Heart Sounds & murmurs
OBJECTIVES

by the end of this lecture you will be able to:

▷ List the major types of normal heart sounds
▷ Understand the physiological basis for the production of normal heart sounds
▷ Understand the pathophysiological basis for the production of heart murmurs.
Heart Sounds Windows

- Detected over anterior chest wall by 2 methods: - 1. Auscultation (Stethoscope). 2. Phonocardiography (sound recording device).
- 4 heart sounds can be detected: - 1st & 2nd heart sounds (usually audible). - 3rd & 4th heart sounds (sometimes detected).

ONLY in male’s slides:
- Ventricular Systole is between First and second heart sounds.
- Ventricular diastole is between Second and First Heart sound.

> Aortic area: 2nd Rt costal cartilage.
> Pulmonary area: 2nd Lt intercostal space.
> Mitral (bicuspid) area: 5th Lt intercostal space crossing mid-clavicular line, or 9cm (2.5-3 inches) from sternum.
> Tricuspid area: lower part of sternum towards Rt side.
### S1
- Due to closure of the A-V valves.
- Recorded at the beginning of the ‘isovolumetric contraction phase.’
- It marks the beginning of ventricular systole.
- Long in duration 0.15 sec. Of low pitch (LUB).
- Its is heavier when compared to the 2nd heart sound.
- (25-35 Hz) ~ (25-45 Hz)
- Best heard at Mitral & Tricuspid areas.

### S2
- Due to closure of semilunar valves.
- Recorded at the beginning of the ‘isovolumetric relaxation phase’.
- Marks the beginning of ventricular diastole.
- Short in duration 0.11-0.125 sec. (0.12 sec) Of high pitch (DUB).
- Soft & Sharp (compared to the 1st heart sound)
- 50 Hz.
- Best heard at Aortic & Pulmonary areas.

### Splitting of the 2nd Heart Sound

- S2 splits physiologically into 2 sounds during inspiration = Physiological Splitting.
- This splitting occurs due to delay closure of pulmonary valve.
Physiological splitting of S2

1. During inspiration, the aortic valve closes before pulmonary valve → reduplication (physiologic splitting of S2).
2. The increased venous return to the right side of the heart delays closure of the pulmonary valve. The right ventricle has more blood than usual to eject and it thus takes more time.
3. No splitting of the second heart sound is normally seen during expiration.

Fixed splitting of S2

1. Splitting of S2 is heard in both during inspiration and expiration, with the aortic valve closing before the pulmonary valve.
2. This is heard in cases of ASD.(atrial septic defect)

Mitral : long black line
Tricuspid: short black line
Wide splitting of S2

A split in the second heart sound during inspiration may become wider and the split may also be seen during expiration if:

1. There is a delay in the closing of the pulmonic valve (as would be seen in right bundle branch block due to delay in right ventricular depolarization and contraction).

2. The aortic valve closes earlier than normal (this is seen with either mitral regurgitation or ventricular septal defect).

Paradoxical (reversed) splitting of S2

Reversed (paradoxical) splitting of the second heart sound is typically heard during expiration, with the pulmonary valve closing before the aortic valve. No splitting is apparent during inspiration, since the pulmonary valve is closing earlier (relative to the aortic valve) than normal.

This may be caused by the following:

1. Delayed onset of left ventricular systole (example: left bundle branch block).
2. Prolonged left ventricular systole (examples: aortic stenosis, severe hypertension, left-sided congestive heart failure).
3. Early onset of right ventricular systole (example: Wolff-Parkinson White syndrome).
Types of S2 Splitting...
Extra Figure

- **Normal**
  - Expiration: S2
  - Inspiration: S2

- **Wide Splitting**
  - Expiration: A2 → P2
  - Inspiration: A2 ← P2
  - S2

- **Fixed Splitting**
  - Expiration: A2 → P2
  - Inspiration: A2 ← P2
  - S2

- **Paradoxical Splitting**
  - Expiration: P2 → A2
  - Inspiration: P2 ← A2 (reversed)
  - S2
3rd Heart Sound = S3

- Recorded during the ‘rapid filling phase’ due to rush of blood into the ventricle.
- S3 is usually not audible (very low pitch.)
- 0.05 sec.
- Frequency: 20-30 Hz
- Heard in children (?).
- Best heard at Mitral area.

