Cardiac Murmurs and Heart Sounds: 
An Audio-Diagnostic Workshop

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I. Factors affecting audibility of heart sounds and murmurs

1. Intensity of sound

2. Duration of sound

3. Pitch of sound (i.e. cycles per second or Hertz)

4. Cardiac output
   * Accentuated with exercise, anxiety, fever, anemia
   * Decreased with low cardiac output or decreased contractility

5. Patient position
   * Supine position favors diastolic filling of the right ventricle.
     Innocent pulmonary flow murmurs, Still's murmur, and murmur of ASD's are accentuated.
   * Sitting position exaggerates turbulence of flow in venous return from head and neck producing venous hum murmur.
   * Standing position reduces venous return to right ventricle and reduces volume of right and left ventricles. Innocent flow murmurs diminish in intensity.

6. Respiration
   * Inspiration increases venous return to right heart and increases flow across the tricuspid valve. Diastolic rumble of ASD is accentuated and second heart sound is widely split. A deep inspiration that is held may decrease murmur intensity by increasing the air interface between the heart and the stethoscope.
   * Expiration decreases air interface between stethoscope and heart. Best phase of respiratory cycle to hear diastolic murmur of pulmonary or aortic insufficiency.
   * Valsalva maneuver decreased venous return. Usually causes decreased intensity of innocent flow murmurs.

7. Chest wall thickness

8. Presence of air or fluid between chest wall and heart, e.g., pneumothorax or pericardial effusion.

II. Heart Sounds

S₁ -- Mitral and tricuspid closure
   * Intensity related to velocity of closure of mitral and tricuspid valves.
   * Split first heart sound is physiologic in slower heart rates. May be mistaken for ejection click.
S₂ - Aortic and pulmonary valve closure
- Loud or single second heart sound suggests:
  - Pulmonary hypertension
  - P₂ not audible (Tet of Fallot, TGA, severe PS)
  - Single semilunar valve (pulmonary/aortic stenosis, tricuspid arteriosus)
- Widely split S₂
  - Volume overload of RV (ASD, PAPVR)
  - Right bundle branch block
  - Pulmonary valve stenosis

S₃ - Rapid ventricular filling following AV valve opening

S₄ - Correlates to atrial contraction
- Suggests elevated ventricular end diastolic pressure and a non-compliant ventricle.
- Pathologic sound found in CHF.

III. Ejection Sounds
1. Aortic ejection clicks are high-pitched and may be heard at LLSB and apex. Accompanies bicuspid aortic valve. Occurs early after S₁.
2. Pulmonary ejection clicks are best at LUSB during expiration. Occur early in systole.
3. Mid or late systolic click at LLSB and apex suggests mitral valve prolapse. Frequently best heard with patient standing.

IV. Murmurs
1. Levine grading system
   - Grade I - Faint murmur heard under ideal conditions
   - Grade II - Soft murmur, readily audible
   - Grade III - Prominent loud murmur
   - Grade IV - Loud murmur associated with a thrill
   - Grade V - Very loud murmur heard with side of diaphragm
   - Grade VI - Murmur heard with stethoscope off chest

2. Classification
   - Systolic murmurs
     - Ejection murmurs begin after S₁ and are crescendo-decrescendo in quality
     - Regurgitant murmurs begin with S₁. Usually holosystolic but may end before S₂ (VSD, MR, TR)
   - Diastolic murmurs
     - Decrescendo murmurs are early diastolic and caused by aortic or pulmonary valve incompetence
     - Diastolic rumbles are in mid diastole and low-pitched. Caused by increased flow across AV valve (PDA, ASD, VSD)
     - Late diastolic murmurs are unusual in pediatrics and caused by mitral/tricuspid stenosis.
   - Continuous murmurs
     - Begin in systole and spill into diastole (i.e. Extend through S₂)
     - Potential causes: PDA, venous hum, AV fistula, collateral arteries, surgical systemic-PA shunt, AP window.
V. Innocent (Normal) Murmurs

1. Characteristics - Asymptomatic
   - No structural abnormality
   - Normal EKG and CXR
   - Grade I-III
   - Not diastolic

2. Types

   * **Pulmonary flow** – Systolic ejection murmur
     - High pitched and best heard with the diaphragm with patient supine
     - Loudest at LUSB
     - Heard from infancy through adolescence

   * **Still's murmur** – Systolic ejection murmur with vibratory (musical) sound best heard at LLSB and apex
     - Low in pitch heard with diaphragm or bell
     - Most common in age 2-6 years
     - Louder when patient is supine

   * **Carotid murmur** – Systolic murmur heard in carotids and suprasternal notch area
     - Best heard with diaphragm
     - Occurs in children and young adults

   * **Peripheral pulmonary stenosis**
     - High pitched systolic murmur of infancy
     - Heard equally in left and right chest, axillae, and across the back
     - Best heard with diaphragm
     - Most commonly heard in newborns. Generally disappears by six months of age

   * **Venous hum** – Continuous murmur heard best in subclavicular area
     - Heard in sitting/standing position and disappears when supine
     - Intensity altered with pressure on ipsilateral neck veins, movement of neck, or Valsalva
     - Common in early childhood

VI. Pathologic Murmurs

1. Characteristic features – All diastolic murmurs
   - Any murmur with a thrill (Grade IV or higher)
   - Murmurs associated with increased impulses
   - Holosystolic murmurs

2. Associated findings – Cyanosis, tachypnea, diaphoresis, poor pulses
   - Abnormal EKG or CXR
   - Other congenital abnormalities
   - Poor growth
   - Family history