

Heart Murmurs

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September 27, 2025

RECOMMENDED CITATION

mohammad looti (2025). *Heart Murmurs*. PSYCHOLOGICAL SCALES. Retrieved from <https://scales.arabpsychology.com/?p=30439>

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Primary Disciplinary Field(s): Cardiology, Medicine, Physiology

1. Core Definition

A heart murmur refers to an abnormal sound heard during the cardiac cycle, distinct from the normal "lub-dub" sounds of the heart valves closing. These sounds are typically described as a "whooshing," "swishing," or "blowing" noise. They are produced by **turbulent blood flow** through or near the heart, rather than the smooth, laminar flow characteristic of a healthy cardiovascular system. This turbulence can arise from a variety of physiological or pathological conditions affecting the heart's chambers, valves, or major blood vessels. Understanding heart murmurs is crucial in clinical practice, as they can be the initial indicator of underlying cardiac disease, though many murmurs are benign.

The normal heart sounds, S1 and S2, correspond to the closing of the atrioventricular (mitral and tricuspid) and semilunar (aortic and pulmonic) valves, respectively. Murmurs, in contrast, are extra sounds that occur between S1 and S2 (systolic murmurs), after S2 and before S1 of the next cycle (diastolic murmurs), or continuously throughout the cycle (continuous murmurs). The intensity, pitch, and timing of these sounds provide critical diagnostic clues to clinicians. While some murmurs are incidental findings in otherwise healthy individuals, often referred to as **innocent murmurs**, others signal significant structural or functional abnormalities that necessitate further investigation and potential intervention.

The distinction between innocent and pathological murmurs is paramount. An innocent murmur is a benign physiological phenomenon, typically heard in children and young adults, and does not indicate any underlying heart condition. These murmurs often change with body position or respiration and are usually soft. Pathological murmurs, however, are indicative of an underlying heart problem, such as valvular disease, congenital heart defects, or other cardiac issues. The presence of a new murmur, or one associated with symptoms, always warrants thorough medical evaluation to rule out serious cardiac pathology.

2. Etymology and Historical Development

The concept of listening to internal body sounds, known as **auscultation**, has roots in ancient medicine, but its systematic application to cardiology began in the early 19th century. The term "murmur" itself, derived from the Latin "murmurare" meaning "to mutter, grumble, or roar," aptly describes the characteristic sound. Before the advent of modern imaging, auscultation was the primary diagnostic tool for identifying heart conditions. Early physicians would often place their ear directly on the patient's chest to listen to heart sounds.

A pivotal moment in the history of auscultation was the invention of the **stethoscope** by René Laennec in 1816. Laennec's innovation revolutionized medical diagnostics, allowing physicians to hear internal body sounds, including heart murmurs, with unprecedented clarity and without direct physical contact. He meticulously described various heart and lung sounds, correlating them with post-mortem findings, thereby laying the groundwork for clinical cardiology. Laennec's work, documented in his 1819 treatise "De l'Auscultation Médiante," provided the first comprehensive classification of heart murmurs, linking specific sounds to particular cardiac pathologies.

Throughout the 19th and 20th centuries, the understanding and classification of heart murmurs continued to evolve. Pioneers like Jean-Baptiste Bouillaud, a contemporary of Laennec, and later clinicians refined the art of auscultation, developing systematic approaches to describe murmur characteristics such as timing, intensity, pitch, and radiation. The development of advanced cardiac imaging technologies, particularly **echocardiography** in the mid-20th century, significantly augmented the diagnostic capabilities, allowing for direct visualization of the heart's structure and function. While imaging has become indispensable, auscultation remains a fundamental and cost-effective initial screening tool, often guiding the decision for further diagnostic studies.

3. Physiological Basis of Murmur Generation

Heart murmurs originate from the principle of **turbulent blood flow**. In a healthy cardiovascular system, blood flows smoothly in a laminar fashion, meaning it moves in parallel layers without significant mixing. However, when certain conditions disrupt this smooth flow, blood particles begin to move chaotically, creating vibrations that are transmitted to the chest wall and perceived as murmurs. Several factors can contribute to the development of turbulent flow and, consequently, heart murmurs.

