

Heart Sounds and Review of Fundamentals

- Systole: The time between S_1 and S_2 - the blood is flowing from the heart to the lungs and body, across the pulmonic and aortic valves. The ventricles are contracting.
- Diastole: The time between S_2 and S_1 - the blood is flowing from the atria to the ventricles, across the bicuspid and tricuspid valves. The atria contract at the end of this phase.
- S_1 : The "lub" in "lub-dub". The sound is from the closing of the bicuspid and tricuspid valves, which live between the atria and ventricles. They close because the ventricles are contracting. You also hear the pulmonic and aortic valves opening at the same time as the blood is forced from the ventricles into the arteries.
- S_2 : The "dub" in "lub-dub". The sound is from the closing of the pulmonic and aortic valves as the pressure from the arteries becomes greater than the pressure in the ventricles - this is the end of systole. You can also hear the bicuspid and tricuspid valves opening.
- A split S_2 is really *always* occurring to some degree, as the closing of the pulmonic and aortic valves don't both occur at the same millisecond. *Both valves closing* make up the S_2 . When you breathe in, the pressure in your thorax decreases - the diaphragm creates a little vacuum. This decreased pressure means less force is placed on the pulmonic valve to close (remember that the pulmonic valve closes when the PA pressure is greater than the RV pressure) than there is during expiration. (During expiration, the pressure in the thorax, and therefore the pulmonary artery, is greater.) With the decreased force, the pulmonic valve becomes encouraged to close slightly later than it would otherwise, so it does - it becomes the second part of S_2 . The pressure in the aorta *isn't* decreased by the inspiration, and it closes the aortic valve at its regular time - as the first half of S_2 . When they close far enough apart for you to hear them each distinctly, that's a split S_2 . The take-home message is that split S_2 's increase their split on inspiration, and decrease their split on expiration. They're a normal finding.
- An S_3 sound comes right after the S_2 - it sounds like a split S_2 , but the size of the split never changes with breathing. It's fairly normal in children and athletes. In other people, it can indicate a non-specific impairment of ventricular function - listen with the bell to determine which ventricle is making the sound (left side at the apex, right side at the xiphoid process).
- An S_4 sound comes right before the S_1 - sounds like a "split S_1 ." It is the sound of the ventricle filling during diastole. It becomes more pronounced when the ventricular wall gets more rigid (as in hypertrophy) such as with ischemia, aortic or pulmonic stenosis (again, use the bell to listen on both sides), HTN, etc.
- Murmurs can occur anywhere in the cardiac cycle. They generally indicate turbulence, often across a valve. You need to be able to identify a few things about a murmur to help you narrow down your differential:
 - How loud is it? Murmurs are graded on a scale with VI being the highest - I-III have no associated thrill, IV-VI do have a thrill.
 - I. Barely audible
 - II. Faint, but easily heard
 - III. Moderately loud

IV. Loud with associated thrill

V. Very loud with thrill, can hear with stethoscope off of chest

VI. Very loud with thrill, can hear without a stethoscope

- What does it sound like? Is it a rumble, a whine, a whoosh?
- During which part of the cardiac cycle does it occur? Be specific - if it's during systole, is it *early systolic*, *late systolic*, or *holosystolic*?
- What does it *do*? Does it crescendo (get progressively louder)? Decrescendo (get progressively quieter)? Stay constant?
- Where do you hear it best? Right Upper Sternal Border (RUSB)? LUSB? LLSB? Over the PMI?
- Does it project anywhere, such as to one or both of the carotids?
- Is there a click associated with the beginning, middle, or end of the murmur?
- Gallops: These are simply the presence of either S₃ or S₄.
- Rubs: The one you're likely to hear is a "pericardial friction rub" which indicates pericarditis. It sounds like what it is - muscle rubbing against thick membrane. Sandpapery.
- Anatomy:
 - The right side receives unoxygenated venous blood from the body via the **superior** and **inferior vena cavae**, into the **right atrium**. It is pumped across the **tricuspid valve**, into the **right ventricle**. It is then pumped across the **pulmonic valve** into the **pulmonary artery** and through the lungs.
 - The left side receives oxygenated blood from the **pulmonary vein** into the **left atrium**. It is then pumped across the **mitral valve** into the **left ventricle**. It is finally pumped across the **aortic valve** into the **ascending aorta** and out to the body.
 - The coronary arteries arise from the base of the aorta.
 - The right coronary artery supplies the right side of the heart, the inferior surface of the heart, and typically the posterior surface, as well, via the **PDA (Posterior Descending Artery)**.
 - The left coronary artery supplies the left side of the heart. The **LAD (Left Anterior Descending)** supplies the anterior wall and the septum. The **Circumflex** supplies the lateral wall, and shares responsibility for the anterolateral surface with the LAD. It can also supply the **PDA** in a common variation.
- Technique: The **diaphragm** of the stethoscope is for high-pitched sounds, like the basic heart sounds, including murmurs. The **bell** is for low-pitched sounds - hold it slightly off the skin (or the skin will act as a diaphragm), and use it to listen for bruits (carotid, renal artery, etc.) or cardiac rubs.

