

# Week 1: Anatomy, Physiology & Hemodynamics

CVSG2280 Cardiovascular Registry Review by Dr. Alice Matthews

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**Registry weight this week.** This is the foundation week. It maps to the **ARDMS RDCS (Adult Echo V24.2) Anatomy/Physiology domain (15%)** and seeds the **Measurement and Views domain (25%)** through the core Doppler formulas. On the **CCI RCS** exam it feeds **Domain D (Hemodynamics / calculations, 29%)**, the single largest CCI domain, plus **Domain B (Anatomy/Physiology, 24%)**. Roughly two of every five registry items lean on something introduced here.

**Note to students:** Reference values in this guide follow the [ASE 2015 Chamber Quantification](#) guideline (dimensions and pressures) and the [ASE/EACVI 2016 LV Diastolic Function algorithm](#) (the registry-exam standard for the diastolic thresholds; the linked ASE 2025 update lowers the  $e'$  cutoffs and is introduced in Week 7). All numbers are reconciled to the program canonical values file so they match every other week. This week is the foundation for the entire course; there is no prior End of Module assessment to build on, so the formulas and normals introduced here are the bedrock that Weeks 4, 6, 7, and 8 all reuse. Always defer to the protocol your clinical site follows.

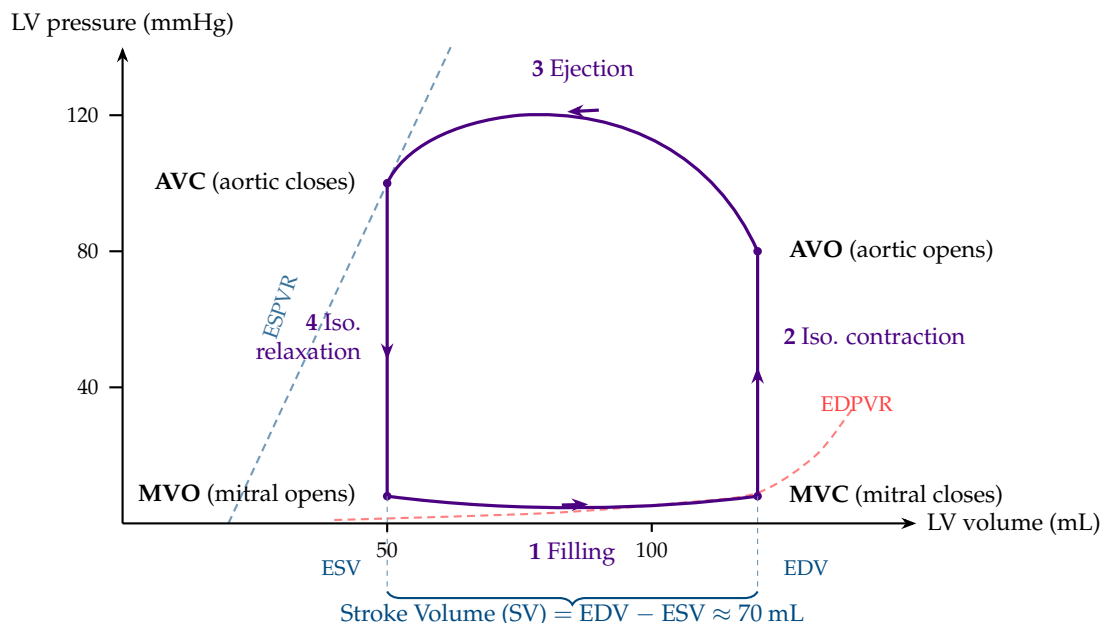
## At a Glance: this week in one box

**Must-know numbers.** LVEF preserved  $\geq 50\%$ ; SV 60 to 100 mL; CO 4 to 8 L/min; mitral E 60 to 100 cm/s, A 40 to 70 cm/s; septal  $e' \geq 7$ , lateral  $e' \geq 10$  cm/s; TR Vmax  $\leq 2.8$  m/s; LAVi  $\leq 34$  mL/m<sup>2</sup>; PASP  $< 35$  mmHg. (PASP  $< 35$  mmHg is the echo screening cutoff; pulmonary hypertension itself is now formally defined by a mean PA pressure  $> 20$  mmHg, covered in Week 7, so do not read  $< 35$  as the only relevant number.)