One primary mechanism involves alterations in the structure or function of the heart valves. If a valve is narrowed (**stenotic**), blood must accelerate through a smaller opening, leading to high-velocity, turbulent jets. Conversely, if a valve does not close completely (**regurgitation** or insufficiency), blood leaks backward against the normal flow, also generating turbulence. These valvular abnormalities are common causes of pathological murmurs. For example, a stenotic aortic valve can cause a harsh systolic ejection murmur as blood is forced through the narrowed opening into the aorta. Mitral regurgitation, where the mitral valve fails to close completely during systole, results in a characteristic holosystolic murmur as blood flows backward into the left atrium.

Beyond valvular issues, other structural abnormalities can induce turbulent flow. **Septal defects**, such as ventricular septal defects (VSDs) or atrial septal defects (ASDs), create abnormal shunts where blood flows directly between cardiac chambers that should be separate, leading to turbulence and murmurs. Changes in blood viscosity (e.g., anemia), increased cardiac output (e.g., fever, hyperthyroidism, pregnancy), or abnormal vessel morphology (e.g., coarctation of the aorta)

can also lead to increased flow velocity or obstruction, resulting in physiological or pathological murmurs. The specific characteristics of a murmur--its timing, location, intensity, and quality--are direct reflections of the underlying hemodynamic disturbance.

4. Classification and Characteristics of Heart Murmurs

Heart murmurs are systematically classified based on several key characteristics, providing a comprehensive description that aids in diagnosis. These characteristics include timing, intensity, pitch, quality, location of maximal intensity, radiation, and response to dynamic maneuvers. The precise identification of these features is essential for differentiating between various cardiac conditions and distinguishing innocent from pathological murmurs.

The **timing** of a murmur within the cardiac cycle is perhaps the most fundamental classification:

Systolic Murmurs: Occur between S1 and S2. These are further divided into:

Ejection Murmurs: Begin after S1, crescendo to a peak, and then decrescendo before S2. Often caused by blood flow through stenotic semilunar valves (e.g., aortic stenosis, pulmonary stenosis) or increased flow across normal valves.

Holosystolic (Pansystolic) Murmurs: Begin with S1 and extend throughout systole to S2 with a constant intensity. Indicative of conditions like mitral regurgitation, tricuspid regurgitation, or ventricular septal defect (VSD).

Mid-systolic Murmurs: Occur in the middle of systole, typically associated with innocent murmurs or conditions like hypertrophic cardiomyopathy.

Diastolic Murmurs: Occur between S2 and S1 of the next cycle. These are always pathological and typically indicate valvular regurgitation of the semilunar valves or stenosis of the atrioventricular valves.

Early Diastolic Murmurs: Begin immediately after S2 and decrescendo. Often caused by aortic regurgitation or pulmonary regurgitation.

Mid-Diastolic Murmurs: Occur in mid-diastole, often with a low pitch. Caused by mitral stenosis or tricuspid stenosis, indicating turbulent flow across stenotic atrioventricular valves.

Pre-systolic Murmurs: Occur just before S1, typically a crescendo sound. Associated with mitral or tricuspid stenosis, reflecting atrial contraction forcing blood through a narrowed valve.

Continuous Murmurs: Heard throughout both systole and diastole without interruption. These are always pathological and are typically caused by shunts between high-pressure and low-pressure vessels, such as patent ductus arteriosus (PDA) or arteriovenous fistulas.

The **intensity** (loudness) of a murmur is graded on a scale of I to VI:

Grade I: Very faint, heard only with careful listening.

Grade II: Faint, but immediately audible.

Grade III: Moderately loud, without thrill (palpable vibration).

Grade IV: Loud, with a palpable thrill.

Grade V: Very loud, heard with stethoscope partially off the chest, with thrill.

Grade VI: Extremely loud, heard with stethoscope entirely off the chest, with thrill.

