Cardiovascular Physiology

Heart Sounds & Murmurs

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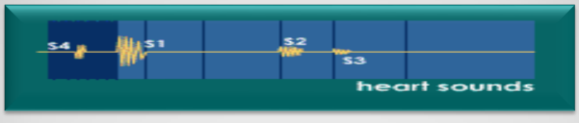
HEART SOUNDS

- **Detected over anterior chest wall by:**
  - **Auscultation:** … (Stethoscope)
  - **Phonocardiography:** (sound recording device)



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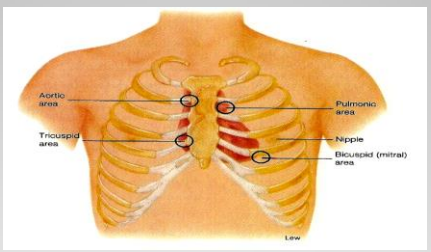
HEART SOUNDS' WINDOWS

- **Best heard at 4 certain areas:**



- **Pulmonary area:**
  - 2nd Lt intercostal space
- **Aortic area:**
  - 2nd Rt costal cartilage
- **Mitral area:**
  - 5nd Lt intercostal space crossing mid-clavicular line, or
  - 9 cm (2.5-3 in) from sternum
- **Tricuspid area:**
  - lower part of sternum towards Rt side

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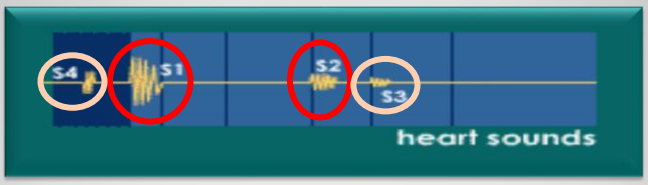
Heart Sounds:

- **'4' heart sounds can be detected:**
  - 1st & 2nd ht sounds … (usually audible)
  - 3rd & 4th ht sounds … (sometimes detected)



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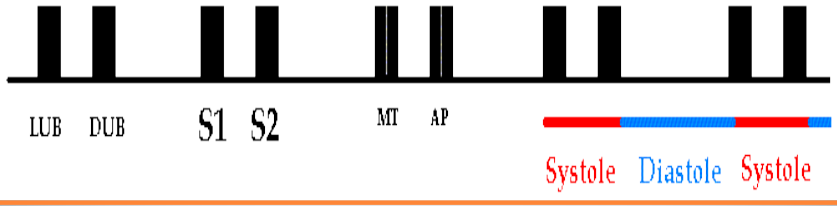
Normal Heart Sounds



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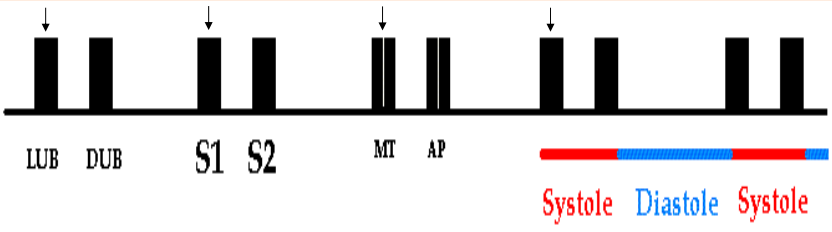
(S1)



- Due to closure of the AV- vs
- Recorded at the beginning of the the 'isovolumetric contraction phase'
- It marks beginning of ventricular systole
- Long in duration (≈ 0.15 sec.)
- Of low pitch (LUB) .. (Loud)
- 25-35 Hz.
- Best heard at Mitral & Tricuspid areas

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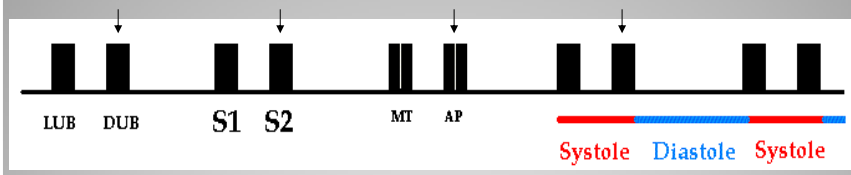
(S2)



- Due to closure of semilunar- vs
- Recorded at the beginning of the 'isovolumetric relaxation phase'
- Marks the beginning of ventricular diastole
- Short in duration (≈ 0.11-0.125 sec.)
- Of high pitch (DUB) .. (Soft & Sharp)
- 50 Hz.
- Best heard at Aortic & Pulmonary areas

