

Week 8: Great Vessels, Aorta & Pericardial Disease

CVSG2280 Cardiovascular Registry Review by Dr. Alice Matthews

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Where this week sits on the registry. On the ARDMS RDCS (Adult Echo, exam content outline V24.2) this week feeds mostly **Pathology (40%)** (aortic aneurysm and dissection, pericardial effusion, tamponade, constriction), with strong overlap into **Measurement, Calculation, and Views (25%)** (aortic root levels, PA pressure formulas, IVC and RAP) and a slice of **Anatomy and Physiology (15%)** (thoracic aorta segments, great vessels). Together that is more than half the adult-echo exam. On the CCI RCS blueprint it lands in **Domain D (Pathology, 29%)** and **Domain B (Measurement and Calculation, 24%)**, with the pericardial-window and great-vessel views touching **Domain C (Image Acquisition, 25%)**.

Note to students: Aortic thresholds in this guide follow the [ACC/AHA 2022 Aortic Disease guideline](#), and the pericardial and right-heart numbers follow the [ASE Pericardial Disease \(2013\)](#) and [ASE 2025 Right Heart / PA pressure](#) recommendations. Every normal value here is quoted from the course canonical-values sheet so it matches the other ten guides. **What last week's EOM gives you:** Week 7 drilled diastolic grading, E/e', and the TR jet; this week you reuse that TR jet to estimate PA pressure and reuse IVC sizing to estimate right atrial pressure. Always defer to the protocol your clinical site follows.

At a Glance: this week in one box

Must-know numbers.

Normal ascending aorta < 3.6 cm (men) / < 3.4 cm (women); sinus of Valsalva absolute aneurysm starts at 4.0 cm; **surgical threshold 5.5 cm** (or indexed > 2.75 cm/m² in Marfan or bicuspid). Abdominal aorta normal < 2.0 cm; **AAA > 3.0 cm**. Pericardial effusion: small < 1 cm, moderate 1 to 2 cm, large > 2 cm (diastolic anterior space). IVC dilated if > 2.1 cm. PH now defined as mean PAP > 20 mmHg.

Formulas you will reuse.

$RVSP = 4(V_{TR})^2 + RAP$ • $PASP = RVSP - (\text{PS gradient})$ • $mPAP = \frac{1}{3}PASP + \frac{2}{3}PADP$ • $PVR = 10 \cdot \frac{TR_{Vmax}}{RVOT_{VTI}} + 0.16$ •
TAPSE/PASP coupling > 0.5 mm/mmHg.

Top 3 EOM traps.

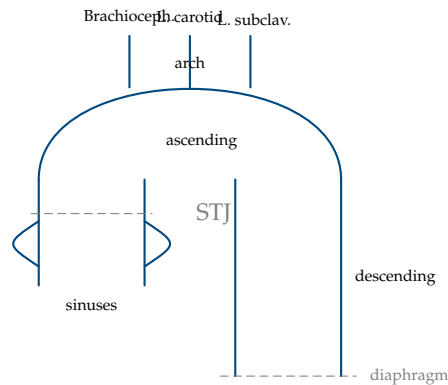
(1) **Annuloaortic ectasia** is one continuous root process (annulus + sinuses + ascending aorta), not a discrete bulge. (2) **Friction rub** (inflammation, disappears as fluid grows) is not the same as **muffled heart sounds** (large effusion or tamponade); **pericardial knock** means constriction. (3) Use **current ACC/AHA 2022** aortic thresholds, not the older 2010 numbers.

Thoracic Aortic Anatomy and Assessment

The aorta is one continuous tube, but the registry expects you to name its segments in order and know where each is best imaged. From the valve outward: the ★ **sinuses of Valsalva** (three out-pouchings just above the cusps; the left and right sinuses give rise to the left and right coronary arteries, the third is the non-coronary sinus), then the ★ **sinotubular junction (STJ)**, the slight narrowing where the bulb tapers into the tube. Beyond the STJ is the **ascending aorta**, then the **aortic arch**, then the **descending thoracic aorta**, then the **abdominal aorta** once it passes the diaphragm.