**Formulas you will reuse.** Simplified Bernoulli  $\Delta P = 4V^2$ ; continuity  $AVA = (CSA_{LVOT} \times VTI_{LVOT}) / VTI_{AV}$ ;  $SV = CSA_{LVOT} \times VTI_{LVOT}$ ;  $CO = SV \times HR$ ;  $EF = (EDV - ESV) / EDV$ ;  $PASP = 4V_{TR}^2 + RAP$ .

**Top 3 EOM traps.** (1) Using simplified Bernoulli when the proximal velocity is  $\geq 1.5$  m/s. (2) Thinking a high E/ $e'$  means good filling (it rises as filling pressure rises). (3) Treating RAP as a fixed number instead of reading it off IVC size and collapse.

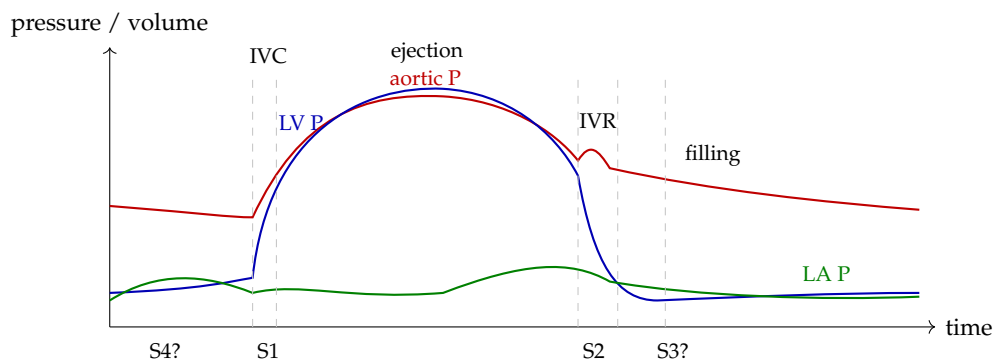
## The Cardiac Cycle and the Wiggers Diagram



Left-ventricular pressure to volume loop. The cycle runs counterclockwise through four phases (1 filling, 2 isovolumetric contraction, 3 ejection, 4 isovolumetric relaxation); valve events occur at the corners. Loop width equals stroke volume (EDV minus ESV).

The cardiac cycle is one complete heartbeat: the coordinated sequence of pressure and volume changes that fills

the ventricles and ejects blood. The **Wiggers diagram** is the single best visual anchor for the whole course. If you can place every Doppler measurement onto the right phase of the cycle, the rest of registry physiology follows.



Wiggers diagram schematic: aortic pressure (red), LV pressure (blue), and LA pressure (green) across one cycle. S1 opens systole at mitral closure; S2 (the dirotic notch) opens diastole at aortic closure. IVC = isovolumetric contraction, IVR = isovolumetric relaxation.

**The seven phases.** The cycle runs through seven phases in order, each tied to a measurement you will take later:

1. Atrial systole: the “atrial kick,” lost in atrial fibrillation and worth roughly 20% of filling (S4 if the ventricle is stiff).
2. Isovolumetric contraction: all four valves closed, pressure climbs (S1 at mitral closure;  $dp/dt$  measured here from an MR jet).
3. Rapid ejection: peak aortic velocity is measured here.
4. Reduced ejection: flow tapers as the ventricle empties.
5. Isovolumetric relaxation: all valves closed again, pressure falls (S2 at aortic closure; IVRT measured here).
6. Rapid filling: 70 to 80% of ventricular filling (the mitral **E wave**; S3 if present).
7. Diastasis: the slow phase that disappears first when the heart rate rises, which is why tachycardia hurts diastolic filling.

