

DOWN AND DIRTY HEMODYNAMICS AND PA CATHETERS

Blood Pressure:

What makes up a blood pressure?

- **Pump**-aka '*the Heart*'-mechanically pushes the blood through the body by dilation and constriction of blood vessels altering perfusion of end organs
- **Volume**-'*Preload*'-the volume of blood in the ventricle at end diastole
- **Squeeze**-'*Contractility*' the percentage of blood the ventricle ejects per beat
 - '*Afterload*'-the resistance the left side of the heart must overcome to eject blood i.e., vasodilation vs. vasoconstriction (systolic pressures). Can be affected by aortic stenosis, peripheral vascular disease, etc.
 - Measured by *Systemic Vascular Resistance (SVR)*-how dilated/constricted arteries.
 - Normal around 1000
 - **High '*afterload*'**-heart is working extremely hard to pump blood against tight or constricted vessels- SVR>1000-
 - **Low '*afterload*'**-vessels are too dilated creates low bp (sepsis)-<1000

Problems with the '*Pump*'-Cardiogenic Shock

$$CO = HR \times SV$$

- Low cardiac output (CO), high Systemic Vascular Resistance (SVR)-the pump is not working, and your vessels are increasing resistance to get an adequate bp to perfuse organs. Increasing

SVR (norepinephrine, epinephrine, neo synephrine, etc.) increases the amount of work from the left ventricle to eject blood.

Pulmonary vascular resistance (PVR) is analogous to SVR. An increase in PVR requires more work from the right ventricle to eject blood. Fun fact, vasopressin does NOT increase PVR.

Problems with the ‘Pump’, ‘Volume’, Squeeze’-Heart Failure

- Low cardiac output (CO), high Systemic Vascular Resistance (SVR), low Mean Arterial Pressures (MAP), high preload, low contractility. The heart is not pumping efficiently. If high preload, there is fluid overload in the ventricle causing it to enlarge and over stretch the heart muscle (Starlings Law), making it difficult to move blood forward to the lungs, backing it up into the circulatory system. Causing congestion in liver and tissues. This is right sided heart failure.
- Low cardiac output (CO), high SVR, high preload, low contractility. The heart is not pumping efficiently to move blood forward through the heart to the circulatory system causing pulmonary congestion, impaired gas exchange and pulmonary edema-Left Sided Heart Failure

Problems with ‘Volume’- Hypovolemic Shock (not enough volume)

- Low cardiac output (CO), low CVP, high HR, high Systemic Vascular Resistance (SVR) -not enough blood volume for the heart to pump effectively leading to high SVR to increase end organ perfusion.

Problems with 'Squeeze'-Septic Shock (dilated arteries)

- High cardiac output (CO), low CVPs, low SVRs-Bacteremia endotoxins cause your vessels to dilate creating low bps. To make up for low bps, your heart starts to pump faster and harder. CO will be high because you still have the same amount of circulating blood volume (colloquially termed hyperdynamic shock).

PA CATHETERS

Why Use? What is wrong with the 'pump', 'volume', and 'squeeze'?

- Post-op Open Hearts
- Impella
- Cardiogenic shock
- Pulmonary artery hypertension

The Catheter

- The catheter is placed through the right jugular or femoral vein through the right atria, down into the right ventricle up into the pulmonary artery.
- **3-lumens:** PA port (**yellow line**), CVP port (**blue line**) and VIP line (**white line**)
 - **PA Port:** reads the pressures on the right side of the heart
 - **PA Systolic:** Normal 18-25
 - *High PA Systolic-pulmonary hypertension from mitral and aortic valve stenosis/regurgitation, Left heart failure, chronic lung disease*
 - **PA Diastolic:** Normal 8-15
 - Good alternative to PAWP to identify left ventricular filling pressures
 - **PAWP (Pulmonary Artery Wedge Pressure) (LVEDP-Left Ventricular End Diastolic Pressure)**-preload of left