4th Heart Sound = S4

- Recorded during ‘atrial systole’ (just before S1).
- S4 is usually not audible (very low pitch.)
- 0.04 sec.
- Frequency: < 20 Hz.
- Heard in elderly (?).
- Best heard at Mitral area.

ONLY in male slides:
- Third and Fourth heart sound are low pitched sounds therefore not audible normally with stethoscope
- S4 may be heard in elderly but is usually pathologic in the young. (opposite of S3)
Significance of Heart Sound

Important for diagnosis of heart murmurs.

Abnormal extra heart sounds heard during the heartbeat cycle.

Produced by turbulence (abnormal patterns) of blood flow through the heart & its valves.

Murmurs are longer than heart sounds.

<table>
<thead>
<tr>
<th>Valve</th>
<th>Abnormality</th>
<th>Timing of Murmur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aortic or pulmonary</td>
<td>Stenosis</td>
<td>Systolic</td>
</tr>
<tr>
<td></td>
<td>Insufficiency</td>
<td>Diastolic</td>
</tr>
<tr>
<td>Mitral or tricuspid</td>
<td>Stenosis</td>
<td>Diastolic</td>
</tr>
<tr>
<td></td>
<td>Insufficiency</td>
<td>Systolic</td>
</tr>
</tbody>
</table>

What makes noise in the heart

Closure of valves of the heart

Increased intra-cardiac hemo-dynamics

Blood striking the left ventricle = (S3, S4)

1) Atrio-ventricular (Mitral & Tricuspid) valves = (S1)

Semilunar (Aortic & Pulmonary) valves = (S2)

• Increased flow across normal valves.
• Turbulent flow through an abnormal valve.
• Turbulent flow through septal defect.

Murmurs

ONLY in male slides
Physiological VS Pathological Murmurs

<table>
<thead>
<tr>
<th>Physiological Murmurs:</th>
<th>Pathological Murmurs:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase blood flow across normal valves:</td>
<td>Turbulent flow through abnormal valves, or septal defect.....Congenital?</td>
</tr>
</tbody>
</table>

- **e.g.:**
  - Pregnancy
  - Hyperthyroidism
  - Anemia
  - Fever
  - Children

- **e.g.:**
  - Tight valve (stenosis) (narrowing): the valve does not open properly.
  - Leaky valve (regurgitation or insufficiency): The valve fails to close completely, and hence causing backflow or leaks of the blood across the insufficient valve. (Valvular insufficiency is also known as Regurgitation or Incompetency).
  - A combination of Stenosis and Insufficiency.

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How to describe Heart Murmurs

- Timing (systolic or diastolic)
- Shape
- Location
- Radiation
- Intensity
- Pitch
- Quality

ONLY in male slides:

**Gallop:** Three or four sounds are spaced to audibly resemble the pace of a horse, the extra sounds occurs after S2.
1- Timing

Murmurs are described according to their position in the cardiac cycle:

- Systolic.
- Diastolic.
- Continuous.

**Systolic murmur**
- Between S1 & S2
- Classified as early, mid, late, holosystolic

**Diastolic murmur**
- Between S2 & S1
- Classified as early, mid, late
2- Shape

Murmurs are described according to the waxing & waning of the sound.

- **Crescendo (grows louder)**
  > increasing intensity

- **Decrescendo**
  > decreasing intensity

- **Decrescendo-decrescendo**

- **Crescendo-decrescendo (diamond shaped)**
  > increasing then immediate decreasing intensity.

- **Plateau (uniform)**
  > the intensity of the murmur remains uniform throughout.

Diamond-shaped murmur.
Describing a Heart Murmurs.....Cont

3- Radiation
Reflects intensity of the murmur & direction of blood flow.

4- Location of maximum intensity (of heart murmurs)
Determined by the site where the murmur originates; e.g. Aortic, Pulmonary, Tricuspid, & Mitral listening areas.
5- Intensity

Graded on a (6) point according to Levine scale:

- **Grade one:** Lowest intensity - Very faint
- **Grade two:** Low intensity - Quiet but heard immediately
- **Grade three:** Medium intensity - Moderately loud
- **Grade four:** Medium intensity - Loud - Thrill
- **Grade five:** Loud intensity - Heard with stethoscope partly off the chest - Thrills
- **Grade six:** Loudest intensity - No stethoscope needed - Thrills
5- Intensity...cont.

