جامعة الملك سعود
King Saud University

Cardiovascular Physiology

Heart Sounds & Murmurs

Dr. Abeer A. Al-Masri

MBBS, MSc, PhD
Associate Professor
Consultant Cardiovascular Physiologist
Faculty of Medicine, KSU

Lecture Outcomes

- Normal heart sounds & its leading causes.
- Causes of abnormal heart sounds.
- Describing abnormal heart sounds.
- Different examples of abnormal heart sounds.

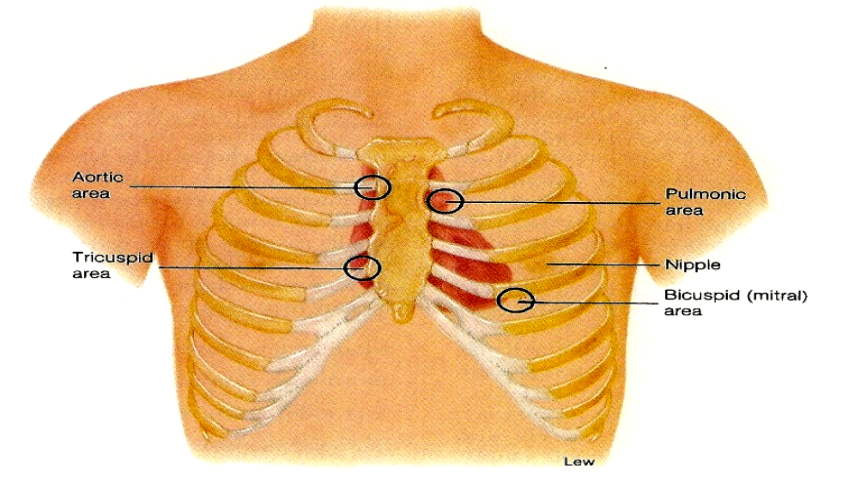
HEART SOUNDS

- **Detected over anterior chest wall by:**
  - **Auscultation:** … (Stethoscope)

  - **Phonocardiography:** (sound recording device)

HEART SOUNDS' WINDOWS

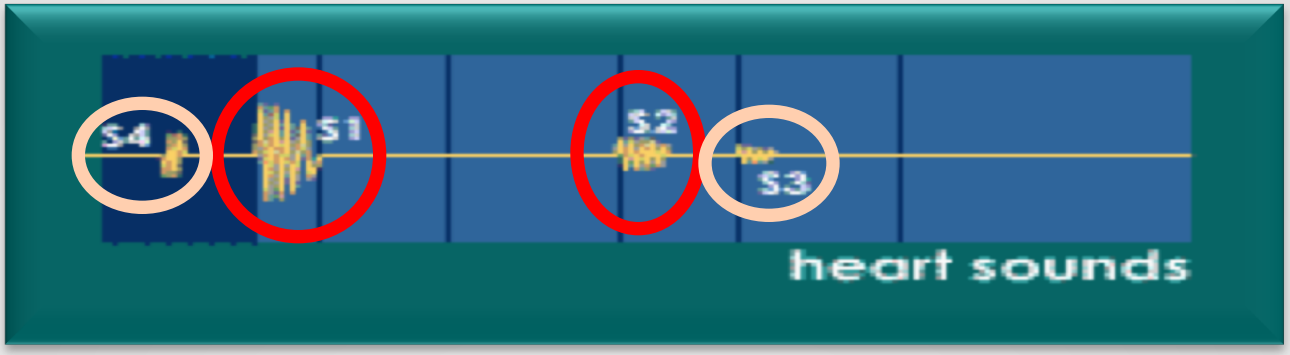
- **Best heard at 4 certain areas:**



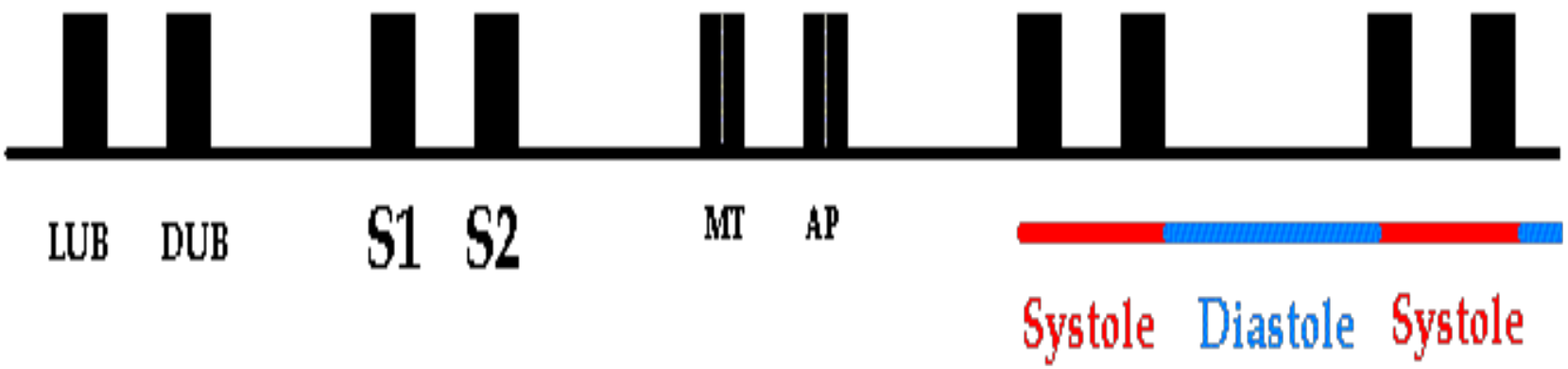
- **Pulmonary area:**
  - 2nd Lt intercostal space
- **Aortic area:**
  - 2nd Rt costal cartilage
- **Mitral area:**
  - 5nd Lt intercostal space crossing mid-clavicular line, or
  - 9 cm (2.5-3 in) from sternum
- **Tricuspid area:**
  - lower part of sternum towards Rt side

