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Learning Series - #36

Echocardiograms: uses, measurements and their significance

Echocardiography is a non-invasive ultrasound technique that provides detailed, real-time images of the heart's **structure and function**, allowing for the assessment of heart chambers, valves, and blood flow. This essential diagnostic tool enhances cardiac evaluation without the use of radiation, making it safe and effective for monitoring various heart conditions.

Echocardiogram types

Echocardiogram types	Purpose	Parameters assessed
Resting Echocardiogram (Standard TTE)	Establishes baseline under resting conditions	• Ejection Fraction (EF) • Valve structure and function • Left ventricular hypertrophy (LVH) • Old myocardial infarction (MI) • Wall motion • Pericardium • Chamber size • Blood flow patterns • Pulmonary artery pressure
Stress Echocardiogram	Evaluates the heart's response to stress (exercise or medication)	• All parameters from Resting Echocardiogram • Ischemia detection • Transient ischemic dilation of the left ventricle • Stress-induced wall motion abnormalities
Transesophageal Echocardiogram (TEE)	Provides clearer images of heart structures, especially posterior structures	• All parameters from Resting Echocardiogram • Detailed images of valves • Atrial appendage assessment • Aorta evaluation • Blood clot detection

Note:
The Stress Echocardiogram builds upon the Resting Echocardiogram by adding stress-induced imaging.

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Echocardiograms: uses, measurements and their significance (cont'd)

Additional Techniques: can be applied to enhance any of the main echocardiogram types.

Technique	Purpose	Parameters Assessed
Doppler Echocardiography	Measures blood flow through heart chambers and valves	Blood flow velocity, direction, and patterns
3D Echocardiography	Provides three-dimensional images of heart structures	Detailed assessment of valve anatomy, ventricular volumes, and complex congenital heart defects
Contrast Echocardiography	• Improves image quality in challenging cases (e.g., obesity, lung disease) • Key uses: detecting apical thrombus, defining endocardium, assessing myocardial perfusion • Enhances detection of ischemia and infarction via myocardial contrast opacification • Essential when standard echo interpretation is limited by poor image quality	Improved endocardial border definition, assessment of myocardial perfusion

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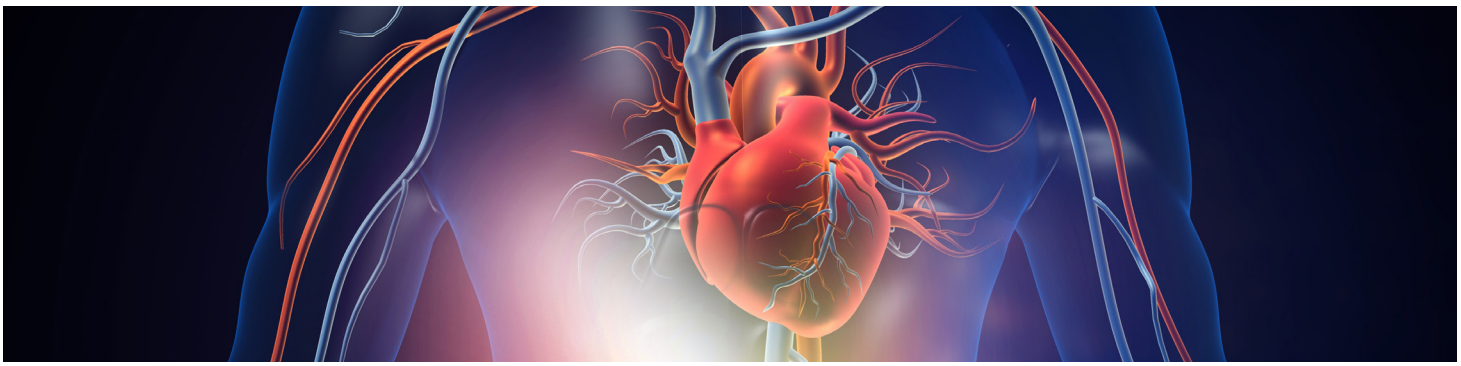
Echocardiograms: uses, measurements and their significance (cont'd)

