. Ask them to repeatedly whisper “99” as you move your stethoscope over the posterior and anterior lung fields. If the whispered sound is augmented, this suggests an underlying consolidation as in pneumonia. You can also check egophony by asking the patient to repeatedly say “E” as you move your stethoscope over the posterior and anterior lung fields. If the sound produced has a nasal or bleating quality and sounds like “A” this also suggests that the underlying lung tissue is
consolidated, as in pneumonia. It is not necessary to do both of these maneuvers since they test the same underlying problem, namely consolidation.

6. Examination of Anterior Chest — Use the same sequence as used for the posterior chest. If a woman’s breast is in the way, gently move it aside or ask the patient to move it for you.

7. Clubbing of the digits — This is a painless, focal enlargement of the connective tissue in the terminal phalanges of the digits. It usually affects the fingers more than the toes and is typically symmetric. It is defined by one of two criteria.
   a. An interphalangeal depth ratio exceeding one — This is measured by comparing the depth of the digit at the base of the nail (denoted by b) compared with the depth of the same digit at the DIP (denoted as a in accompanying picture). The depth ratio is defined as the ratio of the digit’s depth measured at b divided by that at a. The normal digit has a depth of 0.9 and a ratio greater than one indicates clubbing.

Clubbing photo

b. A hyponychial angle exceeding 190 degrees; the normal angle is 180 degrees; this is obviously hard to measure precisely.

c. Differential Diagnosis — clubbing usually indicates serious disease but may occasionally be hereditary. It is **not seen** in COPD. Roughly 80% of cases are seen in patients with lung disorders such as lung tumor, bronchiectasis, lung abscess, empyema, and interstitial fibrosis. It is also seen in congenital cyanotic heart disease, inflammatory bowel disease, liver cirrhosis and infective endocarditis. When seen in a patient with COPD, another cause must be sought to explain it.

C. Pediatric Lung Exam:
   1. Infancy
      a. Tactile fremitus in infants can be felt by placing your hand, whole palm & fingertips on the chest when the baby cries. Percuss the infant’s chest directly by tapping the thoracic wall with one finger or indirectly by using the finger-on-finger method. The percussion note is normally hyperresonant throughout.
      b. Use the bell or small diaphragm of the stethoscope when auscultating the infant’s chest, to pinpoint findings. The breath sounds are louder and harsher than in adults because the stethoscope is closer to the origin of the sounds.

   2. Early and late childhood
      a. Allow the child to handle the stethoscope before you place it on the chest.
      b. Generate tactile fremitus by feeling the chest wall while carrying on a conversation with the child. Ask the child to say “99” or “1, 2, 3”. Demonstrate each maneuver for the child i.e. deep breathing and breath holding. Asking the child to blow may produce full inspiration.
<table>
<thead>
<tr>
<th>Condition</th>
<th>Percussion Note</th>
<th>Fremitus; Egophony</th>
<th>Breath Sounds</th>
<th>Added Sounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>resonant</td>
<td>normal</td>
<td>vesicular</td>
<td>none except near bronchi</td>
</tr>
<tr>
<td>CHF</td>
<td>resonant, except dull at bases</td>
<td>normal</td>
<td>normal</td>
<td>crackles at bases</td>
</tr>
<tr>
<td>Lobar pneumonia</td>
<td>dull</td>
<td>increased;</td>
<td>bronchial</td>
<td>crackles</td>
</tr>
<tr>
<td>Interstitial Pulmonary Fibrosis</td>
<td>resonant</td>
<td>normal</td>
<td>normal</td>
<td>crackles</td>
</tr>
<tr>
<td>Pleural thickening or fluid</td>
<td>dull to flat</td>
<td>decreased to absent;</td>
<td>decreased to absent</td>
<td>none</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>normal to hyper-resonant</td>
<td>decreased to absent</td>
<td>decreased to absent</td>
<td>none</td>
</tr>
<tr>
<td>Atelectasis</td>
<td>dull over atelectatic area</td>
<td>decreased to absent</td>
<td>decreased</td>
<td>crackles above area of atelectasis</td>
</tr>
<tr>
<td>Asthma</td>
<td>normal to hyperresonant</td>
<td>normal</td>
<td>increased expiratory phase</td>
<td>wheezing, especially on expiration</td>
</tr>
<tr>
<td>Bronchitis</td>
<td>resonant</td>
<td>normal;</td>
<td>normal, increased expiratory phase</td>
<td>none to crackles or wheezes</td>
</tr>
<tr>
<td>Emphysema</td>
<td>normal to hyper-resonant</td>
<td>decreased</td>
<td>decreased, vesicular, increased expiratory phase</td>
<td>none or signs of bronchitis</td>
</tr>
</tbody>
</table>
Vocabulary:

**AUSCULTATION**—the act of listening for sounds from within the body, chiefly for ascertaining the condition of the lungs, heart, pleura, abdomen, and other organs.

**RALES**—an abnormal respiratory sound heard in auscultation of the lungs and indicating a pathologic condition.

**WHEEZES**—a high-pitched whistling sound noted on auscultation of the lungs and suggesting that one or more airways are narrowed almost to the point of closure or that all airways are narrowed as from bronchospasm (asthma).

**RHONCHI**—relatively low-pitched sounds that has a “snoring” quality heard on auscultation of the lungs and suggesting partial obstruction of a bronchus as from secretions.

**RUB**—an auscultatory sound caused by the rubbing together of two serous surfaces; the most commonly heard rubs are pericardial friction rubs and pleural friction rubs.

**EGOPHONY**—increased vocal resonance with a high-pitched bleating quality of transmitted vocal sounds noted on auscultation of the lung especially over lung tissue compressed by pleural effusion (E to A change).

**BRONCHOPHONY**—the sound of the voice as heard through the stethoscope applied over a healthy, large bronchus. Heard elsewhere, bronchophony indicates solidification of lung tissue.

**WHISPERED PECTORILOQUY**—the transmission of the sound of whispered word through the chest wall. Normally, the whispered voice is heard faintly and indistinctly, if at all. Loud, clear, whispered words heard on auscultation suggests that air-filled lungs have become airless.

**TYMPANY**—a bell-like percussion note, usually loud and of high pitch such as noted on percussion of the gastric bubble.

**RESONANCE**—the prolongation and intensification of sound produced by the transmission of its vibrations to a cavity, especially a sound elicited by percussion.

**FLATNESS**—the quality of the percussion note elicited upon percussing a solid organ (i.e. the thigh). It is characterized by its soft intensity, high pitch and short duration.

**DULLNESS**—the quality of a percussion note of medium intensity, pitch and duration such as elicited on percussion of the liver through the lower anterior chest.

**VESICULAR BREATH SOUNDS**—the auscultatory sound of normal, quiet breathing. Vesicular breath sounds are soft, of low pitch, and are heard through inspiration, into expiration and fade away part way through the expiratory phase.

**BRONCHIAL BREATH SOUNDS**—Auscultatory sounds of respiration which are louder and of higher pitch than vesicular sounds and which are discontinuous between inspiration and expiration, and are often associated with a prolonged expiratory phase.
Sample write-up of pulmonary exam

Healthy, slightly overweight 18 yo female in no respiratory distress

BP 104/64 P 76 RR 14 Afebrile

Symmetrical excursions, breathing comfortably without use of accessory muscles. No tenderness on percussion of spine or costovertebral angles. Lung fields resonant to percussion throughout. Normal, symmetrical vesicular and bronchovesicular breath sounds to auscultation without wheezes, rhonchi or rales.

Sample write-up of history and physical of a pulmonary case

TF is a 32-year-old man with a history of asthma, who has had more difficulty breathing since he ran out of his bronchodilators one week ago. The past 24 hrs he has been coughing more than usual and two hours ago started having increased wheezing and felt as though he couldn’t take a deep breath. He denies any fever, chills or chest pain. He has tried a humidifier and OTC cough syrup with minimal relief. He has had asthma since childhood and has been treated for 5 years with a steroid inhaler and an Albuterol inhaler as needed for wheezing. He has never been hospitalized for his asthma but has been treated with oral steroids for acute exacerbations, none in the past year. He stopped smoking 5 years ago after 12-pack years.