Heart Sounds:

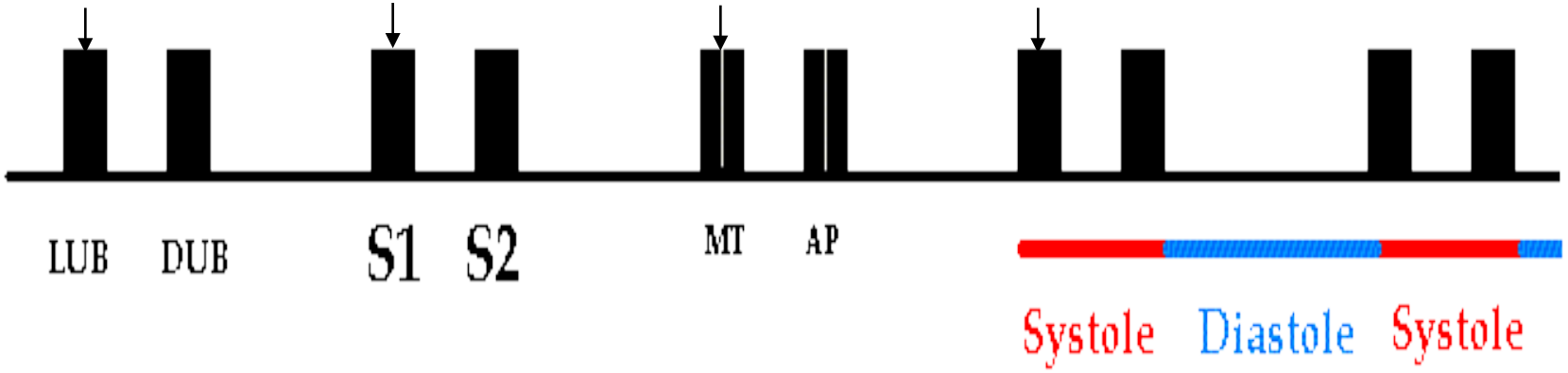
- **‘4’ heart sounds can be detected:**
  - 1st & 2nd ht sounds … (usually audible)
  - 3rd & 4th ht sounds … (sometimes detected)



Normal Heart Sounds

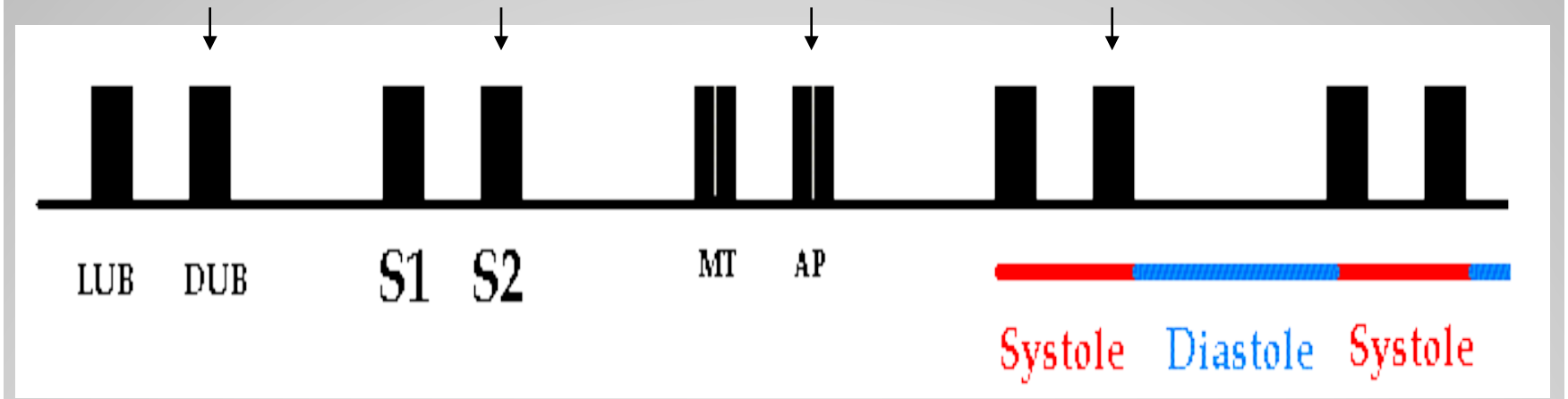


(S1)