Echocardiogram report sections

Echocardiogram Report Section	Technical Details	Key Parameters Assessed
Two-dimensional (2D) Study	Real-time moving images of the heart	• Cardiac chamber size and shape • Wall thickness and motion • Valve structure and function • Ejection fraction • Pericardial assessment
Doppler Study	Ultrasound waves to measure blood flow	• Blood flow velocity and direction • Valve function (regurgitation, stenosis) • Pressure gradients across valves • Intracardiac pressures (estimated) • Diastolic function assessment
Color Flow Doppler	Color-coded visualization of blood flow	• Visual representation of blood flow patterns • Identification of abnormal flows (e.g., regurgitation, shunts)
Spectral Doppler	Graphical representation of blood flow velocities	• Quantitative measurement of blood flow velocities • Assessment of filling patterns and diastolic function

Notes:
- The **2D study** provides the structural assessment of the heart.
- **Doppler studies** (including Color Flow and Spectral) offer functional assessments of blood flow and pressures.
- These sections together provide a comprehensive evaluation of cardiac **structure and function**.



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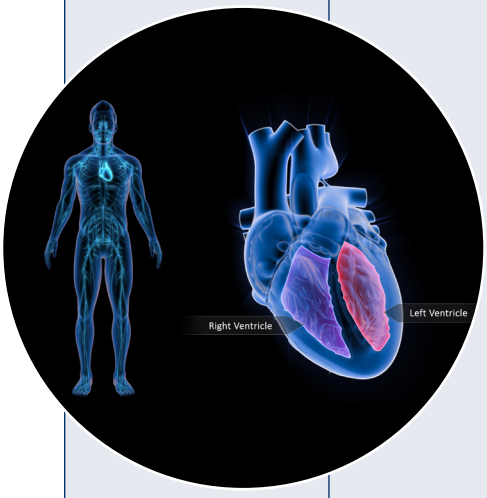
Echocardiograms: uses, measurements and their significance (cont'd)

What is Left Ventricular Ejection Fraction (LVEF)?

- a percentage measure representing the blood ejected from the **left ventricle** (**LV**) to the body with each heartbeat. Serves as the primary indicator of the LV's systolic function.

Echocardiographic assessment: Structural and Functional evaluations with clinical Implications

Component	Evaluation	Abnormalities, causes and clinical implications
Left Ventricle (LV)	Size, wall thickness, and overall pumping efficiency	**Reduced Ejection Fraction (EF <50%):** Causes: Heart attack, Cardiomyopathy, Hypertension, Aortic stenosis, Chronic valve regurgitation Clinical Implications: Heart failure, Risk of sudden cardiac arrest, Impaired cardiac output **Hypertrophy:** Causes: Hypertension, Aortic stenosis Clinical Implications: Increased cardiac workload, Risk of heart failure **Dilation:** Causes: Volume overload conditions Clinical Implications: Heart failure, Reduced exercise capacity
Systolic Function 	Contractile ability	**Reduced LVEF:** Causes: Coronary artery disease, Cardiomyopathies, Valvular heart disease, Hypertension Clinical Implications: Heart failure, Increased mortality risk **Regional wall motion abnormalities:** Causes: Coronary artery disease, Myocardial infarction Clinical Implications: Impaired cardiac function **Reduced global longitudinal strain (GLS):** Causes: Coronary artery disease, Cardiomyopathies Clinical Implications: Heart failure risk *GLS is a sensitive marker for subclinical LV dysfunction, especially in conditions like diabetes, hypertension, or chemotherapy-induced cardiotoxicity. A GLS value >-16% is abnormal and suggests early myocardial dysfunction even when LVEF appears normal **LV enlargement:** Causes: Coronary artery disease, Cardiomyopathies Clinical Implications: Heart failure risk **Thinning of myocardial walls:** Causes: Coronary artery disease, Cardiomyopathies Clinical Implications: Increased heart failure risk