The Saia Method

The best advice I've ever gotten on the cardiac exam was from Dr. John Saia during a review for our checkout exams during second year. It boiled down to just being complete and methodical. This was it:

1. Feel the **PMI** (Point of Maximal Impact).
 2. Listen to the **aortic window** (immediately right of the sternum, 3rd intercostal space).
 3. Listen to the **pulmonary artery window** (immediately left of the sternum, 3rd intercostal space).
 4. Listen to the **tricuspid valve window** (immediately left of the sternum, 5th intercostal space).
 5. Listen to the **mitral valve window** (left mid-clavicular line, 6th intercostal space).
 6. Listen to the right, then to the left **carotid** artery.
 7. **At each area, stop and identify - then characterize - each of these sounds:**
 - S₁
 - Systole
 - S₂
 - Diastole
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The Fedorowski Method

This method forces you to really think about the heart, its function, and its anatomy. The fundamental principle is to "follow the blood" through the heart, listening to all the possible places where problems may occur. This approach is the standard approach to cardiac auscultation in parts of Europe. The windows are the same (obviously, since the valves are in the same place), but the sequence is different.

- The first window is at the apex, the hear LV inflow, as blood crosses the mitral valve.
 - If murmur is heard at the apex, follow the sound to the axilla, to confirm MR.
 - The second window is at the right upper sternal border (2nd intercostal space), to hear LV outflow across the aortic valve.
 - If an aortic valve murmur is heard, listen to the neck next to confirm radiation to the carotids, as you would expect in AS.
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The Right heart exam is similar:

- RV inflow is heard at the left lower sternal border (5th intercostal space) as blood crosses the tricuspid valve
- RV outflow is heard at the left upper sternal border (2nd intercostal space) as blood crosses the pulmonic valve

Basically, the primary pattern is an "X" - Apex, RUSB, LLSB, LUSB - with additional auscultation beyond that X (axilla, carotids, etc) as indicated.

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Common auscultatory findings in patients with cardiovascular disease

Finding	Condition
First heart sound (S1)	
<ol style="list-style-type: none"> 1. Louder than normal 2. Variable in intensity 3. Diminished in intensity 	<ol style="list-style-type: none"> 1. Mitral stenosis, short PR interval 2. Atrial fibrillation, complete heart block 3. Mitral regurgitation, severe aortic regurgitation, long PR interval, calcified mitral valve
Second heart sound (S2)	
<ol style="list-style-type: none"> 1. Fixed splitting 2. Wide, physiologic splitting 3. Paradoxical splitting 4. Increased intensity of A2 5. Increased intensity of P2 6. Decreased intensity of A2 7. Decreased intensity of P2 	<ol style="list-style-type: none"> 1. Atrial septal defect 2. Right bundle branch block, pulmonic stenosis 3. Left bundle branch block, aortic stenosis 4. Severe hypertension 5. Pulmonary hypertension 6. Calcific aortic stenosis 7. Pulmonic stenosis
Extra heart sounds	
<ol style="list-style-type: none"> 1. Third heart sound (S3) 2. Fourth heart sound (S4) 3. Opening snap 4. Ejection sound 	<ol style="list-style-type: none"> 1. Markedly diminished left ventricular diastolic function 2. Modestly diminished left ventricular diastolic function 3. Mitral stenosis 4. Bicuspid aortic valve, pulmonary valve stenosis
Systolic murmurs	
<ol style="list-style-type: none"> 1. Early systolic 2. Midsystolic 3. Holosystolic 4. Late systolic 	<ol style="list-style-type: none"> 1. Acute, severe mitral regurgitation, low-pressure tricuspid regurgitation 2. Aortic sclerosis, aortic dilatation, aortic stenosis, pulmonic stenosis, hypertrophic cardiomyopathy, increased aortic valve flow (can also be caused by anemia, fever, or thyrotoxicosis) 3. Mitral regurgitation, high-pressure tricuspid

	<p>regurgitation, ventricular septal defect</p> <p>4. Mitral valve prolapse</p>
Diastolic murmurs	
<p>1. Early diastolic</p> <p>2. Mid-diastolic</p> <p>3. Late diastolic</p>	<p>1. Aortic regurgitation, high-pressure pulmonary regurgitation</p> <p>2. Mitral stenosis, tricuspid stenosis, severe mitral regurgitation</p> <p>3. Mitral stenosis, severe aortic regurgitation (Austin Flint murmur), left atrial myxoma</p>
Continuous murmurs	
<p>1. Peaks before and after S2</p> <p>2. Rough, noisy, or high-pitched, louder during diastole</p> <p>3. Louder during systole</p>	<p>1. Patent ductus arteriosus</p> <p>2. Normal venous hum</p> <p>3. Mammary souffle</p>