Arch branches, right to left. The arch gives off three great vessels in a fixed order: the ★ **brachiocephalic (innominate) artery**, the **left common carotid**, and the **left subclavian**. The descending thoracic aorta begins just past the left subclavian at the **ligamentum arteriosum** and ends at the aortic hiatus of the diaphragm; the abdominal aorta runs from there to the bifurcation into the iliac arteries.

Memory hook: Think "ABCS" traveling right to left: **A** (arch start), **B**rachiocephalic, **C**arotid (left common), **S**ubclavian (left).



Schematic of the thoracic aorta: sinuses of Valsalva, sinotubular junction, ascending aorta, arch with its three branches (right to left), and descending thoracic aorta.

How to measure. Measure the aortic root in the zoomed **PLAX** view at three levels: the **sinuses of Valsalva**, the **STJ**, and the **proximal ascending aorta**. ASE convention is leading-edge to leading-edge, perpendicular to the long axis, at end-diastole. The **suprasternal notch** view opens the arch and proximal descending aorta. The **descending thoracic aorta** is poorly seen from the chest, so ★ **TEE is the gold standard** for that segment and for dissection.

Common Trap

A new patient has a 4.3 cm ascending aorta. The reading physician asks the student whether this is "annuloaortic ectasia." The student says yes because the aorta is dilated. **What is the error?**

A single dilated ascending-aorta segment is just an **ascending aortic aneurysm**. **Annuloaortic ectasia** is the **diffuse** dilation of the **annulus + sinuses of Valsalva + ascending aorta as one continuous process** (a "pear-shaped" or "tulip-bulb" root), classically in Marfan and connective-tissue disease. The distinction drove a 0/3 student miss in a prior cohort, so know it cold.

Aortic Aneurysm: Definition, Grading, Surveillance

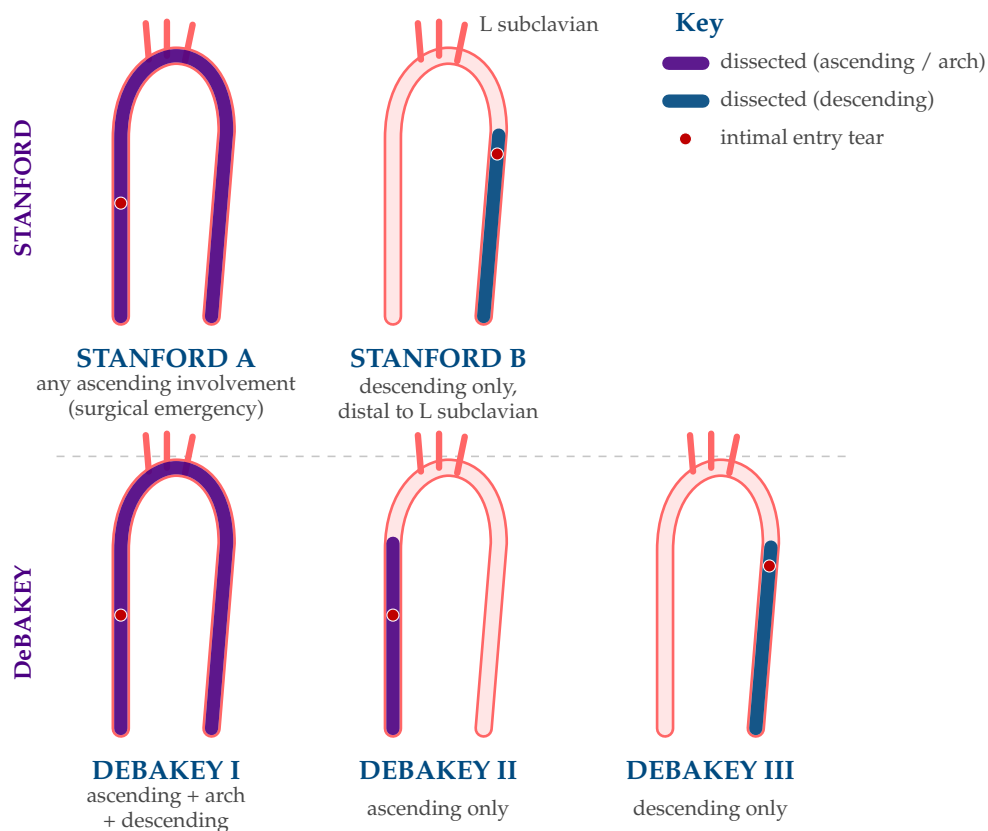
An **aneurysm** is dilation of the aorta to more than 1.5 times its normal expected diameter. The most testable numbers are the **absolute** sinus-of-Valsalva thresholds (simpler than the indexed cutoffs and what the registry leans on).