**Memory hook:** Atrial Kick Comes In Right Rhythm For Diastole (Atrial systole, isovolumetric Contraction, rapid Ejection, Reduced ejection, isovolumetric Relaxation, rapid Filling, Diastasis).

**Heart sounds.** ★ S1 = mitral and tricuspid closure (start of systole). S2 = aortic and pulmonic closure (start of diastole). S3 = rapid ventricular filling (normal in the young; a sign of volume overload or heart failure in adults). S4 = atrial contraction against a stiff ventricle (never normal; tracks with diastolic dysfunction).

**Memory hook:** count them in order: 1 closes the AV valves, 2 closes the semilunars, 3 is the floppy ventricle filling fast, 4 is the atrium kicking a stiff wall.

**Preload, afterload, contractility.** Preload is the stretch on the ventricle at end diastole (how far you draw a bow). Afterload is the resistance the ventricle pushes against (the stiffness of the bow). Contractility is the intrinsic strength of the squeeze. The **Frank-Starling mechanism** states that, up to a point, more preload produces a stronger contraction.

### Common Trap

A board question gives a TR jet of 3.0 m/s with an aortic stenosis jet of 4.5 m/s and a measured LVOT velocity of 1.8 m/s. A student computes the aortic gradient as  $4 \times 4.5^2 = 81$  mmHg. What is the error?

The proximal (LVOT) velocity is  $\geq 1.5$  m/s, so simplified Bernoulli over-counts. Use the modified form  $\Delta P = 4(V_2^2 - V_1^2) = 4(4.5^2 - 1.8^2) = 4(20.25 - 3.24) = 68$  mmHg. Whenever  $V_1 \geq 1.5$  m/s, subtract the proximal velocity before squaring.

## Cardiac Chambers, Great Vessels, and Normal Pressures

Blood returns from the body to the **right atrium** (via SVC and IVC), crosses the tricuspid valve into the **right ventricle**, is pumped through the pulmonic valve to the lungs, returns oxygenated through the pulmonary veins to the **left atrium**, crosses the mitral valve into the **left ventricle**, and is ejected through the aortic valve into the **aorta**. Pressures rise as you move from the venous side to the arterial side; knowing the normal numbers lets you recognize pulmonary hypertension, elevated filling pressures, and shunts on sight.

Figure pending: labeled four-chamber anatomy (RA, RV, LA, LV, aorta).

### ★ Normal chamber pressures (mmHg):

| Location         | Systolic  | Diastolic | Mean      |
|------------------|-----------|-----------|-----------|
| Right atrium     | n/a       | n/a       | 0 to 8    |
| Right ventricle  | 15 to 30  | 0 to 8    | n/a       |
| Pulmonary artery | 15 to 30  | 4 to 14   | 9 to 16   |
| Left atrium      | n/a       | n/a       | 2 to 12   |
| Left ventricle   | 90 to 140 | 5 to 12   | n/a       |
| Aorta            | 90 to 140 | 60 to 90  | 70 to 105 |

### ★ Normal chamber dimensions (ASE 2015):

| Parameter           | Men        | Women      | Units                  |
|---------------------|------------|------------|------------------------|
| LVIDd               | 4.2 to 5.8 | 3.8 to 5.2 | cm                     |
| LVIDs               | 2.5 to 4.0 | 2.2 to 3.5 | cm                     |
| IVSd                | 0.6 to 1.0 | 0.6 to 0.9 | cm                     |
| LV mass index       | $\leq 115$ | $\leq 95$  | $\text{g}/\text{m}^2$  |
| RV basal diameter   | $\leq 4.1$ | $\leq 4.1$ | cm                     |
| RA area (4-chamber) | $\leq 18$  | $\leq 18$  | $\text{cm}^2$          |
| LA volume index     | $\leq 34$  | $\leq 34$  | $\text{mL}/\text{m}^2$ |
| TAPSE               | $\geq 1.7$ | $\geq 1.7$ | cm                     |
| RV S' (TDI)         | $\geq 10$  | $\geq 10$  | cm/s                   |

**Normal valve areas.** Aortic 2.5 to 4.0  $\text{cm}^2$ ; mitral 4.0 to 6.0  $\text{cm}^2$ ; tricuspid 7.0 to 9.0  $\text{cm}^2$ ; pulmonic 2.5 to 4.0  $\text{cm}^2$ . These are the starting points the stenosis cutoffs in Week 4 are measured against.

