

Week 2: Echo Windows, Standard Views & TEE

CVSG2280 Cardiovascular Registry Review by Dr. Alice Matthews

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Registry weight this week. View identification and image acquisition feed the **ARDMS RDCS** (Adult Echo V24.2) **Measurement Techniques & Views** domain (25% of the exam), with anatomy support from Anatomy/Physiology (15%). On the **CCI RCS** exam this week maps to **Domain B Echocardiographic Imaging** (24%) and **Domain D Anatomy/Physiology** (29%), together more than half the test. Roughly one in four registry items expects you to name a view, the structures it shows, or the right window for a given Doppler signal.

Note to students: Views and dimensions in this guide follow the [ASE 2015 Chamber Quantification](#) recommendations and the [ASE guideline library](#) standards for comprehensive TTE and TEE examination. **What last week's EOM gives you:** Week 1 built the chambers, pressures, valve areas, and the cardiac cycle; this week you learn where to put the probe to see each of those structures. Always defer to the protocol your clinical site follows.

At a Glance: this week in one box

Must-know numbers. Aortic root (sinuses) 2.1 to 3.5 cm; aortic annulus 1.8 to 2.6 cm; LVOT diameter 1.8 to 2.2 cm (PLAX, 2 to 3 mm proximal to valve). RV basal diameter ≤ 4.1 cm and RA area ≤ 18 cm² (A4C). TEE probe depth: incisors ≈ 20 cm (upper esophageal), 30 to 35 cm (mid-esophageal), 40+ cm (transgastric).

Formulas you will reuse. W2 carries almost no unique math; it sets up the *where*. LVOT diameter feeds the continuity equation (Week 4). IVS/LVPW wall-thickness ratio and FS come off PLAX M-mode (Weeks 6 to 7). TAPSE (≥ 1.7 cm) and FAC come off the apical/subcostal RV views.

Top 3 EOM traps. (1) Naming three *TEE-superior* pathologies (the 2504 cohort scored 0% here). (2) Mixing up TTE vs TEE contraindications. (3) Calling prolapse from an apical view instead of confirming in PLAX.

TTE Fundamentals: Windows, Probe Handling, and Artifact

Transthoracic echocardiography (TTE) images the heart from four acoustic windows: areas of the chest where ultrasound can reach the heart without passing through bone or air-filled lung. The four windows are **parasternal** (left sternal border, 3rd to 4th intercostal space), **apical** (over the palpable apical impulse), **subcostal** (below the xiphoid), and **suprasternal** (the sternal notch). You move between them by changing probe *position* (which window), *angulation* (where the beam points), and *rotation* (turning the probe to swap long axis for short axis).

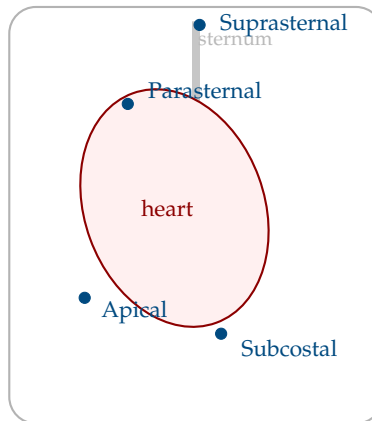
★ The **transducer index marker** orients the image: by convention it points to roughly the 1 to 2 o'clock position in PLAX (marker dot toward the patient's right shoulder) and is rotated 90° clockwise to the 3 to 4 o'clock position for PSAX. In the apical views the marker sits at the 3 to 4 o'clock position so the lateral wall lands on the right of the screen.

Three artifacts you must recognize. **Acoustic shadowing** is loss of signal *distal* to a strongly reflective structure (rib, calcified valve, mechanical prosthesis); it is the reason a mechanical mitral prosthesis hides the left atrium on TTE and drives you to TEE. **Acoustic dropout** is loss of signal where the beam runs parallel to a thin structure (the interatrial septum in the apical 4-chamber), which can mimic an ASD. **Foreshortening** is making a chamber look short and squat by cutting across it off-axis (the classic apical pitfall that fakes a small LV and false apical thickening).

