PULMONARY ARTERY CATHETERIZATION

Introduction

- Pulmonary artery catheters (PAC) provide measured and derived pressure and flow variables of the systemic and pulmonary circulations. Some parameters include
    - Cardiac output / index (with modification, continuously updated cardiac output measurements possible)
    - Cardiac contractility - stroke volume, left ventricular stroke work
    - Preload – pulmonary artery occlusion pressure (PAOP)
    - Afterload – systemic vascular resistance
    - Pulmonary indices – pulmonary artery pressure, pulmonary vascular resistance
    - Allow calculation of total O2 delivery (DO_2), whole body O_2 consumption (VO_2)– although rarely done
    - Right ventricular preload, ejection fraction
    - Mixed venous oxygen saturation (SVO_2)

Indications

- Diagnostic assessment of shock states (cardiogenic, distributive, hypovolemic) and assessment of response to treatment
    - Using cardiac output, stroke volume, systemic vascular resistance
- LV preload and LV performance, pulmonary vasomotor tone, intravascular volume status, especially in the context of acute lung injury
    - -Using PAOP
- Right heart pressures
    - Using right atrial pressure, pulmonary artery pressure
- Intracardiac shunt

Limitations

PAOP approximate LVEDP based on the assumptions that

1. there is a continuous column from right-side heart to left-side heart
2. normal mitral valve
3. normal LV compliance

Problems of misrepresentation when

- Catheter tip outside West's zone 3 (ie $P_{Alveolar} > P_{venous}$)

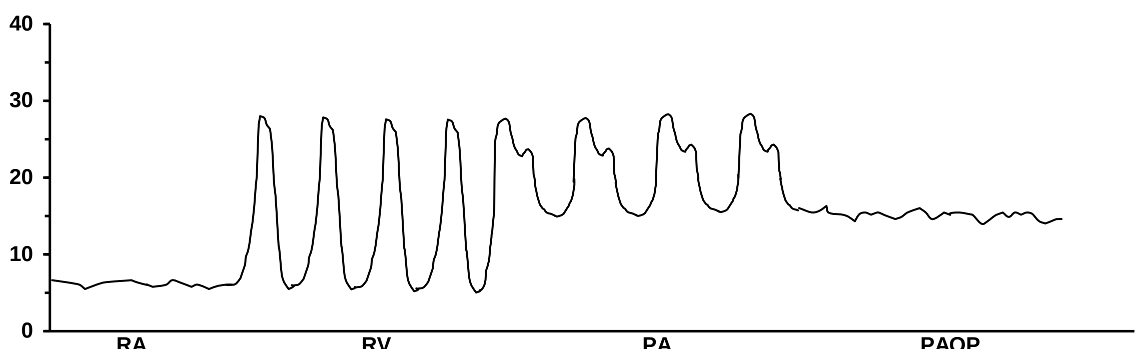
- Mitral valve dysfunction eg mitral stenosis, mitral regurgitation, atrial myxoma (PAOP> LVEDP)
- LV dysfunction (PAOP < LVEDP)

Sites

- IJV, subclavian, femoral also possible

Insertion

- Patient should be placed on continuous ECG and intra-arterial pressure monitoring
- Firstly, insert PAC sheath. Patient preparation and technique similar to CVC insertion (see chapter on central venous catheters).
- Insertion of PAC catheter
    - Check balloon is inflatable
    - Flush all lumens with saline
    - Connect PA port to transducer system and zero it at appropriate scale (0-40 mmHg) on the hameodynamic monitor
    - Pass PA catheter through the sheath with balloon deflated until beyond 15 cm mark, then inflate balloon 1-1.5 ml of air. Use the changing waveforms (RA→RV→PA) on the monitor until reach PA artery occlusion tracing.
    - Deflate balloon – waveform should now show PA tracing. Adjust catheter depth until PAOP trace appears with balloon inflation (1-1.5 ml of air)
    - Take note of the marking on the catheter, locked it in place if feature available on your catheter and suture the sheath to skin. Cover with transparent dressing
    - CXR to confirm position of catheter tip and absence of penumothorax



