Swann Ganz Catheterisation and Cardiac Outputs

Lancashire & South Cumbria Cardiac Network
Cardiac Output

- Cardiac output is the amount of blood pumped per minute by the heart (litres/min).
- Many methods that can be used to determine cardiac output
  - The Fick method
  - Dye dilution
  - Thermodilution
Fick Principle - definition

- Uptake/release of a substance by any organ is the product of the arterio-venous concentration difference of that substance and the blood flow to that organ
Fick method

- Pulmonary blood flow = systemic blood flow
- Pulmonary blood flow is determined by measuring arterio-venous difference of oxygen across the lungs and the uptake of oxygen from room air by the lungs
Fick method

- Most accurate in low cardiac output states
- Requires patient breathes comfortably at a steady state
- Avoid – anxiety, dyspnoea, conditions which create spuriously high oxygen consumption – false high cardiac output
- Avoid – shallow breathing, hypoventilation, over sedation – false low cardiac output
Addition supplemental oxygen

- Mix supplemental oxygen with room air – difficulty in estimating inspired air oxygen content
- Supplemental oxygen should be discontinued 10-15 minutes prior to determination of cardiac output via Fick calculation
- If unable to discontinue – use alternate methods
Thermodilution method

- The Thermodilution method requires the insertion of a thermodilution pulmonary artery catheter (Swann Ganz), that has a temperature sensing device (thermistor), on the distal tip – triple lumen design.
- Placement of the catheter plays an important part in the measurement of cardiac output.
Swann Ganz Catheter

- The Swann Ganz catheter has a balloon at its tip which when inflated
  - allows easy placement of the catheter by the flotation technique
  - facilitates measurement of PCW Pressure by the balloon forming a seal that isolates the tip from PA flow
- 3 ports – triple lumen
  - PA port (distal)
  - CVP port (proximal)
  - Infusion port (proximal)
Swann Ganz Catheter

- At the terminal end of the catheter there is a connector for the thermistor to obtain blood temperature for cardiac output measurement and to monitor the temperature of blood continuously at the tip.
- A port to allow inflation of the balloon with a 2 ml syringe.
Access

- Access
  - Subclavian vein
  - Internal jugular vein
  - Anterior cubital vein
  - Femoral vein
Placement

- When the catheter tip reaches the right atrium (approximately 20 cm), the balloon is inflated using 1.5ml of air.
- As the catheter is advanced, the balloon floats the catheter through the right ventricle and the pulmonary artery into the pulmonary capillary wedge position.
- Deflation of the balloon at this point usually causes the tip to fall back into the pulmonary artery.
- Pressure measurement and/or screening are used to indicate correct placement of the catheter.
- Once in place, PA and PCW pressures can be measured as an important part of routine bedside monitoring.
Injectate temperature

- Once the catheter is in place, with the balloon deflated and the distal tip in pulmonary artery, the cardiac output can be measured.
- A cardiac output computer is used with a temperature probe or thermistor.
- The injectate temperature is obtained by either of two methods:
  - In-Line method
  - Bath method
Blood Temperature

The cardiac output computer will have a connection to the thermistor output of
- the Swann Ganz catheter at its distal tip which enables measurement of blood temperature
Measurement principle

- The thermodilution technique is based upon the principle that a known volume of saline at a known temperature is added to an unknown volume of fluid, the volume of fluid may be determined by measuring the temperature of the mixture.
- The cardiac output computer can then calculate the cardiac output.
Method

- The saline solution should be at least 10° lower than blood temperature for accurate calculation of cardiac output.
- The cardiac output computer is set up by connecting it to the catheter (to record blood temperature) and by placing the temperature probe in a bowl of cold saline solution (to record injectate temperature).
- Half of the saline should be placed in a sterile bowl to be used by the operator to inject.
Method

- The operator draws up a known amount of saline, ‘10ml’, the value having being entered into the computer
- Injectate injected rapidly and smoothly into the right atrium via the proximal port of the catheter
- Ensures uniform mixing of the solution with the blood returning to the right heart
- Temperature change is measured ‘down stream’ in the pulmonary artery (PA) by the thermistor
Accuracy of method

- unnecessary and excessive handling of syringes (which could change injectate temperature)
- careful measurement of volume of injectate
- speed and consistency of injection (< 10 seconds should elapse from removal of syringe from cold saline to completion of injection)
- timing the injections so that they occur during the same phase of respiration
  - The end of expiration is the preferred phase however in practice the timing of the injections is difficult
How many injections should we perform?

To ensure an accurate and consistent representative cardiac output measurement, it is recommended that the average of at least 3 injections be obtained and each of these measurements should be within 10% of each other.
What happens if they are not within 10%?

- If greater variation occurs between the serial measurements it could reflect either poor or inconsistent technique.
- There are instances however, where inconsistent serial determinations may reflect true changes in cardiac output.
True variations

- Variations in cardiac rate or rhythm e.g. VE’s
- Patient movement, which may alter venous return to the heart and change CO
- A drastic change in patient temperature
- A sudden change in the haemodynamic state of the patient
- The presence of valvular insufficiency or intracardiac shunt
  - These conditions make cardiac output measurement inaccurate and unreliable
CO Calculation!

- volume of injectate
- blood temperature
- injectate temperature
- calibration constant
- specific heat capacity of blood
- specific heat capacity of injectate
- correction factor for injectate warming
- area under the curve resulting from graphing temperature Vs time
Cardiac Output Curve

Temperature

Time
Advantages of thermodilution

- Only one catheter is required, which can be inserted at the bedside
- Blood withdrawal is not required
- Serial determinations can be performed rapidly
- Reproducibility is good, provided injection technique is consistent
- The results are not affected by oxygen administration
- A second re-circulation peak is very seldom a problem
Disadvantages of thermodilution

- Potential electrical hazard
- Possible hazards of an indwelling PA catheter
- Fluid overload may be a problem if numerous and frequent determinations are performed
- Potential for injectate contamination (reduced if the ‘in-line’ kit is used)
- Reports of transient bradycardia and atrial fibrillation occurring with the use of iced injectate
- Less accurate in low cardiac output states and is definitely not accurate in the presence of intracardiac shunts or valvular insufficiency
Right sided technique – gives Right Ventricular output?

- This method actually determines right ventricular cardiac output
- Despite the gross differences in the shape, wall thickness and outflow resistance of the right and left ventricles, they eject the same amount of blood
- If right ventricular cardiac output exceeded left ventricular output the lungs would be congested with blood while the systemic vasculatures would be depleted
- There is an equalisation of right and left cardiac outputs and by using the thermodilution technique we are indirectly measuring left ventricular cardiac output
Differences among cardiac output techniques

- Low cardiac output
- Valvular regurgitation
- Intracardiac shunts
- Recirculation of indicator (dye or cold saline)
- Oxygen supplementation
Summary Questions

- What are the 3 methods of measuring cardiac output?
- What veins can we use for swann Ganz catheterisation?
- What are the 2 methods used?
- What Volume do we inject?
- How long should elapse between removing syringe from injectate to injection?
Summary Questions

- What temperature should the injectate be?
- How many injections do we give?
- What gives us a standard of consistency, what is the variability between measurements allowed?
- What causes variability?
- What are the advantages of this technique?
- & Disadvantages?
Summary Questions

- When is this technique not accurate?
- List the 8 things the computer uses to calculate cardiac output!
- What is a normal cardiac output?
- What is the volume of blood in the body?