Sinus of Valsalva diameter (cm)	Classification	Surveillance interval
< 4.0	Normal	Routine
4.0 to 4.4	Mild aneurysm	Annual echo
4.5 to 4.9	Moderate aneurysm	Every 6 months
≥ 5.0	Severe aneurysm	Every 3 months or pre-surgical
≥ 5.5	★ Surgical threshold (uncomplicated)	Surgery recommended

- **Indexed cutoff:** normal sinus < 2.4 cm/m²; surgery is considered at ★ > 2.75 cm/m² in Marfan syndrome or bicuspid aortic valve (these patients are repaired earlier than the 5.5 cm absolute number).
- **ACC/AHA 2022 lowered thresholds:** 5.5 cm is the general registry default, but the 2022 guideline permits surgery at **5.0 cm** at experienced multidisciplinary aortic centers (Class IIb), and at ≥ **4.5 cm** with high-risk features or nonsyndromic heritable thoracic aortic disease. Use 5.5 cm as the default answer unless the question specifies one of these settings.
- **Annuloaortic ectasia** (the pitfall above) carries a high dissection and rupture risk; associations are **Marfan, Ehlers-Danlos, bicuspid aortic valve, and hypertension**.

Memory hook: "Four, four-five, five, five-five" climbs the staircase: 4.0 mild, 4.5 moderate, 5.0 severe, 5.5 cut.

Aortic Dissection: Classification and Echo Findings



Aortic dissection classification. Stanford A (any ascending involvement) is a surgical emergency; Stanford B spares the ascending aorta, beginning distal to the left subclavian. DeBakey I to III map the dissection by segment. The dot marks the intimal entry tear.

A dissection is a tear in the intima that lets blood track into the media, creating a **true lumen** (the original channel) and a **false lumen** (the new space), separated by a mobile ★ **intimal flap**. Two classifications matter for the exam: **DeBakey** (anatomic origin and extent) and **Stanford** (which drives management).

DeBakey type	Ascending	Arch	Descending	Tear origin
I	Yes	Yes	Yes	Ascending aorta
II	Yes	No	No	Ascending (limited)
III	No	No	Yes	Descending aorta

Stanford type	Location	Management
A	Any involvement of the ascending aorta	Surgical emergency
B	Descending only (distal to left subclavian)	Medical (blood-pressure control) unless complicated

Memory hook: "A for Ascending, A for Action (surgery)." Stanford A always involves the ascending aorta and is a surgical emergency; B is below the left subclavian and is managed medically.

Echo findings of dissection. Mobile intimal flap in the aortic lumen; **false lumen typically larger with slower, spontaneous-contrast flow** on color; aortic root dilation; **aortic regurgitation** if the flap reaches the root; and **pericardial effusion** (a red flag for rupture into the pericardium in a Stanford A). ★ **TEE is the test of choice** for the descending aorta and for flap detection, with sensitivity around 95 to 98% versus roughly 60 to 70% for TTE.