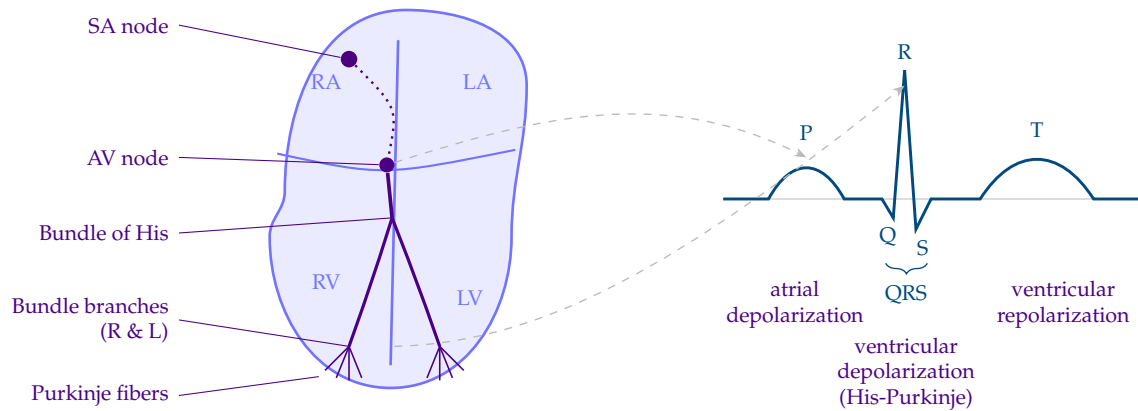
**Right atrial normal variants.** The RA holds several benign structures that students mistake for pathology: the **crista terminalis** (a muscular ridge), the **Eustachian valve** (IVC flap), the **Thebesian valve** (coronary sinus flap), and a **Chiari network** (a lacy mobile remnant). Recognize them so you do not call a normal variant a thrombus or vegetation.

### Common Trap

You estimate PASP from a TR jet of 2.6 m/s and a textbook RAP of 5 mmHg, reporting  $4(2.6)^2 + 5 = 32$  mmHg. The IVC measures 2.4 cm and barely collapses on a sniff. What is the error?

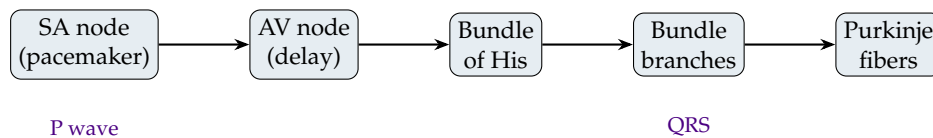
RAP is not a fixed 5 mmHg; it is read off the IVC. A dilated IVC ( $> 2.1$  cm) that collapses less than 50% means RAP is roughly 15 mmHg, not 5. The correct estimate is  $4(2.6)^2 + 15 = 42$  mmHg, which crosses into elevated pulmonary pressure. Always grade the IVC before assigning RAP (3 mmHg small/collapsing, 8 mmHg intermediate, 15 mmHg dilated/fixed).

## The Conduction System



*The cardiac conduction system and its ECG correlates: the SA node fires (P wave, atrial depolarization), the impulse pauses at the AV node, then travels down the bundle of His, the right and left bundle branches, and the Purkinje fibers to depolarize the ventricles (QRS); the T wave marks ventricular repolarization.*

The electrical impulse begins at the **SA node** (the natural pacemaker, in the high right atrium), travels through the atria to the **AV node** (which delays the signal so the atria finish emptying), down the **bundle of His**, into the right and left **bundle branches**, and out through the **Purkinje fibers** to depolarize the ventricles. On the ECG: the **P wave** is atrial depolarization (precedes atrial systole), the **QRS complex** is ventricular depolarization (precedes ventricular systole), and the **T wave** is ventricular repolarization. Lining the ECG up with the Wiggers diagram is how you time every gated measurement.



