Objective

- The major objective of haemodynamic monitoring is to evaluate the performance of the heart as a pump.
- A number of haemodynamic parameters can be calculated from the pressure data and cardiac output determinations.
- These derived parameters serve as a basis for further evaluation of cardiac performance.
Cardiac output

For calculating cardiac output the Fick method is the most simple.

It depends upon the principle that, the rate at which oxygen is consumed is divided by the quantity of oxygen removed from the blood by the body.

The result is the quantity of blood in which the oxygen was contained.
CARDIAC OUTPUT (CO) = \frac{\text{Oxygen consumption}}{\text{Arterial - Venous Oxygen difference}}

The normal Cardiac Output: 5 – 6 litres/min
Cardiac output varies from person to person depending on specific variables.

- The major variable is body size.
- A cardiac output of 4 l/min may be considered normal for a petite woman but could be inadequate for a large man.

For this reason, cardiac output data are often normalised. This is accomplished by dividing the cardiac output by the patient's body surface area (BSA).

- Usually entering the height and weight of the patient into the cardiac output computer allows automatic calculation of the index.

Cardiac Index
Cardiac Index

CARDIAC INDEX (CI) = \frac{\text{Cardiac Output}}{\text{BSA}}

Normal cardiac index: 2.7 to 4.3 litres/min/m²
Cardiac Index

- Cardiac Index values between 1.8 and 2.2 l/min/m² indicate the onset of clinical hypoperfusion.
- Cardiac Index values below 1.8 may be associated with cardiogenic shock.
Trans-pulmonary Gradient

- Measure of fall in pressure across the lung fields
- Indicates excessive pulmonary pressure have had a long lasting effect on the lungs
- Used to assess for heart vs heart-lung transplant
- If the TPG is greater than 12mmHg the pressures indicate heart-lung transplant is preferred
Trans-Pulmonary Gradient

\[ \text{TPG} = \text{MAP} - \text{MRA} \quad \text{mmHg} \]

MAP = mean arterial pressure
MRA = mean right atrial pressure
Systemic Vascular Resistance

- Systemic vascular resistance is a measure of peripheral blood vessel resistance to blood flow and the arterioles are the major determinants of this resistance.
- Resistance to flow is often referred to as afterload.
- SVR is the ratio of the pressure drop across the systemic vascular system to the total flow passing through the systemic circulation.
SVR - Woods

$$SVR = \frac{MAP - MRA (mmHg)}{CO (l/min)}$$

**SVR** = static vascular resistance

**MAP** = mean arterial pressure

**MRA** = mean right atrial pressure

**CO** = cardiac output
SVR – Absolute resistance

To convert from mmHg/l/min (woods units) to absolute resistance units, dynes/sec/cm\(^5\) we must multiply by 80

\[
SVR = \frac{\text{MAP} - \text{MRA}}{\text{CO}} \times 80
\]

Normal SVR : 1000 to 1300 dynes/sec/cm\(^5\)
An abnormally high SVR would indicate peripheral vasoconstriction such as might occur in response to hypovolemia.

An abnormally low SVR would indicate peripheral vasodilation as might occur in septic shock.
Pulmonary Vascular Resistance

- Pulmonary vascular resistance is a measure of the pulmonary blood vessel resistance to blood flow.

- Calculated based on the same principle used to calculate SVR.

- PVR then is the ratio of the pressure drop across the pulmonary vascular system to the total flow passing through the pulmonary circulation.
PVR – Absolute Resistance

\[
PVR = \frac{MPA - PCWP}{CO} \times 80 \text{ dynes/sec/cm}^5
\]

MPA = mean pulmonary artery pressure
PCWP = pulmonary capillary wedge pressure
CO = cardiac output

Normal PVR : 150 to 250 dynes/sec/cm\(^5\)
Note that a normal PVR is approximately one sixth of the normal SVR.

An abnormally high PVR could be indicative of pulmonary hypertension, hypoxia, lung disease or pulmonary embolism.
Intra-cardiac Shunt

- During Cardiac Catheterisation, blood oxygen saturations are taken from the SVC and IVC through to pulmonary artery

- A step up in oxygen saturations of more than 10% from one chamber/vessel to the next, indicates the presence and position of an intracardiac shunt
The quantification of a left to right shunt can easily be calculated by obtaining blood oxygen saturations.

Mixed venous oxygen saturation is the average of SVC, IVC (and right atrial saturations for VSD calculations)

- Take into account volume returning from SVC & IVC!

Other saturations that are needed include Arterial, Pulmonary Artery and Pulmonary Venous (assumed 98%, if not measured)
Shunt Calculation

Left to right shunt  =  \frac{Q_p}{Q_s}

\begin{align*}
Q_s &= \text{systemic blood flow} \\
Q_p &= \text{pulmonary blood flow}
\end{align*}
Shunt Calculation

\[ \frac{Q_p}{Q_s} = \frac{\text{Art } O_2 - \text{MV } O_2}{\text{PV } O_2 - \text{PA } O_2} \]

- **Art O2**: systemic arterial oxygen saturation
- **MV O2**: mixed venous oxygen saturation
- **PV O2**: pulmonary venous oxygen saturation
- **PA O2**: pulmonary arterial oxygen saturation
Quantification

- A small left to right shunt gives a flow ratio of $< 1.5 : 1.0$
- An intermediate left to right shunt gives a flow ratio of $1.5 : 1.0$
- A large left to right shunt gives a flow ratio of $> 1.5 : 1.0$