Ultrasound Preconference

San Diego

2026

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ULTRASOUND RESOURCES & WEBSITES

Website	URL	Description
NephroPOCUS	*nephropocus.com*	Nephrology-focused POCUS. Excellent renal, cardiac, and volume assessment tutorials. Free videos and protocols.
CORE Ultrasound	*coreultrasound.com*	Comprehensive online resource for emergency medicine POCUS. High-quality videos, cases, and educational modules.
POCUS 101	*pocus101.com*	Beginner-friendly guides, protocols, and image galleries covering a wide range of POCUS applications. Great starting point.
Ultrasound Idiots	*ultrasoundidiots.com*	Fun, accessible POCUS education aimed at learners of all levels. Practical teaching with humor and clarity.
LITFL POCUS / Ultrasound Library	*litfl.com/ultrasound-library*	Life in the Fast Lane — extensive ultrasound image library, FAST, lung, and cardiac cases with detailed annotations.
ultrasound.guide	*ultrasound.guide*	Concise, protocol-driven POCUS reference. Clean interface, good for point-of-care quick review.
The POCUS Atlas	*thepocusatlas.com*	Large collection of labeled ultrasound images and videos covering pathology and normal anatomy. (Also has a free phone app
EMCrit RACC	*https://emcrit.org/subject/ultrasound*	Cutting-edge critical care and EM content. Deep-dive POCUS discussions and protocols.
Show me the POCUS	*https://www.showmethepocus.com/*	*Images, algorithms to help you in clinical practice, a Q bank and an image gallery. All open-source, evidence based and free.*

Probe Types & Frequencies

Probe Type	Frequency	Footprint	Depth	Clinical Uses
Phased Array (Cardiac)	1–5 MHz	Small	Up to 35 cm	Cardiac, lung (B-lines), FAST, IVC, eFAST
Curvilinear (Abdominal)	2–5 MHz	Large curved	Up to 40 cm	FAST, RUSH, renal, abdominal aorta, OB
Linear (Vascular)	7–15 MHz	Flat/wide	Up to 9 cm	Vascular access, DVT, soft tissue, nerve blocks, pleural line detail

Physics

KEY PRINCIPLE: Resolution vs. Penetration

Higher frequency = BETTER resolution, LESS penetration

Lower frequency = WORSE resolution, MORE penetration

Use HIGH frequency for superficial structures (vessels, tendons).

Use LOW frequency for deep structures (aorta, heart, deep abscesses).

Probe-Movements to Remember

- Slide: Move probe along the skin
- Tilt/Fan: Angle the probe
- Rotate: Spin the probe
- Rock: Tilt along long axis
- Compress: Apply pressure for compressibility tests

How Piezoelectric Crystals Work

Piezoelectricity is the physical property that makes ultrasound possible. The word comes from the Greek 'piezein' (to press). Ultrasound probes contain arrays of piezoelectric crystals (usually lead zirconate titanate — PZT) arranged in a precise pattern.

TRANSMIT Phase (Electrical → Sound)

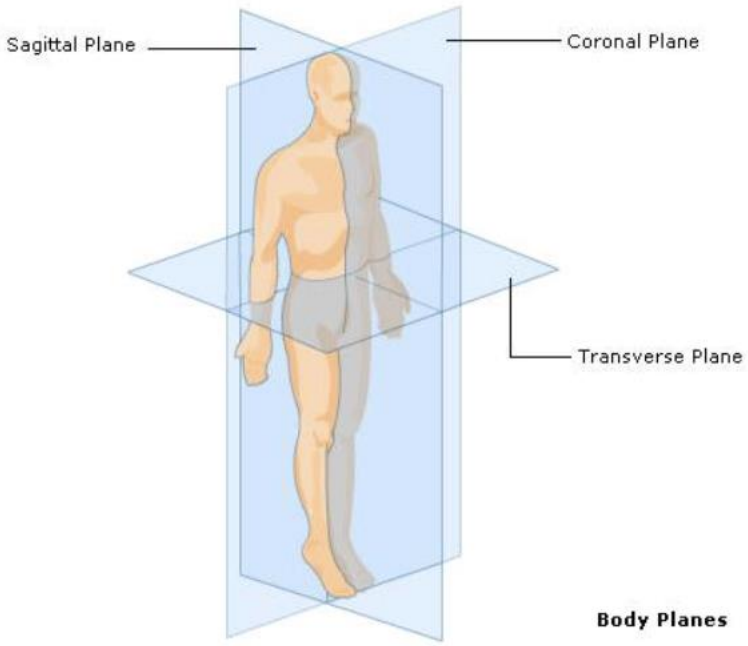
1. The machine sends a brief electrical pulse to the crystals.
2. The voltage causes the crystals to physically deform (expand/contract).
3. This mechanical deformation generates high-frequency pressure waves (ultrasound) that travel into tissue.

RECEIVE Phase (Sound → Electrical)

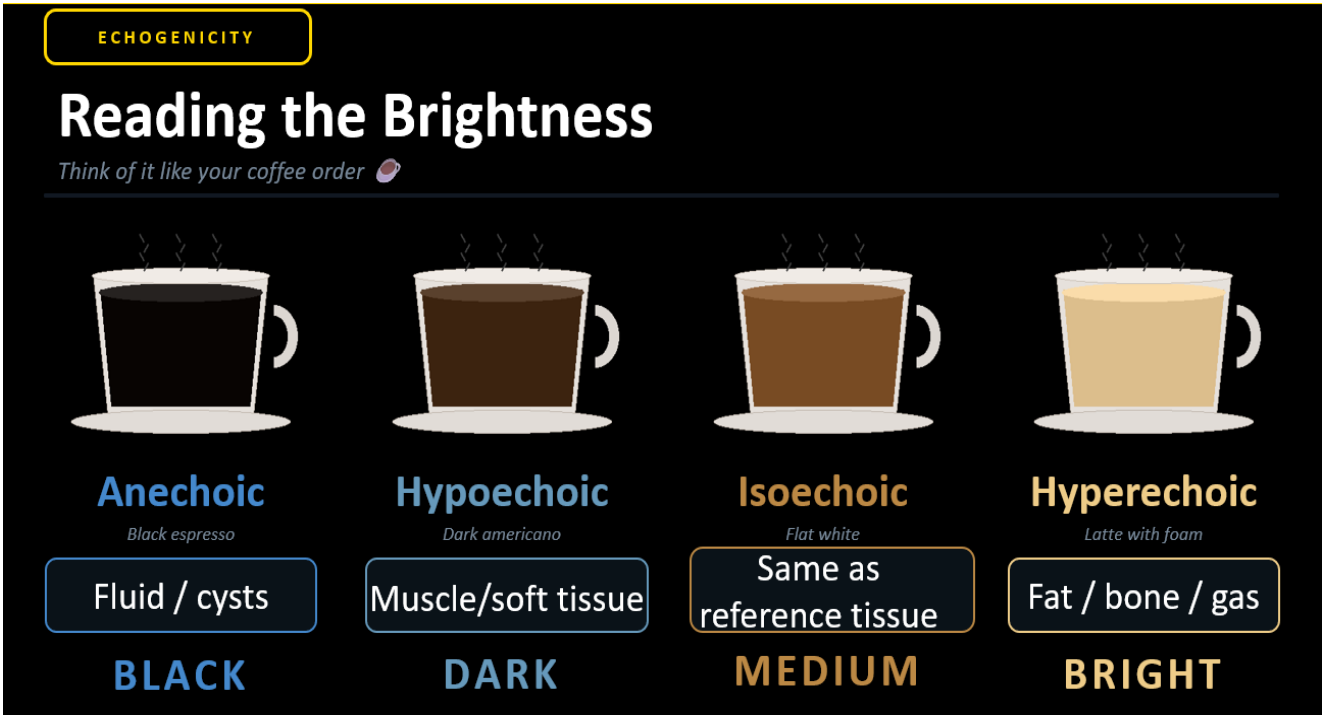
1. Returning echoes from tissue interfaces hit the crystals.
2. These pressure waves deform the crystals, generating small voltages.
3. The machine processes these signals and reconstructs a 2D image.

Important Physics Concepts

- Impedance mismatch: Sound reflects at tissue interfaces with different acoustic impedance — this creates the image.
- Attenuation: Signal weakens as it travels deeper. Compensated by Time-Gain Compensation (TGC).
- Speed of sound in tissue: ~1,540 m/s — the machine uses this constant to calculate depth from echo return time.
- Duty cycle: Probe spends ~1% of time transmitting and ~99% receiving. This is why one probe both sends and receives.
- Acoustic gel eliminates air between probe and skin — air has very high impedance and would reflect nearly all sound.



- Coronal
- Sagittal
- Transverse

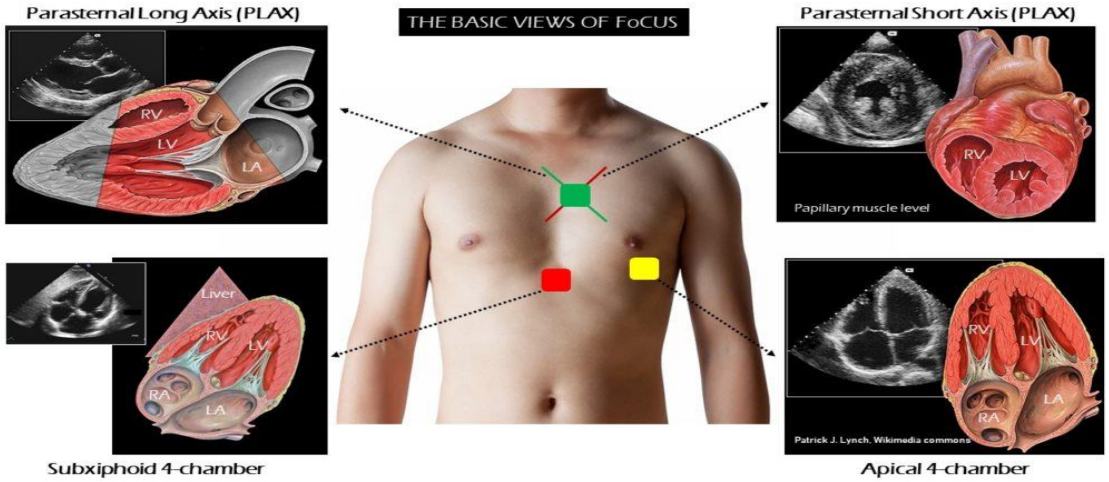


Ultrasound Artifacts Reference Guide

Common artifacts encountered in diagnostic ultrasound and their clinical significance

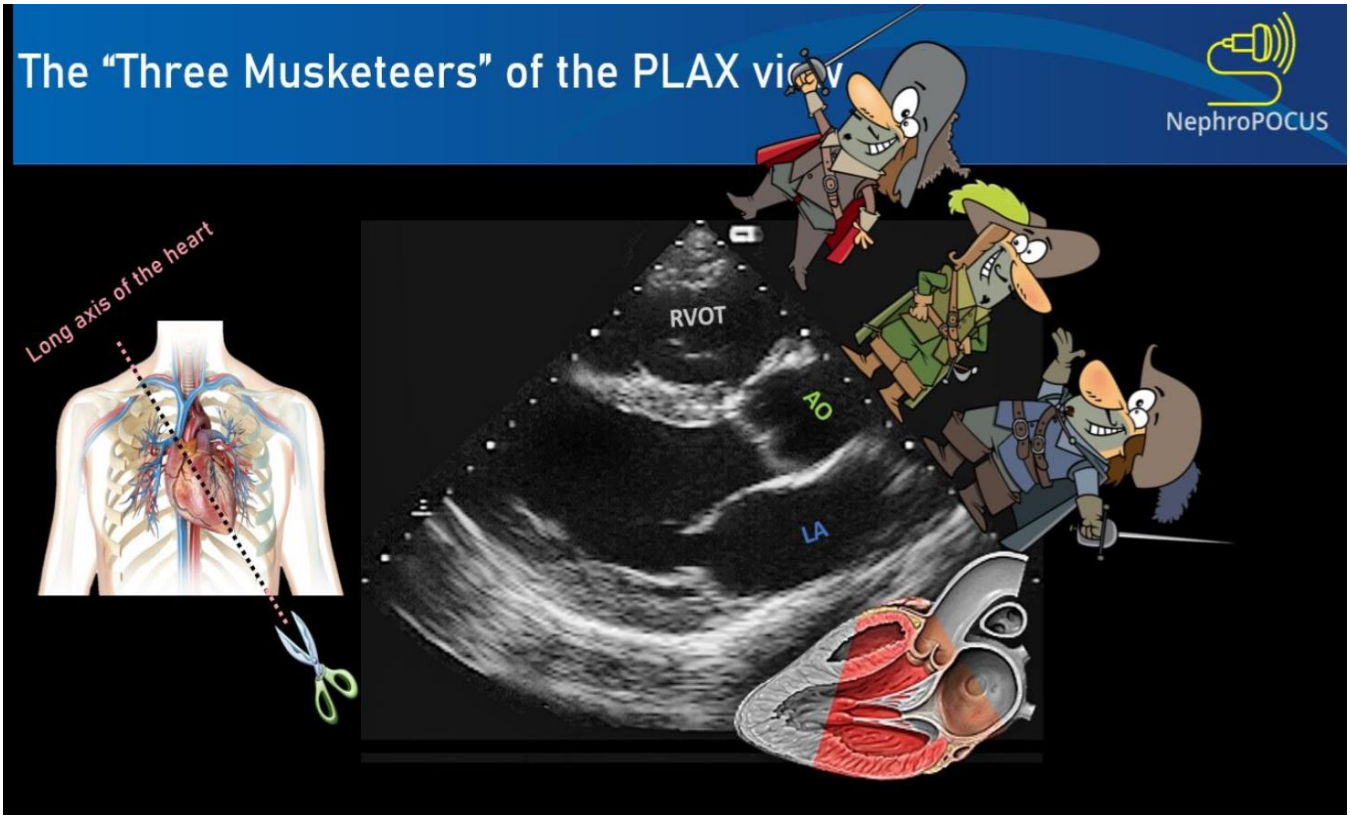
Ultrasound Artifact	Description	Clinical Relevance / When Useful
Acoustic Shadowing	Dark (anechoic) shadow posterior to a highly reflective or attenuating structure (e.g., calculi, bone, calcifications).	Identifying gallstones, kidney stones, calcified structures; confirms presence of dense material.
Posterior Acoustic Enhancement	Increased brightness deep to a fluid-filled structure due to reduced attenuation by fluid.	Confirming cystic lesions (e.g., cysts, bladder, gallbladder); distinguishes cysts from solid masses.
Reverberation	Multiple equally spaced lines parallel to a strong reflector, caused by sound bouncing between interfaces.	Recognizing bowel gas, metallic foreign bodies, chest tubes; seen in pleural line assessment.
Comet-Tail / Ring-Down Artifact	A specific reverberation producing a tapering trail of echoes ('comet tail') from a small reflector.	Identifying B-lines in lung ultrasound (pulmonary edema); metallic objects; cholesterol crystals in gallbladder.
Mirror Image Artifact	A duplicate of a real structure appearing on the opposite side of a strong reflector (e.g., diaphragm).	Recognized in liver/lung interface; can mimic pleural effusion or free fluid if misinterpreted.
Refraction / Edge Shadowing	Lateral shadowing arising from edges of curved structures due to refraction of the beam.	Seen at edges of cysts, gallbladder, and vessels; helps confirm smooth rounded borders.
Anisotropy	Decreased echogenicity of tendons/muscles when beam is not perpendicular to the structure.	Important in musculoskeletal ultrasound; avoiding false hypoechoic appearance by adjusting probe angle.
Twinkle Artifact	Rapidly alternating color signal on Doppler behind a calcification or rough surface.	Detecting kidney stones and calcifications on Doppler; confirms presence of calculi.

