ECHOCARDIOGRAPHY DERIVED HAEMODYNAMICS

CALCULATION OF LV STROKE VOLUME (SV), CO & CI

Stroke volume = stroke area x stroke distance
Stroke volume (volume of cylinder) = LVOT cross sectional area x stroke distance = CSA_{LVOT} x VTI_{LVOT}
CSA = 2 x 3.14 x $(radius)^2$ OR = 0.785 x $(diameter)^2$
CO = SV x HR/1000
CI = CO/BSA

CONTINUITY EQUATION (stroke volumes are equal through all valves and points, in the absence of regurgitation or shunts) - is used to estimate:

1. **Valve area**: continuity equation → VTI_1 x CSA_1 = VTI_2 x CSA_2. → Valve area can be estimated if VTI across this valve is known as well as CSA & VTI across another valve or point. For example, CSA_{AV} = (VTI_{LVOT} x CSA_{LVOT}) ÷ VTI_{AV}
2. **Regurgitant volume & regurgitant fraction**: differences in stroke volume across two valves may reflect regurgitation at one of these two valves. For example, aortic regurgitant volume is simply the difference between the aortic stroke volume and the mitral stroke volume, and regurgitant fraction (%) is the regurgitant volume divided by the Aortic stroke volume x100
3. **Shunt ratio (pulmonic to systemic flow ratio, Qp:Qs)**: in the presence of significant left-to-right intracardiac shunts, flow (stroke volume) measurements can calculate the pulmonic to systemic flow ratio (Qp:Qs). For example, in a patient with ASD, pulmonary stroke volume will be much higher than aortic stroke volume; the ratio of the two is equivalent to the Qp:Qs ratio, provided that there is no semilunar valve stenosis or regurgitation.

BERNOULLI EQUATION (pressure gradient)- can be used to estimate:

1. **Calculation of peak gradient through stenotic valve**: PG (ΔP) = 4 ($V_2^2 - V_1^2$)
   Where V_1 is the velocity proximal to the stenosis and V_2 is the velocity distal to the stenosis.
   If V_1 negligible, $\Delta P = 4\ V_2^2$
2. **Calculation of chamber or artery pressure (RVSP/PSAP, PADP, LAP/LVDP/PAWP) using the gradient pressure of abnormal flow (regurgitation or L-R shunt)**: *simply pressure gradient of abnormal flow (regurgitation or shunt) equals the difference between pressure of the leaking chamber and pressure of the receiving chamber at the time of flow (systole or diastole)*:
   1. **RVSP/PASP:**
      - **TR gradient (systolic) = (RVSP – RAP)** → (RVSP = TR gradient + RAP) → (PSAP = TR gradient + RAP)
      - **VSD gradient (systolic) = (LVSP– RVSP)** → (RVSP = LVSP - VSD gradient) → (RVSP = SBP – VSD gradient)
      - **PDA gradient (systolic) = (SBP – PASP)** → (RVSP = SBP – PDA gradient)
   2. **PADP:**
      - **PR gradient (diastolic) = (PADP – RVDP)** → (PADP = PR gradient + RVDP) → (PADP = PR gradient + RAP)
   3. **LVDP/LAP/PAWP**
      - **AR gradient (diastolic) = (DBP – LVEDP)** → (LVDP = DBP – AR gradient)
      - **MR gradient (systolic) = (LVSP – LAP)** → (LAP = LVSP – MR gradient) → (**LAP** = SBP – MR gradient)

Hints:

- SB of a ventricle is equal the systolic pressure of the artery arising from it (in absence of obstruction between them)
- DB in a ventricle equals the pressure of the atrium connected to it (in absence of obstruction between them)
- Pressure in an atrium equals the pressure in the proximal blood vessel (in absence of obstruction between them)

Accordingly:

- RVSP equals PASP (in the absence of PS and RVOT obstruction). In the presence of PS, **PASP = RVSP – PS gradient** = (TR gradient + RAP) – PS gradient.
- LVSP equals SBP (in the absence of AS or LVOT obstruction)
- RAP equals RVDP (in the absence of TS)
- LAP equals LVEDP (in the absence of MS)
- RAP equals CVP, and similarly LAP equals PAWP (in the absence of pulmonary vascular disease)

CALCULATING THE RATE OF LV PRESSURE RISE IN EARLY SYSTOLE (as a measure of LV systolic pressure) using MR jet:

LV dP/dt = 32/Ti (where Ti is the time interval between the point of 1m/sec and the point of 3m/sec on the MR jet)

ESTIMATION OF RAP (mmHg)

	0–5	5–10	10–15	15–20	> 20
IVC size (cm)	< 1.5	1.5–2.5	1.5–2.5	> 2.5	> 2.5
IVC Respiratory/sniff variation	collapse	↓> 50%	↓< 50%	↓< 50%	No change
RA size	normal	normal	↑	↑↑	↑↑
Hepatic vein size				↑	↑↑