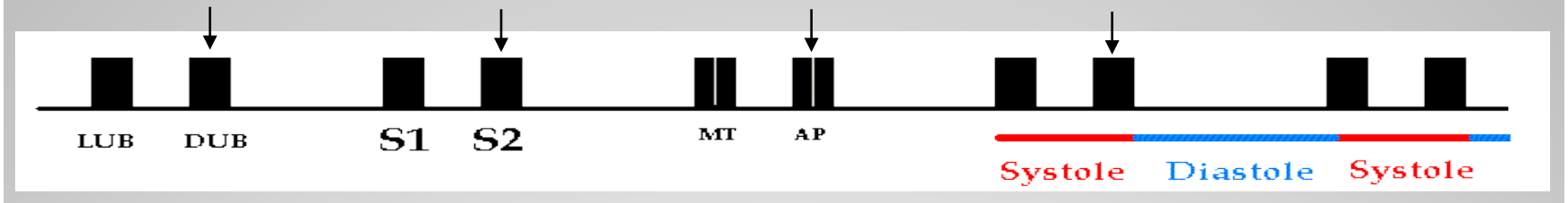
- Due to closure of the AV- vs.
- It marks beginning of ventricular systole.
- Recorded at the beginning of the 'isometric contraction' phase.
- Long in duration (≈0.15 sec.)
- Of low pitch (LUB) .. (Loud)
- 25-35 Hz.
- Best heard at Mitral & Tricuspid areas.

(S2)



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

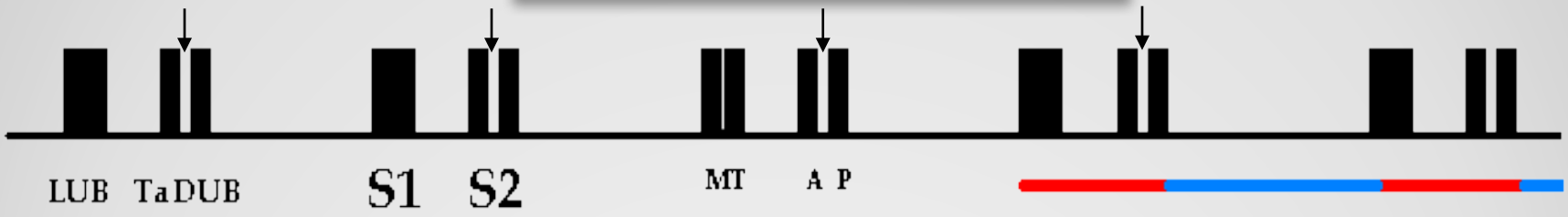
(S2)



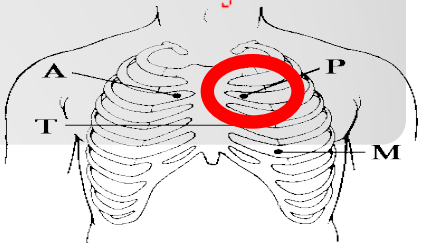
- S2 splits physiologically into 2 sounds during inspiration

  = Physiological Splitting

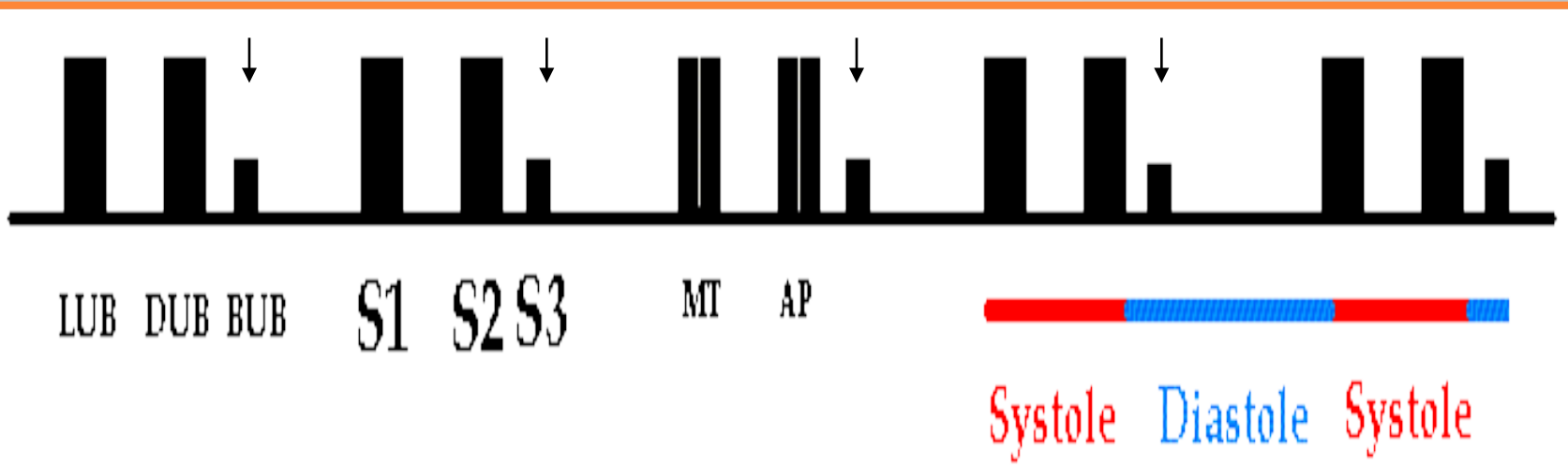
Physiological splitting during INSPIRATION