Common Trap

A student sees two lumens in the descending aorta on TEE and labels the larger, slower-flowing one the "true lumen" because it is bigger. **What is the error?**

The **false lumen is usually the larger one** with slower flow and spontaneous echo contrast; the **true lumen** is the smaller, faster channel that communicates with the aortic valve and coronary ostia in systole. Size alone does not name the lumen; flow timing and continuity with the valve do.

Figure pending: Aortic dissection intimal flap (TEE)

Abdominal Aorta Assessment

The **abdominal aorta** runs from the diaphragm to the iliac bifurcation and is imaged from **subcostal longitudinal and transverse** windows.

- **Normal abdominal aorta:** < 2.0 cm.
- ★ **Abdominal aortic aneurysm (AAA):** > 3.0 cm.
- **Surveillance:** annual at 3.0 to 3.9 cm; every 6 months at 4.0 to 4.9 cm; **repair at ≥ 5.5 cm** (same surgical number to remember as the ascending aorta).

Memory hook: "Two normal, three is an aneurysm, five-five for the knife."

Pericardial Effusion: Sizing and Location

Effusion size is graded by the **echo-free space measured in diastole**, with the anterior space the standard reference. A **circumferential** effusion is more concerning than an isolated anterior stripe, and a ★ **loculated** effusion can cause tamponade at a smaller total volume because it compresses one chamber selectively.

Grade	Anterior space (diastole)	Pattern	Concern
Trace / small	< 1 cm	May be loculated	Usually benign
Moderate	1 to 2 cm	Circumferential	Monitor for tamponade
Large	> 2 cm	Circumferential	High tamponade risk
Very large	> 3 cm	Circumferential, may be loculated	Imminent tamponade

Pericardial versus pleural effusion. This is a classic image question, decided by the **descending thoracic aorta** in the PLAX view.

- ★ **Pericardial** fluid tracks **anterior** to the descending aorta and behind the left atrium.
- **Pleural** fluid tracks **posterior** to the descending aorta and may compress the LA from outside.

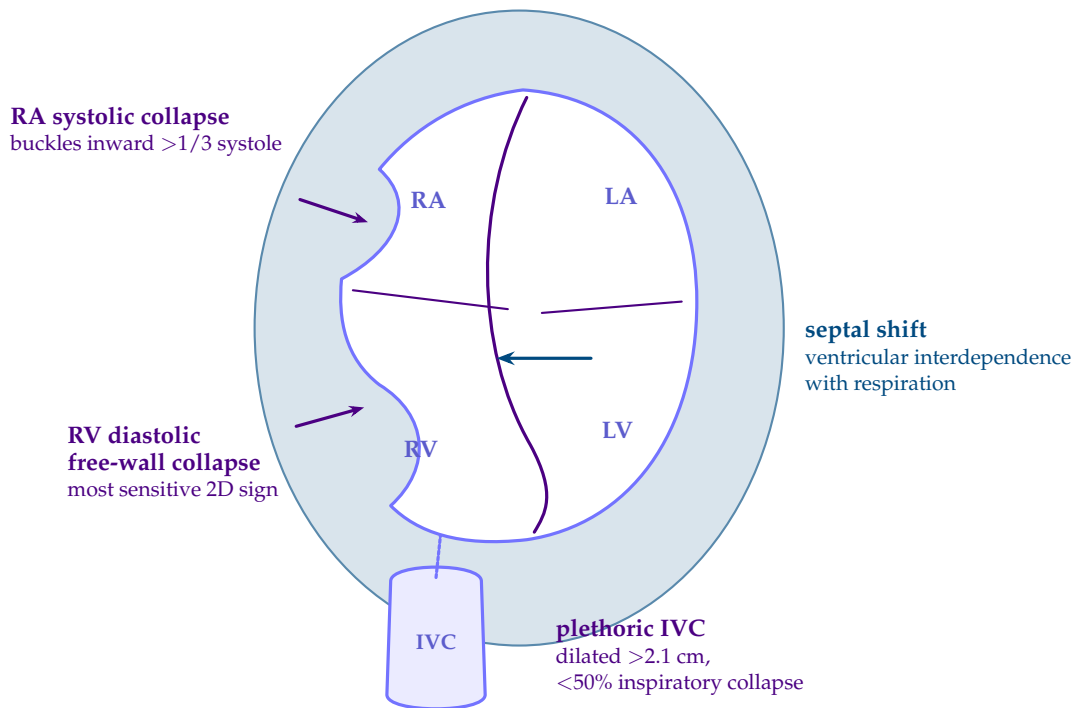
Memory hook: "Pericardial passes in front; pleural parks behind" the descending aorta.