Common Trap

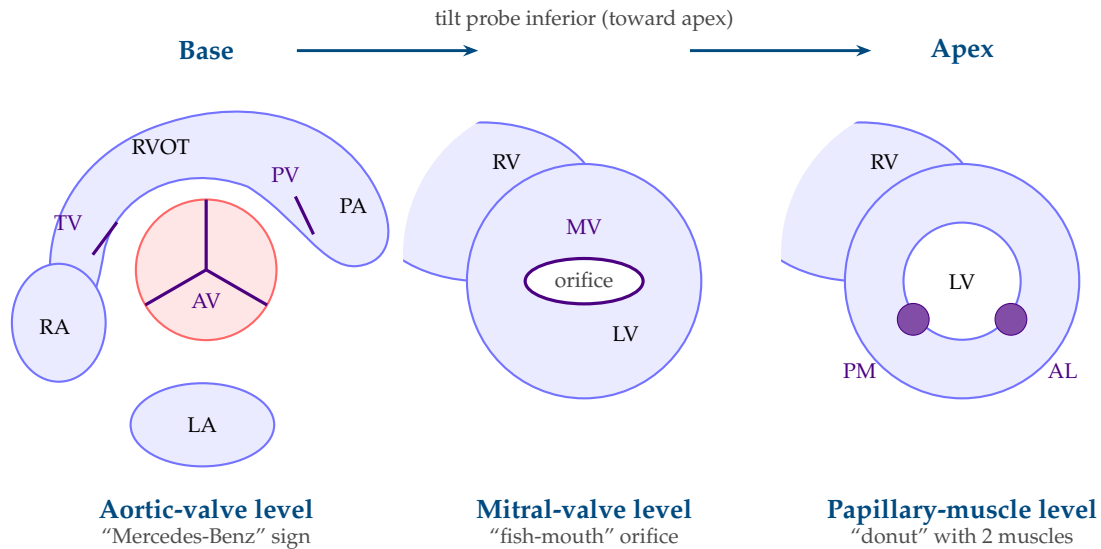
A student images the apical 4-chamber, sees an apparent gap in the mid interatrial septum, and reports a secundum ASD. **What is the error?**

The interatrial septum lies nearly *parallel* to the apical beam, so it drops out from the angle alone (this is dropout, not a defect). Confirm a true ASD in the **subcostal** view, where the septum is perpendicular to the beam, ideally with color or an agitated-saline study before calling a shunt.



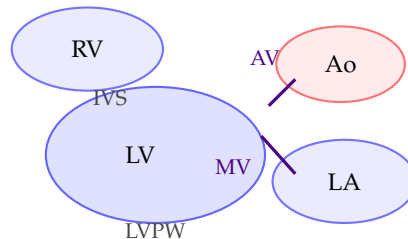
The four TTE acoustic windows. Each avoids rib and lung to reach the heart from a different angle.

Parasternal Long-Axis (PLAX) and Short-Axis (PSAX)



Parasternal short-axis (PSAX) sweep, base to apex. Aortic-valve level: the closed three-cusp aortic valve ("Mercedes-Benz" sign) ringed by RA, RVOT, pulmonary valve and PA, and LA. Mitral-valve level: the "fish-mouth" mitral orifice inside the round LV. Papillary-muscle level: the donut LV with the anterolateral (AL) and posteromedial (PM) papillary muscles and a crescent RV.

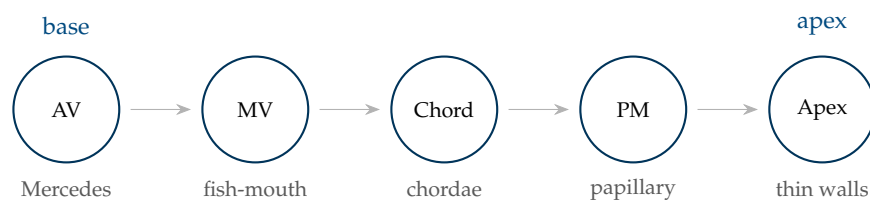
★ The **PLAX** is usually the first image of the study. It shows the LV, the mitral valve, the LVOT and aortic valve, the proximal aortic root, the LA, a slice of RV anteriorly, and the descending thoracic aorta in cross-section behind the LA. PLAX is where you measure LVOT diameter (2 to 3 mm proximal to the aortic valve, mid-systole, inner edge to inner edge), aortic root dimensions, and (by M-mode) the LV cavity and wall thickness. Two PLAX tilts give the right-heart variants: a medial/inferior tilt opens the **RV inflow** view (RA, RV, tricuspid valve) and a superior tilt opens the **RV outflow** view (RVOT, pulmonic valve, main PA).



