Cardiac Output Monitoring

Indications

- Management of post-operative open heart surgical patients
- Management of complicated myocardial infarction
- Assessment and guidance of therapy for all types of shock
- Guidance of therapy for right ventricular failure due to severe pulmonary hypertension

Principle and method

- Thermodilution using the pulmonary artery catheter or the Swan-Ganz catheter
- Physical Basis: Stewart's "indicator-dilution" method that relies on injection of an indicator and subsequent measurement of a time concentration curve allowing flow to be calculated.
- Manual Bolus CO measurement: A 10 ml bolus of saline with a known temperature (the indicator) is injected through the proximal (blue) lumen into the right atrium. The blood temperature is measured in the pulmonary artery by a thermistor at the tip of the SGC.
- Continuous thermodilution catheters use a heating element to generate temperature changes. It appears to offer the same clinical accuracy but can have a time lag of up to 5 minutes.

THE SWAN GANZ CATHETER (SGC)

Is a balloon-tipped, flow directed pulmonary artery catheter first introduced by Swan and associates in 1970. It is considered the gold standard for measurement of cardiac output.

When indicated, it should only be inserted by Intensivists, experienced senior ICU registrars or ICU registrars under the direct supervision of the former two.

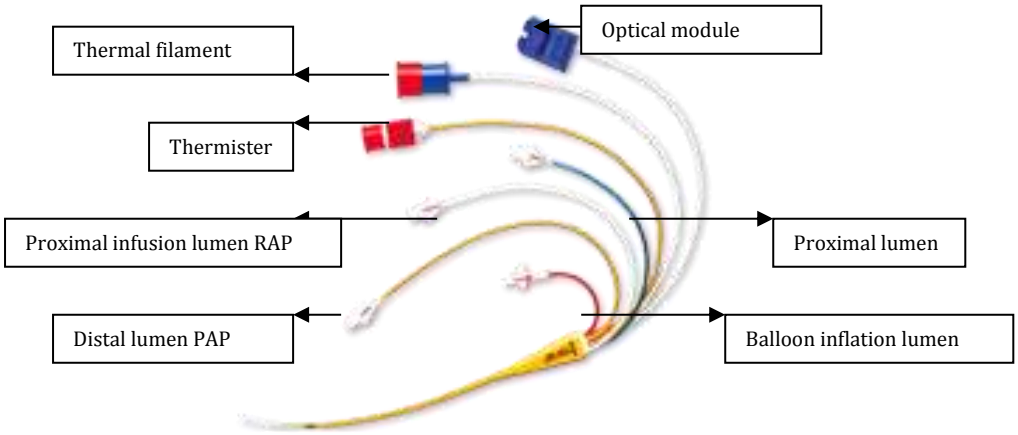
Complications

- Related to the insertion of a central venous catheter.
- Related to the SGC
    - Balloon rupture
    - Knotting
    - Pulmonary infarction
    - Pulmonary artery perforation
    - Thrombosis, embolism
    - Arrhythmias (particularly during insertion)
    - Intracardiac damage
    - Infections
- Related to the detrimental effects of any intervention as a result of incorrect interpretation of results.

Equipment

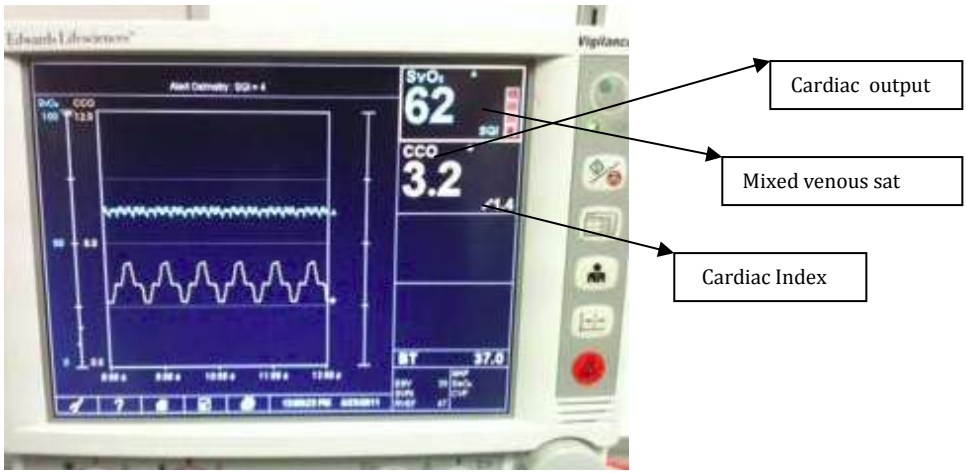
1. Pulmonary artery catheter (Swan-Ganz catheter or SGC)
    a. Edwards Lifesciences Swan-Ganz CCO 7.5F
    b. Edwards Lifesciences Swan-Ganz CCOmbo/SvO_2 7.5F
    c. Arrow Percutaneous Introducer set 8.5F (minimum 8F)
    d. Edwards Lifesciences Vigilance II monitor
    e. Pressure transducer set, sterile extension tubing, three way taps