Common Trap

On PLAX, an echo-free space lies behind the heart. The student calls it a large pericardial effusion and starts worrying about tamponade. The space is posterior to the descending thoracic aorta. **What is the error?**

Fluid that lies **posterior to the descending aorta** is a **pleural effusion**, not pericardial. Pericardial fluid passes **anterior** to the descending aorta and behind the left atrium. Using the descending aorta as the landmark prevents the over-call.

Pericardial Tamponade: Physiology and Echo Criteria



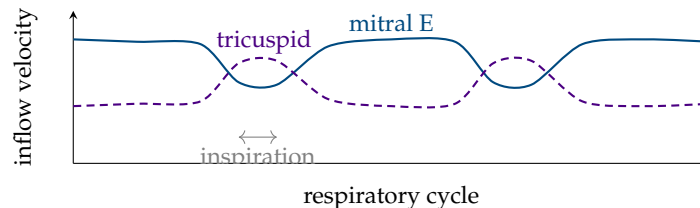
Cardiac tamponade: a circumferential anechoic pericardial effusion compresses the low-pressure right heart, producing RA systolic collapse, RV diastolic free-wall collapse, a plethoric non-collapsing IVC, and leftward septal shift (ventricular interdependence) with respiration.

Tamponade is hemodynamic collapse: pericardial pressure rises until it exceeds the filling pressure of the right heart, so venous return falls, ventricular filling drops, stroke volume falls, and the patient becomes hypotensive. The clinical bedside triad is ★ **Beck's triad: hypotension, jugular venous distension, and muffled heart sounds.**

Memory hook: Beck's triad = "low pressure, big neck veins, quiet heart."

Echo hallmarks. Listed roughly in the order chambers collapse (low-pressure chambers buckle first):

- ★ **RA systolic collapse:** inward buckling of the right atrium for $> 1/3$ of systole. High specificity, lower sensitivity.
- ★ **RV diastolic collapse:** inversion of the RV free wall in early diastole. The **most sensitive** 2D sign.
- IVC plethora:** dilated IVC > 2.1 cm with $< 50\%$ inspiratory collapse, reflecting elevated right atrial pressure.
- Respiratory inflow variation (echo pulsus paradoxus):** $> 25\%$ variation in **mitral E** velocity and $> 40\%$ variation in **tricuspid** inflow between inspiration and expiration.



Respirophasic inflow in tamponade and constriction: mitral inflow drops with inspiration while tricuspid rises (ventricular interdependence). Mitral variation $> 25\%$ and tricuspid $> 40\%$ are the cutoffs.

Sounds, and what they mean. This trio was a 0/5 student miss in a prior cohort:

- ★ **Friction rub:** scratchy, to-and-fro sound of **pericarditis** (inflamed, rubbing pericardial surfaces). It **disappears** as the effusion grows and separates the layers.
- Muffled heart sounds:** a **large effusion or tamponade** (fluid dampens sound transmission); part of Beck's triad.
- Pericardial knock:** an early-diastolic sound of **constriction**, not effusion.