<table>
<thead>
<tr>
<th></th>
<th>Grading Of Heart Murmurs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Soft murmur heard in quiet surroundings.</td>
</tr>
<tr>
<td>2</td>
<td>Soft murmur heard in noisy surroundings.</td>
</tr>
<tr>
<td>3</td>
<td>Prominent heard murmurs.</td>
</tr>
<tr>
<td>4</td>
<td>Loud murmur with a thrill.</td>
</tr>
<tr>
<td>5</td>
<td>Loud murmur heard with edge of the steth tilted against the chest + thrill</td>
</tr>
<tr>
<td>6</td>
<td>Loud murmur heard 5-10 mm from the chest + thrill.</td>
</tr>
</tbody>
</table>

A **thrill** is a slight palpable vibration felt by the hand over the chest wall.
Describing a Heart Murmurs.....Cont

6-Pitch:
- High
- Medium
- Low

7- Quality:
- Blowing
- harsh
  (hard)
- resonant
  (rumbling)
  & musical

8- Others:

i. Variation with respiration.
   - Murmurs increasing with expiration originate with left side (aortic or mitral) valves, while murmurs increasing in intensity with inspiration originate with tricuspid or pulmonary valves.

ii. Variation with position of patient.

iii. Variation with special maneuvers:
   - Valsalva (forced expiration) → Murmurs ↓ in length (duration) & intensity (of most murmurs)
Systolic Murmurs

- Early Systolic
- Mid Systolic
- Late Systolic
- Pansystolic (holosystolic)

Derived from harsh & turbulence in blood flow.

Associated with:
1) Increased flow across normal valve.
2) Increased flow into a dilated great vessel.
3) Increased flow across an abnormal valve, or narrowed ventricular outflow tract.
   - e.g. aortic /pulmonary stenosis.
4) Increased flow across an incompetent AV valve.
   - e.g. mitral/tricuspid regurgitation.
5) Increased flow across the inter-ventricular septum.
   - e.g. VSD.
Common Systolic Murmurs and Timing

1) **Aortic stenosis** – ejection murmur.
2) **Pulmonary stenosis** – ejection murmur (+2nd split)
3) **Mitral / Tricuspid regurgitation** – holosystolic.
4) **Mitral valve prolapse** – mid-late systole.
5) **Ventricular septal defect (VSD)** – holosystolic.

**Ejection (Mid- Systolic) Murmurs:**
Most common kind of heart murmur. Usually crescendo-decrescendo.
They may be:
1) **Innocent**: Common in children & young adults.
2) **Physiological**: Can be detected in hyper-dynamic states.
   - e.g. anemia, pregnancy, fever & hyperthyroidism.
3) **Pathological**: Secondary to structural CV abnormalities.
   - e.g. Aortic/pulmonary stenosis, Hypertrophic cardiomyopathy & mitral prolapse.

**Pan-Systolic (Holosystolic) Murmurs:**
Pathological murmur.
Begins immediately with S1 & continues up to S2
Heard with:
- Mitral/tricuspid regurgitation.
- Ventricular septal defect (VSD)
## Systolic Murmurs

<table>
<thead>
<tr>
<th></th>
<th>Aortic Stenosis</th>
<th>Mitral Prolapse</th>
<th>Mitral Regurgitation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cause</strong></td>
<td>Obstruction of flow from LV into ascending aorta.</td>
<td>Bulging of 1 or 2 mitral valve leaflets into LA during LV systole.</td>
<td>Retrograde flow from LV into LA through an incompetent mitral valve.</td>
</tr>
<tr>
<td><strong>Timing</strong></td>
<td>Mid-systolic murmur.</td>
<td>Mid-late systolic murmur.</td>
<td>Holosystolic murmur.</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Best heard on aortic area, radiates along carotid arteries.</td>
<td>Best heard at the apex.</td>
<td>Best heard at apex, radiates to left axilla.</td>
</tr>
<tr>
<td><strong>Character</strong></td>
<td>Harsh, loud, may have associated with thrill, “ejection click.”</td>
<td>Mid systolic click.</td>
<td>Soft, high-pitched, blowing.</td>
</tr>
<tr>
<td><strong>Association</strong></td>
<td>Old age, bicuspid aortic valve, rheumatic fever.</td>
<td>~5% normal population, asymptomatic, ? Sudden death.</td>
<td>MV prolapse, or myxomatous degeneration, rheumatic heart disease, endocarditis.</td>
</tr>
</tbody>
</table>
Diastolic Murmurs

- Almost always indicate heart disease.