Cardiac



[Introduction to Focused Cardiac Ultrasound: The Parasternal Long Axis View - Renal Fellow Network]

View	Location	Indicator	Tips
Parasternal Long Axis	Left sternal border, 3rd–4th ICS	Right shoulder ↖	Big motions until you find the window then small motions to refine the view
Parasternal Short Axis	Same as PLAX → rotate 90°	Left shoulder ↗	Keep the PLAX view and turn the probe to the other shoulder
Apical four chamber	PMI near left nipple	Left side →	Move lateral if on the screen the septum is tilted to the patient's right side
Apical five chamber	Same as A4C	Left side →	Tilt anterior to open LVOT
Subxiphoid 4 chamber	Below xiphoid	Left side →	Overhand grip (like holding a remote), probe flat
IVC	Right of subxiphoid	Head ↑	Follow IVC to RA



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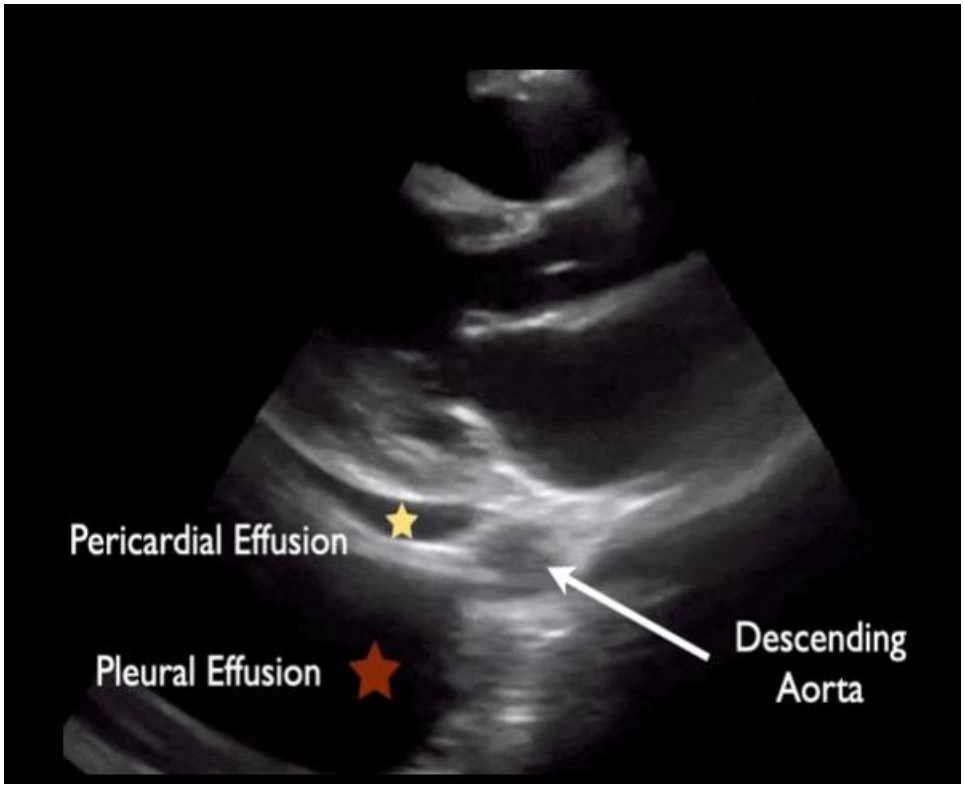
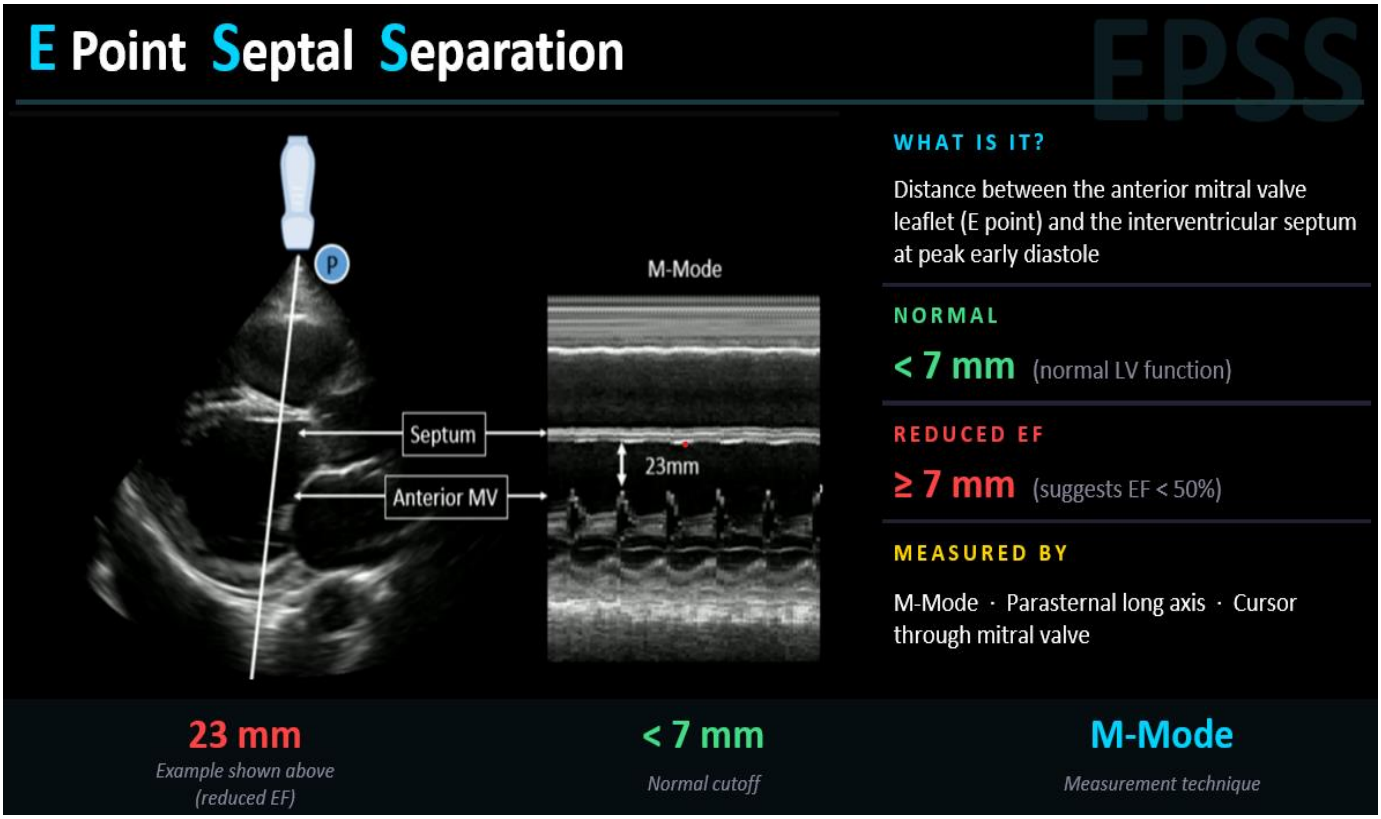
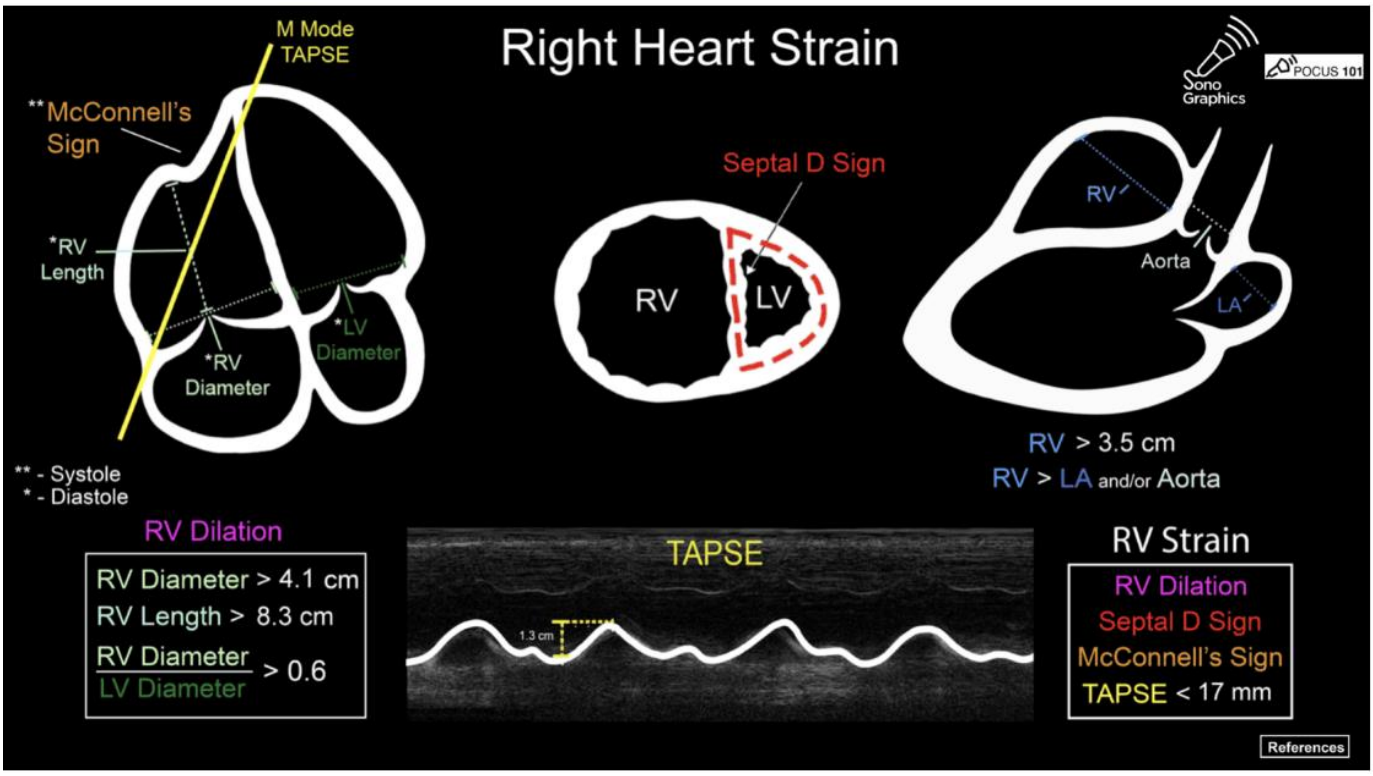
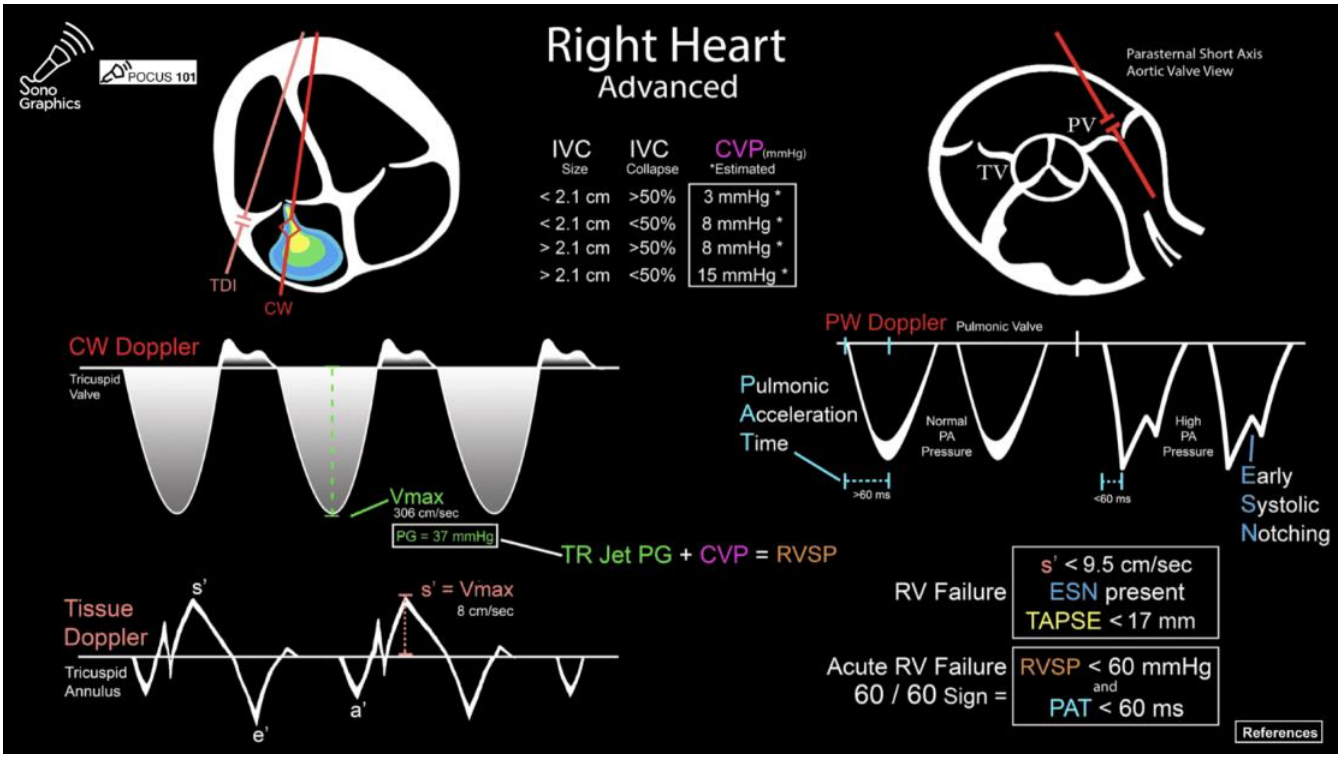


