ICU/IMC Overview of “Pressures”

1. Core Heart & Vascular Pressures

Right-Sided Pressures

These reflect **preload, RV function, and pulmonary circulation**.

Pressure	Normal Range	What it Represents
Right Atrial Pressure (RAP / CVP)	2–6 mmHg	RV preload, volume status, venous return
Right Ventricular Pressure (RVP)	15–30 / 2–8 mmHg	RV systolic function & compliance
Pulmonary Artery Systolic (PAS)	15–30 mmHg	Pulmonary vascular load
Pulmonary Artery Diastolic (PAD)	4–12 mmHg	LV filling pressure surrogate (if normal lungs)
Pulmonary Artery Mean (PAM)	10–20 mmHg	Overall pulmonary pressure
Pulmonary Capillary Wedge Pressure (PCWP / PAOP)	6–12 mmHg	**Left atrial pressure surrogate**

Left-Sided Pressures

Usually measured **directly in cath lab**, indirectly in ICU.

Pressure	Normal Range	What it Represents
Left Atrial Pressure (LAP)	6–12 mmHg	LV preload
Left Ventricular End-Diastolic Pressure (LVEDP)	5–12 mmHg	LV compliance, diastolic function
Left Ventricular Systolic Pressure (LVSP)	~90–140 mmHg	LV contractility
Aortic Pressure	~120/80 mmHg	Afterload, systemic perfusion

Derived / Calculated Pressures

These come from combining values.

Measurement	Formula	Why It Matters
MAP	(SBP + 2×DBP) / 3	Organ perfusion
Pulmonary Vascular Resistance (PVR)	(PAM – PCWP) / CO	Pulmonary HTN
Systemic Vascular Resistance (SVR)	(MAP – RAP) / CO	Shock states
Transpulmonary Gradient (TPG)	PAM – PCWP	Pre- vs post-capillary PH

2. Where These Are Measured

Cardiac Catheterization Lab

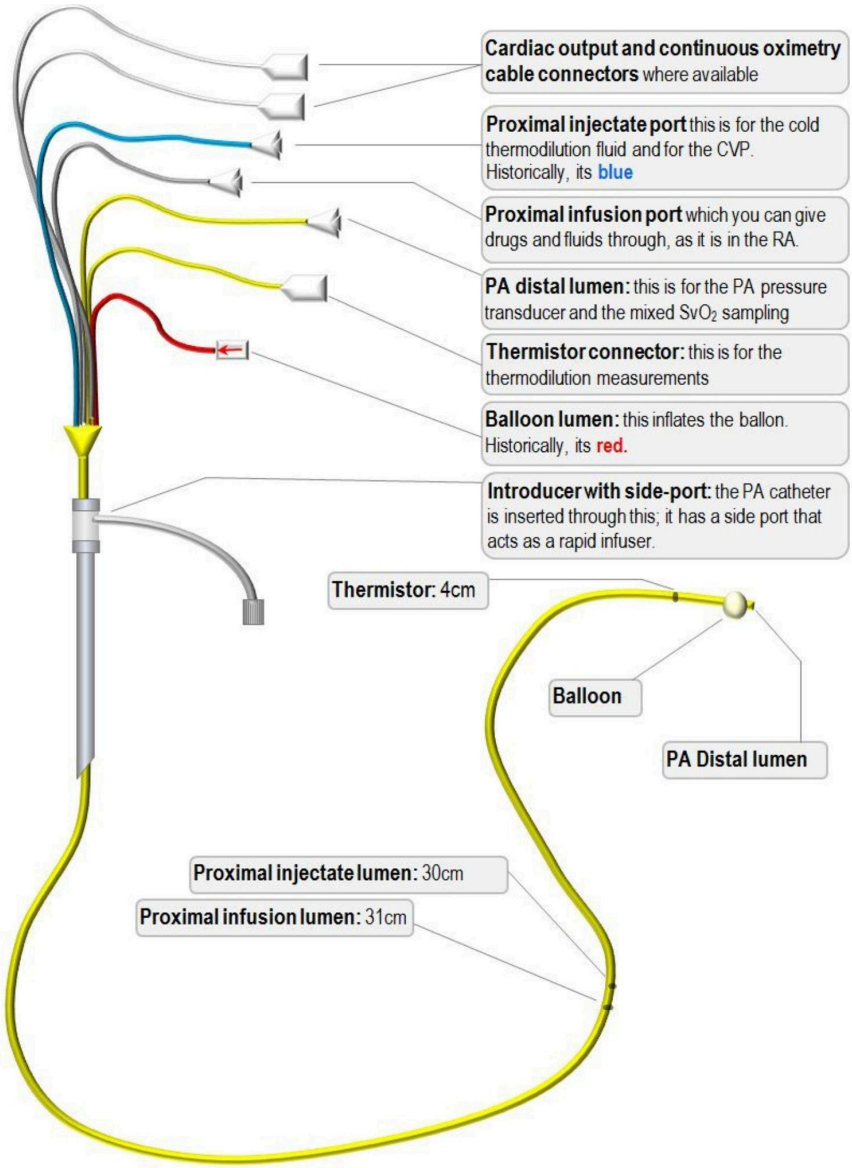
- Direct intracardiac measurements
- Gold standard for:
    - LVEDP
    - PCWP confirmation
    - Pulmonary hypertension workups
    - Valve gradients (AS, MS)
    - Shunt calculations (Qp/Qs)