Swan-Ganz CCOmbo/SVO_2 catheter (Edward Lifesciences)



RAP = Right atrial pressure
PAP = Pulmonary artery pressure

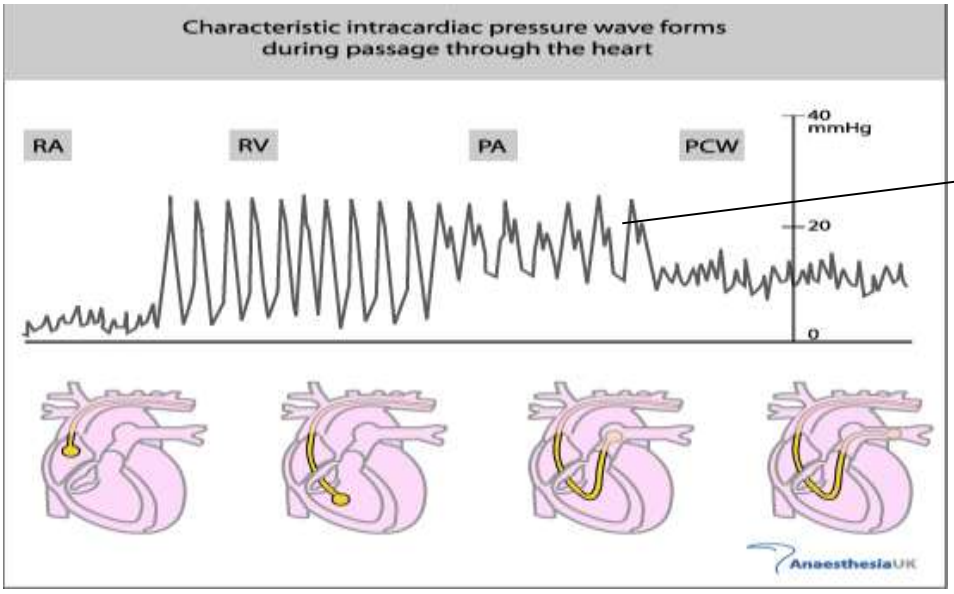
Vigilance II Monitor (Courtesy RPH)



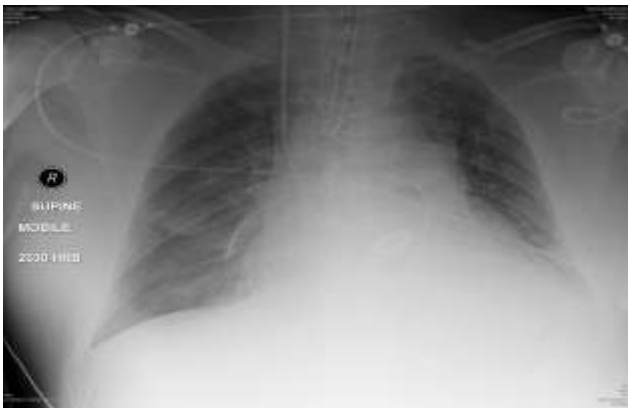
In this unit, the large digital display is usually the cardiac index with the cardiac output in a smaller display at the bottom right corner.