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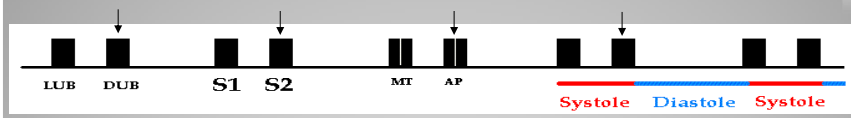
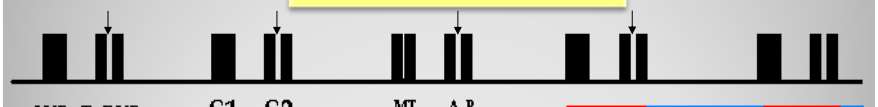
(S2)

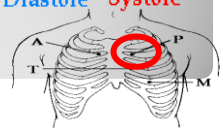


- S2 splits physiologically into 2 sounds during inspiration
  = Physiological Splitting

Physiological splitting during INSPIRATION



- This splitting occurs due to delay closure of pulmonary valve



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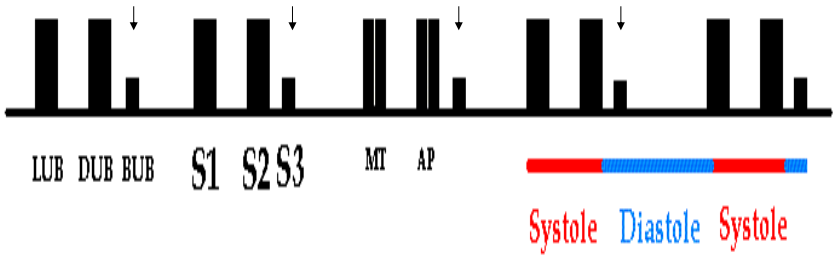
(S3)



- Recorded during the 'rapid filling phase' due to rush of blood into the ventricle
- S3 is usually not audible .. (very low pitch)
- Duration ≈ 0.05 sec.
- ? heard in children
- Best heard at Mitral area

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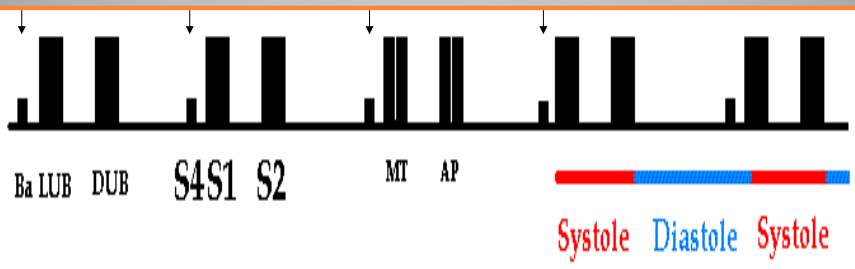
(S4)



- Recorded during 'atrial systole'
- S4 is usually not audible .. (very low pitch)
- Duration ≈ 0.04 sec.
- ? heard in elderly
- Best heard at Mitral area

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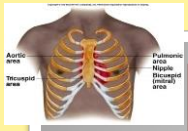

In Summary
Different Heart Sounds

	S1	S2	S3	S4
Cause	Sudden closure of AV-vs	Sudden closure of semilunar vs	Rush of bl during rapid vent filling → vibration of vent ms.	Vibration produced by cont of atrial ms (attributed to vent filling)
C-cycle	Marks beginning of vent systole (Isovolumetric contraction)	Marks beginning of vent diastole (Isovolumetric relaxation)	Max vent filling phase of diastole	Atrial systole (just before 1st HS)
Duration	0.15 sec (Longer)	0.11-0.125 sec (Shorter)	0.05 sec	0.04 sec
Frequency	25-35 Hz	50 Hz	Very low pitch	Very low pitch
Character	Low pitch (LUB) (Louder)	High pitch (DUB) (Softer, sharper) Split into 2 sounds during inspiration = Physiological splitting (due to delay closure of pulm v).	Usually not audible	Usually not audible (Rarely heard)
Best heard	M & T	A & P	M	M

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Significance of heart sounds?

Important for diagnosis of abnormal heart sounds (murmurs)

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What Makes Noises in the Heart?