- This splitting occurs due to delay closure of pulmonary valve

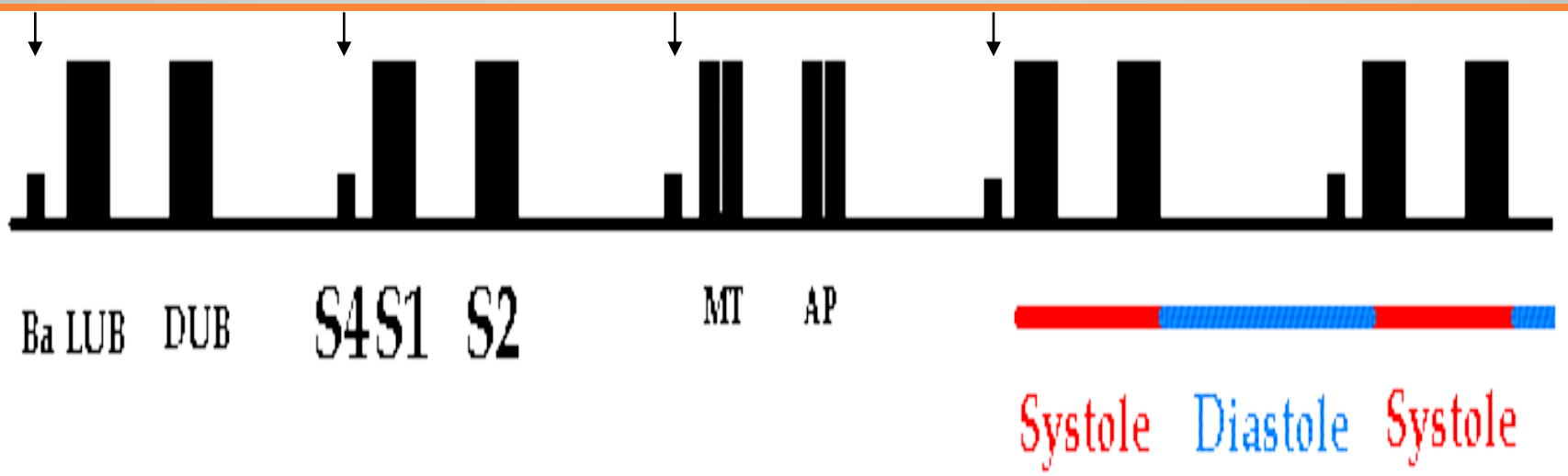


(S3)



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

(S4)



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

Significance of heart sounds?

Important for diagnosis of heart murmurs.

- **Abnormal extra heart sounds heard during the heart beat cycle.**
- **Produced by turbulence (abnormal patterns) of blood flow through the heart & its valves.**
- **Murmurs are longer than heart sounds.**

What Makes Noises in the Heart?

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

Physiological vs. Pathological 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)

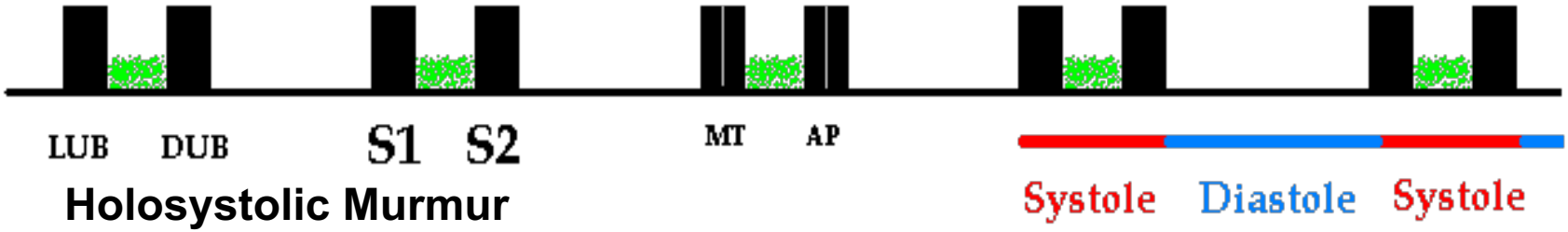
How to Describe Heart Murmurs?

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

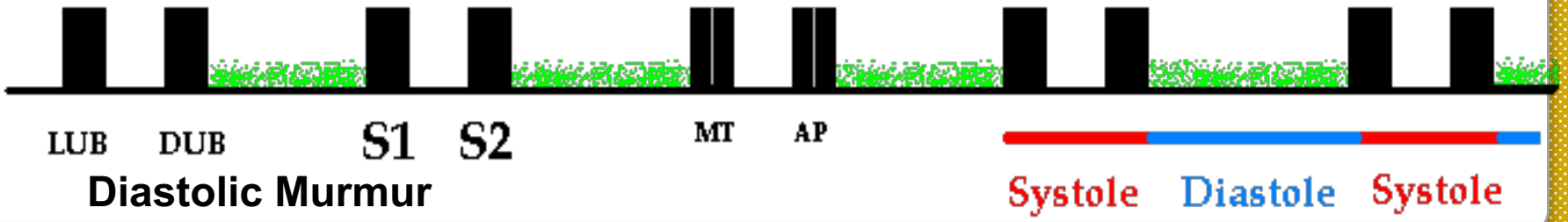
1. Timing:

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

- Systolic.
- Diastolic.
- Continuous.