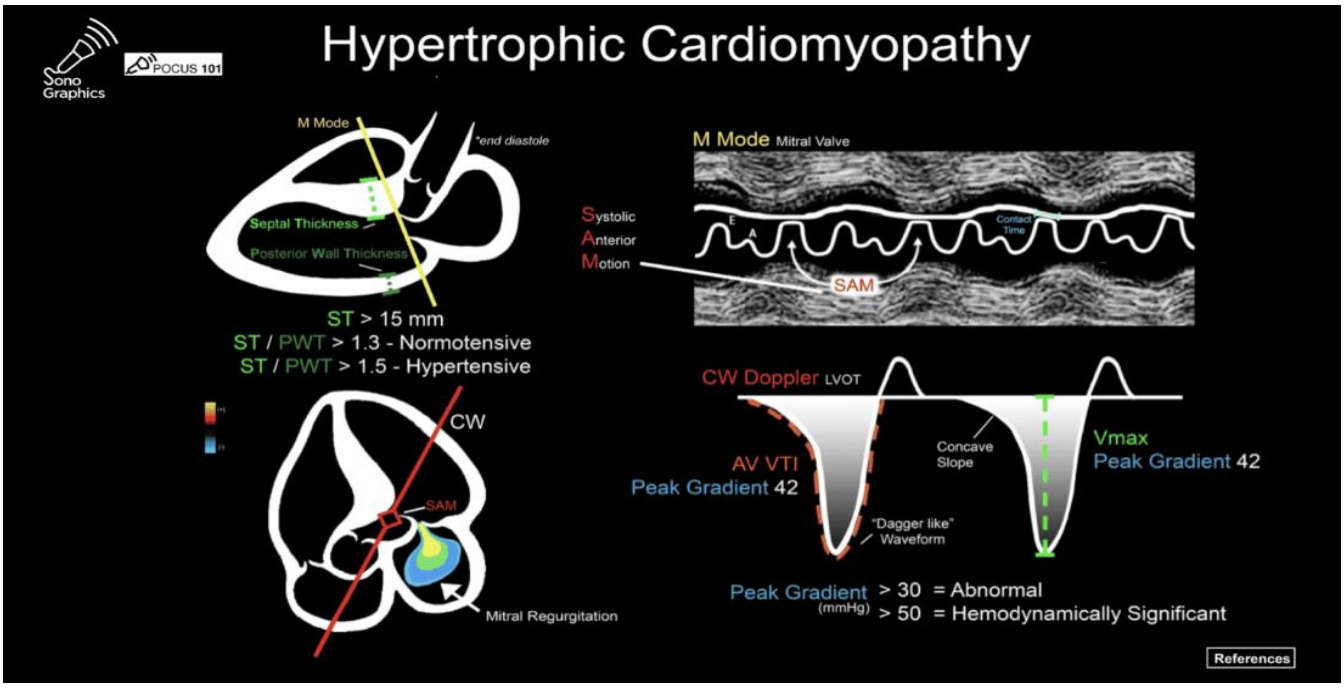




POCUS 101. (n.d.) Right heart *pocket card* [Image]. POCUS 101. https://www.pocus101.com/pocket-cards/

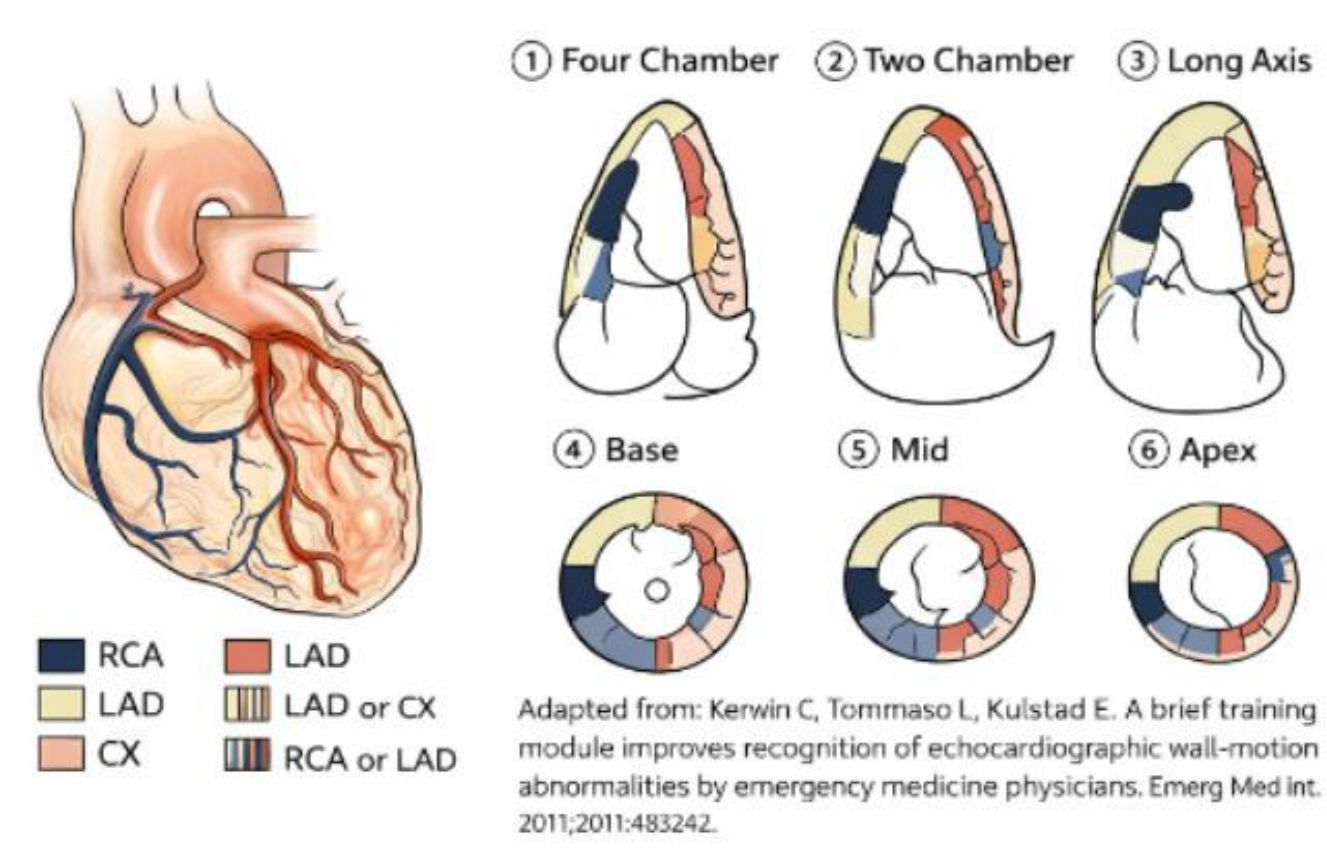


POCUS 101. (n.d.) Right Heart Advanced *pocket card* [Image]. POCUS 101. https://www.pocus101.com/pocket-cards/

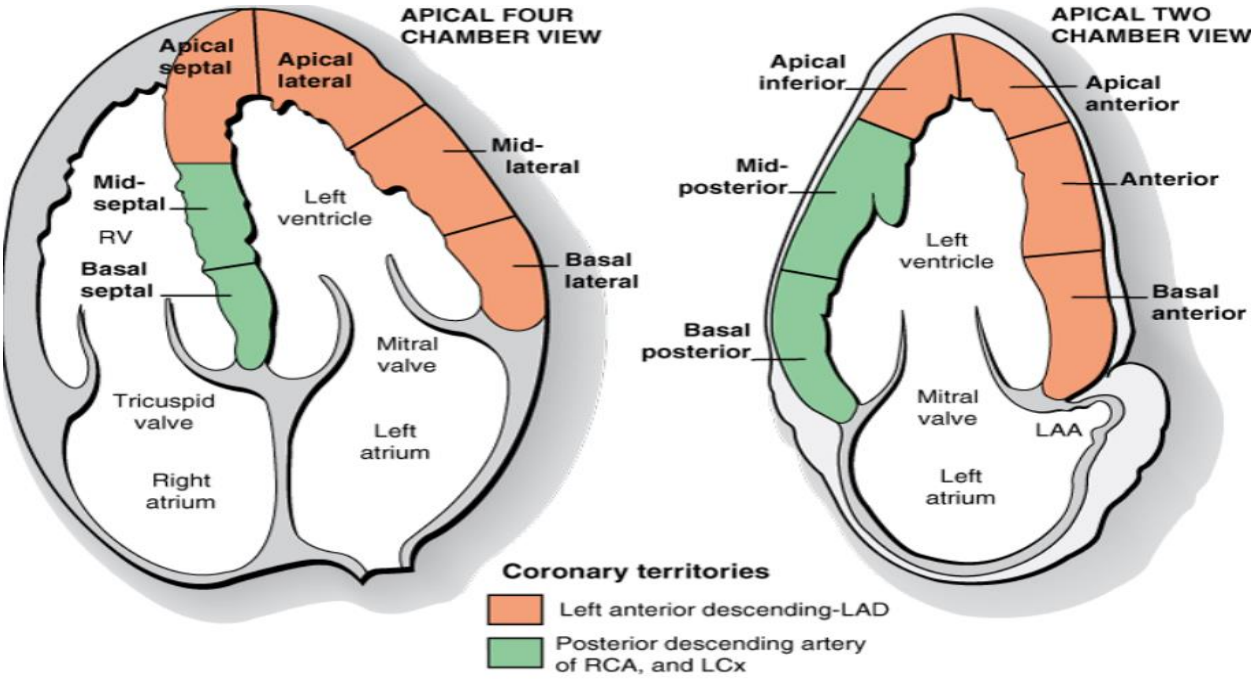


POCUS 101. (n.d.) Hypertrophic Cardiomyopathy *pocket card* [Image]. POCUS 101. https://www.pocus101.com/pocket-cards/

Wall Motion Abnormalities

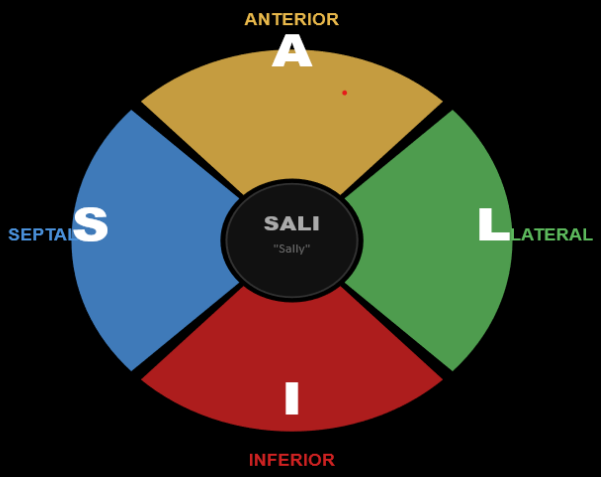


Adapted from: Kerwin C, Tommaso L, Kulstad E. A brief training module improves recognition of echocardiographic wall-motion abnormalities by emergency medicine physicians. Emerg Med Int. 2011;2011:483242.



PSAX: The "SALI" Method

Pronounced "Sally" — your mnemonic for wall orientation



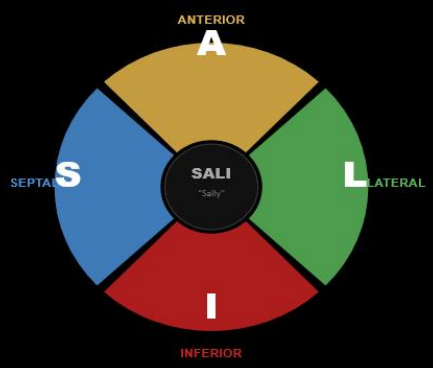
S — Septal
LAD territory — screen left

A — Anterior
LAD territory — top

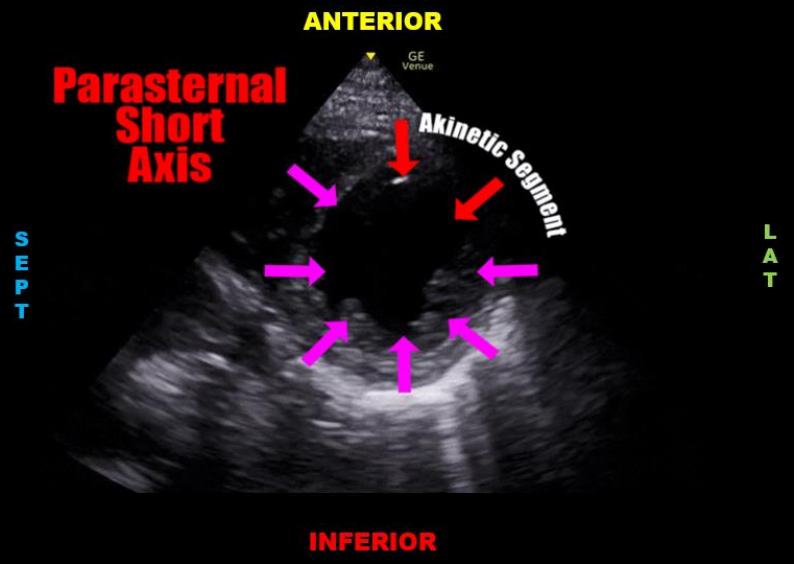
L — Lateral
LCx territory — screen right

I — Inferior
RCA territory — bottom

PSAX — Reading the Short Axis



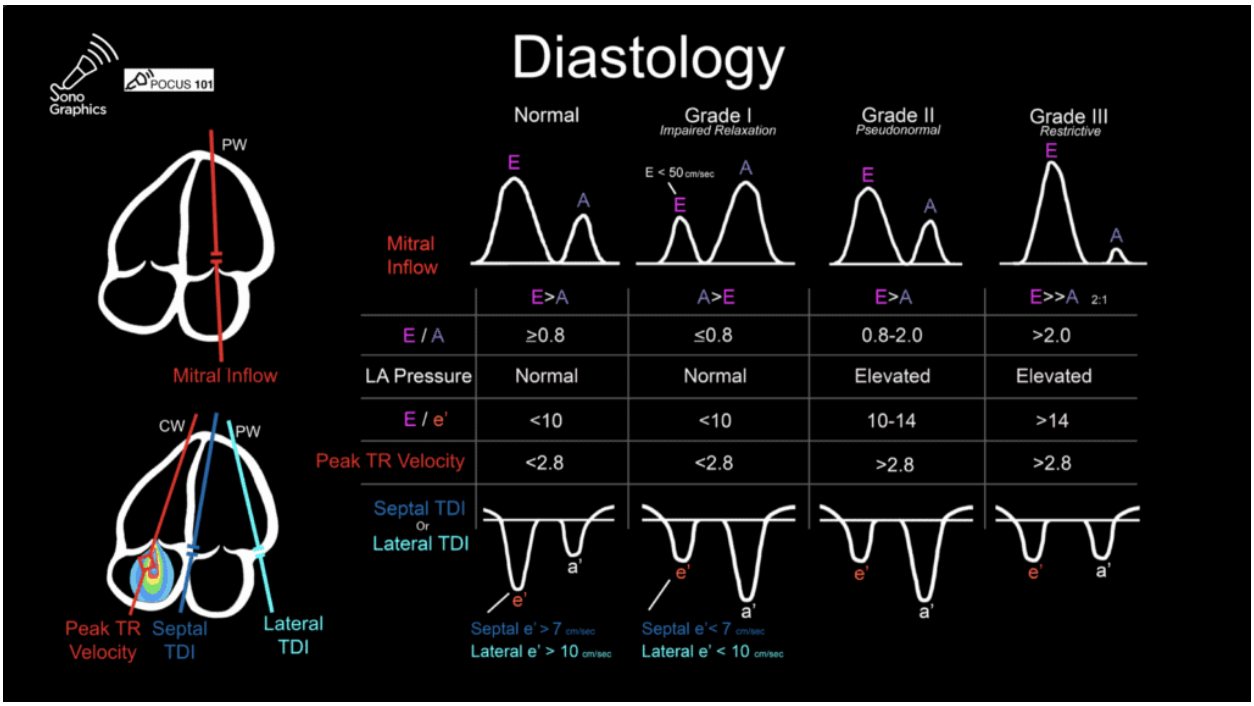
Reference Orientation



Tip: The probe marker points toward the left shoulder — Septal wall appears on screen LEFT

Cardiac Doppler Modalities

Modality	How It Works	Best Used For	Velocity Limit
Color Flow Doppler (CFD)	Multiple PW sample gates across a region. Encodes flow direction as color: RED = toward probe, BLUE = away from probe (BART). Aliasing (mosaic) indicates turbulence or high velocity.	Screening for valve regurgitation and stenosis; identifying flow direction across valves; guiding placement of PW/CW sample volume; detecting septal defects; evaluating tricuspid/mitral regurgitation jet size.	Subject to aliasing (Nyquist limit ~50–70 cm/s). Qualitative only — does not provide exact velocities.
Pulsed Wave Doppler (PW)	Sends and receives pulses from a single sample gate (user-placed). Provides velocity information at a specific location (range-gated). Displays a spectral waveform over time.	Measuring LVOT velocity for VTI and cardiac output; assessing diastolic function (mitral inflow E/A waves); evaluating low-to-moderate velocity flows where location specificity matters.	Limited to ~1.5–2.0 m/s before aliasing. Cannot measure high-velocity stenotic jets.
Continuous Wave Doppler (CW)	Continuously transmits and receives along the entire beam path simultaneously. No range gating — captures the highest velocity anywhere along the beam. Displays the maximum velocity spectral envelope. Used with the Bernoulli equation: $\Delta P = 4V^2$.	Measuring peak aortic stenosis velocity and gradient; quantifying high-velocity regurgitant jets (TR for RVSP); grading AS/MR severity. Cannot localize where along the beam the high velocity originates.	No velocity limit — can measure jets >5 m/s. No range resolution (range ambiguity).
Tissue Doppler Imaging (TDI)	Measures myocardial velocity at the mitral annulus (septal and lateral). Uses pulsed-wave Doppler gated at the tissue level. Provides e' (early diastolic), a' (late), and s' (systolic) velocities	Measuring e' to assess LV relaxation and estimate filling pressures (E/e' ratio). Assessing LV systolic function (s'). Less affected by preload than transmitral Doppler.	No velocity aliasing — myocardial velocities are low (3–20 cm/s). Requires careful angle alignment. Low frequency filter must be OFF.