Common Trap

A patient with a large pericardial effusion is documented as having a loud pericardial friction rub, cited as evidence the effusion is severe. **What is the error?**

A **friction rub fades as the effusion enlarges**, because fluid separates the two pericardial surfaces that were rubbing. A large effusion or tamponade produces **muffled** heart sounds, not a louder rub. A rub points to **pericarditis**; a knock points to **constriction**.

Figure pending: Pericardial effusion with RV diastolic collapse

Constriction versus Restrictive Cardiomyopathy

These two cause the same clinical picture (right heart failure with preserved chamber size) but have opposite fixes, so the registry loves the differential. The deciding clue is the **pericardium: thick in constriction, normal in restriction**.

Feature	Constriction (thick pericardium)	Restrictive cardiomyopathy (normal pericardium)
Pericardial thickness	> 3 mm (CT or MRI gold standard)	Normal
Septal bounce	Prominent ("square root" sign)	Absent or mild
Respiratory mitral / TR variation	> 25% / > 40%	< 25% / < 40%
E/A ratio	Often restrictive-appearing (high E/A, short DT) with marked respiratory variation	Often > 2 (restrictive)
LA size	Often dilated	Often very dilated
Mitral annular e' (TDI)	Preserved or high (annulus paradoxus)	Reduced
Treatment	Pericardiectomy	Manage heart failure

Echo of constriction. A mid-diastolic ★ **septal bounce** (the septum snaps toward the LV as the RV fills first under the fixed pericardial shell), the **dip-plateau or "square root" sign** on the ventricular pressure trace, and **pronounced respirophasic inflow swapping** (mitral falls with inspiration as tricuspid rises). The counter-intuitive ★ **annulus paradoxus** (a normal or even high medial e' despite obvious diastolic failure) helps separate constriction from restriction, where e' is reduced.

Common Trap

A patient has right heart failure, dilated atria, and a high E/e' suggesting elevated filling pressure; the student calls it restrictive cardiomyopathy. The medial e' is preserved at 11 cm/s and a septal bounce is present. **What is the error?**

Preserved or high medial e' (annulus paradoxus) plus a septal bounce points to constriction, not restriction. In restrictive cardiomyopathy the myocardium is infiltrated, so e' is **reduced**. Confirm pericardial thickening on CT or MRI; the treatments differ (pericardiectomy versus medical management).

Right Heart Hemodynamics: PA Pressure and RAP

This is where Week 7's TR jet pays off. You estimate right-sided pressures noninvasively from Doppler velocities and the IVC.

RAP from the IVC. The first step is to estimate right atrial pressure from IVC size and inspiratory collapse:

IVC size	Inspiratory collapse	Estimated RAP
≤ 2.1 cm	$> 50\%$	3 mmHg (range 0 to 5)
≤ 2.1 cm	$< 50\%$	8 mmHg (range 5 to 10)
> 2.1 cm	$> 50\%$	8 mmHg (range 5 to 10)
> 2.1 cm	$< 50\%$	15 mmHg (range 10 to 20)

Memory hook: "Small and collapsing = low (3); big and fixed = high (15)." The two mixed cases land in the middle at 8.

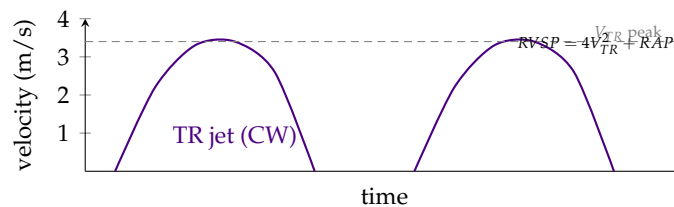
Discordant rule: whenever IVC size and collapse disagree (small but fixed, or dilated but still collapsing $> 50\%$), default to the intermediate **8 mmHg** RAP estimate (range 5 to 10).