*Conduction pathway: SA node fires (P wave), the AV node delays, then His-Purkinje spreads ventricular depolarization (QRS).*

**Memory hook:** Some Athletes Have Big Purkinje (SA node, AV node, His bundle, Bundle branches, Purkinje) is the fixed order from pacemaker to ventricle.

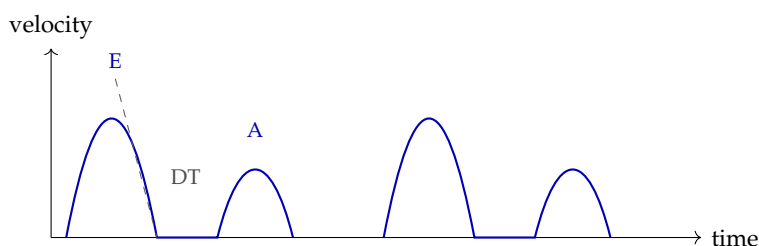
**Embryology pitfall.** ★ Cardiac jelly (the gelatinous matrix in the early heart tube that becomes the endocardial cushions, which form the valves and septa) is not the same as the endothelial lining of the mature heart wall. Confusing the two is a classic registry trip-up.

## Normal Blood Flow and Diastolic Function

Normal flow is laminar and follows predictable velocities at each site. Diastolic function describes how easily the LV relaxes and fills; it is graded from the mitral inflow pattern, tissue Doppler of the mitral annulus, LA size, and the TR jet.

★ Normal Doppler velocities:

| Measurement          | Location                             | Normal         |
|----------------------|--------------------------------------|----------------|
| LVOT diameter        | PLAX, 2 to 3 mm proximal to valve    | 1.8 to 2.2 cm  |
| LVOT VTI             | PW, apical 5-chamber                 | 18 to 22 cm    |
| Peak aortic velocity | CW, apical 5-chamber or suprasternal | < 2.5 m/s      |
| Mitral E wave        | PW at MV leaflet tips                | 60 to 100 cm/s |
| Mitral A wave        | PW at MV leaflet tips                | 40 to 70 cm/s  |
| Septal e' (TDI)      | apical 4-chamber                     | ≥ 7 cm/s       |
| Lateral e' (TDI)     | apical 4-chamber                     | ≥ 10 cm/s      |
| TR peak velocity     | CW, apical 4-chamber                 | ≤ 2.8 m/s      |



Normal mitral inflow: a dominant early (E) wave and a smaller atrial (A) wave, with  $E > A$ . The E-wave downslope is the deceleration time (DT).

**Diastolic grading (ASE/EACVI 2016 algorithm, the registry standard).** ★ The four pillars are: average E/e', septal and lateral e', LA volume index, and peak TR velocity. The 2016 framework treats LV filling pressure as normal when fewer than half of the available pillars are abnormal, and elevated when more than half are. The septal  $e' \geq 7$  and lateral  $e' \geq 10$  cm/s values below are the 2016 cutoffs; the ASE 2025 update lowers them (septal  $\leq 6$ , lateral  $\leq 7$  cm/s) and adds LA reservoir strain, both taught with the formal step-by-step flowchart in Week 7. For now, learn the four normal values and the direction each one moves.

| Parameter                            | Normal     | Borderline                 | Abnormal                                |
|--------------------------------------|------------|----------------------------|-----------------------------------------|
| E/A ratio                            | 0.8 to 2.0 | n/a                        | < 0.8 (impaired) or > 2.0 (restrictive) |
| Average E/e'                         | < 8        | 8 to 14                    | > 14                                    |
| Septal e' (cm/s)                     | ≥ 7        | n/a                        | < 7                                     |
| Lateral e' (cm/s)                    | ≥ 10       | n/a                        | < 10                                    |
| IVRT (ms)                            | 60 to 90   | > 90 (impaired relaxation) | < 70 (restrictive)                      |
| Deceleration time (ms)               | 160 to 200 | n/a                        | > 200 (impaired) or < 160 (restrictive) |
| LA volume index (mL/m <sup>2</sup> ) | < 28       | 28 to 34                   | > 34                                    |
| TR Vmax (m/s)                        | ≤ 2.8      | n/a                        | > 2.8                                   |