POCUS 101. (n.d.) Diastology *pocket card* [Image]. POCUS 101. https://www.pocus101.com/pocket-cards/

Diastology: Assessing Diastolic Function (2025 ASE Guidelines)

The 2025 ASE guidelines (Nagueh et al., JASE 2025;38:537–69) supersede the 2016 ASE/EACVI guidelines. Key changes: a single universal algorithm for all patients, a lower e' cutoff (average ≤6.5 cm/s vs. prior ≤7/≤10), inclusion of Left Atrial Reservoir Strain (LARS) as an adjudicating parameter, removal of TR velocity from the primary diagnostic criteria for diastolic dysfunction (but retained for filling pressure estimation), and a new dedicated algorithm for HFpEF diagnosis.

Key Measurements: What They Are and How to Obtain Them

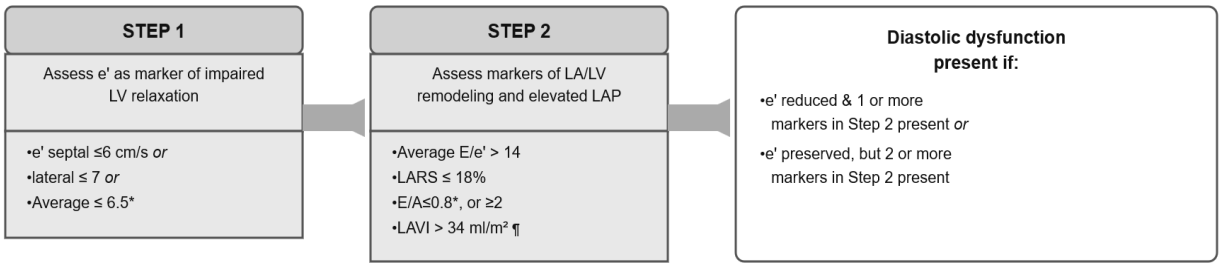
Measurement	What It Represents	How to Obtain (2025 ASE)	2025 Cutoffs & Clinical Meaning
E Wave **(Mitral Inflow)**	Peak early diastolic transmitral velocity. Driven by the LA-to-LV pressure gradient during rapid passive filling. Reflects both LV relaxation and LA pressure. Correlates with mean LAP (Left atrial pressure). Rises when LA pressure is elevated regardless of relaxation status.	**View:** Apical 4-Chamber. **Mode:** PW Doppler. Sample gate 1–3 mm at mitral leaflet tips. Low wall filter (100–200 Hz). Sweep speed 100 mm/s. Minimize spectral broadening. Measure peak modal velocity after ECG T wave.	**E/A ≤0.8:** Grade 1 pattern (impaired relaxation, normal LAP). **E/A 0.8–2:** intermediate — use additional parameters. **E/A ≥2:** Grade 3 pattern (restrictive, elevated LAP). Note: E/A ≥2 may be normal in young patients if e' is normal.

A Wave **(Mitral Inflow)**	Late diastolic transmitral velocity from atrial contraction. Dominant in impaired relaxation (Grade 1). Absent in atrial fibrillation. Correlates better with LVEDP than with mean LAP. A-wave duration at the annulus and pulmonary vein Ar-A duration difference help estimate LVEDP specifically.	**View:** Same acquisition as E wave. A wave = second velocity spike before MV closure. For A duration, lower sample gate a few mm toward annulus if end of A wave is unclear. Measure peak and duration from onset to offset at zero baseline.	**E/A ≤0.8:** A-dominant = impaired relaxation. **E/A ≥2:** restrictive filling. If the **pulmonary vein atrial reversal (Ar) lasts more than 30 milliseconds longer than the mitral A wave**, it suggests that the **left ventricular end-diastolic pressure (LVEDP) is elevated**. (useful when E/A appears normal). Not measured in AF.
e' Wave **(TDI)**	Early diastolic mitral annular tissue velocity. The primary parameter for diagnosing diastolic dysfunction in the 2025 guidelines. Reflects intrinsic myocardial relaxation capacity. Relatively load-independent — unlike the E wave, e' does NOT rise with elevated LA pressure when relaxation is impaired. A reduced e' is the first step in the 2025 diagnostic algorithm.	**View:** A4C with TDI mode (TVI/Tissue preset). **Septal e':** 5–10 mm gate at septal annulus. **Lateral e':** Gate at lateral annulus. Beam parallel to annular motion. Measure peak early diastolic (negative) deflection after T wave. Average septal and lateral e' whenever both are available.	**2025 CHANGE — NEW LOWER CUTOFF:** Average e' ≤6.5 cm/s = impaired relaxation (was avg ≤7 in 2016). If only one site available: septal e' ≤6 cm/s or lateral e'≤7 cm/s. Age-specific reference ranges recommended for optimal accuracy. A reduced e' is now the required first step before applying the LAP estimation algorithm.
E/e' Ratio	Best non-invasive surrogate for mean LAP (not LVEDP). Because E rises with elevated LA pressure but e' stays low when relaxation is impaired, a high ratio = high LA pressure being needed to fill a stiff/poorly relaxing ventricle. Retained as a primary parameter in the 2025 filling pressure algorithm.	Calculated from the same acquisitions: E (cm/s) ÷ average e' (cm/s). Use average of septal and lateral e' when both available. If only septal: cutoff >15. If only lateral: cutoff >13. The 2025 guidelines retain E/e' as a primary variable but pair it with TR velocity and e' in a tripartite first step.	**Average E/e' ≤8:** normal LAP. **E/e' 9–14:** grey zone — use LARS or other supplemental parameters. **E/e' >14:** elevated LAP. Thresholds unchanged from 2016 for this ratio.
TR Peak Velocity	Peak TR velocity estimates PASP (RV-RA pressure gradient).	CW Doppler aligned parallel to TR jet (from any view with best alignment	**≤2.8 m/s:** normal LAP (in absence of pulmonary hypertension). **>2.8 m/s:**

(PASP surrogate)	Elevated PASP reflects elevated LAP because chronically elevated LA pressure is transmitted backward through the pulmonary circulation. In the 2025 algorithm, TR velocity is used in the LAP estimation step (tripartite first step: e' + E/e' + TR velocity), but is **not** used in the Step 1 diastolic dysfunction diagnosis criteria.	via color Doppler). Adjust gain to obtain complete profile without spectral bearding. Measure peak velocity averaged over respiratory cycle. Sweep speed 50–100 mm/s.	elevated LAP. Threshold unchanged from 2016. Not obtainable in all patients; if absent, use other parameters.
LAVi (LA Volume Index)	Structural marker of chronically elevated LAP. LA enlarges over time in response to persistently elevated filling pressures. Measured at end-systole (just before MV opening). Indexed to BSA. In 2025, used as a secondary/supplemental parameter rather than a primary one for LAP estimation, because LAVi can be enlarged for non-diastolic reasons (AF, MR, anemia, athlete heart).	Apical 4-chamber and 2-chamber views. Trace LA area excluding pulmonary veins and LAA. Measure LA length from center of MV annulus to superior LA wall. Use method of disks or area-length method. End-systole = 1–2 frames before MV opening. Ensure long-axis lengths within 5 mm of each other.	**Normal: ≤34 mL/m^2.** >34 mL/m^2: structural evidence of elevated LAP (after excluding AF, MR, athletic heart, anemia). Threshold unchanged from 2016. Used as supplemental parameter in 2025 when primary parameters are discordant.
LARS (LA Reservoir Strain) ★NEW 2025	LA longitudinal deformation measured by speckle-tracking echocardiography, A reduced LARS indicates impaired LA reservoir function, which closely correlates with elevated LV filling pressures. **New in 2025: LARS is now the preferred adjudicating parameter** when primary parameters are discordant, replacing LAVi as the primary tiebreaker.	Obtained from apical 4-chamber and 2-chamber views using speckle-tracking software. Trace the LA endocardial border; exclude the LAA. Use P-wave onset as reference (R-wave onset if unavailable). Measure peak positive strain during systole/isovolumic relaxation period. Average from at least two apical views. Requires adequate 2D image quality and vendor-specific STE software.	**LARS ≤18%:** elevated LAP (high specificity). **LARS >18%:** LAP likely normal. Cutoff of 19–24% = low normal range with higher sensitivity but lower specificity. LARS≤18% is the preferred adjudicating cutoff in the 2025 algorithm when primary parameters are indeterminate.

2025 ASE Two-Step Algorithm (Sinus Rhythm, General Population)

Step	Question / Action	Criteria & Interpretation
1	**Is LV relaxation impaired?** Measure average e'	**Average e' >6.5 cm/s (or septal >6 / lateral >7):** Relaxation NORMAL → check if E/A ≥2 with any two elevated LAP markers; if not, diagnosis is NORMAL diastolic function. **Average e' ≤6.5 cm/s (or septal ≤6 / lateral ≤7):** Relaxation IMPAIRED → proceed to Step 2 to assess LAP. Also check E/A ratio: if ≤0.8 with normal LAP markers → Grade 1. If E/A ≥2 → Grade 3.
2	**Is LAP elevated?** Apply tripartite primary assessment	**Assess three primary variables: (1) Average E/e' >14, (2) TR velocity >2.8 m/s, (3) E/A ratio.** If majority are abnormal → elevated LAP = **Grade 2 DD.** If majority are normal → LAP normal = **Grade 1 DD.** If discordant (only 1 of 3 abnormal, or parameters unavailable) → apply supplemental parameters: **LARS ≤18%** (preferred first tiebreaker), then pulmonary vein S/D ratio ≤0.67, LAVi >34 mL/m^2, or IVRT. If supplemental parameters also inconclusive → grade as **Indeterminate; consider diastolic stress echo in symptomatic patients.**



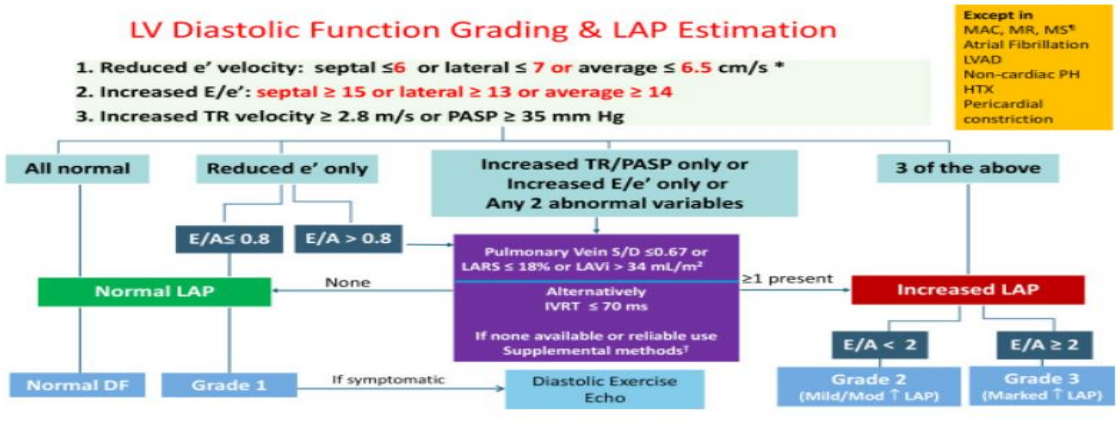
* : can also consider age specific cutoff values to identify abnormally reduced e' velocity or abnormally reduced E/A ratio
: after excluding LA enlargement in athletes, or due to anemia, atrial fibrillation or flutter, and mitral valve disease
¶ : another finding consistent with diastolic dysfunction: LV mass index >95 g/m² in women or 115 g/m² in men, after exclusion of increased LV mass in athletes

Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography and for Heart Failure With Preserved Ejection Fraction Diagnosis: An Update From the American Society of Echocardiography Journal of the American Society of Echocardiography, 38, 537-5

Diastolic Dysfunction Grading (2025 ASE)

Grade	Avg e' (cm/s)	E/A	Avg E/e'	LARS	LAP	Clinical Pattern
Normal	>6.5	0.8–2	≤8	>18%	Normal	Normal LV relaxation and filling pressures
Grade 1 Impaired Relaxation, Normal LAP	≤6.5	≤0.8	≤8	>18%	Normal	Slow LV relaxation, normal filling pressures. A-dominant inflow. Common with aging and HTN. LVEDP may be mildly elevated even with normal LAP.
Grade 2 Impaired Relaxation, Elevated LAP	≤6.5	0.8–2*	>14	≤18%	Elevated	Replaces "pseudonormal" terminology. E/A 0.8–2 with majority of LAP markers abnormal. Elevated LA pressure despite E/A appearing intermediate. TDI e' confirms impaired relaxation. Most common presentation in clinical HFpEF.
Grade 3 Restrictive Filling	≤6.5	≥2	>14	≤18%	Severely Elevated	Stiff, non-compliant LV. E-dominant with high LA pressure driving rapid filling. Deceleration time <160 ms