He takes no other medications.
Alcohol -one glass of wine with dinner.
Family hx - positive for asthma in his mother and sister

Physical Exam
Tachypneic male in mild respiratory distress with pursed lip breathing
VS: BP 130/88, P 115/min., RR 32, T 99.6
Chest: Increased use of accessory muscles, resonant to percussion, diffuse expiratory wheezes throughout both lung fields, no rales or dullness
CV normal S1 and S2, no murmurs, gallops or rubs
Ext: no cyanosis, clubbing

Case #1: Hazel Harris
Ms. Hazel Harris is a 20-year-old woman who presents to your office complaining of a cough. Her vital signs reveal:
BP: 120/75
Pulse: 96
Respiration: 20 Temperature: 101.4°F

You have 10 minutes to evaluate Ms. Harris. What history do you want to take and what parts of the physical examination do you want to perform?
Advanced Cardiovascular Physical Exam

Preparation for September 9th, 16th and 23rd sessions:
1. Review the CV video on the normal Cardiovascular Exam before today’s session. (on reserve in Dana Library)
2. Syllabus — Physical Diagnosis pp. 51 - 61, Cardiovascular Physical Exam
   The Heart, Chapter 13; Peripheral Vascular Exam Chapter 14; Pediatric Cardiac and Chest Exam, pp. 694-695

Learning Objectives (in addition to those listed for year 1 cardiac exam)
1. Characterize the carotid upstroke, and use the carotid pulse to time events in the cardiac cycle.
2. Recognize the characteristics of a normal first and second heart sound
3. Estimate central venous pressure by observing the jugular venous pulse and know the normal range.
4. Evaluate the apical impulse to recognize left ventricular eccentric or concentric hypertrophy.
5. Listen for S3 and S4 gallops and understand their significance
6. Distinguish AS from MR
7. Examine a patient for aortic insufficiency
8. Examine for edema

A. Review the Cardiac Cycle—
B. Examination of the Neck —
   1. Carotid Pulse — The carotid pulse is felt between the sternomastoid muscle and trachea. Palpate low in the neck to avoid stimulating the carotid sinus (which can cause reflex bradycardia and hypotension). A delayed or diminished upstroke suggests aortic stenosis.

   ![Diagram of the neck with labeled structures: Carotid Artery (Carotid Sinus), External Jugular Vein, Sternomastoid Muscle, Sternocleidomastoid Triangle, Internal Jugular Vein.]

   2. Jugular Venous Pulsations — The external jugular vein is anterior to the sternomastoid muscle and is usually visible, but is not very useful for evaluating the venous pressure. The internal jugular vein gives a much better estimate of venous pressure, although it lies beneath the sternomastoid muscle and is thus not visible. Its pulsations can usually be seen in the lower part of the sternocleidomastoid triangle. Look for double pulsations ("a" wave during atrial contraction, "v" wave during ventricular contraction) to distinguish the jugular vein from the single pulse of the carotid artery.

   3. Estimating Central Venous Pressure by Evaluation of the Jugular Venous Pulse — Hydrostatic pressure is measured "vertically": The pressure in a chamber (e.g., the right atrium) is measured by the vertical height of a column of water (blood) that can be supported above that chamber (e.g., in the internal jugular vein above the right atrium).

   Position the patient so that the internal jugular pulsations are visualized in the sternocleidomastoid triangle (best seen in tangential light). These pulsations indicate the top of the column of blood supported by right atrial pressure. The right atrial pressure is determined by noting the highest point above the right atrium at which jugular venous pulsations can be observed. Use the sternal angle (angle of Louis) as the external landmark for this measurement. It is approximately 5 cm above the right atrium regardless of the angle at which the patient is lying, e.g., if the pulsations are visible 4 cm above the angle of Louis, then the central venous pressure is roughly 9 cm.