### Common Trap

A patient has a mitral E wave of 100 cm/s and an average e' of 5 cm/s, giving  $E/e' = 20$ . A student reasons that a high ratio means the ventricle is filling well and relaxing normally. What is the error?

$E/e'$  moves the opposite direction from intuition: it **rises** as LV filling pressure rises. A low  $e'$  (poor relaxation) in the denominator pushes the ratio up. An average  $E/e' > 14$  indicates **elevated** filling pressure (impaired diastolic function), not healthy filling. Normal is  $< 8$ .

### Aortic Root and Ascending Aorta (PLAX)

| Location                  | Normal (cm) |
|---------------------------|-------------|
| Aortic annulus            | 1.8 to 2.6  |
| Sinuses of Valsalva       | 2.1 to 3.5  |
| Sinotubular junction      | 1.7 to 3.4  |
| Ascending aorta (men)     | $< 3.6$     |
| Ascending aorta (women)   | $< 3.4$     |
| Aortic arch               | $< 3.8$     |
| Descending thoracic aorta | $< 3.0$     |

These baselines matter in Week 8, where aneurysm, dissection, and annuloaortic ectasia are graded against them.

### Systolic Function and Cardiac Output

| Parameter             | Normal                          | Notes                                                                                                     |
|-----------------------|---------------------------------|-----------------------------------------------------------------------------------------------------------|
| LVEF (men)            | 52 to 72%                       | Preserved $\geq 50\%$ ; mildly reduced 41 to 49%; moderately reduced 30 to 40%; severely reduced $< 30\%$ |
| LVEF (women)          | 54 to 74%                       | Same classification bands                                                                                 |
| Fractional shortening | 25 to 45%                       | M-mode PLAX                                                                                               |
| Stroke volume         | 60 to 100 mL                    | n/a                                                                                                       |
| Stroke volume index   | 33 to 47 mL/m <sup>2</sup>      | n/a                                                                                                       |
| Cardiac output        | 4 to 8 L/min                    | $< 4$ reduced                                                                                             |
| Cardiac index         | 2.5 to 4.0 L/min/m <sup>2</sup> | $< 2.0$ reduced                                                                                           |
| dP/dt                 | $> 1200$ mmHg/s                 | From the MR jet ascending limb; 800 to 1200 mildly reduced                                                |
| Tei index (MPI)       | LV $< 0.40$ ; RV $< 0.55$       | Combined systolic + diastolic measure                                                                     |

**Embryology and fetal circulation.** ★ Three fetal shunts bypass the lungs and liver: the **foramen ovale** (right atrium to left atrium, leaving a probe-patent PFO in 25 to 30% of adults), the **ductus arteriosus** (pulmonary artery to descending aorta, normally closing into the ligamentum arteriosum), and the **ductus venosus** (umbilical vein to IVC, closing into the ligamentum venosum). After birth, the rising left atrial pressure and falling pulmonary resistance close them.

**Memory hook:** three fetal “bypasses,” three normal closures: **O**vale, **A**rteriosus, **V**enosus.

## Essential Formulas

Every formula below is reused later in the course; learn them once now. (No worked examples here; you will apply them in Weeks 4, 6, 7, and 8.)

**Simplified Bernoulli:**  $\Delta P = 4V^2$  converts a Doppler velocity into a pressure gradient. Plain English: a faster jet means a bigger pressure difference. Why it matters: this is how every stenosis gradient and pressure estimate is derived. Use the modified form  $\Delta P = 4(V_2^2 - V_1^2)$  when the proximal velocity  $V_1 \geq 1.5$  m/s.