PA pressure classification (ASE 2025). Note that the modern definition of pulmonary hypertension is ★ **mean PAP > 20 mmHg** (lowered from the older > 25). By echo, a PASP above roughly 35 to 40 mmHg remains the practical screening flag.

Classification	mean PAP (mmHg)	PASP (mmHg)
Normal	≤ 20	≤ 35
Pulmonary hypertension	> 20	> 35 to 40 (echo screen)

Historical note: the older definition reserved the "pulmonary hypertension" label for mean PAP ≥ 25 mmHg and called mean PAP 21 to 24 a "borderline / elevated" band. Current ESC/ERS and ASE 2025 standards define PH at mean PAP > 20 mmHg, so a mean PAP of 22 mmHg now counts as pulmonary hypertension.

RV-PA coupling. A newer 2025 emphasis: the ★ **TAPSE/PASP ratio > 0.5 mm/mmHg** indicates the RV is tolerating its afterload (good coupling); a falling ratio signals the RV is failing against the load. RV free-wall longitudinal strain more negative than -20% is normal.



Continuous-wave TR envelope. The peak velocity feeds the Bernoulli step; add estimated RAP to get RVSP, which equals PASP when there is no pulmonic stenosis.

Essential Formulas

Right ventricular systolic pressure: $RVSP = 4(V_{TR})^2 + RAP$

Plain English: square the peak TR jet velocity, multiply by four (simplified Bernoulli), and add the right atrial pressure you estimated from the IVC. *Why it matters:* this is the single most important right-heart number on the registry and the gateway to every PA-pressure estimate.

PA systolic pressure: $PASP = RVSP - \Delta P_{PS}$

Plain English: PASP equals RVSP unless there is pulmonic stenosis, in which case you subtract the pulmonic peak gradient. *Why it matters:* equating RVSP with PASP when PS is present over-calls pulmonary hypertension.

Mean PA pressure: $mPAP = \frac{1}{3}PASP + \frac{2}{3}PADP$

Plain English: a weighted average that leans toward the diastolic pressure, just like systemic mean arterial pressure. *Why it matters:* mean PAP > 20 mmHg is now the defining number for pulmonary hypertension. An alternate Doppler form is $mPAP = 79 - (0.45 \times RVOT_{AT}) + RAP$.

PA diastolic pressure: $PADP = 4(V_{PR,ed})^2 + RAP$

Plain English: apply Bernoulli to the end-diastolic pulmonic-regurgitation velocity, then add RAP. *Why it matters:* it supplies the diastolic term in the mean-PAP formula.

Pulmonary vascular resistance (Abbas method): $PVR = 10 \times \frac{TR_{Vmax}}{RVOT_{VTI}} + 0.16$

Plain English: the ratio of TR peak velocity (in m/s) to RVOT VTI (in cm) scaled into Wood units. *Why it matters:* PVR > 3 Wood units separates pre-capillary (vascular) from post-capillary (left-heart) pulmonary hypertension noninvasively.

Simplified Bernoulli: $\Delta P = 4V^2$

Plain English: pressure gradient across any narrowing or jet is four times the square of its peak velocity. *Why it matters:* every pressure estimate above is built on this one equation carried forward from Weeks 4 and 7.

Topic Cheat Sheet

Topic	Best window / view	Key cutoff or sign
Aortic root and ascending aorta	Zoomed PLAX (leading edge to leading edge)	Surgery at ≥ 5.5 cm; > 2.75 cm/m ² if Marfan or bicuspid
Aortic arch and branches	Suprasternal notch	Brachiocephalic, L common carotid, L subclavian (R to L)
Descending aorta and dissection	TEE (gold standard)	Mobile intimal flap; false lumen larger, slower flow
Abdominal aorta	Subcostal long and transverse	Normal < 2.0 cm; AAA > 3.0 cm
Pericardial vs pleural effusion	PLAX, use descending aorta as landmark	Pericardial anterior to aorta; pleural posterior
Effusion size	Subcostal / PLAX, diastolic anterior space	Small < 1 cm; moderate 1 to 2 cm; large > 2 cm
Tamponade	Subcostal, A4C, IVC	RV diastolic collapse (most sensitive); RA systolic collapse (most specific)
Constriction	A4C, M-mode septum	Septal bounce; annulus paradoxus; pericardium > 3 mm
RAP	Subcostal IVC	≤ 2.1 cm and collapsing = 3; > 2.1 cm and fixed = 15
PA pressure	A4C TR jet (CW)	$RVSP = 4V_{TR}^2 + RAP$; PH if mean PAP > 20