- **Valves closing:**
  - Atrio-ventricular = (S1)
  - Semilunar = (S2)
- **Increased intra-cardiac hemodynamics (Murmurs):**
  - Blood striking the left ventricle, e.g. S3, S4
  - Increased flow across normal valves
  - Turbulent flow through an abnormal valve
  - Turbulent flow through septal defect

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Causes of Heart Murmurs

1. Physiological Murmurs:

- **↑ blood flow across normal valves:**

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

2. Pathological Murmurs:

- **Turbulent flow through abnormal valves, or septal defect..**

? Congenital

e.g.
- Tight valve (stenosis)
- Leaky valve (regurgitation or insufficiency)

- **N.B. Murmurs are longer than heart sounds**

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How to Describe Heart Murmurs?

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

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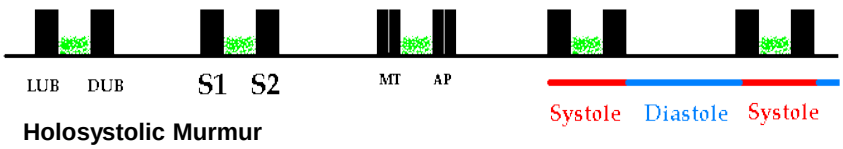
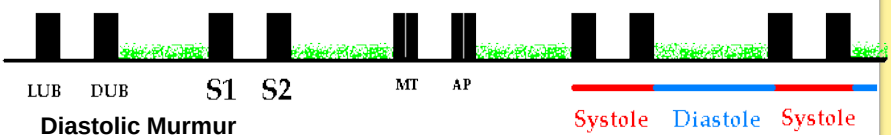
1. Timing:

- Systolic
- Diastolic
- Continuous



Holosystolic Murmur



Diastolic Murmur

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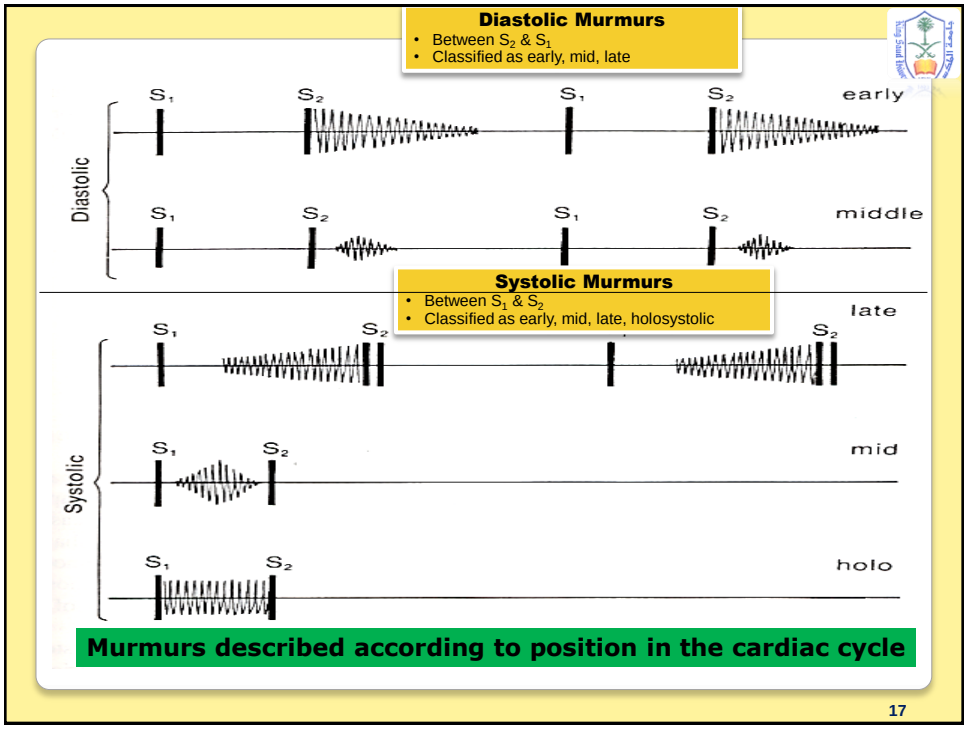
Diastolic Murmurs
• Between S_2 & S_1
• Classified as early, mid, late
S_1 S_2 S_1 S_2 early
Diastolic
S_1 S_2 S_1 S_2 middle
Systolic Murmurs
• Between S_1 & S_2
• Classified as early, mid, late, holosystolic
late
S_1 S_2 S_2
Systolic
S_1 S_2 mid
S_1 S_2 holo
Murmurs described according to position in the cardiac cycle
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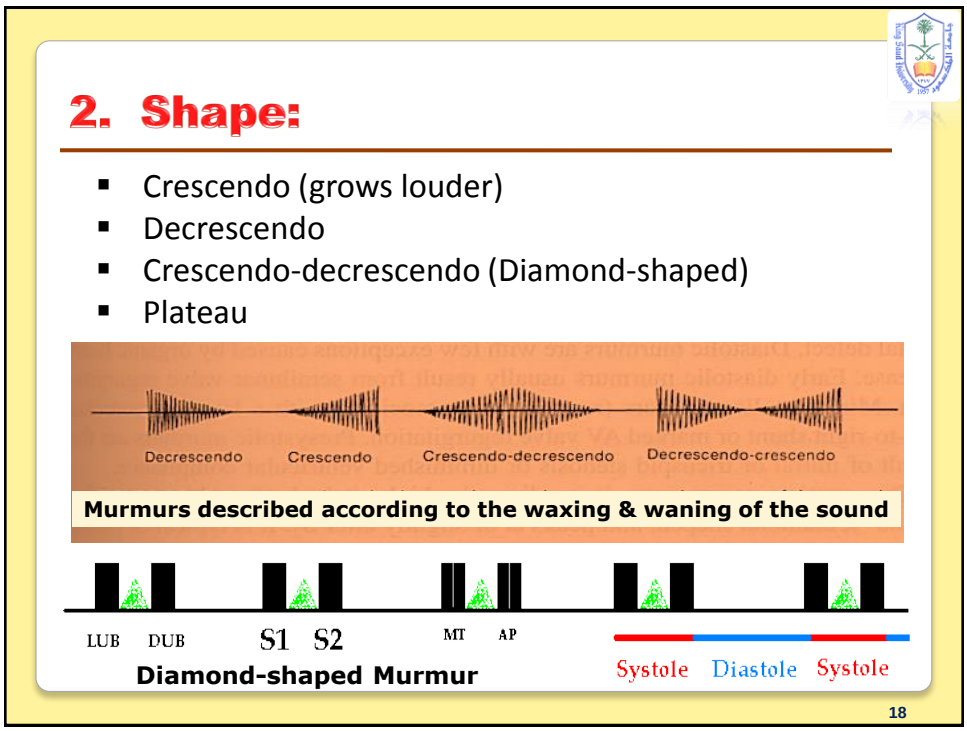
2. Shape:
Crescendo (grows louder)
Decrescendo
Crescendo-decrescendo (Diamond-shaped)
Plateau
Decrescendo
Crescendo
Crescendo-decrescendo
Decrescendo-crescendo
Murmurs described according to the waxing & waning of the sound
LUB DUB S1 S2 MT AP
Diamond-shaped Murmur
Systole Diastole Systole
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Describing a heart murmur … (Cont.)

3. Location of maximum intensity

Determined by the site where the murmur originates e.g. A, P, T, M listening areas

4. Radiation

Reflects intensity of the murmur & direction of blood flow

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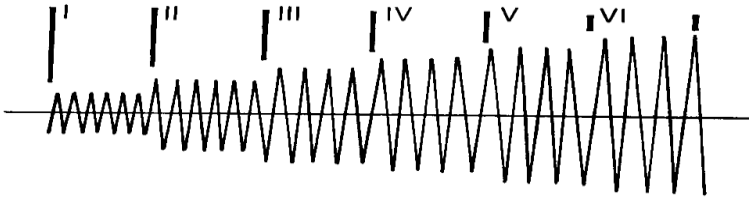
5. Intensity:

- **Graded on a 6 point according to Levine scale:**



Classification of murmurs by loudness

Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6
• Lowest intensity • Very faint	• Low intensity • Quiet but heard immediately	• Medium intensity • Moderately loud	• Medium intensity • Loud • Thrills	• Loud intensity • Heard with stethoscope partly off the chest • Thrills	• Loudest intensity • No stethoscope needed • Thrills

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Heart murmurs Intensity

I / VI	need quiet room and trained ear to hear. (difficult to hear even by expert listeners)
II / VI	audible to anyone who listens attentively (usually audible by all listeners)
III / VI	loud, but not palpable (easy to hear even by inexperienced listeners, but without a palpable thrill)
IV / VI	loud and palpable: it produces a precordial thrill
V / VI	audible with your stethoscope placed perpendicular to chest wall
VI / VI	audible without a stethoscope

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Describing a heart murmur … (Cont.)