Parasternal long-axis (PLAX) schematic: anterior RV, a large LV, with the aortic root (Ao) and left atrium (LA) posterior; the mitral valve (MV) lies between LV and LA and the aortic valve (AV) between LV and Ao. IVS = septum, LVPW = LV posterior wall.

★ Rotating the probe 90° clockwise from PLAX gives the **PSAX** stack: five short-axis cuts swept from base to apex by tilting the beam inferiorly (toward the apex) at a fixed window. From base to apex they are: **aortic-valve level** (the "Mercedes sign" of three AV cusps, with the tricuspid valve at 9 o'clock and the RVOT/pulmonic valve wrapping at 3 o'clock), **mitral-valve level** (the "fish-mouth" diastolic opening), **chordal level**, **papillary-muscle level** (anterolateral and posteromedial muscles at roughly 3 and 8 o'clock, the standard mid-LV cut for wall motion), and the **apical level** (thin walls, small cavity).

Memory hook: "All My Children Play Around" = Aortic valve, Mitral valve, Chordae, Papillary muscles, Apex (the base-to-apex PSAX sweep order).



PSAX five-cut progression: tilt the beam from base toward apex through five short-axis levels.

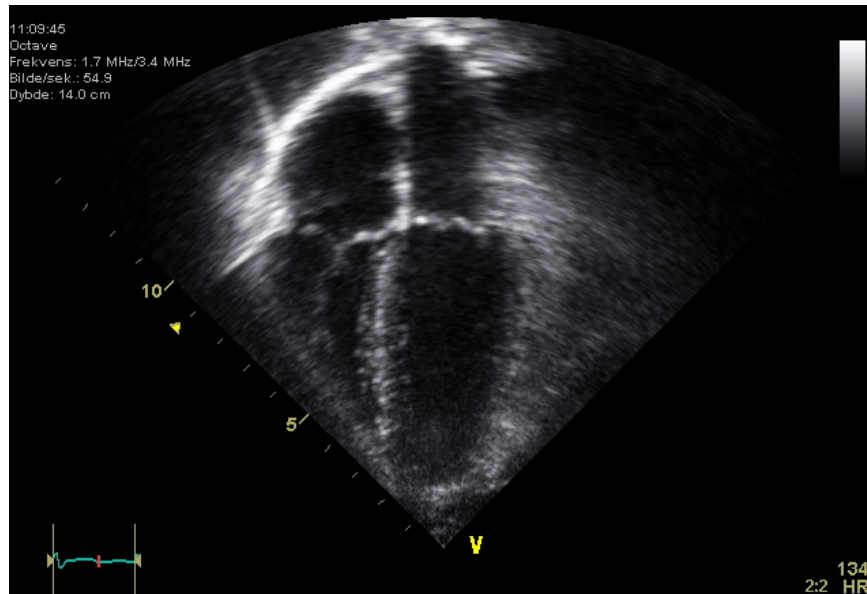
Common Trap

A short-axis cut at what the sonographer calls the "aortic valve level" shows only two cusps. The sonographer documents a bicuspid aortic valve. **What is the error?**

A *tangential*, off-axis PSAX flattens the third cusp and fakes a bicuspid valve. A true bicuspid call requires seeing the valve open in systole with only two commissures (a "fish-mouth" rather than the three-cusp Mercedes), confirmed across cardiac cycles and ideally with PLAX. Re-center the beam perpendicular to the aortic root before reporting cusp count.

Apical, Subcostal, and Suprasternal Views

★ The **apical 4-chamber (A4C)** displays all four chambers and both AV valves in one plane and is the workhorse for chamber size, LV function, septal assessment, and mitral/tricuspid Doppler. From A4C, counterclockwise rotation opens the **A2C** (LA and LV, inferior and anterior walls), then the **A3C / apical long-axis** (anterior wall, LVOT, aortic valve), and a slight anterior tilt off A4C brings in the aortic valve for the **A5C**, the best window for aligning CW Doppler with LV outflow and the aortic valve.