Pulmonary Artery Catheter Insertion

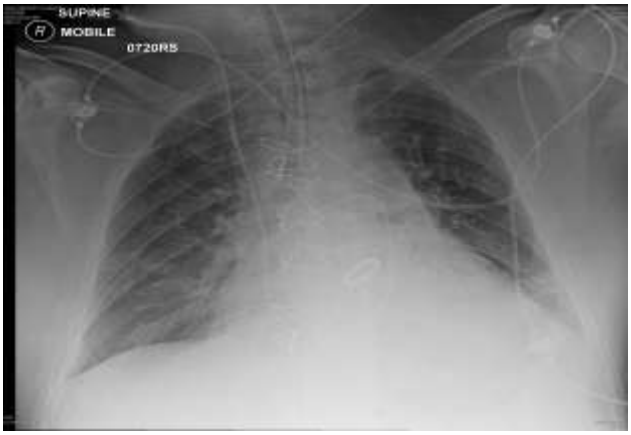
- The patient should be in the supine position with ECG monitoring.
- **The procedure must be done under total aseptic conditions (Cap, mask, scrub, gown and glove with the patient fully draped after cleaning a wide area around the pre-determined insertion site with 1% chlorhexidine in 70% alcohol or Povidone Iodine if allergic to former).**
- An 8.5 Arrow introducer sheath is first inserted. Aspirate sheath to ensure free flow of blood and flush with N/S.
- Attach 3 way taps to and prime all lumens of the SGC with N/S.
- Test balloon using special syringe supplied with set that allows only 1.5 mls of air to be injected via the balloon lumen.
- Insert SGC through the sterile sleeve also supplied with the set.
- One end of the sterile extension tubing should be handed to your assistant for connecting to the transducer set. The other end is to be connected to the distal (yellow) lumen of the catheter. Flush N/S through tubing and distal lumen to expel any air bubbles.
- **Level and zero transducer** and ensure that the pressure trace is displayed on the monitor. The PAP trace is displayed in yellow.
- Insert catheter through the introducer sheath to a depth of 20 cm (markers are present along the length of the catheter to guide the depth of insertion with each thin line indicating 10 cm and a thick line indicating 50 cm) and inflate balloon with 1.5 mls of air. The right atrial pressure should now be displayed on the monitor. With the balloon inflated, advance the catheter until the right ventricular pressure tracing, the pulmonary artery pressure tracing and eventually the pulmonary artery occlusion pressure (PAOP) tracing is seen. The balloon is now deflated and the pulmonary artery pressure trace should again be displayed on the monitor. The SGC is now in position. The depth of the SGC should be noted and recorded.



- **The balloon must be inflated when advancing the SGC and deflated when being withdrawn.**
- Secure introducer sheath with suture. Open sterile sleeve to protect SGC and lock at both ends. This allows the SGC to be repositioned for up to 6 hours post insertion **after which time it can only be withdrawn but NOT advanced through the introducer to minimize the introduction of bacteria into the bloodstream.**
- Reinflate the balloon by slowly injecting air into the syringe observing the pulmonary artery trace. Once the PAOP trace is seen, no further air should be injected. The PAOP is recorded.
- A chest x-ray must be done to check catheter position and to exclude any complications of catheter insertion.



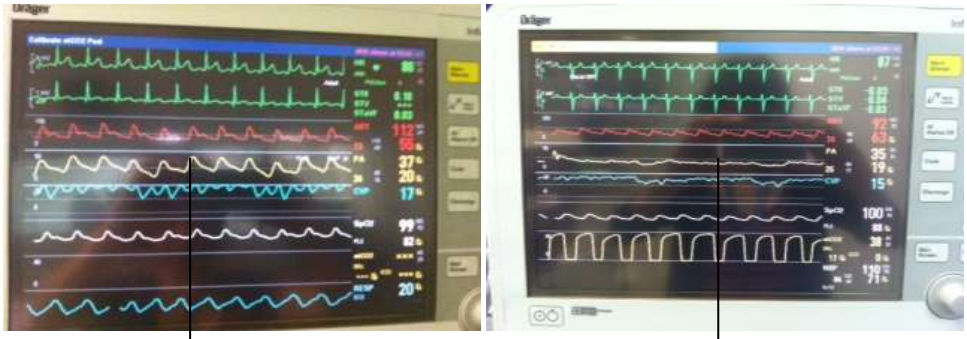
SGC is too distal. There is risk of rupture of the pulmonary artery when balloon is inflated.
The catheter must be pulled back.



Correct position of SGC

Connect SGC to vigilance II monitor to allow continuous display of cardiac output, cardiac index, and body temperature +/- mixed venous saturation. For SvO_2 monitoring, mixed venous blood is withdrawn from the distal (yellow) port of the SGC for blood gas analysis. The SvO_2, Hb and/or HCT values are entered into the Vigilance II monitor for calibration. Calibration should be done 3X/day or anytime if the SvO_2 reading appears inconsistent with the patient's clinical state.

An abrupt change to the pulmonary artery pressure or to the shape of the pulmonary artery pressure tracing on the monitor may be an indication of the change in cardiac status of the patient or the position of the SGC in the heart, which must be investigated by examination of the patient.



PAP trace that should be displayed

PAOP trace. Should only be displayed when balloon is inflated briefly. Check SGC position if displayed on monitor at any other times.

The information obtained from the SGC must not be used in isolation but should be used to guide therapy in conjunction with the clinical status of the patient.

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