Other characteristics include **pitch** (high, medium, low), **quality** (blowing, harsh, musical, rumbling), **location of maximal intensity** (where it is heard loudest on the chest, corresponding to the valve or defect site), and **radiation** (where the sound transmits, e.g., to the neck for aortic stenosis or axilla for mitral regurgitation). Additionally, observing how a murmur changes with various **dynamic maneuvers** (e.g., Valsalva maneuver, standing, squatting, handgrip) can provide further diagnostic information, as these maneuvers alter cardiac preload, afterload, or contractility, thereby modifying the murmur's characteristics.

5. Causes of Pathological Heart Murmurs

Pathological heart murmurs arise from a variety of structural or functional abnormalities within the cardiovascular system, indicating an underlying medical condition that often requires intervention. These causes can be broadly categorized into valvular heart disease, congenital heart defects, and other less common conditions that lead to turbulent blood flow. Differentiating among these causes is critical for appropriate diagnosis and management.

Valvular heart disease is one of the most common causes of pathological murmurs. This category includes both valvular stenosis and valvular regurgitation.

Valvular Stenosis: Occurs when a heart valve opening is narrowed, restricting blood flow. Examples include:

Aortic Stenosis: Narrowing of the aortic valve, often causing a harsh, crescendo-decrescendo systolic ejection murmur best heard at the right upper sternal border, radiating to the neck.

Pulmonary Stenosis: Narrowing of the pulmonary valve, producing a systolic ejection murmur heard at the left upper sternal border.

Mitral Stenosis: Narrowing of the mitral valve, typically causing a low-pitched, mid-diastolic rumble best heard at the apex.

Tricuspid Stenosis: Narrowing of the tricuspid valve, leading to a mid-diastolic rumble heard at the left lower sternal border.

Valvular Regurgitation (Insufficiency): Occurs when a heart valve does not close completely, allowing blood to leak backward. Examples include:

Aortic Regurgitation: Incomplete closure of the aortic valve, causing an early diastolic decrescendo murmur best heard at the left sternal border.

Pulmonary Regurgitation: Incomplete closure of the pulmonary valve, resulting in a diastolic murmur heard at the left upper sternal border.

Mitral Regurgitation: Incomplete closure of the mitral valve, producing a holosystolic murmur radiating to the axilla.

Tricuspid Regurgitation: Incomplete closure of the tricuspid valve, leading to a holosystolic murmur best heard at the left lower sternal border.

Congenital heart defects are structural problems present at birth that can significantly alter blood flow dynamics and generate murmurs. These include:

Ventricular Septal Defect (VSD): A hole in the wall separating the two lower chambers of the heart, causing a loud, holosystolic murmur at the left lower sternal border.

Atrial Septal Defect (ASD): A hole in the wall separating the two upper chambers, often leading to a wide, fixed splitting of S2 and a systolic ejection murmur at the left upper sternal border due to increased flow across the pulmonary valve.

Patent Ductus Arteriosus (PDA): A persistent opening between the aorta and pulmonary artery, producing a characteristic "machinery-like" continuous murmur best heard at the left upper sternal border.

Coarctation of the Aorta: A narrowing of the aorta, which can produce a systolic murmur heard over the back or left infraclavicular area.

Other causes of pathological murmurs include **hypertrophic cardiomyopathy**, where thickening of the heart muscle can obstruct blood flow and cause a systolic ejection murmur that increases with the Valsalva maneuver, and conditions that lead to hyperdynamic states such as severe anemia, hyperthyroidism, or pregnancy, which can sometimes produce physiological murmurs that may mimic pathological ones due to increased blood flow velocity. Infective endocarditis, an infection of the heart valves, can also cause new or changing murmurs due to damage to the valve leaflets.

6. Associated Symptoms and Clinical Presentation

While innocent heart murmurs are typically asymptomatic, pathological murmurs are often accompanied by a range of symptoms that reflect the underlying cardiac dysfunction. The severity and type of symptoms depend heavily on the specific heart condition causing the murmur, its extent, and the duration of the disease. Recognizing these symptoms is crucial, as they often prompt further diagnostic evaluation beyond initial auscultation.