Two basic types:

1. **Early decrescendo diastolic murmurs:**
   Signify regurgitant flow through an incompetent semilunar valve.
   e.g. aortic/pulmonary regurgitation.

2. **Rumbling diastolic murmurs in mid- or late diastole:**
   Suggest stenosis of an AV valve.
   e.g. mitral/tricuspid stenosis.

**In Summary**

**Common Diastolic Murmurs & Timing**

- Soft, blowing, gurgle

1. Aortic regurgitation → early diastole.
2. Mitral stenosis → mid to late (pre-systolic) diastole.
## Diastolic Murmurs

<table>
<thead>
<tr>
<th></th>
<th>Aortic Regurgitation</th>
<th>Mitral Stenosis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cause</strong></td>
<td>Retrograde flow from aorta into LV through incompetent aortic cusps.</td>
<td>Obstruction of flow from LA to LV (Valve becomes narrowed, thickened &amp; calcified).</td>
</tr>
<tr>
<td><strong>Timing</strong></td>
<td>Diastolic (early) murmur.</td>
<td>Diastolic (mid-diastolic, or pre-systolic) murmur.</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Best heard at 2nd-4th left intercostal spaces.</td>
<td>Best heard at apex.</td>
</tr>
<tr>
<td><strong>Character</strong></td>
<td>High-pitched, blowing, decrescendo.</td>
<td>Low pitched (heard with bell).</td>
</tr>
<tr>
<td><strong>Association</strong></td>
<td>Aortic root degeneration, rheumatic heart disease, VSD with aortic valve prolapse (kids).</td>
<td>Rheumatic fever.</td>
</tr>
</tbody>
</table>
Murmurs of Ventricular Septal Defect & Patent Ductus Arteriosus

Ventricular Septal Defect

Patent ductus arteriosus
Murmurs of **Ventricular Septal Defect VS Patent Ductus Arteriosus**

<table>
<thead>
<tr>
<th></th>
<th>Ventricular septal defect</th>
<th>Patent ductus arteriosus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cause</strong></td>
<td>A congenital condition associated with abnormal blood flow between the left ventricle and the right ventricle</td>
<td>Failure of closure of duct (ductus arteriosus) between pulmonary artery &amp; aorta</td>
</tr>
<tr>
<td><strong>Timing</strong></td>
<td>Holosystolic murmur, may be diastolic murmur due to turbulent flow through mitral valve</td>
<td>Continuous murmur</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Best heard at tricuspid area</td>
<td>Best heard at upper left sternal border</td>
</tr>
<tr>
<td><strong>Character</strong></td>
<td>A medium pitched murmur fills all of systole</td>
<td>Machine-like</td>
</tr>
<tr>
<td><strong>Association</strong></td>
<td>Volume overload of right ventricle</td>
<td>Left to right shunt, cyanosis</td>
</tr>
</tbody>
</table>
Summary

A. Presystolic murmur.
   ○ Mitral/Tricuspid stenosis.
B. Mitral/Tricuspid regurge.
C. Aortic ejection murmur.
D. Pulmonic stenosis (spilling through S2).
E. Aortic/Pulm. diastolic murmur.
F. Mitral stenosis w/ Opening snap.
G. Mid-diastolic inflow murmur.
H. Continuous murmur of PDA.
Summary

How to Describe Heart Murmurs

Timing
(systolic or diastolic)

Murmurs are described according to their position in the cardiac cycle:
* Systolic.
* Diastolic.
* Continuous.

Shape
Murmurs are described according to the waxing & waning of the sound.

Radiation
Reflects intensity of the murmur & direction of blood flow.

Location
Determined by the site where the murmur originates; e.g. Aortic, Pulmonary, Tricuspid, & Mitral listening areas.

Pitch
High, medium, low.

Intensity
Graded on a (6) point according to Levine scale.