Apical 4-chamber view (shown apex-up): ventricles in the upper half (LV to the left of the septum, RV to the right), atria below (LA, RA), with the mitral and tricuspid valves at the central crux. The yellow marks are machine sector and focus indicators, not anatomical pointers. Image by Kjetil Lenes via

Wikimedia Commons, public domain.

The **subcostal** window is the rescue view: it sees all four chambers when parasternal and apical windows fail (obesity, COPD, ventilated or post-sternotomy patients) because the beam comes up through the liver. It is also the best view of the **interatrial septum** (perpendicular to the beam, so ASDs do not drop out) and the home of the **IVC view** for right atrial pressure estimation. The **suprasternal** window looks down onto the aortic arch and its branches and is where you sample arch flow, coarctation, and aortic-valve CW with a Pedoff probe when apical angles are poor.

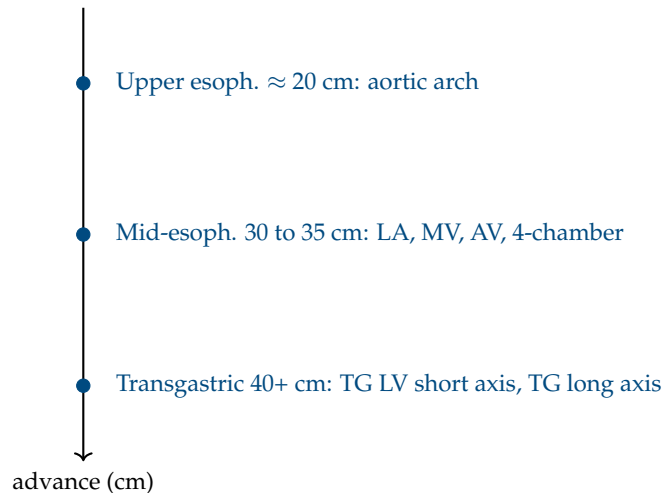
★ **IVC and RAP:** from the subcostal IVC view, an IVC ≤ 2.1 cm that collapses more than 50% with a sniff corresponds to a normal RAP of about **3 mmHg**; a dilated IVC (> 2.1 cm) that collapses less than 50% corresponds to roughly **15 mmHg**; intermediate findings are estimated at **8 mmHg**. This RAP value plugs straight into the RVSP equation you carry from Week 1.

Transesophageal Echocardiography (TEE)

TEE places a high-frequency (about 5 to 7 MHz) phased-array transducer on the tip of a flexible endoscope in the esophagus and stomach, immediately behind the left atrium. The higher frequency is possible precisely because

the esophageal window sits so close to the heart that little penetration is needed; trading penetration for frequency buys better axial resolution of the posterior structures. Because there is no rib, lung, or chest-wall fat between probe and heart, TEE gives superior resolution of those posterior structures: the left atrial appendage, interatrial septum, mitral apparatus, prosthetic valves, and the thoracic aorta. The probe is advanced and the imaging plane is electronically rotated from 0° to 180° to sweep through structures without moving the probe.

★ **Probe-depth landmarks (from the incisors): upper esophageal** $\approx$ 20 cm (aortic arch), **mid-esophageal** 30 to 35 cm (the LA, mitral and aortic valves, all four chambers), and **transgastric** 40+ cm, where the probe sits in the stomach looking up at the LV short axis and the transgastric long-axis used for deep CW alignment to the aortic valve.



TEE probe-depth scale. Deeper insertion images more inferior structures; the plane angle (0 to 180°) sweeps within each level.

Contraindications. The **absolute** contraindication is active upper-GI bleeding (and any perforated or unstable esophagus). **Relative** contraindications are esophageal varices, strictures, recent upper-GI surgery, cervical-spine instability, and severe dysphagia. TEE requires conscious sedation, NPO status, topical pharyngeal anesthesia, and monitoring; the serious complication rate (perforation, major bleed, aspiration) is low, on the order of a fraction of one percent.