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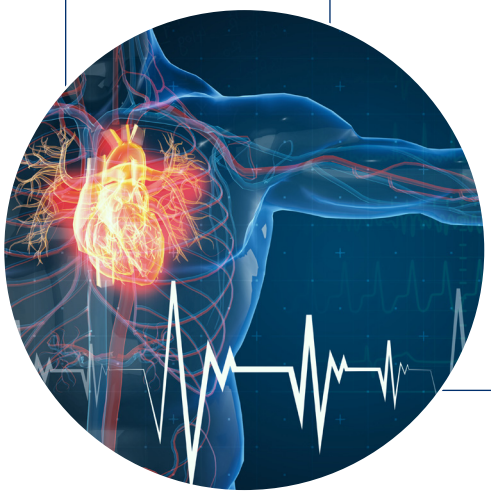
Echocardiograms: uses, measurements and their significance (cont'd)

Component	Evaluation	Abnormalities, causes and clinical implications
Diastolic Function	Relaxation ability graded as Normal or one of three degrees of dysfunction (Grade I, II, III)	**GRADING OF DIASTOLIC DYSFUNCTION** **Grade I (mild): Impaired relaxation.** Causes: Hypertension, coronary artery disease, aging Clinical Implications: Exercise intolerance, E/A ratio <1, prolonged deceleration time (>200 ms) **Grade II (moderate): Pseudo-normal filling.** Causes: Hypertension, coronary artery disease Clinical Implications: Elevated left atrial pressures, normal-appearing E/A ratio (0.8-1.5), normal deceleration time (160-200 ms) **Grade III (severe): Restrictive filling (reversible)** Causes: Hypertension, restrictive cardiomyopathy Clinical Implications: Significantly elevated left atrial pressures, E/A ratio >2.0, shortened deceleration time (<160 ms) **Grade IV (fixed restrictive):** Causes: End-stage heart failure, advanced restrictive cardiomyopathies (e.g., amyloid cardiomyopathy) Clinical Implications: Very elevated left atrial pressures, poor prognosis, E/A ratio >2.0, no change with Valsalva maneuver **ADDITIONAL PARAMETERS** **Abnormal E/A ratio:** Causes: Hypertension, coronary artery disease, aging Clinical Implications: Indicator of diastolic dysfunction, varies by grade of dysfunction **Altered deceleration time:** Causes: Hypertension, coronary artery disease Clinical Implications: Reflects changes in left ventricular compliance and filling pressures **Prolonged isovolumetric relaxation time:** Cause: Hypertension, impaired left ventricular relaxation Clinical Implications: Indicator of diastolic dysfunction, typically >80–100 ms in Grade I dysfunction; This is assessed using Doppler methods and reflects delayed left ventricular relaxation associated with early diastolic dysfunction



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Echocardiograms: uses, measurements and their significance (cont'd)

Component	Evaluation	Abnormalities, causes and clinical implications
Right Ventricle (RV)	Size and function	**Hypertrophy:** Causes: Pulmonary hypertension, Congenital heart defects, Tricuspid regurgitation Clinical Implications: Right-sided heart failure and impaired pulmonary circulation **Dilation:** Causes: Volume overload due to pulmonary conditions Clinical Implications: Right-sided heart failure and impaired pulmonary circulation
Left Atrium	Size	**Enlargement:** Causes: Mitral valve disease, Atrial fibrillation, Hypertension, Diastolic dysfunction Clinical Implications: Increased risk of atrial fibrillation and thromboembolic events
Right Atrium	Size	**Enlargement:** Causes: Tricuspid valve disease, Pulmonary hypertension, Right ventricular dysfunction, Chronic pulmonary disease, Congenital heart defects Clinical Implications: Right heart strain and impaired venous return
Valves (Aortic, Mitral, Tricuspid, Pulmonic)	Valve structure and function	**Stenosis:** Causes: Calcification, Rheumatic heart disease, Congenital defects Clinical Implications: Altered hemodynamics and heart failure; increased risk of endocarditis **Regurgitation:** Causes: Endocarditis, Prolapse Clinical Implications: Altered hemodynamics and heart failure; increased risk of endocarditis **Prolapse:** Causes: Congenital defects Clinical Implications: Altered hemodynamics and potential arrhythmias ***Prosthetic valves** Echocardiography evaluates parameters such as effective orifice area (EOA), peak/mean gradients, and Doppler velocity index (DVI). Abnormal findings, such as elevated gradients or reduced EOA, may indicate prosthesis-patient mismatch or structural valve deterioration. **Vegetation (endocarditis):** Causes: Infection leading to vegetations on valves Clinical Implications: Increased risk of stroke if untreated **Calcification:** Causes: Age-related changes Clinical Implications: Increased risk of stenosis and impaired valve function