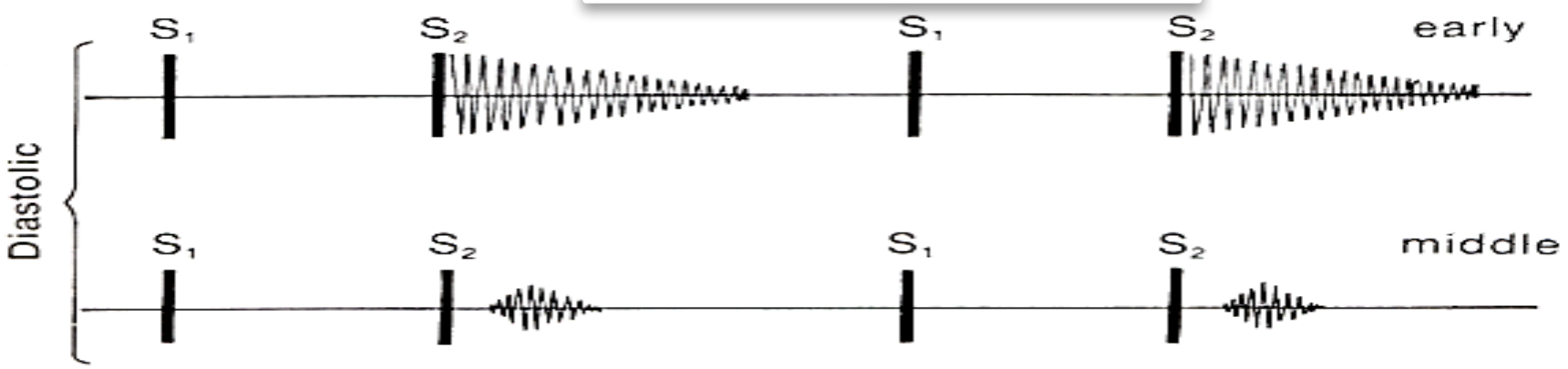
Holosystolic Murmur

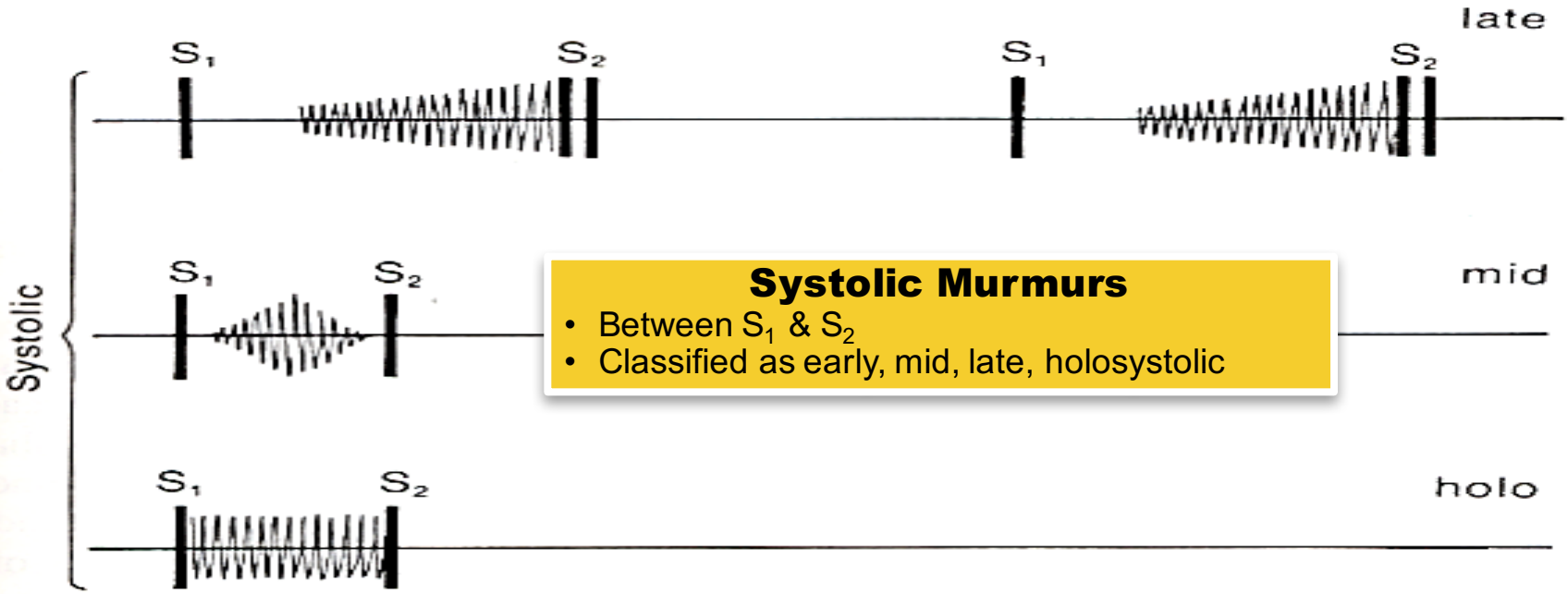


Diastolic Murmur

Diastolic Murmurs

- Between S_2 & S_1
- Classified as early, mid, late



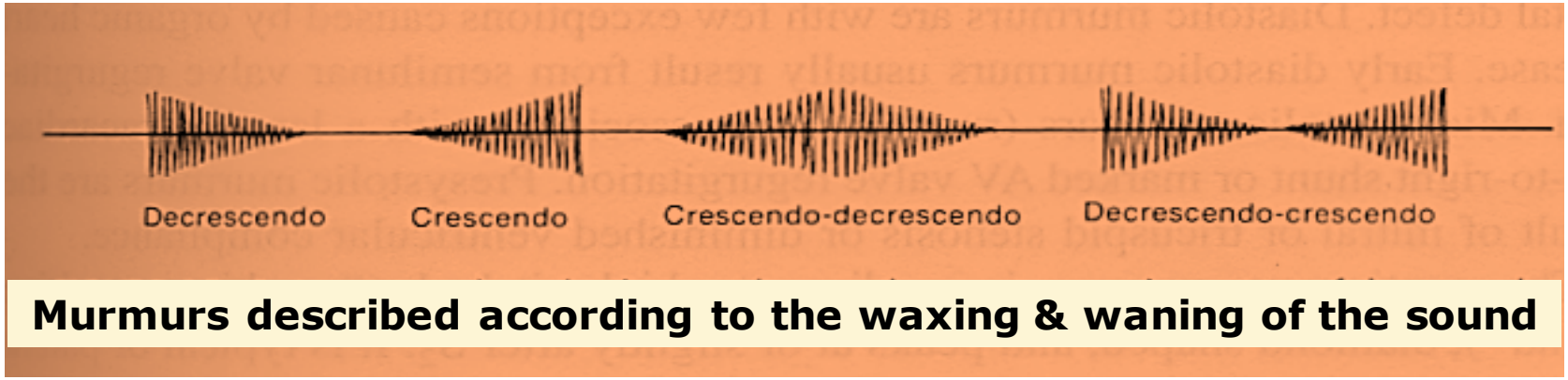


Systolic Murmurs

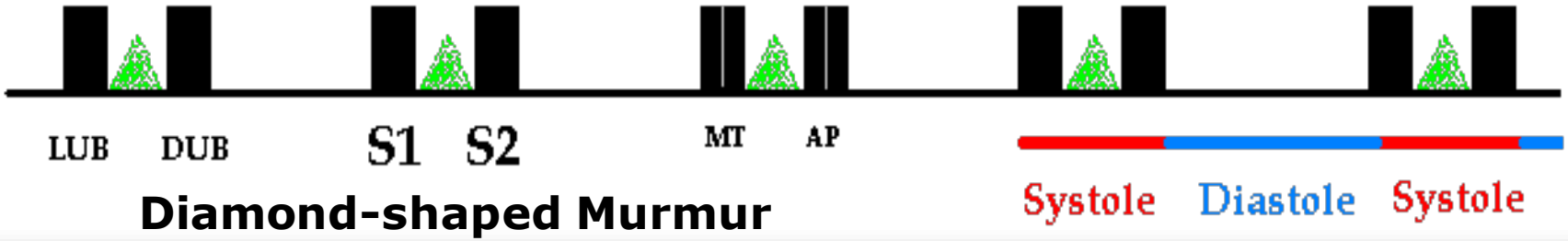
- Between S_1 & S_2
- Classified as early, mid, late, holosystolic

2. Shape:

- Crescendo (grows louder.)
- Decrescendo.
- Crescendo-decrescendo (Diamond-shaped.)
- Plateau.



Murmurs described according to the waxing & waning of the sound