Common Trap

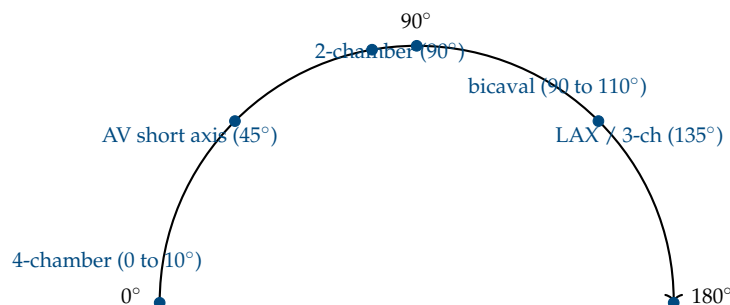
A patient with severe obesity and a mechanical aortic valve needs better images of a possible left-atrial thrombus. A student lists the patient's obesity as a contraindication to TEE. **What is the error?**

Obesity is a limitation of **TTE** (poor body-habitus windows), not a contraindication to **TEE**. TEE contraindications are *esophageal/upper-GI*: active GI bleed (absolute), varices, strictures, instability (relative). Obesity, COPD, ventilation, and post-sternotomy are exactly the situations where you escalate *to* TEE.

Memory hook: TEE blocks live in the esophagus; TTE blocks live in the chest wall. Esophageal pathology (bleed, varices, stricture) stops TEE; body habitus and air (obesity, COPD, ventilation, sternotomy) defeat TTE.

TEE Standard Views and Rotation Protocol

A complete TEE sweeps three levels. At the **mid-esophageal (ME)** level, advancing the plane angle gives the **4-chamber** (about 0 to 10°), the **AV short-axis** (45 to 60°; three cusps individually, ideal for endocarditis), the **2-chamber** (about 90°), the **bicaval** view (about 90 to 110°; SVC on the right, IVC on the left, RA, interatrial septum and fossa ovalis, the best shunt, PFO/ASD, and bubble-study view), and the **long-axis / 3-chamber** (120 to 135°; anterior wall, LVOT, aortic valve in long axis). At the **transgastric (TG)** level you get the basal, mid, and apical LV short-axis cuts and a TG long-axis. The **descending thoracic aorta** is imaged in long axis (0°) and short axis (90°), and the **upper-esophageal** level shows the aortic arch.



Mid-esophageal rotation protocol: the plane angle sweeps from 0° to 180° without moving the probe.

TEE-Superior Pathologies (drill these)

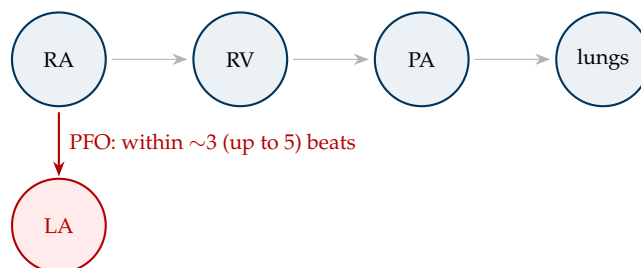
★ This is the single highest-yield W2 table and the historical pain point: in a prior cohort, *nobody* named three TEE-superior pathologies correctly. TEE beats TTE whenever the target is posterior, small, or hidden behind a shadowing prosthesis.

Pathology	Why TEE beats TTE	Key TEE finding
LAA thrombus	LA appendage is posterior; TTE cannot see behind the LA wall	Layered or mobile mass in the appendage; pre-cardioversion clearance in AF
Descending thoracic aortic dissection	TTE cannot reach the descending aorta	Intimal flap separating true and false lumens; best bedside / point-of-care test for the unstable patient (CT angiography is the overall first-line gold standard per 2022 ACC/AHA); excels for the descending aorta
Prosthetic valve dysfunction	Mechanical prosthesis shadows the LA/RA on TTE	Direct view of leaflets; pannus, thrombus, dehiscence
Paravalvular leak	Shadowing hides the sewing ring	Eccentric jet originating outside the native annulus
Sinus venosus ASD	Sits high on the septum near the SVC; TTE views are tangential	Direct interatrial septal defect with RA-to-LA flow
Vegetations / endocarditis	Small vegetations missed on TTE	Oscillating leaflet masses; perivalvular abscess
PFO	Better Valsalva and saline-timing control	Microbubbles crossing RA to LA within about 3 (up to 5) beats

Memory hook: "LAA, Aorta, Prosthetics, Paravalvular, Septum, Sepsis, Shunt" = the seven things you reach for TEE to see (the posterior/shadowed/small targets).