Quality
Blowing, harsh (hard), resonant (rumbling) & musical.

i. Variation with respiration:
ii. Variation with position of patient:
iii. Variation with special maneuvers

Others

Normal Heart Sounds:
4 heart sounds can be detected:
- 1st & 2nd heart sounds (usually audible)
- 3rd & 4th heart sounds (sometimes detected)

1st Heart Sound
- Due to closure of the atrio-ventricular valves.
- Recorded at the beginning of the "isovolumetric contraction phase."
- It marks the onset of ventricular systole.
- Long duration (0.15 sec.) longest duration of all sounds.
- Best heard at Mitral & Tricuspid areas.

2nd Heart Sound
- Due to closure of semilunar valves.
- Recorded at the beginning of the "isometric relaxation" phase.
- Marks the beginning of ventricular diastole.
- Short in duration (0.07-0.125 sec.)
- Best heard at Aortic & Pulmonary areas.

3rd Heart Sound
- Recorded during the "rapid filling" phase, due to rush of blood into the ventricle.
- Duration 0.05 sec.
- S3 is usually not audible (soft and very low pitch)
- Heard in children and young individuals.
- Best heard at Mitral area.

4th Heart Sound
- Recorded during "atrial systole."
- Duration 0.04 sec.
- S4 is usually not audible (very low pitch)
- Usually heard in elderly.
- Best heard at Mitral area.
<table>
<thead>
<tr>
<th>Heart Murmurs</th>
<th>Early</th>
<th>Mid (Ejection)</th>
<th>Late</th>
<th>Holo (Pan)</th>
<th>Diastolic murmur</th>
<th>Late</th>
<th>Continuous murmur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic murmur</td>
<td>Aortic stenosis: Narrowing of aortic outflow tract causing obstruction of flow from left ventricle into ascending aorta</td>
<td>Location</td>
<td>Character</td>
<td>Association</td>
<td>Aortic Regurgitation: Retrograde flow from aorta into LV through incompetent aortic cusps</td>
<td>Best heard at apex radiates to left axilla</td>
<td>Soft, high pitched, blowing</td>
</tr>
<tr>
<td>Early</td>
<td>Mid (Ejection)</td>
<td>Best heard at aortic area, radiates along Carotid arteries</td>
<td>Harsh, Loud, may have associated thrill; “ejection click.”</td>
<td>Older age, bicuspid aortic valve, rheumatic fever.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Late</td>
<td>Mid systolic click</td>
<td>5% normal population, asymptomatic, sudden death</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holo (Pan)</td>
<td>Mitral Regurgitation: Retrograde flow from left ventricle to left atrium through an incompetent mitral valve</td>
<td></td>
<td>Mitral Stenosis: Obstruction of flow from LA to LV because of a narrowed mitral orifice (Valve becomes thickened &amp; calcified) (it’s mid-late systole)</td>
<td></td>
<td>Best heard at apex</td>
<td>Low pitched (heard with bell of stethoscope), opening snap after closure of aortic valve</td>
<td>Rheumatic fever</td>
</tr>
<tr>
<td>Late</td>
<td>Patent Ductus Arteriosus: Failure of closure of the duct between pulmonary artery &amp; aorta</td>
<td>Upper left sternal border</td>
<td>Machine like</td>
<td>Left to right shunt, cyanosis</td>
<td></td>
<td></td>
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</table>

Special thanks for 436 team
Quiz

1. Closure of AV valves causes which sound?
   A- S3
   B- S2
   C- S4
   D- S1

2. Aortic regurgitation is best heard at which location?
   A- apex of heart
   B- pulmonary area
   C- 2-4 left intercostal spaces
   D- aortic area

3. 4th lead of ECG (V4) is on the same location of:
   A- aortic area
   B- mitral areas
   C- pulmonary area
   D- tricuspid area

4. S1 sound is soft at which condition?
   A- bradycardia
   B- tachycardia

5. This sound is usually heard in children:
   A- S1
   B- S2
   C- S3
   D- S4

6. Which heart sound has long duration:
   A- S1
   B- S2
   C- S3
   D- S4
7. physiological splitting of S2 sound is heard at:
A- inspiration only
B- both inspiration and expiration
C- expiration only

8. which of the following causes a mid-late systolic murmur?
A- aortic regurgitation
B- aortic stenosis
C- mitral regurgitation
D- mitral prolapse

9. which valvular abnormality causes the disappearance of pressure difference between LA and LV?
A- aortic regurgitation
B- aortic stenosis
C- mitral regurgitation
D- mitral stenosis
Thank you for checking our work

Any questions?

Contact us at

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