Diamond-shaped Murmur

Describing a heart murmur … (Cont.)

3. Location of maximum intensity

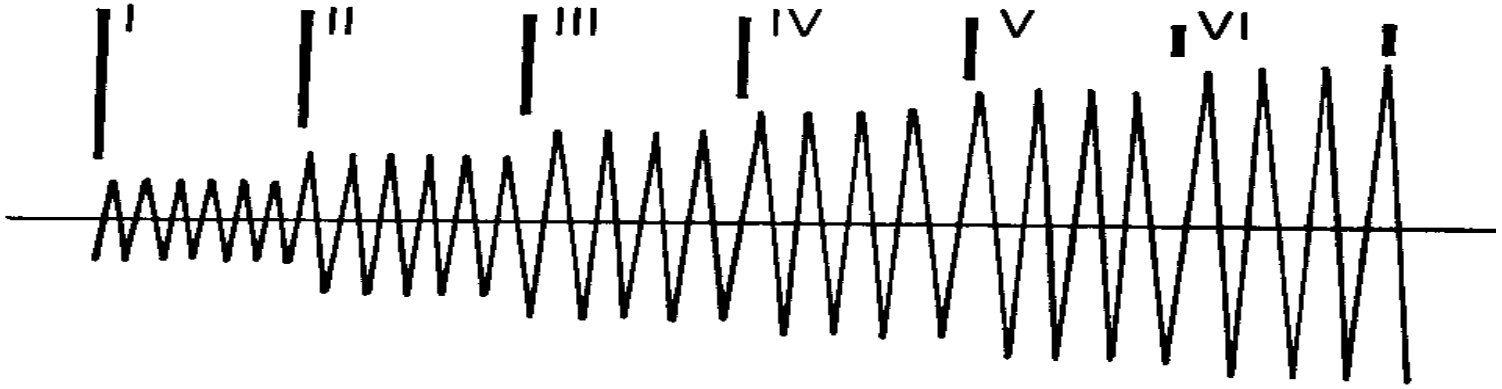
Determined by the site where the murmur originates; e.g. Aortic, Pulmonary, Tricuspid, & Mitral listening areas.

4. Radiation

Reflects intensity of the murmur & direction of blood flow.

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

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

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.