Agitated Saline (Bubble) Study

★ A bubble study detects right-to-left shunts. Agitate 9 mL saline with 1 mL air between two syringes, inject IV, and watch the right atrium opacify. **Normal:** bubbles fill the RA and RV and clear into the lungs; none reach the LA. **PFO / ASD (intracardiac shunt):** microbubbles appear in the **left atrium within about 3 (up to 5) beats** of RA opacification (early crossing). **Intrapulmonary (pulmonary arteriovenous) shunt:** microbubbles appear **later, after about 4 to 6 beats**, having traversed the lungs via the pulmonary veins. A **Valsalva** release transiently raises right-heart pressure and unmasks a probe-patent PFO that is silent at rest.



Normal path RA → RV → PA → lungs (bubbles trapped). Early bubbles in LA (within about 3, up to 5, beats) indicate an intracardiac shunt; later crossing (after about 4 to 6 beats) indicates an intrapulmonary shunt.

Common Trap

During a bubble study, microbubbles appear in the left atrium eight beats after the right atrium opacifies. A student reports a PFO. **What is the error?**

Timing matters. *Early* crossing (within about 3, up to 5, beats) indicates an **intracardiac** shunt (PFO/ASD). *Late* crossing (after about 4 to 6 beats) points to a **pulmonary** (intrapulmonary) arteriovenous shunt instead, because the bubbles had to traverse the lungs via the pulmonary veins. Report the timing, not just the presence of left-sided bubbles.

Implanted Devices and Artifacts

CCI Domain D now includes implanted cardiac hardware. Recognize the device, its leads, and the shadowing/reverberation artifacts it throws, and know what to assess.

- **ICD (implantable cardioverter-defibrillator):** senses and shocks ventricular tachycardia or fibrillation; bright linear lead echoes in the RA and RV with posterior shadowing. Confirm the RV lead seats in the apex.
- **Pacemaker (PPM):** paces for bradycardia or AV block; leads in RA and/or RV. For a dual-chamber device, confirm normal AV synchrony (mitral and tricuspid filling sequence).
- **LAA occluder (Watchman):** percutaneous LAA closure as an anticoagulation alternative in AF; an umbrella-shaped device at the appendage ostium seen on TEE. Assess full deployment and any residual peri-device leak jet.
- **ASD/PFO closure device (Amplatzer):** a double-disc spanning the atrial septum; color should show no residual shunt across the defect.
- **Mechanical circulatory support (LVAD, ECMO, total artificial heart):** bridge or destination therapy; assess native function in context, cannula position, and device thrombosis.

Common Trap

A bright linear echo with dense posterior shadowing crosses the right atrium on a study with an ICD. The student labels it a thrombus. **What is the error?**

That is the **lead artifact**: a pacing or defibrillator lead is strongly reflective and casts an acoustic shadow. Track the structure along its course into the RV apex and recognize the reverberation pattern before calling a mass; true lead thrombus is rare and looks like soft tissue adherent to the lead, not the bright line itself.

M-Mode Imaging

M-mode plots one scan line against time, giving the best temporal resolution of any echo mode, so it is still used for precise dimensions and timing. From a **PLAX** M-mode you measure LVIDd, LVIDs, IVS, and LVPW (and from those, fractional shortening). M-mode of the **mitral valve** shows systolic anterior motion (SAM) in HCM and the “B-notch” of elevated LV end-diastolic pressure in DCM; M-mode of the **aortic valve** shows the box-shaped opening and mid-systolic closure in some pathologies. The IVS/LVPW wall-thickness ratio from PLAX M-mode separates concentric from asymmetric hypertrophy and carries forward to the cardiomyopathy week.

Essential Formulas and Thresholds

W2 is anatomy-and-views, so it carries only the few measurements that *originate* in these windows and feed later math. No worked examples needed.

LVOT diameter (PLAX): $CSA_{LVOT} = \pi \left(\frac{d}{2}\right)^2$ where d is measured 2 to 3 mm proximal to the aortic valve, mid-systole, inner edge to inner edge (normal d 1.8 to 2.2 cm). Plain English: turn the outflow-tract diameter into a circle area. Clinical use: this CSA is the input to the continuity equation for aortic valve area in Week 4, so a small diameter error squares into a large area error.