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Echocardiograms: uses, measurements and their significance (cont'd)

Component	Evaluation	Abnormalities, causes and clinical implications
Aorta	Dimensions of aortic root and ascending aorta	**Enlargement:** Causes: Marfan syndrome, Hypertension, Bicuspid aortic valve Clinical Implications: Risk of aortic dissection or rupture **Aneurysm:** Causes: Atherosclerosis, Genetic conditions Clinical Implications: Risk of rupture and life-threatening complications **Dissection:** Causes: Hypertension, Connective tissue disorders Clinical Implications: Life-threatening emergency requiring immediate intervention **Coarctation:** Causes: Congenital heart defect Clinical Implications: Can lead to hypertension and heart failure if untreated **Atherosclerotic plaque:** Causes: Age-related vascular changes Clinical Implications: Risk of cardiovascular events such as myocardial infarction or stroke
Interatrial Septum	Checks for defects	**Atrial Septal Defects (ASD):** Causes: Congenital heart defects, Patent foramen ovale Clinical Implications: Right-to-left shunting; risk of paradoxical embolism and Eisenmenger syndrome
Interventricular Septum	Checks for defects	**Ventricular Septal Defects (VSD):** Causes: Congenital heart defects Clinical Implications: Left-to-right shunting; potential for pulmonary hypertension and heart failure
Pericardium	Effusions and other abnormalities	**Pericardial Effusion:** Causes: Infection, Cancer, Autoimmune diseases, Post-cardiac injury syndrome, Tuberculosis, Previous cardiac surgery, Radiation therapy. Clinical Implications: Cardiac tamponade; impaired diastolic filling. **Constrictive Pericarditis:** Causes: Infection, Cancer, Autoimmune diseases, Previous cardiac surgery. Clinical Implications: Cardiac tamponade; impaired diastolic filling. **Pericardial Thickening:** Causes: Infection, Cancer, Autoimmune diseases. Clinical Implications: Cardiac tamponade; impaired diastolic filling

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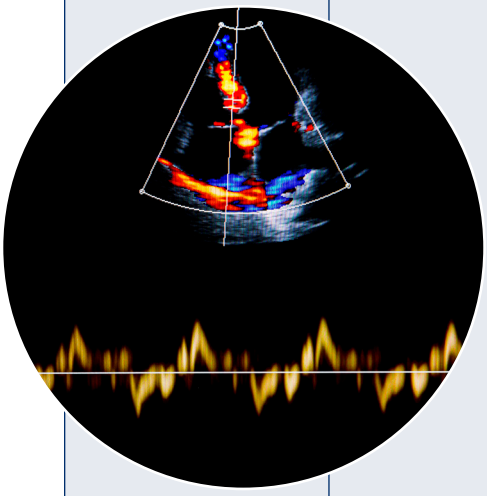
Echocardiograms: uses, measurements and their significance (cont'd)