According to the provided source content, an abnormal heart murmur may be associated with several key symptoms, which warrant immediate medical attention. These include **chest pain**, which can indicate myocardial ischemia or severe valvular disease; **dizziness** and **fainting (syncope)**, suggesting reduced cerebral perfusion often due to decreased cardiac output or arrhythmias; and visible signs of poor oxygenation such as **bluish skin, nails, and lips (cyanosis)**, which is particularly concerning for congenital heart defects with significant shunting.

Furthermore, symptoms related to heart failure or fluid overload can present, including **swelling (edema)** in the legs, ankles, or abdomen due to fluid retention; a **persistent cough**, particularly when lying down, indicative of pulmonary congestion; and **enlarged veins in the neck (jugular venous distension)**, signaling elevated right atrial pressure. Other systemic symptoms may include a **poor appetite** and significant **heavy sweating even with minimal or no exertion**, both of which can reflect the increased metabolic demand and systemic impact of chronic cardiac strain. In infants and children, poor feeding, failure to thrive, and rapid breathing can be crucial indicators of a pathological murmur. The presence of any of these symptoms alongside a newly detected or changing heart murmur necessitates a comprehensive cardiac workup.

7. Diagnostic Approaches and Tools

The diagnostic process for heart murmurs begins with a thorough clinical history and physical examination, where auscultation plays a central role. However, confirming the nature and cause of a murmur often requires a combination of non-invasive and, in some cases, invasive diagnostic tools. The goal is to accurately identify whether the murmur is innocent or pathological, and if pathological, to pinpoint the specific underlying cardiac anomaly.

After initial auscultation, several diagnostic tests may be employed:

Echocardiography: This is the most crucial non-invasive test for evaluating heart murmurs. An echocardiogram uses ultrasound waves to produce detailed images of the heart's structure, including the chambers, valves, and great vessels. It can directly visualize valvular stenosis or regurgitation, septal defects, chamber enlargement, and abnormalities in myocardial function. Doppler echocardiography specifically assesses blood flow velocity and direction, quantifying the severity of valvular lesions or shunts. Both transthoracic echocardiography (TTE) and transesophageal echocardiography (TEE) offer different perspectives and levels of detail.

Electrocardiogram (ECG): An ECG records the electrical activity of the heart. While it does not directly visualize murmurs, it can reveal signs of chamber enlargement, hypertrophy, arrhythmias, or myocardial ischemia, which are often associated with conditions causing pathological murmurs. For example, left ventricular hypertrophy on an ECG might support a diagnosis of severe aortic stenosis.

Chest X-ray: A chest X-ray provides an image of the heart and lungs. It can show signs of cardiomegaly (enlarged heart), pulmonary congestion, or specific cardiac chamber enlargement that may suggest underlying valvular disease or congenital defects. It is particularly useful in assessing the impact of a heart condition on the lungs.

Cardiac Catheterization: This is an invasive procedure typically reserved for cases where non-invasive tests are inconclusive or when precise hemodynamic measurements are required before surgical intervention. During cardiac catheterization, a thin, flexible tube is inserted into a blood vessel and guided to the heart, allowing for direct measurement of pressures within the heart chambers and great vessels, assessment of blood flow, and visualization of coronary arteries. It can provide definitive diagnostic information on the severity of valvular lesions or shunts.

Cardiac MRI/CT: In certain complex cases, Cardiac Magnetic Resonance Imaging (MRI) or Computed Tomography (CT) can provide highly detailed anatomical and functional information, especially for congenital heart disease, complex valvular lesions, or evaluation of the great vessels.

The choice of diagnostic tests is guided by the patient's symptoms, the characteristics of the murmur, and the initial clinical suspicion. For innocent murmurs, reassurance and follow-up may be sufficient. For pathological murmurs, the diagnostic workup aims to precisely identify the etiology and severity, guiding subsequent management strategies.