Fractional shortening (PLAX M-mode): $FS = \frac{LVIDd - LVIDs}{LVIDd} \times 100\%$. Plain English: how much the cavity diameter shrinks each beat. Clinical use: a quick linear surrogate for systolic function from a single M-mode line (normal 25 to 45%); it assumes uniform contraction, so it misleads when wall motion is regional.

Wall-thickness ratio (PLAX M-mode): $\text{ratio} = \frac{IVSd}{LVPWd}$. Plain English: compares septal to posterior-wall thickness. Clinical use: a ratio ≥ 1.3 to 1.5 suggests asymmetric septal hypertrophy (HCM pattern) rather than the uniform thickening of pressure overload.

TAPSE (apical / subcostal, M-mode of the lateral tricuspid annulus): $TAPSE \geq 1.7 \text{ cm} = \text{normal RV systole}$. Plain English: how far the tricuspid annulus moves toward the apex in systole. Clinical use: a fast, load-tolerant marker of RV function used throughout the right-heart and pulmonary-hypertension weeks.

View Selection Cheat Sheet

Target / measurement	Best view	Probe / window
LVOT diameter, aortic root	PLAX	Parasternal
LV cavity, FS, wall thickness (M-mode)	PLAX	Parasternal
Aortic-valve cusp count (Mercedes)	PSAX aortic level	Parasternal
Mid-LV regional wall motion	PSAX papillary level	Parasternal
Four-chamber size and LV function	A4C	Apical
Aortic-valve CW Doppler / LVOT velocity	A5C	Apical
Mitral and tricuspid inflow Doppler	A4C	Apical
Interatrial septum / ASD, IVC and RAP	Subcostal	Subcostal
Aortic arch, coarctation	Suprasternal long axis	Suprasternal
LAA thrombus, descending-aorta dissection	TEE (bicaval, descending aorta)	Transesophageal
Prosthetic mitral valve, paravalvular leak	TEE mid-esophageal	Transesophageal

Glossary

- **Acoustic window** — chest area where the beam reaches the heart
- **Transducer marker** — index dot setting image orientation
- **Acoustic shadowing** — signal loss distal to a strong reflector
- **Acoustic dropout** — signal loss where the beam runs parallel
- **Foreshortening** — off-axis cut that shortens a chamber
- **Off-axis** — probe angle misaligned with the target
- **Long axis (LAX)** — view along a chamber's long dimension
- **Short axis (SAX)** — cross-sectional view (PSAX)
- **Mercedes sign** — three aortic cusps in PSAX
- **Fish-mouth** — diastolic mitral orifice in PSAX
- **A4C / A2C / A3C / A5C** — apical 4-, 2-, 3-, 5-chamber views
- **Subcostal** — subxiphoid window; septum, IVC, RAP
- **Suprasternal** — sternal-notch window for the arch
- **Bicaval** — TEE view of SVC and IVC; shunt detection
- **Mid-esophageal (ME)** — TEE 30 to 35 cm; LA, valves, 4-ch
- **Transgastric (TG)** — TEE 40+ cm; LV short axis
- **Intimal flap** — torn intima separating true from false lumen
- **True lumen** — original channel arising from the root
- **False lumen** — space distal to the flap; may rupture
- **LAA** — left atrial appendage; thrombus site in AF
- **Microbubbles** — agitated-saline contrast for shunts
- **Valsalva** — bearing down to unmask a PFO
- **TAPSE** — tricuspid annular plane systolic excursion
- **SAM** — systolic anterior motion of the mitral valve (HCM)

Registry Connection

This week feeds the **ARDMS RDCS Measurement Techniques & Views** subdomain (25%, second-largest on the Adult Echo exam) plus Anatomy/Physiology (15%); on the **CCI RCS** exam it maps to **Domain B Echocardiographic Imaging (24%)** and **Domain D Anatomy/Physiology (29%)**. **Item formats to expect:** labeled-image "name this view"; "which window best shows structure X" matching; "which is TEE-superior" multiple-response; TTE-vs-TEE contraindication discrimination; bubble-study timing. Drill the TEE-superior table and the view cheat sheet until they are automatic.

Carry forward into Week 3: these windows and probe angles are produced by the ultrasound physics of Week 3 (frequency, depth, focus, Nyquist, Doppler angle), which explains *why* each view looks the way it does.

Study smart. Scan with confidence.

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