**Grade 2 E/A is intermediate (0.8–2), but LAP is elevated based on the majority of primary/supplemental parameters. The 2025 guidelines remove the "pseudonormal" label and replace it with a more straightforward Grade 2 (impaired relaxation + elevated LAP). Note: the algorithm should NOT be applied in children, pregnancy, or the intraoperative setting. In AF, a modified algorithm applies. Reference: Nagueh et al., JASE 2025;38:537–569. DOI: 10.1016/j.echo.2025.03.011*

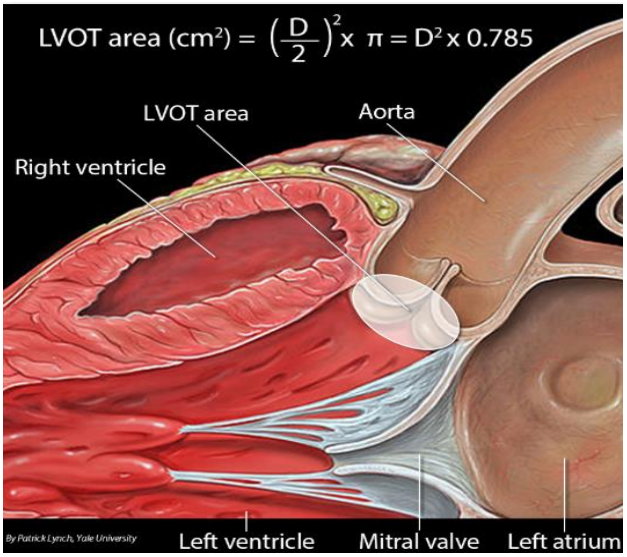


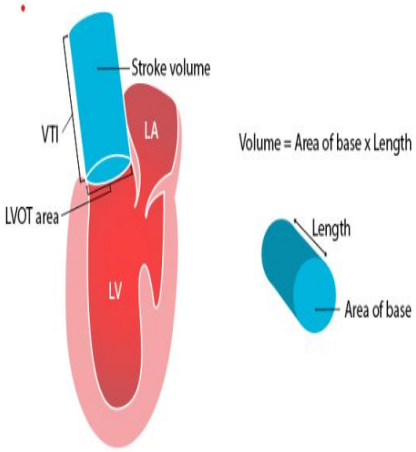
Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography and for Heart Failure With Preserved Ejection Fraction Diagnosis: An Update From the American Society of Echocardiography Journal of the American Society of Echocardiography, 38, 537-569

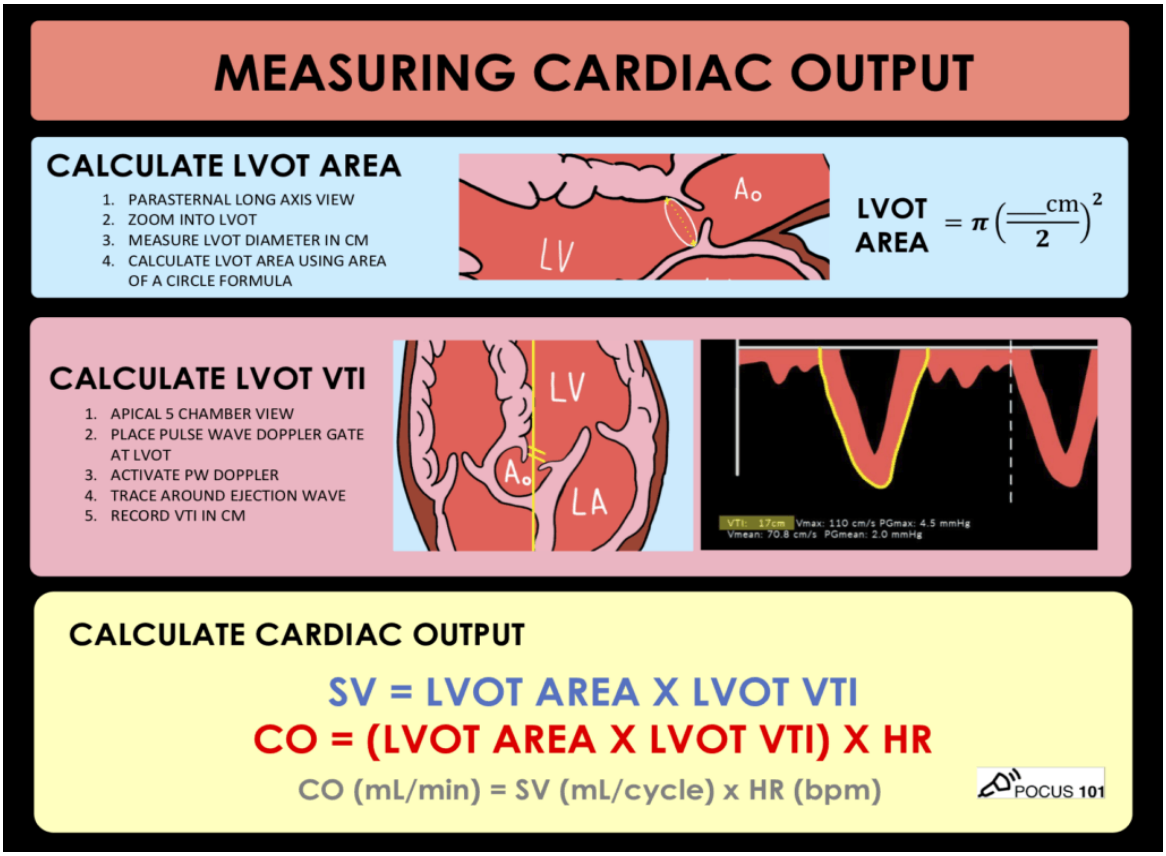
Obtaining a VTI (Velocity-Time Integral)

The VTI represents the distance blood travels with each heartbeat (stroke distance, in cm). It is the area under the spectral Doppler envelope and is used to calculate stroke volume and cardiac output, as well as aortic valve area via the continuity equation.

Step	Action	Tips / Key Points
1	Obtain **Apical 5-Chamber (A5C)** view	Start from A4C, then tilt the probe anteriorly to open the LVOT and visualize the aortic valve. The beam must be as parallel to LVOT flow as possible — angle correction is NOT used in Doppler.
2	Activate **Pulsed Wave (PW) Doppler**	Place the sample gate (cursor) in the LVOT, just proximal (apical side) to the aortic valve leaflets — approximately 0.5–1.0 cm below the aortic annulus.
3	Optimize the **spectral waveform**	Adjust gain and scale so the waveform fills the display without clipping. The envelope should be a smooth, clean systolic curve with a clear peak. Hollow (dark center) = laminar flow — this is good.
4	Freeze and **trace the spectral envelope**	Freeze the image, then use the trace/caliper function to outline the outer edge of the systolic waveform from baseline to baseline. The machine automatically calculates the VTI (cm). Average 3–5 beats; use 5 beats if the patient is in atrial fibrillation.
5	Calculate **Stroke Volume & Cardiac Output**	Cardiac Output (L/min) = [3.14 × (LVOT diameter ÷ 2)^2 × LVOT VTI × Heart Rate] ÷ 1000







POCUS 101. (n.d.). ***Measuring cardiac Output*** **[Image]. POCUS 101. https://www.pocus101.com/pocket-cards/**

Evaluating Valvular Disease

Valvular heart disease occurs when a valve fails to open (stenosis) or close (regurgitation) properly. It affects ~2.5% of adults and prevalence increases with age. The three most common disorders encountered in critical care are summarized below.

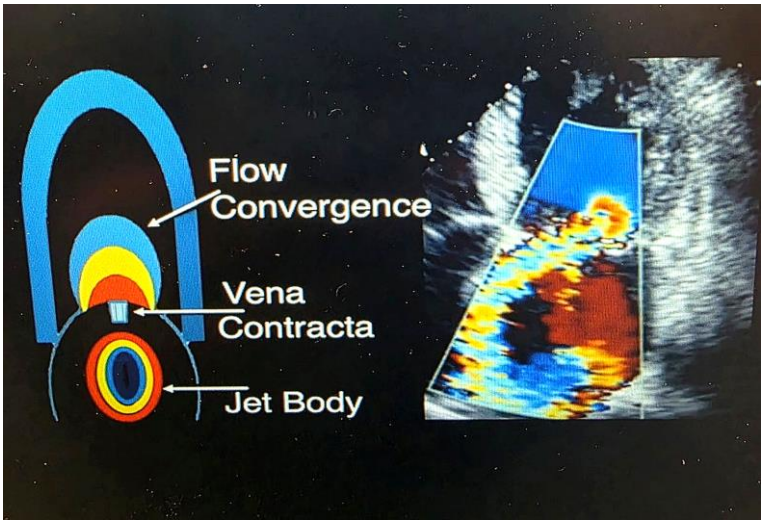
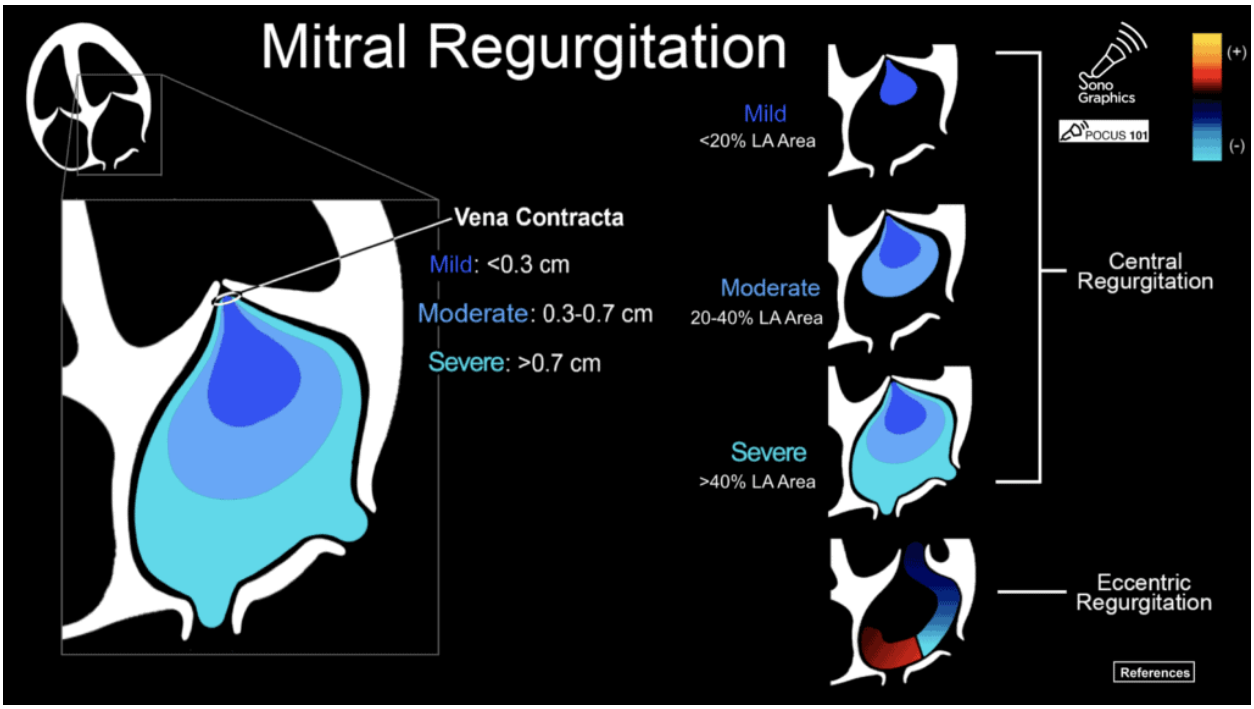


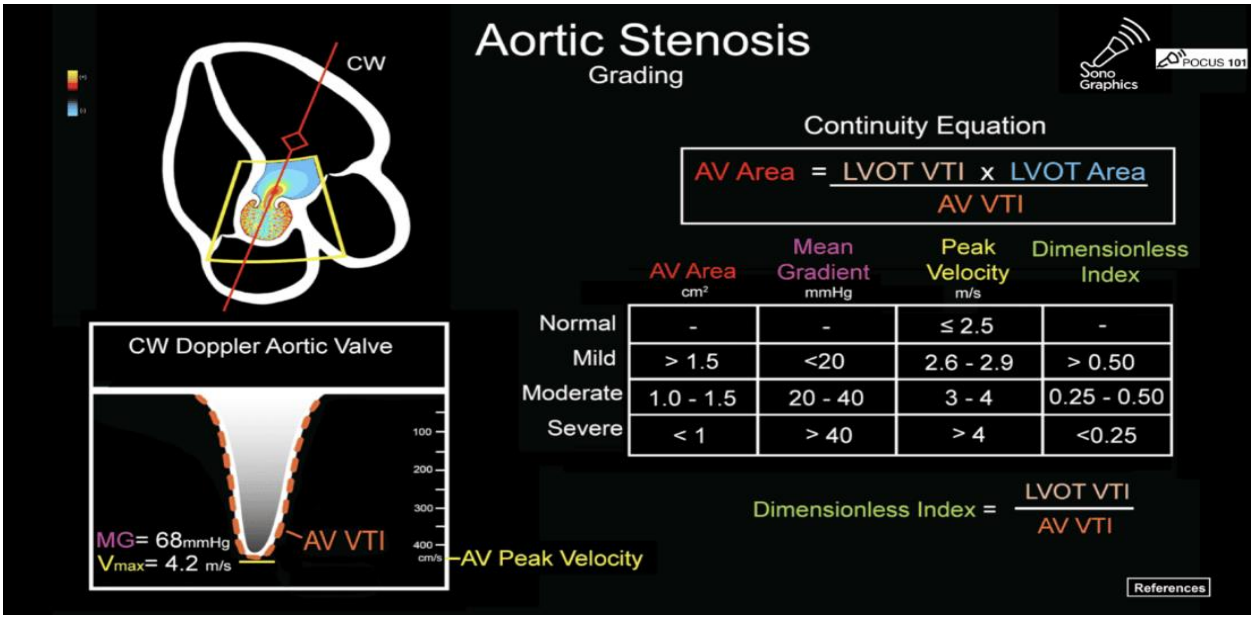
Figure: Regurgitant jet anatomy — flow convergence (PISA hemisphere), vena contracta (narrowest point), and jet body in the receiving chamber.