Glossary

- **STJ** — sinotubular junction; narrowing between sinuses and ascending aorta
- **Sinuses of Valsalva** — three root out-pouchings; left and right give rise to the coronary arteries
- **Annuloaortic ectasia** — diffuse dilation of annulus, sinuses, and ascending aorta as one process
- **Aneurysm** — dilation > 1.5 times the expected normal diameter
- **DeBakey** — anatomic dissection classification (types I, II, III by origin and extent)
- **Stanford** — clinical dissection classification (A = ascending, surgical; B = descending, medical)
- **Intimal flap** — torn intima separating true and false lumens
- **True lumen** — original aortic channel; communicates with the coronary ostia
- **False lumen** — space outside the tear; usually larger with

- slower flow
- **AAA** — abdominal aortic aneurysm; > 3.0 cm
- **Effusion** — fluid in the pericardial space
- **Loculated** — compartmentalized effusion; tamponade at smaller volume
- **Tamponade** — hemodynamic collapse from pericardial fluid compression
- **Beck's triad** — hypotension, jugular venous distension, muffled heart sounds
- **RA systolic collapse** — inward buckling of the right atrium in systole (specific)
- **RV diastolic collapse** — early-diastolic RV free-wall inversion (sensitive)
- **Pulsus paradoxus** — exaggerated inspiratory fall in systolic BP (> 10 mmHg)
- **Respirophasic variation** — breathing-driven swings in mitral and TR inflow
- **Friction rub** — scratchy to-and-fro sound of pericarditis; fades as fluid grows
- **Pericardial knock** — early-diastolic sound of constriction
- **Septal bounce** — mid-diastolic septal reversal; constriction hallmark
- **Square root sign** — dip-plateau ventricular pressure tracing in constriction
- **Annulus paradoxus** — preserved or high medial e' in constriction despite diastolic failure
- **IVC plethora** — dilated, non-collapsing IVC reflecting high RAP
- **RVSP** — right ventricular systolic pressure; estimates PA systolic pressure
- **PASP / PADP** — pulmonary artery systolic and diastolic pressures
- **mPAP** — mean pulmonary artery pressure; PH if > 20 mmHg
- **PVR** — pulmonary vascular resistance (Wood units); elevated > 3
- **TAPSE/PASP** — RV-PA coupling ratio; normal > 0.5 mm/mmHg

Registry Connection

This week feeds **ARDMS RDCS Pathology (40%)** and **Measurement, Calculation and Views (25%)**, plus **Anatomy and Physiology (15%)** for the great-vessel anatomy. On **CCI RCS** it maps to **Domain D (Pathology, 29%)** and **Domain B (Measurement and Calculation, 24%)**, with pericardial and great-vessel windows touching **Domain C (Image Acquisition, 25%)**. **Expect these item formats:** image-based identification (intimal flap, RV diastolic collapse, pericardial vs pleural effusion on PLAX), threshold recall (aortic 5.5 cm surgical, AAA 3.0 cm, IVC 2.1 cm), and calculation items (RVSP and mean PAP from a TR velocity and RAP). **Carry forward into Week 9:** the great-vessel anatomy here sets up congenital lesions (coarctation, PDA, transposition), and the pericardial-effusion eye sets up cardiac masses and effusions from tumor.

Study smart. Scan with confidence.

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