Systolic Murmurs

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

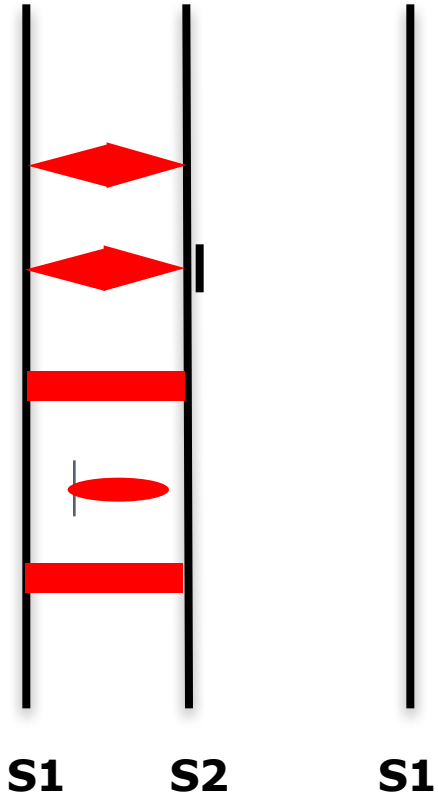
SYSTOLIC MURMURS

- **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.

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.



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.

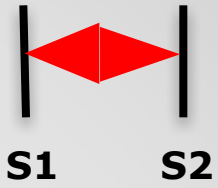
PAN-SYSTOLIC (HOLOSYSTOLIC) MURMURS

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

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.

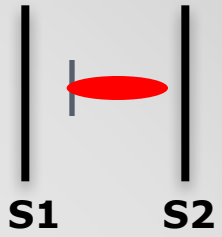


- **C-** harsh, loud, may have associated thrill, "ejection click."
- **A-** older age, bicuspid aortic valve, rheumatic fever.

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

Mitral Prolapse

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

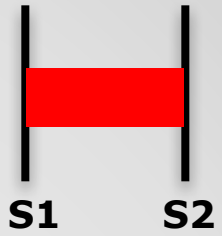


- **T-** mid- late systolic murmur.
- **L-** best heard @ apex.
- **C-** mid systolic click.
- **A-** ~5% normal population, asymptomatic, ? sudden death.

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

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

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.

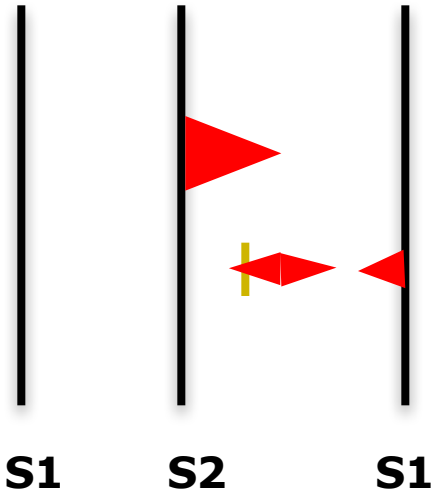
2. **Rumbling diastolic murmurs in mid- or late diastole:**

   Suggest stenosis of an AV valve,
   e.g. mitral/tricuspid stenosis.

IN SUMMARY:
COMMON DIASTOLIC MURMURS AND TIMING

Soft, blowing, gurgle

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



Aortic Regurgitation

Retrograde flow from aorta into LV through incompetent aortic cusps

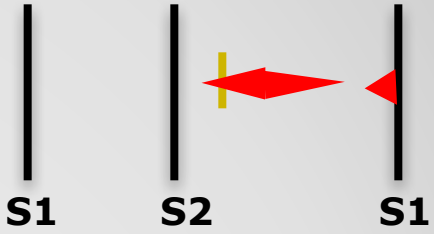
- **T-** diastolic (early) murmur.
- **L-** best heard @2nd-4th left intercostal spaces.
- **C-** high-pitched, blowing, decrescendo.
- **A-** aortic root degeneration, rheumatic heart disease, VSD w/aortic valve prolapse (kids.)

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

Mitral Stenosis

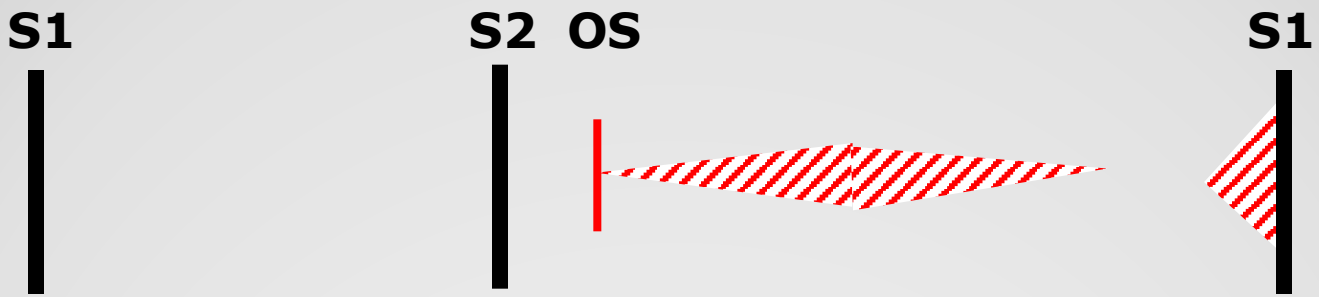
Obstruction of flow from LA to LV because of a narrowed mitral orifice (Valve becomes thickened & calcified)

- **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

Mitral Stenosis … (Cont.)