Color Flow Jets: Concentric vs. Eccentric & Jet Anatomy

Concept	Description	Clinical Significance
Flow Convergence Zone (PISA)	Hemispheric shell of blood accelerating toward the regurgitant orifice on the upstream side of the valve. Seen on color Doppler as a series of concentric color-aliasing arcs (blue/yellow shells). Also called Proximal Isovelocity Surface Area (PISA). Formula: EROA = ($2\pi r^2$ × Va) / Vpeak, where r = PISA radius, Va = aliasing velocity, Vpeak = peak regurgitant velocity by CW.	Quantifies regurgitant severity. A PISA radius >1.0 cm at baseline Nyquist of 40 cm/s strongly suggests severe MR. Larger PISA = more severe regurgitation. Used to calculate EROA and regurgitant volume (RVol = EROA × VTI of regurgitant jet).
Vena Contracta	The narrowest point of the color jet immediately at or just downstream of the regurgitant orifice. It represents the true effective orifice size. Appears as the most constricted, highest-velocity portion of the jet on color Doppler — typically the brightest mosaic area at the valve plane. Measured in the zoom view perpendicular to the jet direction.	Quick, reliable severity marker. MR: VC ≥7 mm = severe. TR: VC ≥7 mm = severe. AR: VC <3 mm = mild; ≥6 mm = severe. Less affected by machine settings than jet area. Works equally well for central and eccentric jets.
Jet Body	The color jet body is the expanding mosaic/turbulent signal in the receiving chamber downstream of the vena contracta. Its size and shape depend on jet momentum, chamber geometry, and Coanda effect (wall-hugging). Jet area as % of receiving chamber area is used qualitatively but is highly machine- and setting-dependent.	Qualitative screening only. Mild MR: jet area <4 cm^2 or <20% LA area. Severe MR: >10 cm^2 or >40% LA area. Jet area alone is NOT reliable — always confirm with vena contracta, PISA, and quantitative methods.
Concentric (Central) Jet	A regurgitant jet that travels centrally into the receiving chamber, away from the walls. Caused by symmetric leaflet abnormality (e.g., annular dilation, symmetric leaflet restriction). The color jet expands freely and symmetrically. PISA hemisphere is well-formed and can be easily measured. Jet area correlates reasonably well with severity for central jets.	Jet area, vena contracta, and PISA are all more reliable for central jets. Seen in: dilated cardiomyopathy (functional MR), annular dilation, symmetric leaflet tethering, and degenerative disease with symmetric prolapse.

Eccentric (Wall-Hugging) Jet	A jet that deflects along and wraps around the chamber wall (Coanda effect). Caused by asymmetric leaflet pathology: prolapse or flail of one leaflet directs the jet in the opposite direction (e.g., posterior leaflet prolapse → anterior/wall-hugging jet). The jet "disappears" into the wall — its true area is underestimated because it cannot expand freely. The PISA hemisphere may be distorted or incomplete.	⚠ **PITFALL:** Jet area significantly UNDERESTIMATES severity for eccentric jets. Always rely on vena contracta width and PISA/EROA rather than jet area. A wall-hugging jet that appears "small" on color Doppler may represent severe MR. Look for the cause: leaflet prolapse, flail, or chord rupture.
Coanda Effect	The physical tendency of a fluid jet to attach to and follow a nearby surface. In regurgitation, this causes the jet to hug the atrial or ventricular wall rather than traveling freely. The jet entrains surrounding fluid and creates low-pressure zone between the jet and wall, drawing it toward the surface. Common in posterior MV leaflet prolapse (anterior eccentric jet hugs the anterior LA wall).	Recognition is critical: a wall-hugging "thin" jet must not be dismissed as mild. The jet appears to "disappear" as it wraps along the wall. Tip: trace the jet along the wall and note if it wraps all the way to the pulmonary veins (suggests severe MR). Always use vena contracta and PISA for quantification.





POCUS 101. (n.d.). *Mitral regurgitation pocket card* [Image]. POCUS 101. https://www.pocus101.com/pocket-cards/

Aortic Stenosis (AS)

Murmur: crescendo-decrescendo midsystolic ejection murmur. The **continuity equation** is used to calculate AV area: *AV Area = (LVOT VTI × LVOT Area) / AV VTI*

Severity	AV Area (cm^2)	Mean Gradient (mmHg)	Peak Velocity (m/s)	Dimensionless Index
Normal	—	—	≤2.5	—
Mild	>1.5	<20	2.6–2.9	>0.50
Moderate	1.0–1.5	20–40	3.0–4.0	0.25–0.50
Severe	**<1.0**	**≥40**	**≥4.0**	**<0.25**

Mitral Regurgitation (MR)

Causes: mitral valve prolapse, rheumatic heart disease, cardiomyopathy, congenital defects, endocarditis, myocardial infarction, radiation therapy.

Severity	Mild	Moderate	Mod–Severe	Severe
EROA (cm^2)	<0.20	0.20–0.29	0.30–0.39	**≥0.40**
RVol (mL)	<30	30–44	45–59	**≥60**
RF%	<30	30–39	40–49	**≥50**

Tricuspid Regurgitation (TR)

Murmur: high-pitched holosystolic murmur at the lower left sternal border.

Measure	Mild	Moderate	Severe
Color Flow Jet Area	Small, narrow central jet	Moderate central jet	**Large central jet**
EROA (cm^2)	<0.20	0.20–0.39	**≥0.40**
RVol (mL)	<30	30–44	**≥45**

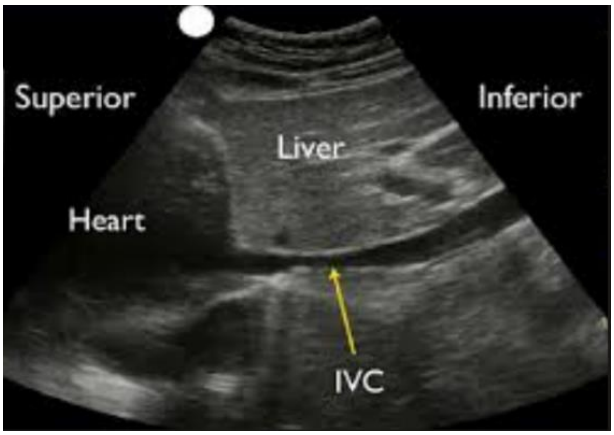
Note: EROA = effective regurgitant orifice area; RVol = regurgitant volume; RF = regurgitant fraction. Use color flow Doppler to screen, PW Doppler for EROA/RVol by PISA method, and CW Doppler for peak velocity and gradients. Always correlate with clinical findings and symptoms. Source: AAHFN Connections Winter 2025

IVC Size & CVP Estimation

Measured in subcostal view, 2 cm distal to the IVC–RA junction. Assess diameter at end-expiration and collapsibility with a sniff (spontaneously breathing) or with positive pressure (ventilated patients).

IVC Diameter	Collapsibility (Sniff)	Est. RAP / CVP	Interpretation	Clinical Implications
< 2.1 cm	> 50% collapse	**~3 mmHg (0–5 mmHg)**	LOW right atrial pressure	Likely Volume responsive. Consider fluid bolus in shock.
< 2.1 cm	< 50% collapse	**~8 mmHg (5–10 mmHg)**	INTERMEDIATE — indeterminate	Intermediate RAP. Correlate clinically.
> 2.1 cm	< 50% collapse	**~15 mmHg (10–20 mmHg)**	HIGH right atrial pressure	Unlikely volume responsive. Consider RV failure, tamponade, PE, RV infarct.
> 2.1 cm	No collapse ("fixed")	**> 20 mmHg**	SEVERELY elevated RAP	Potential Causes: Cardiac tamponade, massive PE, severe TR, decompensated right heart failure.

Note: *CVP estimated by IVC is a surrogate and should be interpreted in clinical context. Ventilated patients: use >18% IVC collapsibility (plethysmographic variability) rather than sniff. IVC collapsibility index = (IVC max – IVC min) / IVC max × 100%.*



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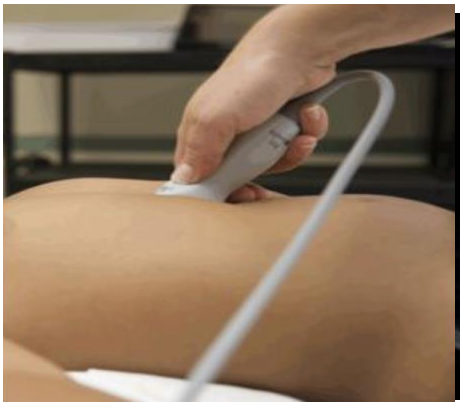
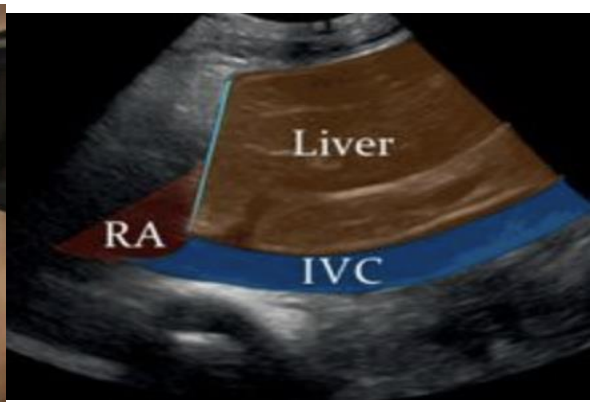
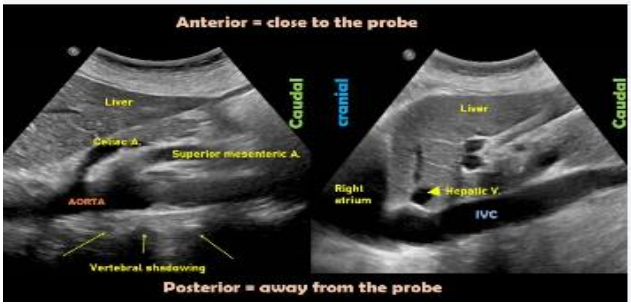
Obtaining the IVC view





IVC vs Aorta: Key Distinguishing Features

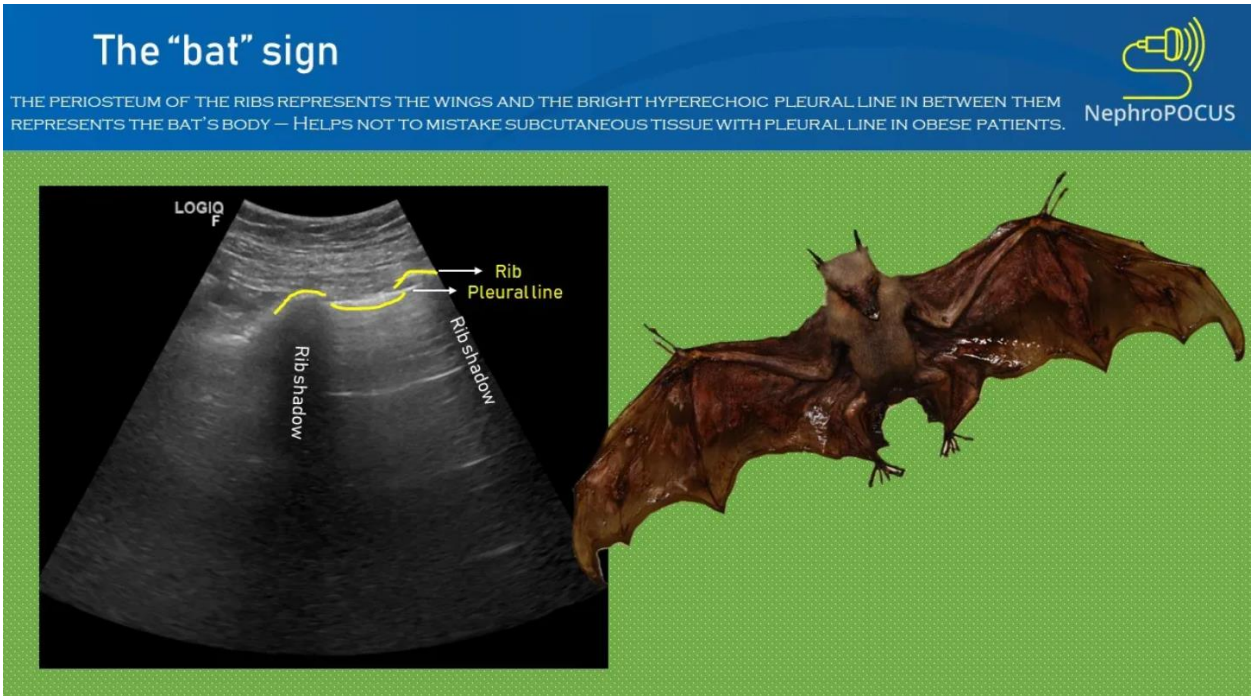
IVC	AORTA
Lies to the right of the midline in the abdomen	Midline; left relative to the IVC
Thin walled	Thick-walled structure
No anterior tributaries outside the liver	Anterior branches present (celiac, superior mesenteric arteries)
Respiratory variation present unless RAP is high or mechanically ventilated	Absent
Attached to the liver (passes through posterior part of it)	Slightly away from the liver; anterior to the vertebral column (look for vertebral shadowing behind it)
Joins the right atrium at the diaphragmatic level	Does not (continuous with the thoracic aorta)
May be compressible in thin, non-intubated patients	Non-compressible



Lung Ultrasound Fundamentals

Normal lung contains air, which reflects nearly all ultrasound. We interpret ARTIFACTS rather than direct anatomy. Probe: Phased array or curvilinear (low frequency). Patient: Supine or sitting. Probe indicator: CRANIAL (toward head).

Finding	Appearance	Significance	Clinical Correlation
A-Lines	Horizontal, equally-spaced bright lines deep to pleural line	NORMAL aerated lung (reverberation artifact from pleural line)	Normal lungs, COPD/asthma (air trapping), pneumothorax (with absent sliding)
B-Lines	Vertical, laser-like bright lines from pleural line to bottom of screen. Erase A-lines.	Interstitial fluid (pulmonary edema). 3+ per zone = SIGNIFICANT ("wet lungs")	CHF, pneumonia, ARDS, pulmonary fibrosis, contusion
Lung Sliding	Shimmering/gliding motion at pleural line with respiration	PRESENT = visceral and parietal pleura in contact. ABSENT = pneumothorax until proven otherwise.	PTX, pleurodesis, large bullae, mainstem intubation, complete atelectasis (can all cause absent sliding)
Lung Point	Intermittent sliding at junction between PTX and normal lung	**PATHOGNOMONIC for pneumothorax (100% specific)**	Location of lung point correlates with size of pneumothorax
Consolidation	Tissue-like ("hepatized") area in lung with air bronchograms	Pneumonia, atelectasis, pulmonary infarct (post-PE)	Dynamic air bronchograms (moving bright dots) = pneumonia. Static = reabsorptive atelectasis.
Pleural Effusion	Anechoic/hypoechoic space above diaphragm. "Spine sign."	Transudative (clear) or exudative (complex). Guides thoracentesis.	Look for atelectatic lung ("jellyfish sign"), septations, echogenic fluid (exudate/blood/pus)