ICU / CVICU

- Continuous or semi-continuous monitoring
- Trending and response-to-therapy focused
- Often **surrogates**, not direct chamber access

3. Devices That Measure These Pressures

Pulmonary Artery Catheter (Swan-Ganz)



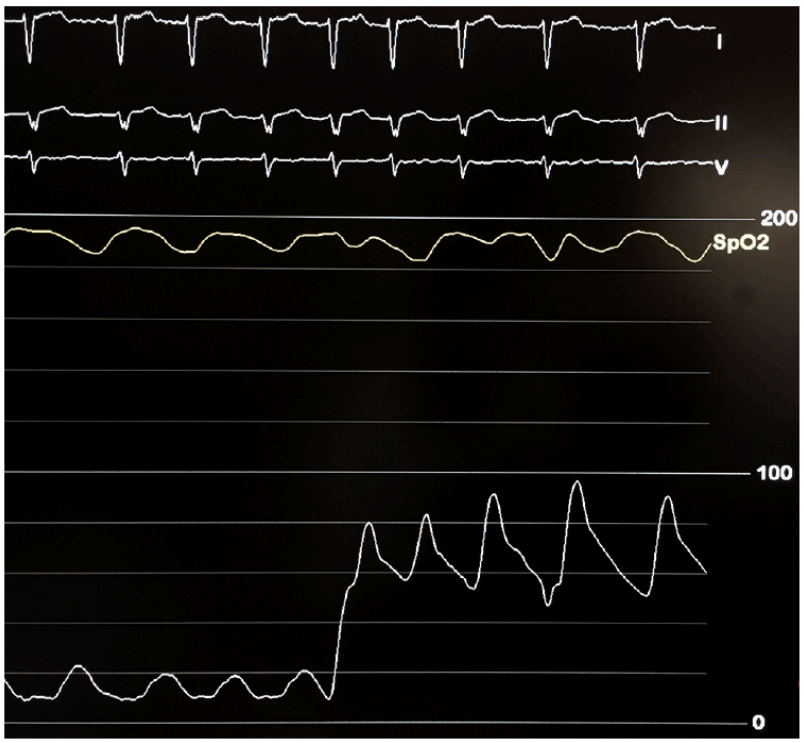
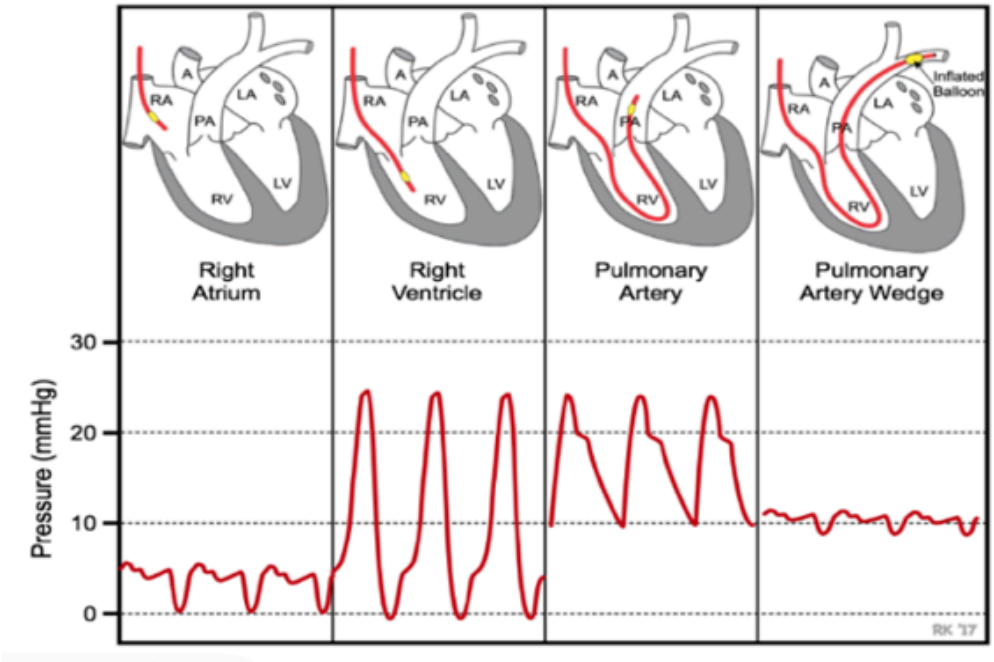


FIGURE 2. Coronary catheter pressure returns back to baseline, on an immediate pullback of the catheter following damping.