   An elevated CVP is a very useful physical diagnosis technique because it has great specificity. A normal CVP rules out R sided congestive heart failure (CHF). Differential diagnosis of a high CVP includes: right ventricular infarct, pericardial effusion, massive pulmonary emboli, tamponade, left heart failure and superior venous caval obstruction. The normal range for CVP is 5-8 cm.
4. Chest wall landmarks and Auscultatory Areas —

It is important to describe where on the chest wall specific cardiac impulses and sounds are located. Start by locating the sternal angle (or angle of Louis), which lines up with the second rib. This allows you to identify the other ribs by number. Any point on the chest wall can be then localized to an intercostal space (ICS), which is named for the rib above it. Vertical landmarks include the right and left sternal borders (RSB & LSB), the midclavicular line (MCL), and the anterior axillary line (AAL).

Four auscultatory areas are localized where the corresponding valve abnormalities are best heard:
1. Aortic area- 2nd right intercostal space, upper right sternal border (2nd R ICS, URSB)
2. Pulmonic area- 2nd left intercostal space, upper left sternal border (2nd L ICS, ULSB)
3. Tricuspid area (also called the right ventricular area)- 4th & 5th L ICS, LLSB
4. Mitral area (also called the apex)- 5th intercostal space, L mid-clavicular line (5th ICS, MCL)
5. Palpation —
   a. Apical Impulse — (Note: The apical impulse is *usually* the point of maximum impulse (PMI). Examine for this with the patient **SUPINE**.

      Location — Normally felt in the 5th left intercostal space, midclavicular line (patient supine). The impulse is *displaced laterally* in left ventricular eccentric hypertrophy

      Size — Normally less than 2 cm. in diameter
      The impulse is **larger** in left ventricular concentric hypertrophy

      Timing — Normally a quick outward impulse with rapid systolic retraction
      The impulse is **sustained** in left ventricular concentric hypertrophy

   b. Other Impulses —
      Aortic Area — A vibration here (classically called a "thrill") suggests Aortic Stenosis.
      Pulmonic Area — A prominent impulse here suggests Pulmonary Hypertension.
      Tricuspid Area — A prominent impulse here suggests Right Ventricular Hypertrophy.

6. Cardiac Auscultation —
   a. Use of the Stethoscope: The bell of the stethoscope is designed to pick up the full range of frequencies; it is particularly good for the low frequency gallop sounds. Use light skin contact or you will convert the bell to a diaphragm. The diaphragm filters out the lower frequency sounds; it is better for listening to the higher frequency murmurs and the second heart sound.

   b. Heart Sounds —

      **S1**
      Occurs at time of mitral and tricuspid valve closure, You may hear 2 components: "M1" and "T1"
      The sound is actually produced by vibration of the ventricular walls (not valve closure).
      **Identification:** Occurs just before carotid upstroke. Louder at apex, and softer at aortic and pulmonic areas

      **S2**
      Sound produced by closure of the aortic and pulmonic valves (A2 preceding P2)
      **Identification:** Occurs just after carotid upstroke. Louder at aortic & pulmonic areas, softer at apex.
      **Splitting of S2** —
      The normal P2 is heard only at the pulmonic area. A loud P2, e.g., one heard away from the pulmonic area, suggests pulmonary hypertension
      Respiratory variation: P2 occurs later during inspiration
      Increased splitting occurs with RBBB (P2 occurs later)
      Paradoxical splitting occurs with LBBB (A2 occurs after P2)
      Fixed splitting occurs in atrial septal defect

   c. Extra Heart Sounds —

      **Gallops**
      Gallops are left ventricular filling sounds heard during diastole. They are best heard at the apex with patient rolled up on left side (left lateral decubitus position). These sounds are soft and low frequency, so they are difficult to hear. Unless you put the patient in the left lateral decubitus position and listen with the bell of your stethoscope in a quiet room, you may miss this important physical exam finding.
S3
Timing — Occurs during rapid filling of ventricle in early diastole (just after S2)
The S3 can be physiologic until age 40. Later in life, it is caused by left ventricular failure and ventricular volume loads (e.g.- MR, AI, VSD)
Identification: this is best heard at or medial to the apex, listening with the bell supine first. If it isn't heard, ask the patient to roll over into the left lateral decubitus position.
A right sided S3 is is heard along the left lower (LL) sternal border or below the xiphoid and will be louder on inspiration.