Component	Evaluation	Abnormalities, causes and clinical implications
Wall Motion 	Motion	**Hypokinesia (Reduced contraction and thickening):** Causes: Coronary artery disease, Myocardial infarction, Cardiomyopathies, Myocarditis, Takotsubo cardiomyopathy, Cardiac tumors, Myocardial contusion, Cardiac sarcoidosis. Clinical Implications: Indicators of adverse cardiovascular events and death; impaired cardiac output. **Hyperkinesia (Increased wall thickening and systolic inward excursion)** Causes: Compensatory mechanism in non-infarcted areas, early stages of some cardiomyopathies Clinical Implications: May indicate presence of ischemia in other regions, potential positive prognostic indicator **Akinesia (Absence of contraction and thickening):** Causes: Coronary artery disease, Myocardial infarction. Clinical Implications: Indicators of adverse cardiovascular events and death; impaired cardiac output. **Dyskinesia (Paradoxical outward movement during systole):** Causes: Coronary artery disease, Myocardial infarction. Clinical Implications: Indicators of adverse cardiovascular events and death; impaired cardiac output. **Tardokinesis (Delayed excursion and thickening or post-systolic shortening)** Causes: Coronary artery disease. Clinical Implications: Indicators of adverse cardiovascular events and death; impaired cardiac output. **Paradoxical Septal Motion:** Causes: Coronary artery disease. Clinical Implications: Indicators of adverse cardiovascular events and death; impaired cardiac output. *The WMSI is calculated by dividing the sum of wall motion scores by the number of segments analyzed (typically 16 or 17). A higher WMSI indicates greater regional wall motion abnormalities, often linked to ischemia or myocardial infarction. A WMSI >1.7 is associated with higher mortality risk in acute coronary syndromes.
Pulmonary Artery Pressure	Pressure in pulmonary arteries	**Elevation:** Causes: Left-sided heart disease, Chronic lung diseases, Chronic thromboembolic disease, Connective tissue disorders. Clinical Implications: Pulmonary hypertension; right heart failure; reduced exercise capacity.

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Echocardiograms: uses, measurements and their significance (cont'd)

Underwriting considerations:

1. Echocardiogram findings are influenced by age, sex, and body size. Underwriters should consider:

A. Age-related changes:

- **Children/adolescents:** Measurements normalized to body surface area (BSA) and age using Z-scores to account for growth and development.
- **Adults:** Established reference ranges and BSA indexing used; age-related changes include increased wall thickness and reduced diastolic function.

B. Sex differences:

- **Men:** Larger chambers, thicker walls, higher coronary artery disease risk
- **Women:** Higher ejection fractions, more prone to mitral valve prolapse

C. Body size impact:

- **High BMI:** Increased left ventricular mass and wall thickness.
- **Low BMI:** Lower cardiac output and reduced muscle mass

2. Abnormal Stress echocardiogram results:

- **Resting Stage:**
  - Enlarged LV, reduced EF (~40%).
  - Resting wall motion abnormality
- **Exercise/Stress Stage:**
  - Inadequate HR/BP response
  - Chest pain or arrhythmias
  - New/worsening wall motion abnormalities
  - Decreased EF with stress.
  - Transient ischemic dilation (TID) of the LV
    - > is a marker of severe ischemia and suggests extensive coronary artery disease (CAD).
    - > It is often associated with poor perfusion across multiple vascular territories and should prompt further invasive or non-invasive evaluation for revascularization.

  For example, TID ratios >1.19 in stress echocardiography may correlate with multivessel CAD.
- **Immediate post-exercise:**
  - Slow HR/BP recovery
  - Persistent new wall motion abnormalities
- **Recovery Stage:**
  - Delayed return to baseline HR/BP
  - Persistent wall motion abnormalities

3. Left ventricular geometry:

- **Concentric Remodeling:**
  - Early indicator of cardiovascular disease and pressure overload.
  - Characterized by increased relative wall thickness (RWT) with normal LV mass index (LVMi).
- **Implications:**
  - Associated with higher cardiovascular risk, early hypertension, and potential reduction in LV volume and stroke volume.

4. Congestive heart failure with low EF: Watch for very high NT-proBNT or the drug **Entresto**.

5. Limitations: While echocardiography is a powerful diagnostic tool, its accuracy can be affected by poor acoustic windows (e.g., in obese patients), operator dependency, and interobserver variability. Advanced techniques like 3D echo or MRI may be required for certain structural abnormalities.