Measures (direct or calculated):

- RAP / CVP
- RVP
- PAP (sys/diastolic/mean)
- PCWP
- CO (thermodilution)
- SVR, PVR, SvO_2

Where used:

- CVICU, shock, advanced HF, transplant, ECMO

Pros

- Most comprehensive hemodynamic data
- Gold standard bedside tool

Cons

- Invasive
- Requires expertise to interpret correctly

Central Venous Catheter (CVC)

Measures:

- CVP (RAP surrogate)

Where used:

- ICU, IMC, OR, PACU

Limitations:

- Poor predictor of volume responsiveness alone
- Still useful for **trends**, not absolutes

Arterial Line (A-line)

Measures:

- SBP / DBP / MAP
- Arterial waveform morphology

Advanced analysis (device-dependent):

- Stroke volume variation
- Pulse pressure variation
- Cardiac output (with algorithms)

CardioMEMS (Implantable PA Sensor)

Measures:

- Pulmonary artery diastolic & mean pressure

Where used:

- Chronic heart failure outpatient management
- Remote daily monitoring

Key role:

- Prevent HF admissions by detecting congestion early

FIRE1 ReDS / FIRE1 System

Measures:

- Estimated intracardiac filling pressures
- Right-sided congestion trends

Where used:

- HF monitoring, emerging ICU/step-down use

Role:

- Trending congestion rather than exact pressures

Echocardiography (TTE / TEE)

Estimates:

- RAP (via IVC size/collapsibility)
- PASP (via TR jet)
- LVEDP (E/e′)
- Cardiac output

Pros

- Noninvasive
- Bedside
- Structural + functional insight

Cons

- Operator-dependent
- Estimates, not direct pressures

Less Common / Advanced Devices

Device	Measures	Notes
PiCCO	CO, GEDV, EVLW	Requires arterial + central line
LiDCO	CO, SVV	Less invasive CO
FloTrac	CO, SVV	Uses A-line waveform
Implantable LA sensors	LAP	Research / select HF pts

Mental ICU Shortcut (Super Useful)

- **CVP ≠ preload**, but ↑ CVP + ↓ UOP + ↑ PAP → think **congestion**
- **PCWP ≈ LA pressure ≈ LV preload**
- **PAD tracks PCWP** *if lungs are normal*
- **LVEDP ≠ PCWP** in MR, stiff ventricles, or mitral disease
- Treat **numbers + waveform + patient**, never numbers alone

Safety note: always verify **transducer level/zero**, waveform quality, and that the number fits the patient before treating it.

Pressure → Pathology → Intervention (ICU/CVICU)

1) CVP / RAP (Right atrial pressure)

Pressure finding	Common pathologies	What to check first	Typical interventions
High CVP (trend up, esp >12–15)	RV failure (PE, RV infarct), volume overload, tamponade, tension PTX, TR, severe pulmonary HTN, high PEEP	JVP/edema, hepatomegaly, bedside echo (RV size, septal bowing), ventilator/PEEP, CVP waveform (large V waves = TR)	If **overloaded**: diurese/CRRT. If **RV failure**: reduce RV afterload (optimize O2/vent, treat PE), inotrope (dobutamine/milrinone), cautious fluids only if underfilled. If **tamponade/PTX**: urgent decompression/pericardiocentesis. Lower PEEP if appropriate.
Low CVP (<5 with poor perfusion)	Hypovolemia/bleeding, vasodilation, aggressive diuresis	I&O, lactate, bedside echo (small LV, IVC), response to passive leg raise	Fluid bolus if fluid responsive; blood products if hemorrhage; start/uptitrate pressor for distributive shock.