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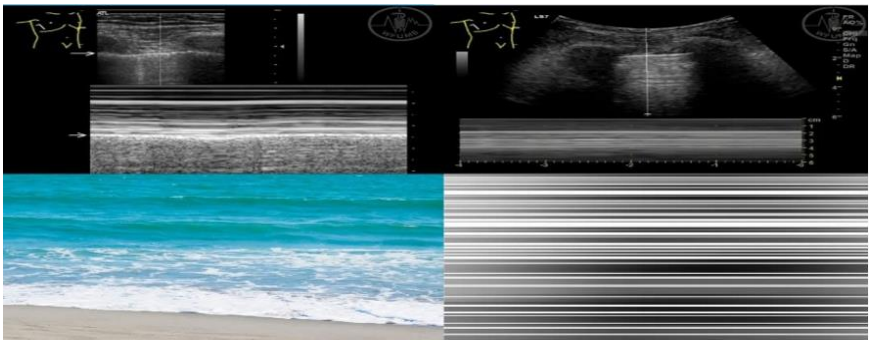
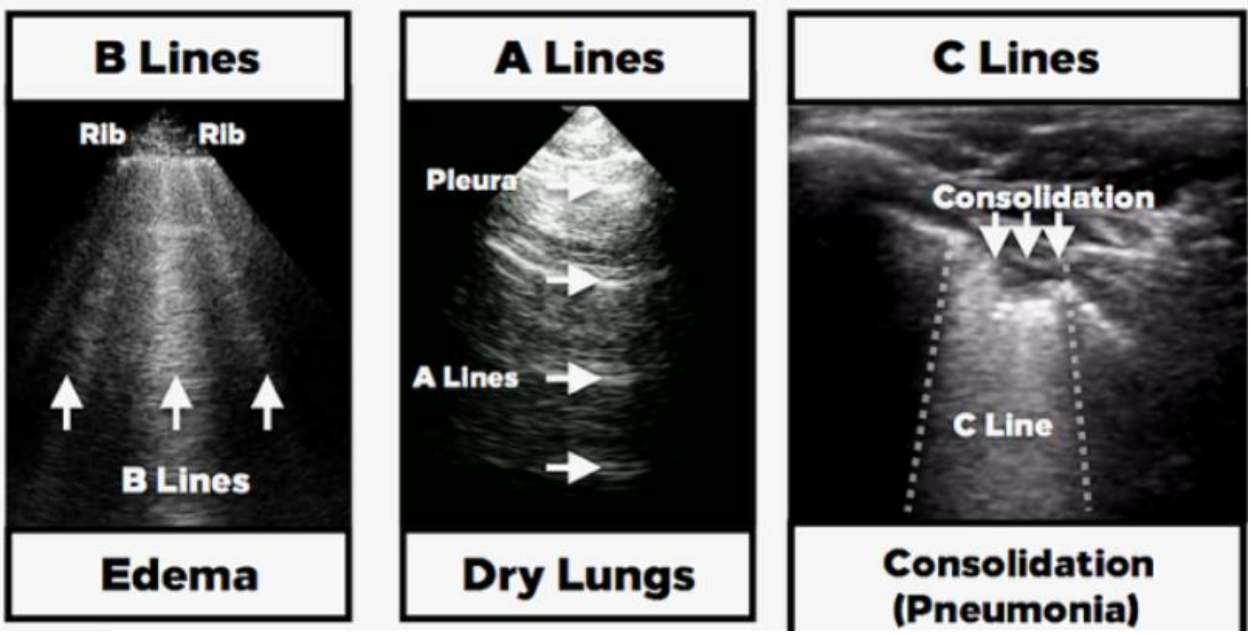
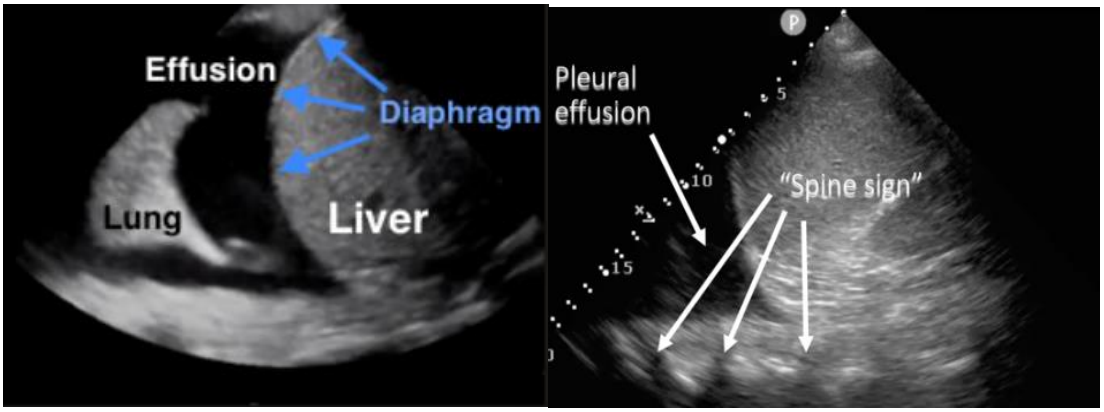
Seashore Sign vs. Barcode Sign

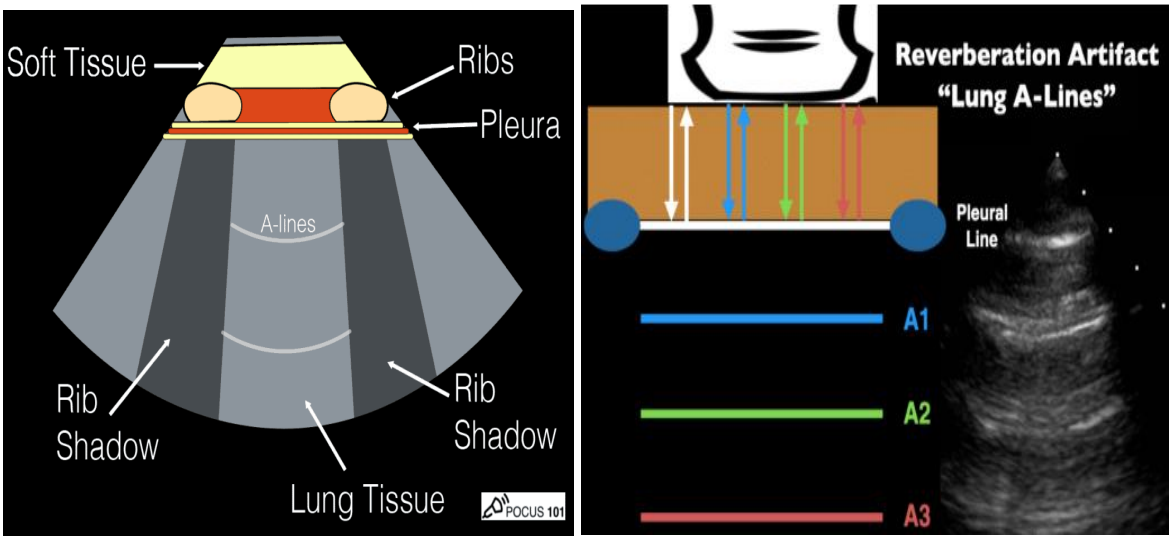
M-mode POCUS interpretation of lung sliding

Feature	Seashore Sign ✓	Barcode Sign ✗
M-mode appearance	Granular, sandy pattern below the pleural line	Parallel horizontal lines throughout
Lung sliding	Present	Absent
What it represents	Normal pleural interface	No lung sliding
Clinical significance	Normal finding	Warrants evaluation for pneumothorax



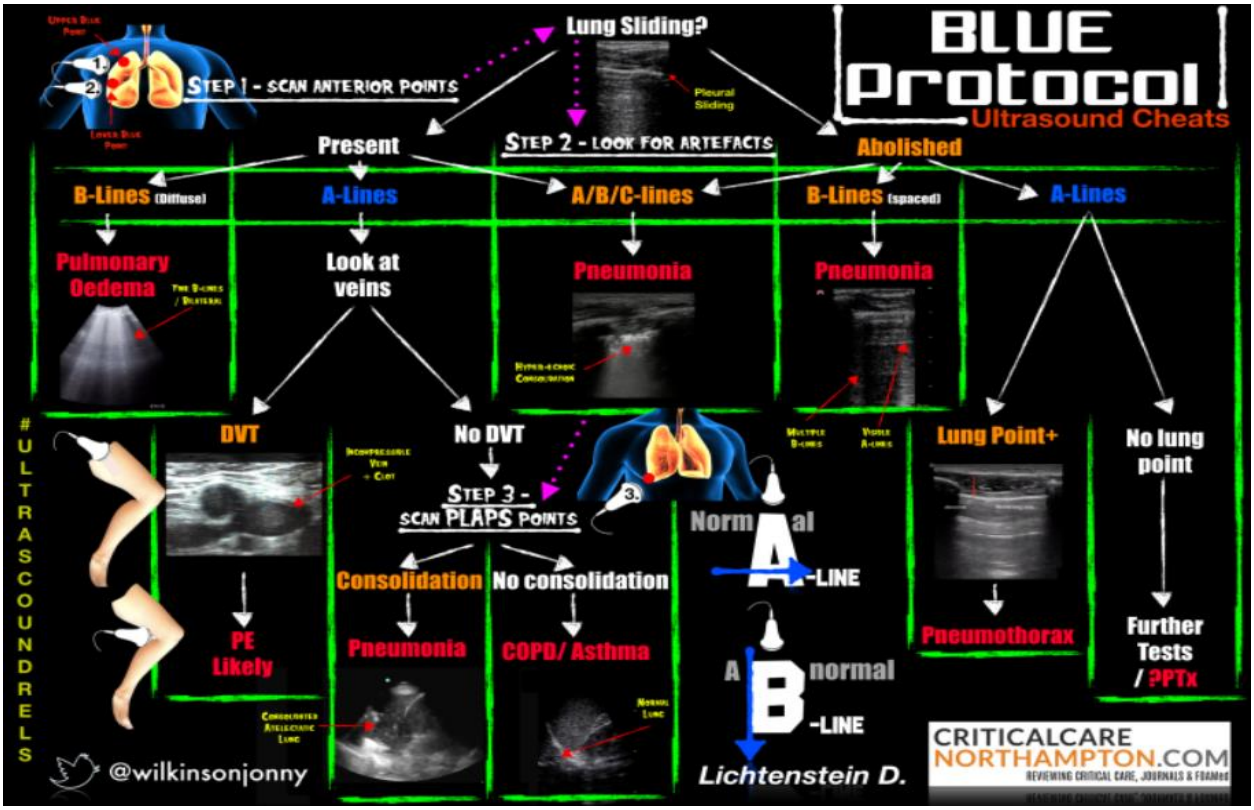

B Lines
Rib
Rib
B Lines
Edema
A Lines
Pleura
A Lines
Dry Lungs
C Lines
Consolidation
C Line
Consolidation
(Pneumonia)


Effusion
Diaphragm
Lung
Liver
Pleural
effusion
"Spine sign"


Soft Tissue
Ribs
Pleura
A-lines
Rib
Shadow
Rib
Shadow
Lung Tissue
POCUS 101
Reverberation Artifact
"Lung A-Lines"
Pleural
Line
A1
A2
A3

BLUE Protocol (Bedside Lung Ultrasound in Emergency)

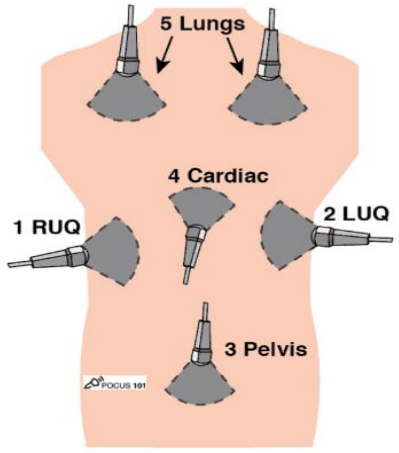
The BLUE protocol (Lichtenstein, 2008) is a stepwise algorithm for diagnosing acute respiratory failure using lung ultrasound.



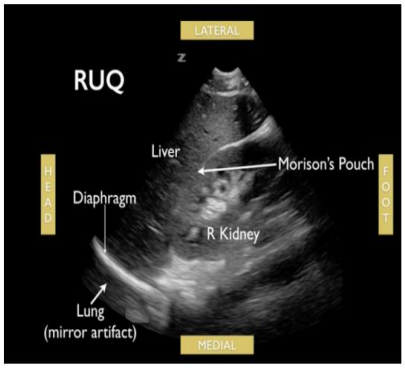
#	Ultrasound Finding	BLUE Profile	Differential Diagnosis
A	A-lines bilateral + lung sliding present + no DVT	**A Profile**	ASTHMA or COPD (airway disease)
B	B-lines bilateral + lung sliding present	**B Profile**	PULMONARY EDEMA (cardiogenic or non-cardiogenic)
A'	A-lines bilateral + ABSENT lung sliding + no lung point found	**A' Profile**	PNEUMOTHORAX (if lung point found — CONFIRMED PTX)
C	Anterior alveolar consolidation ± A-lines (asymmetric findings)	**C Profile**	PNEUMONIA (consolidation with dynamic air bronchograms)
A+	A-lines + DVT on venous compression ultrasound	**A+DVT Profile**	Posible PULMONARY EMBOLISM (A lines + DVT = PE until proven otherwise)

eFAST Views — Systematic Approach

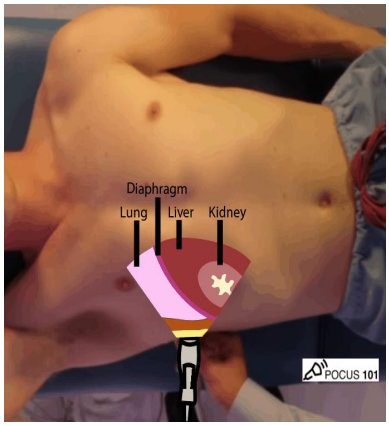
#	View/Location	Probe	Indicator Direction	What You're Looking For	POSITIVE Finding (Pathology)
1	Right Upper Quadrant (RUQ) — Morrison's Pouch	Phased array or Curvilinear	**Toward HEAD (12 o'clock)** ↑	Hepatorenal interface between liver and kidney (Morison's pouch)	**Anechoic/hypoechoic stripe between liver and kidney = FREE FLUID/BLOOD. Also check subphrenic space.**
2	Left Upper Quadrant (LUQ) — Splenorenal Pouch	Phased array or Curvilinear	**Toward HEAD (12 o'clock)** ↑	Splenorenal interface; left subphrenic space. More posterior than RUQ.	**Anechoic fluid between spleen and kidney. Subphrenic fluid (between spleen and diaphragm). Often harder to see than RUQ.**
3	Pelvis (Pouch of Douglas / Rectovesical)	Phased array or Curvilinear	**Toward patient's RIGHT (transverse) or TOWARD HEAD (sagittal)** ← / ↑	Bladder and pelvic free space: rectovesical pouch (male) or pouch of Douglas (female).	**Free fluid posterior or superior to bladder. Dependent pooling in pelvis. Best view with full bladder.**
4	Cardiac View (Subxiphoid or PLAX)	Phased array (cardiac)	**Subxiphoid: Patient's LEFT (→). PLAX: Right shoulder (↗)** →	Pericardial space, all 4 cardiac chambers, IVC-RA junction. PLAX: LV, RV, aortic root, LA, mitral and aortic valves, pericardial effusion	**Anechoic fluid in pericardial space = HEMOPERICARDIUM. Collapse of RV/RA in diastole = tamponade. PLAX: pericardial effusion posterior to LV, pleural effusion (posterior to descending aorta).**
5	Right Anterior Chest (2nd–3rd ICS, MCL)	Linear or phased array	**Toward HEAD (12 o'clock)** ↑	Pleural line, lung sliding, A-lines, B-lines	**ABSENT lung sliding + A-lines = pneumothorax. LUNG POINT = pathognomonic. B-lines = PTX excluded at that zone.**
6	Left Anterior Chest (2nd–3rd ICS, MCL)	Linear or phased array	**Toward HEAD (12 o'clock)** ↑	Same as right side — compare bilaterally	**Absent sliding on left after RSI/intubation → may indicate right mainstem intubation. PTX until proven otherwise.**