6. **Pitch**

   High, medium, low

7. **Quality**

   Blowing, harsh, rumbling & musical

8. **Others:**

   i. **Variation with respiration**

      Right sided murmurs change > left sided

   ii. **Variation with position of patient**

   iii. **Variation with special maneuvers**

      Valsalva ⇒ Murmurs ↓ in length & intensity

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Systolic Murmurs

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

SYSTOLIC MURMURS

- **Derived from harsh & ↑ turbulence in flow**
- **Associated with:**
  1. ↑ flow across normal valve
  2. ↑ flow into a dilated great vessel
  3. ↑ flow across an abnormal valve, or narrowed ventricular outflow tract - e.g. aortic /pulmonary stenosis
  4. ↑ flow across an incompetent AV valve - e.g. mitral/tricuspid regurgitation
  5. ↑ flow across the inter-ventricular septum - e.g. VSD

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MID-SYSTOLIC (EJECTION) MURMURS

- Most common kind of heart murmur
- Usually crescendo-decrescendo
- They ? 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

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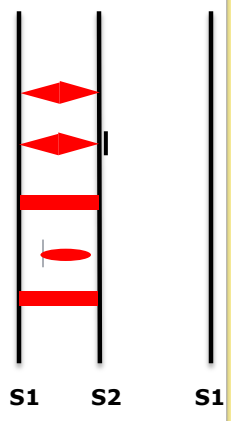
IN SUMMARY: COMMON SYSTOLIC MURMURS AND TIMING

1. **Aortic stenosis –** ejection murmur
2. **Pulmonary stenosis –** ejection murmur + spilling S2
3. **Mitral / Tricuspid regurgitation –** holosystolic
4. **Mitral valve prolapse –** mid-late systole
5. **Ventricular septal defect (VSD) –** holosystolic



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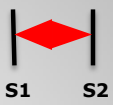
Aortic Stenosis

Narrowing of aortic outflow tract causing obstruction of flow from LV into ascending aorta

- **T-** mid-systolic (ejection) murmur
- **L-** best heard @ aortic area, radiates along carotid arteries
- **C-** harsh, loud, may have associated thrill, "ejection click"
- **A-** older age, bicuspid aortic valve, rheumatic fever



Note: T- Timing; **L-** Location; **C-** Character; **A-** Association

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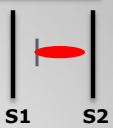
Mitral Prolapse

Bulging of one or both mitral valve leaflets into LA during LV systole

- **T-** mid- late systolic murmur
- **L-** best heard @ apex
- **C-** mid systolic click
- **A-** ~5% normal population, asymptomatic, ? sudden death



Note: T- Timing; **L-** Location; **C-** Character; **A-** Association

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PAN-SYSTOLIC (HOLOSYSTOLIC) MURMURS

- Pathological murmur
- Begins immediately with S1 & continues up to S2
- Heard with:
  - Mitral/tricuspid regurgitation
  - Ventricular septal defect (VSD)

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Mitral Regurgitation

Retrograde flow from LV into LA through an incompetent mitral valve

- **T**- holosystolic murmur
- **L**- best heard @ apex, radiates to left axilla
- **C**- soft, high-pitched, blowing
- **A**- MV prolapse, MV myxomatous degeneration, MI, rheumatic heart disease, cardiomyopathy, endocarditis

Note: T- Timing; **L-** Location; **C-** Character; **A-** Association

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Diastolic Murmurs

Early diastolic

Mid diastolic

Late diastolic

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

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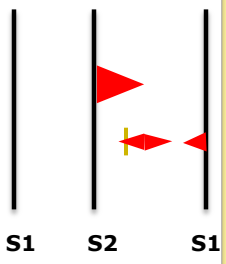
IN SUMMARY: COMMON DIASTOLIC MURMURS AND TIMING

Soft, blowing, gurgle

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



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Aortic Regurgitation

Retrograde flow from aorta into LV through incompetent aortic cusps

- **T-** diastolic (early) murmur
- **L-** best heard @2nd-4th left intercostal spaces
- **C-** high-pitched, blowing, decrescendo
- **A-** aortic root degeneration, rheumatic heart disease, VSD w/aortic valve prolapse (kids)

Note: T- Timing; **L-** Location; **C-** Character; **A-** Association

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Mitral Stenosis

Obstruction of flow from LA to LV because of a narrowed mitral orifice (Valve becomes thickened & calcified)