2) Pulmonary Artery Pressure (PAP: PAS/PAD/Mean)

Pressure finding	Common pathologies	What to check first	Typical interventions
High PAP + high CVP	Pulmonary HTN, RV failure, PE, hypoxia/hypercarbia, ARDS/high PEEP	SpO_2/ABG/$EtCO_2$, CXR, echo (RV dilation), ventilator settings, consider PE workup	Fix hypoxia/hypercarbia, avoid acidosis, reduce PEEP if feasible, pulmonary vasodilators (inhaled nitric/epoprostenol), inotrope for RV, treat PE, keep MAP adequate for RV perfusion (pressors).
High PAP + high PCWP	Left-sided failure / pulmonary edema ("post-capillary" PH)	Lung exam/CXR, wedge quality, LV function on echo	Diuresis, afterload reduction if tolerated, inotrope if low CO, treat ischemia/valve issue, consider NIPPV/vent support.
High PAD with normal/low wedge (↑PAD–PCWP gradient)	"Pre-capillary" PH / high PVR (PE, COPD, ARDS, hypoxia)	Calculate **TPG = mPAP–PCWP**, **PVR = (mPAP–PCWP)/CO**	Treat cause (PE/hypoxia), pulmonary vasodilators selectively, RV support.

3) PCWP (Wedge) / PAOP

Pressure finding	Common pathologies	What to check first	Typical interventions
High wedge (>18 or rising)	LV failure, volume overload, MR, diastolic dysfunction, cardiogenic pulmonary edema	Wedge waveform (a/v waves), CXR/US, echo (EF/MR), correlate with dyspnea/oxygenation	Diuresis, vasodilators if BP allows (nitro), inotrope if low CO, treat ischemia, consider mechanical support if shock (IABP/Impella per scenario), avoid unnecessary fluids.
Low wedge (<8 with shock)	Underfilling/hypovolemia, excessive diuresis, distributive shock	PLR/echo fluid responsiveness, bleeding	Fluids/blood if responsive, pressors for distributive shock, re-evaluate frequently.
Huge V waves on wedge	Severe MR (or catheter artifact)	Compare to PA waveform; echo to confirm MR	Afterload reduction, diuresis, inotrope if needed; urgent structural/cardiac surgery consult if acute severe MR.

4) LVEDP (Cath lab) / Diastolic filling pressure

Finding	Common pathologies	Check first	Interventions
High LVEDP	Stiff LV (HFpEF), ischemia, hypertensive crisis, volume overload, aortic stenosis	BP, ischemia markers, echo diastology, volume status	Diuresis, treat ischemia, control BP, careful rate control (improves filling), avoid tachycardia.
Low LVEDP	Underfilling	Hemorrhage/volume	Fluids/blood, reassess.

5) Arterial Line: MAP / SBP / DBP (Perfusion + Afterload)

Pressure finding	Common pathologies	What to check first	Typical interventions
Low MAP (<65 or patient-specific)	Distributive shock, cardiogenic shock, hypovolemia, obstructive shock	A-line damping? rhythm? bedside echo, lactate/UOP/mentation	**Pressors** (norepi first-line), fluid if responsive, inotrope if low CO, treat obstruction (tamponade/PE/PTX).
Wide pulse pressure (low DBP)	Vasodilation (sepsis), aortic regurg	Clinical context, echo if AR suspected	Vasopressor to restore tone/DBP; address sepsis.
Narrow pulse pressure	Low stroke volume (cardiogenic, tamponade)	Echo, CO/CI, signs of poor perfusion	Inotrope/support, relieve tamponade, optimize preload carefully.
High SBP/MAP	Pain/anxiety, sympathetic surge, HTN emergency	Neuro status, end-organ signs	Analgesia/sedation, antihypertensives, reduce afterload (careful in shock).

“Pattern Recognition” Combos (Fast bedside)

Pattern	Likely physiology	What you do first
CVP ↑ + PAP ↑ + PCWP normal/low + CO ↓	**RV failure / PE / high PVR**	Optimize oxygenation/vent, reduce RV afterload, inotrope, consider inhaled pulm vasodilator, evaluate/treat PE, maintain MAP
PCWP ↑ + PAP ↑ + CVP normal/↑ + CO ↓	**LV failure / cardiogenic pulmonary edema**	Diurese + afterload reduction if tolerated; inotrope if low CO; consider MCS if shock
CVP ↑ + PCWP ↑ + CO ↓	**Biventricular failure** or fluid overload	Decongest + inotrope; consider CRRT; evaluate for MCS
CVP ↑ with hypotension + equalization tendency	**Tamponade** (or severe RV failure)	Echo immediately; urgent pericardiocentesis pathway
All pressures low + MAP low	**Underfilled / distributive**	Fluid responsiveness check → fluids/blood vs pressors

Interventions by “Which side is the problem?”

- **Right-sided (RV) problem:** oxygenation/vent strategy, avoid acidosis, reduce PVR, inotrope, cautious preload, maintain coronary perfusion (MAP).
- **Left-sided (LV) congestion:** diuresis, afterload reduction if safe, inotrope if low output, fix ischemia/valves, consider support.
- **Obstructive:** fix the obstruction (tamponade/PE/PTX) *first*.