**Continuity (AVA):**  $AVA = \frac{CSA_{LVOT} \times VTI_{LVOT}}{VTI_{AV}}$  uses conservation of flow: what goes into the LVOT must come out the valve, with  $CSA_{LVOT} = \pi(d/2)^2$ . Why it matters: it is the backbone of aortic stenosis grading in Week 4 and is unaffected by flow state.

**Dimensionless index:**  $DVI = \frac{VTI_{LVOT}}{VTI_{AV}}$  a ratio needing no diameter measurement. Why it matters: severe AS when  $< 0.25$ , and it sidesteps the error-prone LVOT diameter.

**Stroke volume and output:**  $SV = CSA_{LVOT} \times VTI_{LVOT}$ ,  $CO = SV \times HR$ ,  $CI = \frac{CO}{BSA}$ . Plain English: volume per beat, times beats per minute, normalized to body size. Why it matters: low forward output drives most heart-failure findings.

**Ejection fraction and fractional shortening:**  $EF = \frac{EDV - ESV}{EDV} \times 100\%$ ,  $FS = \frac{LVIDd - LVIDs}{LVIDd} \times 100\%$ . EF is the volume measure (Simpson biplane); FS is the linear M-mode shortcut. Why it matters: EF is the headline systolic number on every report.

**Pressure half-time (MVA):**  $MVA = \frac{220}{PHT}$  the slower the mitral inflow decays, the tighter the valve. Why it matters: fast bedside mitral stenosis estimate; do not use it on a prosthetic valve.

**PISA (regurgitation):**  $EROA = \frac{2\pi r^2 \times V_{alias}}{V_{max}}$  and  $RVol = EROA \times VTI_{regurg}$ . Plain English: a bigger color hemisphere means a bigger leak. Why it matters: the quantitative core of MR and AR severity.

**PASP via TR:**  $PASP = 4(V_{TR})^2 + RAP$  estimates pulmonary pressure from the TR jet plus right atrial pressure (RAP from IVC size and collapse). Why it matters: the screening test for pulmonary hypertension; normal  $< 35$  mmHg.

**E/e' (filling pressure):**  $E/e' = \frac{\text{mitral } E}{e'}$  a surrogate for LV filling pressure. Why it matters: it rises as filling pressure rises;  $> 14$  suggests elevated pressure.

**Shunt and regurgitant fraction:**  $Qp:Qs = \frac{SV_{pulm}}{SV_{syst}}$  (significant shunt  $\geq 1.5$ ) and  $RF = \frac{RVol}{SV_{total}} \times 100\%$  (severe  $\geq 50\%$ ). Why it matters: quantifies congenital shunts and the regurgitant burden.

**dP/dt and Tei index:**  $dP/dt = \frac{32}{\Delta t}$  (mmHg/s; from the MR jet, normal  $> 1200$ ) and  $MPI = \frac{IVCT + IVRT}{ET}$  (normal LV  $< 0.40$ , RV  $< 0.55$ ). Why it matters: load-light contractility and a combined systolic-diastolic index.

**Doppler equation:**  $\Delta F = \frac{2F_0 V \cos \theta}{c}$  the physics behind every velocity you measure; angle matters, which is why  $\theta$  should be near zero ( $c = 1540$  m/s). Why it matters: covered fully in Week 3, but every number above starts here.