6. Key echocardiographic measurements: normal ranges and Case studies

NOTE:

1) The order below prioritizes the assessment of LVH, followed by LV size and function, and then LA assessment.
2) Indexing is not routinely applied to parameters like LVESD or RWT due to their established diagnostic thresholds independent of body surface area (BSA)

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Measurement	Normal Range	BSA Indexed Range	Case study
Left Ventricular Mass Index (LVMi)	M: 88-224 g F: 67-162 g	M: 49-115 g/m² F: 43-95 g/m²	55-year-old female, BSA 1.7 m² LV Mass: 180 g, LVMi: 106 g/m² Interpretation: LV hypertrophy
Interventricular Septal Thickness (IVSd)	0.6-1.1 cm	Not typically indexed	50-year-old female IVSd: 1.3 cm Interpretation: Septal hypertrophy
Left Ventricular Posterior Wall Thickness (LVPWd)	0.6-1.1 cm	Not typically indexed	65-year-old male LVPWd: 1.2 cm Interpretation: Mild posterior wall thickening
Left Ventricular End-Diastolic Diameter (LVEDD)	M: 4.2-5.9 cm F: 3.9-5.3 cm	2.2-3.1 cm/m² 2D Derived indexed normal range: • Normal: ≤30 mm/m² (both M & F) • Mildly dilated: 31-33 mm/m² • Moderately dilated: 34-36 mm/m² • Markedly dilated: > 37 mm/m²	60-year-old male, BSA 1.8 m² LVEDD: 6.5 cm, indexed: 3.6 cm/m² Interpretation: Moderately dilated LV (based on indexed value)
Left Ventricular End-Systolic Diameter (LVESD)	2.0-4.0 cm	Not typically indexed	55-year-old male; LVESD: 4.2 cm Interpretation: Mildly dilated LV in systole
Left Atrial Volume Index (LAVi)		16-34 mL/m²	65-year-old male, BSA 1.9 m² LA Volume: 76 mL, LAVi: 40 mL/m² Interpretation: LA enlargement
Left Atrial Diameter	M < 4.0 cm F < 3.8 cm	1.5-2.3 cm/m²	70-year-old male, BSA 2.0 m² LA Diameter: 4.2 cm, Indexed: 2.1 cm/m² Interpretation: LA enlargement
Right Atrial Volume Index (RAVi)		≤ 30 mL/m²	45-year-old female, BSA 1.6 m² RA Volume: 60 mL, RAVi: 37.5 mL/m² Interpretation: RA enlargement
Aortic Root Diameter	M < 4.0 cm F < 3.6 cm	1.4-2.1 cm/m² - indexed only for outliers not general population	50-year-old male, BSA 1.9 m² Aortic Root: 4.5 cm, Index: 2.37 cm/m² Interpretation: Aortic root dilation

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Echocardiograms: uses, measurements and their significance (cont'd)

Measurement	Normal Range	BSA Indexed Range	Case study
Relative Wall Thickness (RWT)	< 0.42	Not indexed	60-year-old female RWT: 0.45 Interpretation: Concentric remodeling of LV
Pulmonary Artery Systolic Pressure (PASP)	< 25 mmHg	Not indexed	55-year-old female, PASP: 40 mmHg Interpretation: Elevated, suggests pulmonary hypertension
Tricuspid Regurgitation Peak Velocity	< 2.8 m/s	Not indexed	60-year-old male, TR velocity: 3.5 m/s Interpretation: Elevated, indicates increased RV pressure
Right Ventricular Systolic Pressure (RVSP)	< 30 mmHg	Not indexed	50-year-old male, RVSP: 45 mmHg Interpretation: Elevated, suggests pulmonary hypertension
Right Ventricular Basal Diameter	M: 2.5-4.1 cm F: 2.1-3.5 cm	Not indexed	65-year-old female, RV basal diameter: 4.3 cm Interpretation: RV dilation
Inferior Vena Cava Diameter	< 2.1 cm	Not indexed	70-year-old male, IVC diameter: 2.5 cm Interpretation: Dilated IVC, suggests elevated RA pressure

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