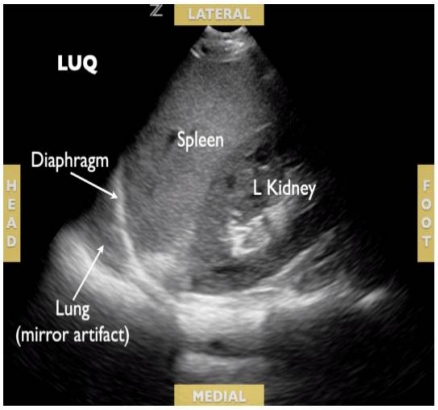


Recommended eFAST exam Sequence

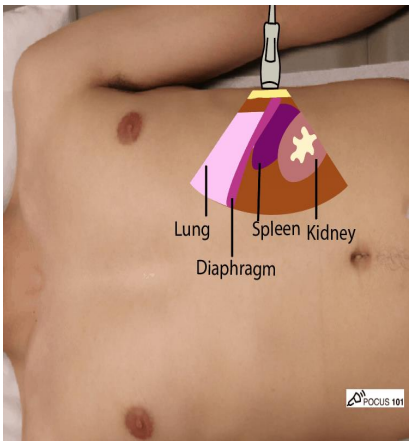


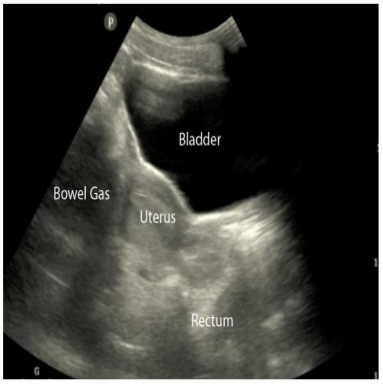
Normal RUQ – eFAST exam



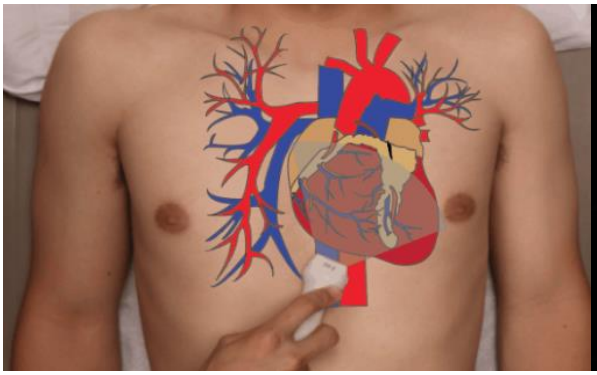


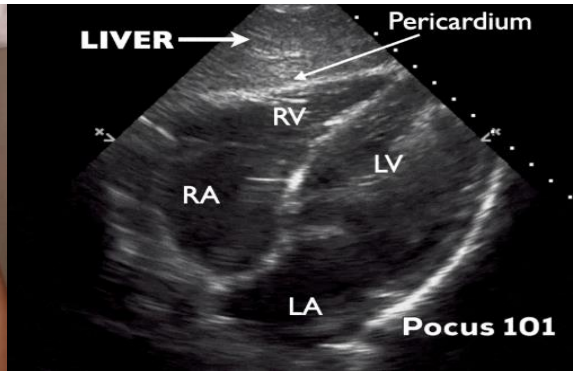
Normal LUQ – eFAST exam





Female eFAST exam Pelvic View – Longitudinal





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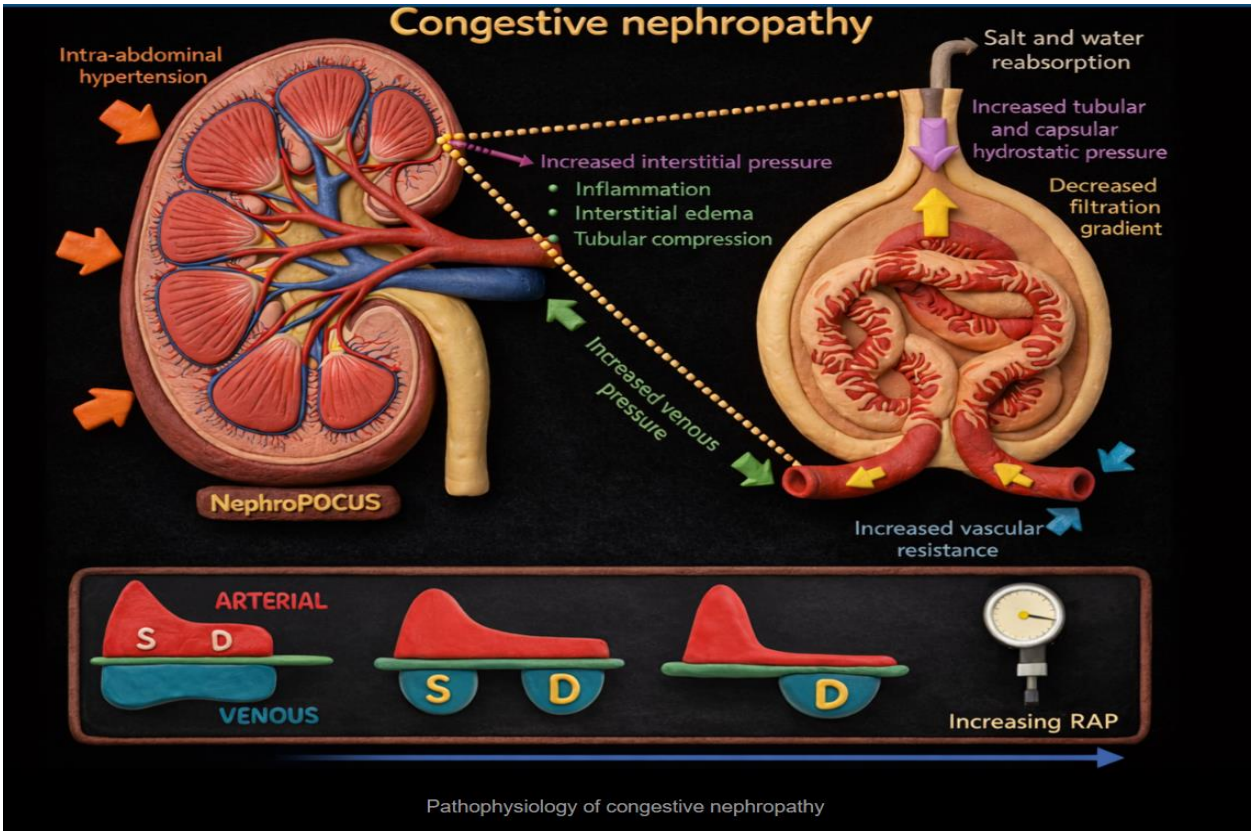

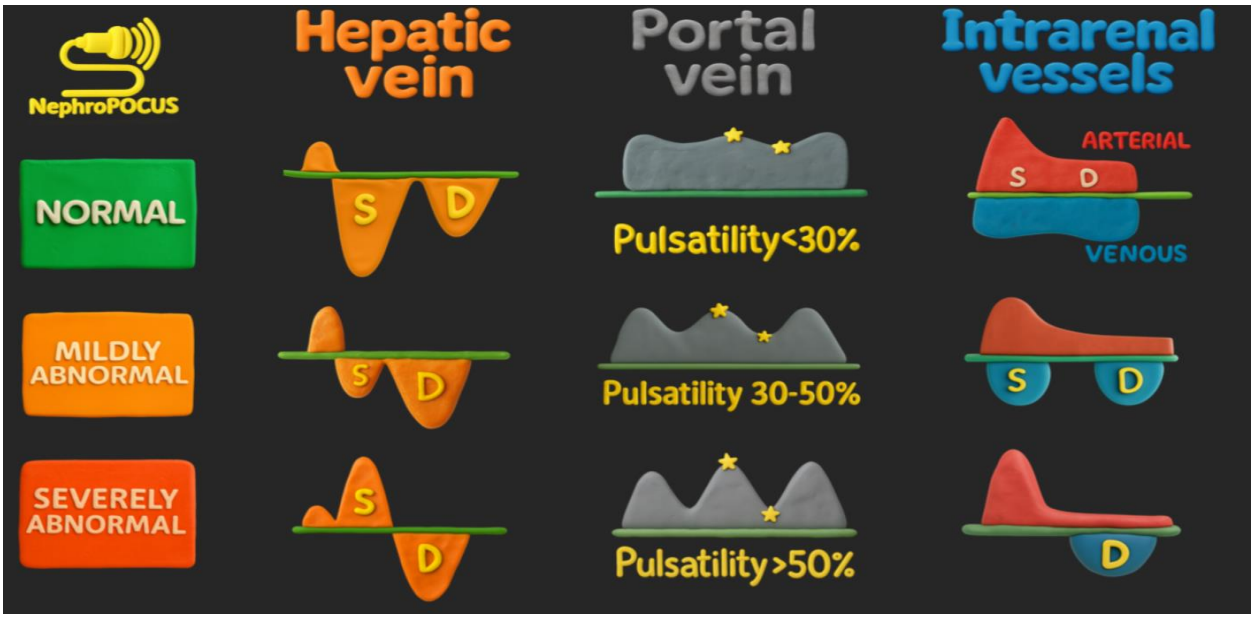

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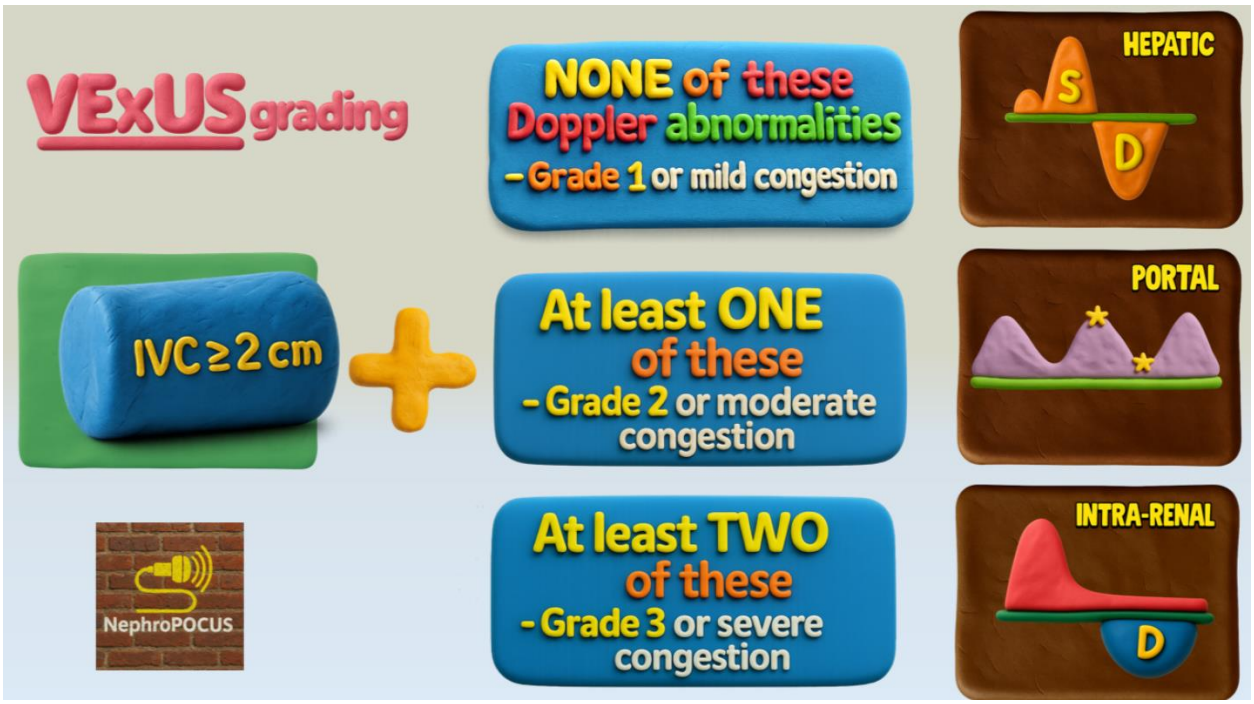

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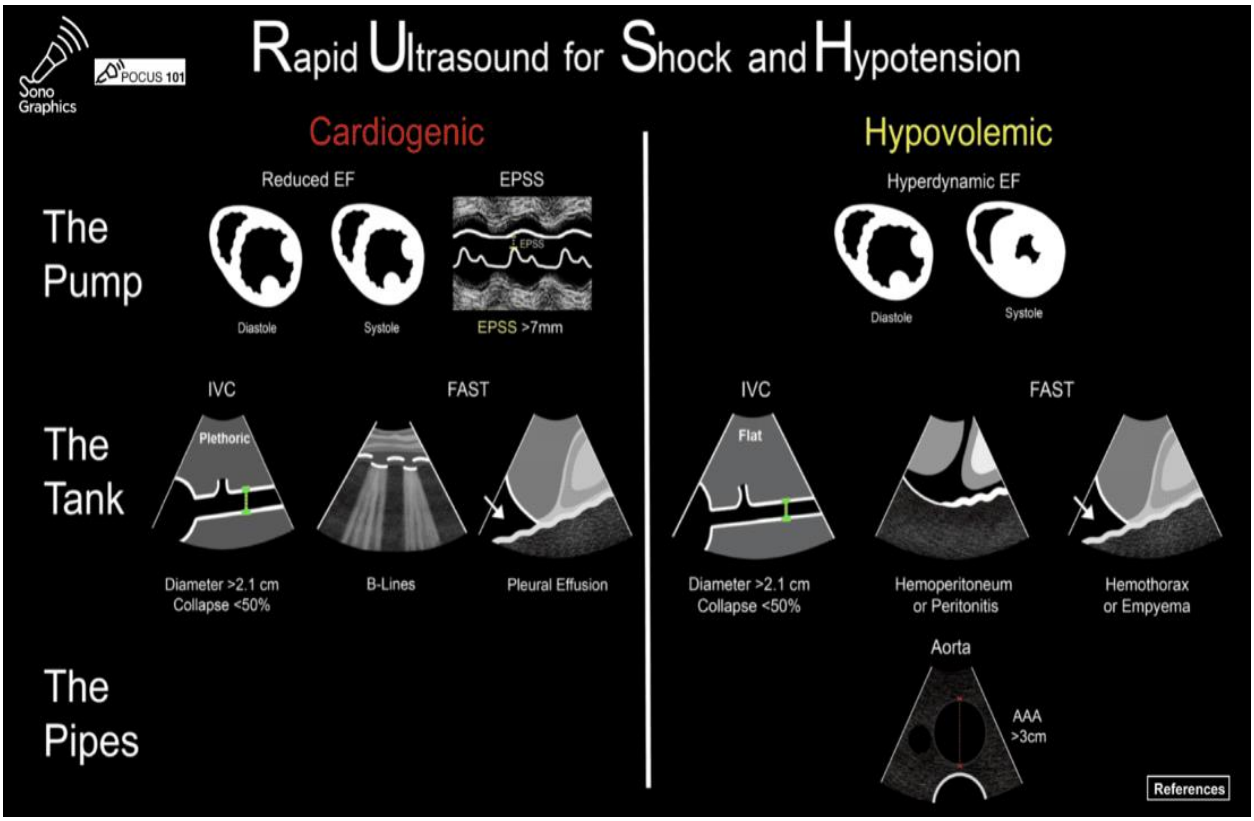

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