S4
Timing — Occurs with the atrial kick during late diastolic ventricular filling (just before S1)
Caused by decreased ventricular compliance (e.g.- LVH, myocardial ischemia or infarction)
Identification: listen at or medial to the apex with the bell of your stethoscope.

Midsystolic click
Heard during mid-systole in patients with mitral valve prolapse, the click is caused by abnormal ballooning of the mitral valve into the left atrium. It is high pitched and clicking in quality and best heard between the apex and the lower sternal border with the diaphragm of your stethoscope.

Opening snap of the mitral valve
Early diastolic sound produced by the opening of a stenotic mitral valve. It is usually high-pitched and clicking in quality and is best heard between the apex and the left lower sternal border.

d. Cardiac Murmurs —
Normal blood flow through the circulatory system is laminar, i.e. blood travelling at the same velocity and direction. Valve defects create turbulent flow, i.e. blood traveling at different velocities in different directions.

i. Causes — Murmurs are caused by either:
   a. increased flow through a normal or abnormal valve orifice.
   b. forward flow across a stenotic or narrowed orifice.
   c. backward flow across an incompetent valve, called regurgitation or insufficiency.

ii. Timing in the cardiac cycle — Murmurs may occur in systole, diastole or continuous.

iii. Location — Where the murmur is heard the loudest. This should be noted in your write up.

iv. Intensity — The intensity of a murmur depends on the velocity and volume of blood flow and the size of the valve orifice. The intensity of a murmur does NOT correlate with the severity of the valvular disease. Intensity is graded on a 1 to 6 scale, based on its loudness. If a thrill is present, the murmur is at least a grade 4. A thrill is the superficial vibration felt on the skin overlying an area of turbulence; they are best palpated by using the heads of the metacarpal bones rather than the fingertips, applying gentle pressure to the skin. The intensity of a murmur is described as "grade 1/6" or "grade 4/6" when writing up the cardiac exam.

1/6 Lowest intensity, often inaudible
2/6 Low intensity, faint and usually audible
3/6 Medium intensity without a thrill - easily heard
4/6 Medium intensity with a thrill
5/6 Very loud, able to be heard with stethoscope placed lightly on the chest; thrill present
6/6 Loudest intensity; audible when stethoscope is removed from chest; associated with a thrill
v. Shape — The intensity of a murmur may change during the cardiac cycle and experienced clinicians recognize murmurs by their timing, location and shape.

   a. Crescendo-decrescendo (diamond shaped) - the typical pattern of an ejection murmur such as aortic stenosis

   b. Holosystolic: this murmur doesn't change it's intensity during the cardiac cycle; the typical pattern of mitral regurgitation

   c. Decrescendo: the typical pattern of aortic regurgitation, a diastolic murmur that is hard to hear

vi. Radiation — Murmurs often radiate, i.e. can be heard, in different precordial areas, or in the neck or back depending on the direction of the turbulent blood flow. The radiation of a murmur gives us useful information about its cause. When you hear a murmur at the base, also listen in the neck over the subclavian artery to see if it radiates there. Listen in the axilla to murmurs heard at the apex to see if they radiate there. Describe the pattern of radiation of a murmur when writing up your cardiac exam.

vii. Quality — Some murmurs are musical, others are rough or blowing. Stenotic murmurs are typically harsh and rough whereas regurgitant murmurs are more musical.

viii. Interventions — One can change the intensity of a murmur by positioning, exercise and other maneuvers. You will learn about these during your clinical rotations.