## Week 1 Normal-Values Cheat Sheet

| Domain    | Parameter             | Normal                          |
|-----------|-----------------------|---------------------------------|
| Systolic  | LVEF (preserved)      | $\geq 50\%$                     |
| Systolic  | Stroke volume         | 60 to 100 mL                    |
| Systolic  | Cardiac output        | 4 to 8 L/min                    |
| Systolic  | Cardiac index         | 2.5 to 4.0 L/min/m <sup>2</sup> |
| Systolic  | Fractional shortening | 25 to 45%                       |
| Systolic  | dP/dt                 | $> 1200$ mmHg/s                 |
| Diastolic | Mitral E / A          | 60 to 100 / 40 to 70 cm/s       |
| Diastolic | E/A ratio             | 0.8 to 2.0                      |
| Diastolic | Septal / lateral e'   | $\geq 7$ / $\geq 10$ cm/s       |
| Diastolic | Average E/e'          | $< 8$                           |
| Diastolic | LA volume index       | $\leq 34$ mL/m <sup>2</sup>     |
| Diastolic | Deceleration time     | 160 to 200 ms                   |
| Pressures | RA mean / PA mean     | 0 to 8 / 9 to 16 mmHg           |
| Pressures | PASP (estimated)      | $< 35$ mmHg                     |
| Outflow   | LVOT diameter / VTI   | 1.8 to 2.2 cm / 18 to 22 cm     |
| Outflow   | Peak aortic velocity  | $< 2.5$ m/s                     |
| Valves    | TR peak velocity      | $\leq 2.8$ m/s                  |

## Glossary

- **Preload** — end-diastolic ventricular stretch (volume load)
- **Afterload** — resistance the ventricle ejects against
- **Contractility** — intrinsic strength of contraction (dP/dt)
- **Frank-Starling** — more preload yields a stronger contraction, to a limit
- **Cardiac cycle** — one full heartbeat: systole plus diastole
- **Systole** — contraction phase; begins at S1
- **Diastole** — relaxation and filling; begins at S2
- **Isovolumetric** — all four valves closed; pressure changes, volume does not
- **Atrial kick** — atrial systole contribution to filling; lost in AF
- **Rapid filling** — early diastole, 70 to 80% of LV filling (E wave)
- **Compliance** — ability of a chamber to stretch; inverse of stiffness
- **EF** — ejection fraction (volume-based systolic measure)
- **FS** — fractional shortening (linear M-mode measure)
- **SV / CO / CI** — stroke volume / cardiac output / cardiac index
- **VTI** — velocity-time integral (Doppler envelope area, cm)
- **LVOT** — left ventricular outflow tract
- **E wave / A wave** — early passive / late atrial mitral inflow
- **e'** — mitral annular tissue-Doppler relaxation velocity
- **E/e'** — surrogate for LV filling pressure
- **LAVi** — left atrial volume index (mL/m<sup>2</sup>)
- **RAP** — right atrial pressure (from IVC size and collapse)
- **PASP / RVSP** — pulmonary artery / RV systolic pressure
- **Qp:Qs** — pulmonary-to-systemic shunt ratio
- **MPI (Tei)** — myocardial performance index
- **Doppler shift** — frequency change off moving blood
- **Annulus** — fibrous ring at a valve base
- **Foramen ovale (PFO)** — fetal interatrial opening; probe-patent in 25 to 30% of adults
- **Ductus arteriosus** — fetal PA-to-aorta shunt; becomes ligamentum arteriosum
- **Ductus venosus** — fetal umbilical-vein-to-IVC shunt
- **Cardiac jelly** — early matrix forming the endocardial cushions (valves/septa)

## Registry Connection

This week feeds the **ARDMS RDCS Anatomy and Physiology subdomain (15%)** and seeds the **Measurement and Views subdomain (25%)**; on **CCI RCS** it feeds **Domain D (Hemodynamics/calculations, 29%)** and **Domain B (Anatomy/Physiology, 24%)**. Expect item formats that ask you to: place a Doppler measurement on the correct cardiac-cycle phase; identify S1 through S4 by timing; read normal chamber pressures, dimensions, and valve areas; and calculate SV, CO, EF, FS, and a Bernoulli gradient. You will reuse Bernoulli, continuity, PISA, and the TR-jet pressure estimate from Week 4 onward.

**Carry forward into Week 2:** the chamber anatomy and normal flow directions you learned here become the standard echo windows and views, where you will learn which probe position best shows each structure.

*Study smart. Scan with confidence.*

[Dr. Alice Matthews](https://deepneuro.ai/alice) · [deepneuro.ai/alice](https://deepneuro.ai/alice)