Measurement of pressure

- Reference to mid-axillary line
- Measure at end-expiratory pressure for both ventilated (lowest point) and spontaneous breathing (highest point) patients
- Do not disconnect ventilated patients during measurements
- Cardiac output measurements – thermodilution technique. We use 10 mls of 5% dextrose at room temperature each time. Inject as rapidly as possible. Do at least 3 readings and get the average.
- Data obtained by measurement include PAOP, CO, CVP, HR, PA and arterial pressures. Additional haemodynamic data is derived from calculation
- Record all data into a separate haemodynamic flowsheet

Maintenance

- As for CVCs except in general, PACs are removed much earlier than CVC. In this unit, it is unusual to keep a PAC in-situ for > 3days

Complications

- Related to cannulation (see chapter on CVCs)
- Related to insertion or use of a PAC
  - Tachyarrhythmias
  - RBBB
  - Cardiac perforation
  - Thromboembolism
  - Pulmonary infarction (2^0 to persistent wedging)
  - Pulmonary artery rupture
  - Catheter related sepsis
  - Endocarditis
  - Pulmonary valve insufficiency
  - Catheter knotting
  - Balloon fragmentation/embolism

Haemodynamic parameters measured

Parameter	**Normal range**
Central venous pressure	0 – 7 mmHg
Right atrial pressure	0 – 7 mmHg

Pulmonary artery systolic pressure	15-25 mm Hg
Pulmonary artery diastolic pressure	8 – 15 mmHg
Pulmonary artery mean pressure	10-20 mmHg
Pulmonary artery occlusion pressure	6 – 15 mm Hg

Haemodynamic equations

Variable	Formula	Normal range
Cardiac index (CI)	CI = CO/BSA	2.5-3.6 L/min/m^2
Systemic vascular resistance (SVR)	$SVR = \frac{MAP - RAP}{CO} \times 80$	750-1500 dyn.sec/cm^5
Systemic vascular resistance index (SVRI)	SVR/BSA	1400-2400 dyn.sec/cm^5/m^2
Pulmonary vascular resistance (PVR)	$PVR = \frac{\text{mean } PAP - PAOP}{CO} \times 80$	50-150 dyn.sec/cm^5
Pulmonary vascular resistance index (PVRI)	$PVR = \frac{\text{mean } PAP - PAOP}{CO} \times 80$ /BSA	150-250 dyn.sec/cm^5/m^2
Stroke volume index (SVI)	$SVI = \frac{CI}{HR}$	40–60 ml/beat/m^2
Left ventricular stroke work index	LVSWI = (MAP-PAOP) x SVI x 0.0136	50-120 g/m^2/beat
Right ventricular stroke work index	RVSWI = (MAP-RAP) x SVI x 0.0136	25-25 g/m^2/beat
Arterial oxygen content	CaO_2 = (Hb x 1.34 x SaO_2) + (PaO_2 X 0.003)	17-20 ml/100 ml
Mixed venous oxygen content	C_vO_2 = (Hb x 1.34 x S_vO_2) + (P_vO_2 X 0.003)	12-15 ml/100 ml
Mixed venous oxygen saturation (S_vO2)		≈ 75%
Oxygen delivery index	DO_2 I = CI x CaO_2 x 10	550-750 ml/min/m^2
Oxygen consumption index	VO_2 I = CI x (CaO_2 – CvO_2) x 10	115-160 ml/min/m^2
Oxygen extraction ratio	$O_2ER = \frac{VO_2\ I}{DO_2\ I}$	0.24-0.4

Shunt equation	$Qs = \frac{(CcO_2 - CaO_2)}{(CcO_2 - CvO_2)} \times 100$	5-15%
End capillary oxygen content	CcO2 = (Hb x 1.34 x 1.0) = (P_AO_2 x 0.003)	80-100 ml/100 ml
Alveolar gas equation	$P_AO_2 = FiO_2 (760 - 47) - (PaCO_2 \times 1.25)$	100-650 mmHg