8. Clinical Significance and Management

The clinical significance of a heart murmur lies in its potential to be the earliest audible sign of significant cardiovascular disease. While innocent murmurs require no specific treatment, pathological murmurs demand careful evaluation and often specific management to prevent progression of heart damage, alleviate symptoms, and improve patient outcomes. The management strategy is highly individualized, depending on the underlying cause, severity, and the patient's overall health status.

For conditions causing pathological murmurs, such as valvular heart disease or congenital heart defects, management can range from watchful waiting and medical therapy to interventional procedures and surgery.

Medical Management: Medications are often used to manage symptoms, slow disease progression, or treat associated conditions. For example, diuretics may be prescribed for fluid retention associated with heart failure, vasodilators to reduce the workload on the heart, or anticoagulants to prevent blood clots in conditions like atrial fibrillation complicating valvular disease. Regular monitoring, including serial echocardiograms, is essential to track disease progression.

Interventional Procedures: Less invasive procedures can sometimes repair or replace damaged heart valves or close septal defects. Examples include percutaneous balloon valvuloplasty for stenotic valves or transcatheter aortic valve replacement (TAVR) for severe aortic stenosis in select patients. Device closure can be used for certain septal defects.

Surgical Intervention: For severe valvular heart disease that causes significant symptoms or progressive heart dysfunction, surgical repair or replacement of the affected valve(s) may be necessary. Similarly, complex congenital heart defects often require surgical correction. Advances in cardiac surgery have significantly improved the prognosis for many of these conditions.

The impact of timely diagnosis and appropriate management of pathological murmurs is profound. Early identification of conditions like severe valvular disease or congenital heart defects can prevent irreversible cardiac damage, improve quality of life, and extend life expectancy. Regular follow-up with a cardiologist is crucial for individuals with known pathological murmurs, even after intervention, to monitor for recurrence, progression, or new complications. Education of patients regarding their condition and recognition of warning signs of worsening symptoms also forms a vital part of comprehensive management.

9. Debates and Challenges in Auscultation

Despite its historical significance and ongoing utility, auscultation of heart murmurs is not without its challenges and limitations, sparking ongoing debates in clinical practice. The primary challenges revolve around the subjective nature of auscultation, inter-observer variability, and the increasing reliance on advanced imaging technologies. While the stethoscope remains a powerful screening tool, its diagnostic accuracy can be influenced by numerous factors.

One significant challenge is the **subjectivity and skill dependency** of auscultation. Interpreting heart sounds and murmurs accurately requires considerable experience and a finely tuned auditory perception. The quality of a murmur can be influenced by factors such as the patient's body habitus, lung sounds, and environmental noise, making consistent detection and characterization difficult. Studies have shown significant **inter-observer variability** in the detection and grading of murmurs, even among experienced clinicians, leading to potential misdiagnosis or delayed diagnosis of serious conditions, or conversely, unnecessary referrals for innocent murmurs. This variability underscores the need for continuous training and standardization in auscultation techniques.

The advent of highly accurate **imaging technologies**, particularly echocardiography, has led to debates about the diminishing role of auscultation. While echocardiography provides objective, detailed anatomical and functional information that often confirms or refutes auscultatory findings, it is more expensive and less accessible for initial screening. The challenge lies in striking a balance: using auscultation as an effective, low-cost screening tool while acknowledging its limitations and

appropriately employing advanced imaging when indicated. There's also the risk of ****over-investigation**** of innocent murmurs, leading to patient anxiety and increased healthcare costs, versus the risk of ****under-diagnosis**** of a subtle, yet significant, pathological murmur. Digital stethoscopes and AI-assisted auscultation are emerging technologies that aim to reduce subjectivity and improve diagnostic accuracy, potentially bridging the gap between traditional auscultation and advanced imaging.

Further Reading

[Heart Murmur - Wikipedia](#)

[Heart murmurs - Mayo Clinic](#)

[Auscultation of Heart Sounds and Murmurs - Circulation AHA](#)

[Physiology, Murmurs - StatPearls - NCBI Bookshelf](#)

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