# Cardiac Calculations

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# 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

$$\text{CARDIAC OUTPUT (CO)} = \frac{\text{Oxygen consumption}}{\text{Arterial – Venous Oxygen difference}}$$

The normal Cardiac Output : 5 – 6 litres/min

# Cardiac Index

- Cardiac output varies from person to person depending on specific variables
- 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 patients' 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

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

Normal cardiac index : 2.7 to 4.3 litres/min/$m^2$

# Cardiac Index

- Cardiac Index values between 1.8 and 2.2 $l/min/m^2$ 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

TPG = MAP – MRA 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

$$SVR = \frac{MAP - MRA\ (mmHg)}{CO\ \ (l/min)} \quad \frac{\text{(pressure drop)}}{\text{(total flow)}}$$

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/cm5 we must multiply by 80

$$SVR = \frac{MAP - MRA}{CO} \times 80$$

Normal SVR : 1000 to 1300 dynes/sec/cm5

# SVR

- 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

$$PVR = \frac{MPA - PCWP}{CO} \times 80 \quad \text{dynes/sec/cm5}$$

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

Normal PVR : 150 to 250 dynes/sec/cm5

# PVR

- 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

# Shunt Calculation

- 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

$$\text{Left to right shunt} = \frac{Qp}{Qs}$$

Qs = systemic blood flow
Qp = pulmonary blood flow

# Shunt Calculation

$$\frac{Qp}{Qs} = \frac{\text{Art O2} - \text{MV O2}}{\text{PV O2} - \text{PA O2}}$$

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