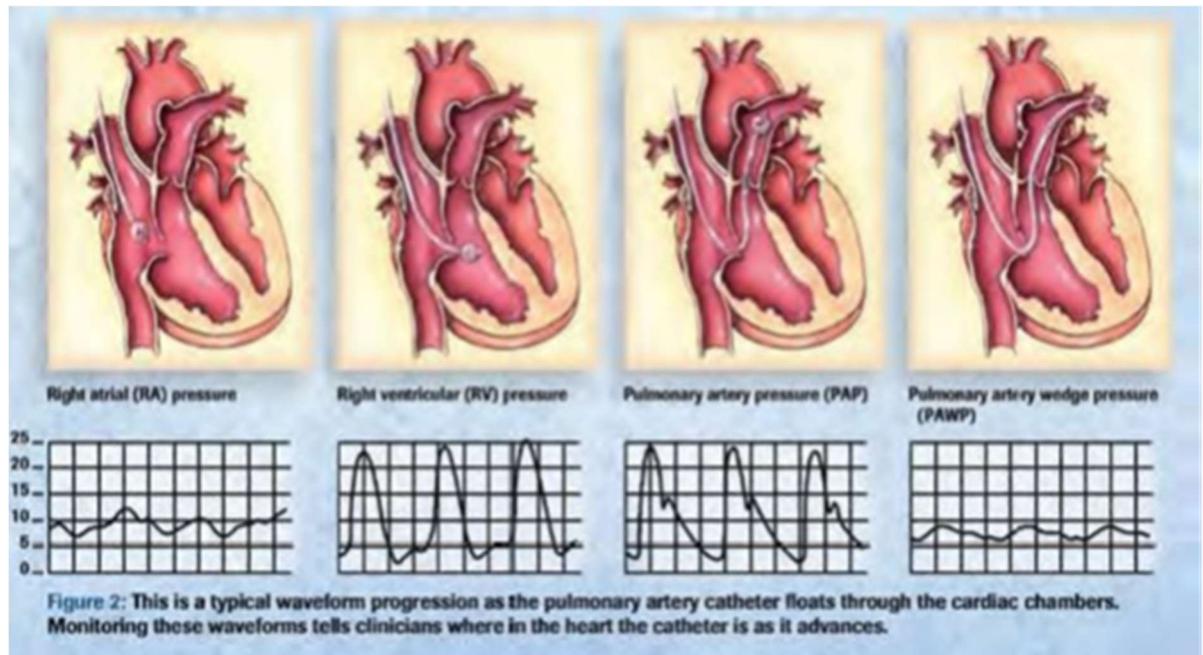
ventricle, reflecting the left ventricular compliance and intravascular pressures-

- Normal 4-12 (Can use PAD instead of PAWP)
 - *High PA Diastolic or PAWP-Severe left ventricular heart failure and mitral stenosis*
 - **NOT AN INFUSION PORT, USED TO CALIBRATE SVO2 ONLY**
- **CVP Port (RAP-Right Atrial Pressure): measures preload of the RV**
 - Normal 8-12
 - High CVP-fluid overload
 - Low CVP-hypovolemia
 - Can infuse IVF/medications
 - **White Port: VIP line or infusion port**

Monitoring with Swan-Ganz Catheter-

- Chart hourly or prn-PA pressures, CVP, Cardiac Index, cardiac output, and SVO2
- Wrench in on 'Vitals flowsheet', click on 'additional vitals', go to 'Invasive Hemodynamic' and check the boxes for PAP, CVP, CO, CI, SVO2
 - Cardiac Output/Cardiac Index
 - $CO = HR \times \text{Stroke Volume}$
 - CO=Liters of blood your heart pumps each minute
 - Normal is 4-5 L/min at rest
 - Cardiac index is CO indexed to the patients BSA-normal 2.5-4.5 liters/min
 - On Vigilance box (Swan box)-it is found on right side in 2nd box

- Turn on the Swan box, go to the icon on the right that looks like a person, click and put in height, weight in kg and hemoglobin/hematocrit
- Once patient arrives, insert the blue chip to cord (do not disconnect blue chip or you will lose your data and have to recalibrate SVO2) and connect cord to swan box. Go to the 'person' icon and click on 'recall OM data'.
- If blue chip was already connected to cord, your SVO2 should come up and there will be a message across the top that says 'Collecting Data CO'. It will take a couple of minutes for it to appear.
- There are STAT boxes that will show now time CO/CI- Go to the bottom and click on the double boxes



- Mixed Venous Saturation (SvO2)-Measure of oxygen content of blood returning to right side of heart from the rest of the body. Adequate SvO2 indicates the CO is high enough to

meet patient's tissue oxygen needs-end organ perfusion is adequate

- Normal 65-75%
 - Low SvO₂-CO is not high enough to meet tissue oxygen needs i.e., low hemoglobin, low CO, low O₂ too and oxygen consumption has increased without an increase in oxygen delivery
- SvO₂ needs to be calibrated upon initial insertion of PA catheter and every 24 hrs. or with bleeding
- To calibrate-click on 1st box on right upper corner, click on 'In vivo-calibration'
 - Click on Draw-slowly draw a 3-ml waste out of the PA or yellow catheter. Using an ABG syringe draw 1-2 ml from port. Provide patient temperature and call RT.
 - Once blood is drawn, put in new hemoglobin, hematocrit and SvO₂

***A sample of blood pulled off of any central line whose tip is NOT in the pulmonary artery is NOT a SvO₂, that sample is an ScvO₂. An ScvO₂ sample has a higher concentration of cerebral venous blood than an SvO₂.**