- **T-** diastolic (mid-diastolic, or pre-systolic) murmur with 'opening snap' after closure of aortic valve
- **L-** best heard @ apex
- **C-** low pitched (heard with bell)
- **A-** rheumatic fever

Note: T- Timing; **L-** Location; **C-** Character; **A-** Association

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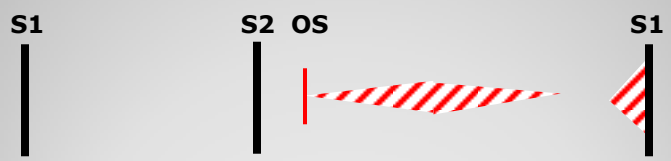
Mitral Stenosis … (Cont.)



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Continuous Murmurs

Continuous Murmurs

- Begin in systole, ? peak near S2 & continue into all or part of diastole
- Heard with:
  - Patent ductus arteriosus (PDA)
  - Ventricular septal defect (VSD)

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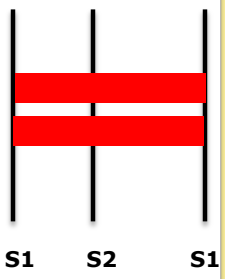
IN SUMMARY:
COMMON CONTINUOUS MURMURS AND TIMING

1. **Patent ductus arteriosus (PDA)**
2. **? Ventricular septal defect (VSD)**



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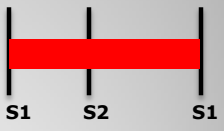
Patent Ductus Arteriosus

Failure of closure of the duct between pulmonary artery & aorta

- **T-** continuous murmur
- **L-** best heard @ upper left sternal border
- **C-** machine-like
- **A-** left to right shunt, cyanosis



Note: T- Timing; **L-** Location; **C-** Character; **A-** Association

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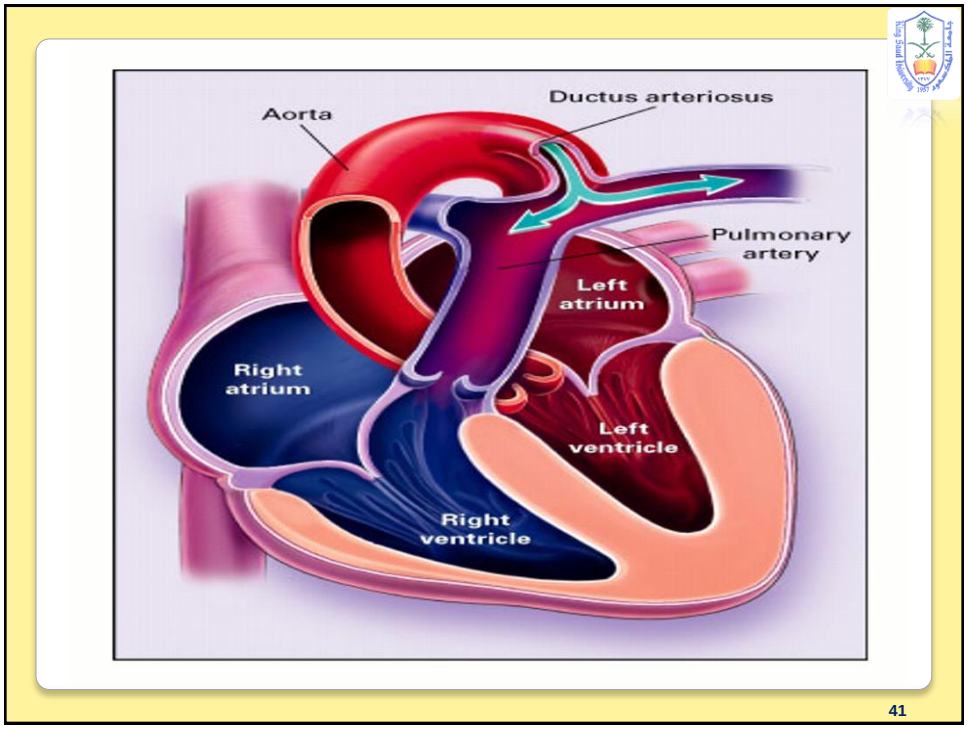
Aorta
Ductus arteriosus
Pulmonary artery
Left atrium
Right atrium
Left ventricle
Right ventricle
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Thank You