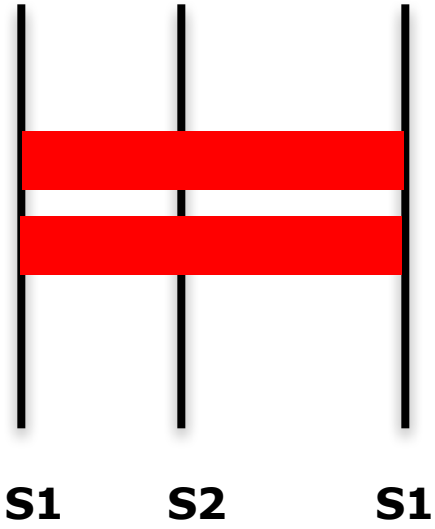
Continuous Murmurs

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)

IN SUMMARY:
COMMON CONTINUOUS MURMURS AND TIMING

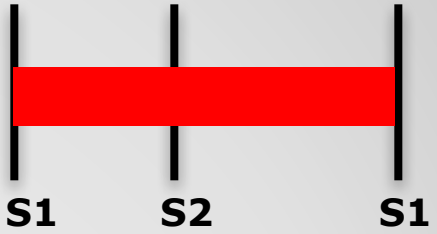
1. Patent ductus arteriosus (PDA)
2. ? Ventricular septal defect (VSD)



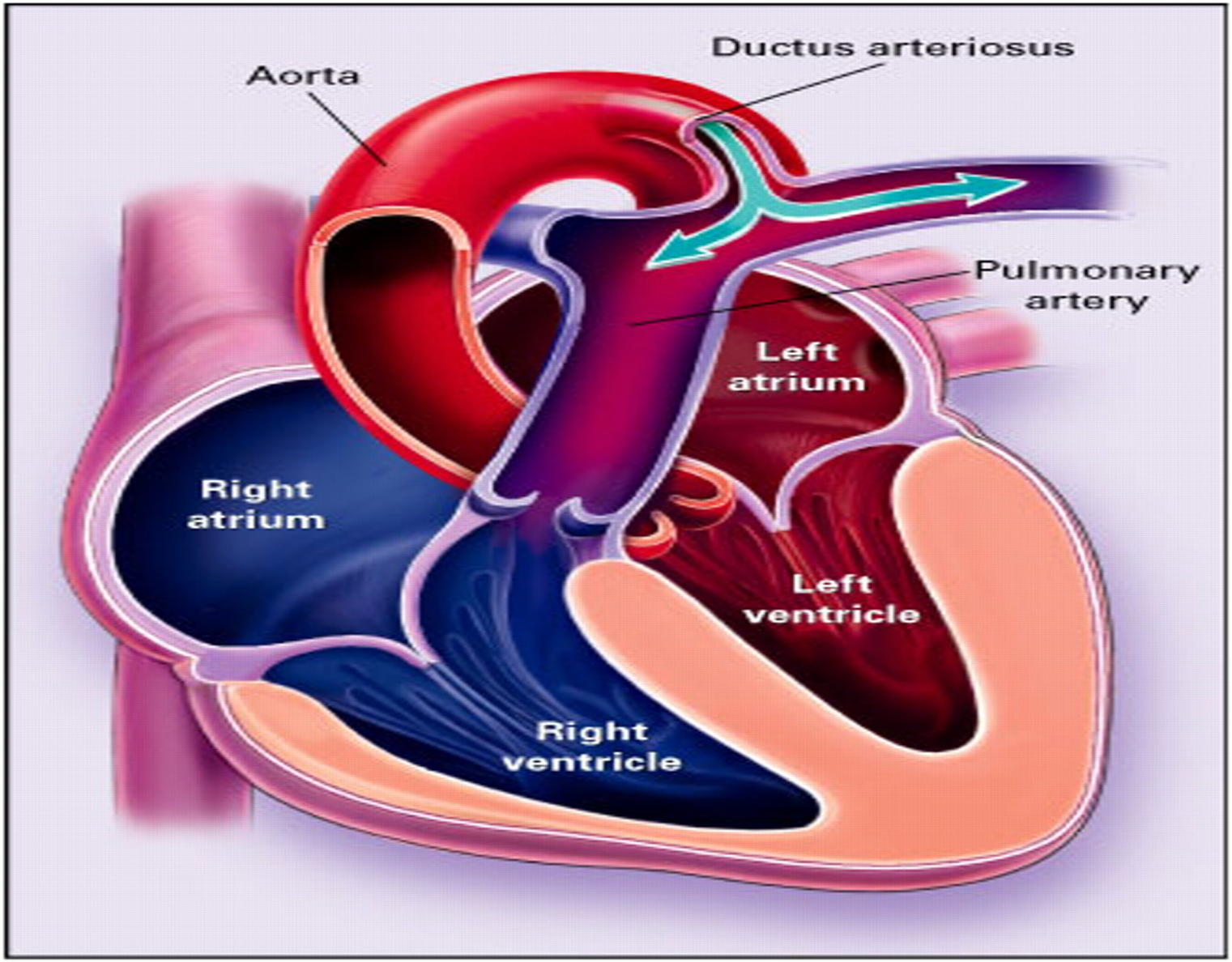
Patent Ductus Arteriosus

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


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


Thank You