Guideline for Pulmonary Artery Catheter Management in ICU

TARGET AUDIENCE
Medical and Nursing staff in The Alfred Hospital Intensive Care Unit who are providing care for a patient who requires insertion, removal and ongoing safe management of a Pulmonary Artery Catheter (PAC).

PURPOSE
To provide a guideline for the recommended practice related to the insertion, management and removal of a PAC, with emphasis on safety and avoidance of complications. It is not intended to be a guide to therapy based PAC data.

There are different models of PAC, this guideline is focused on the model used within Alfred Health – Edward Lifesciences VIP Tri-Lumen Infusion Thermodilution Catheter with AMC thromboshield (REF: 834HF75)

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INDICATIONS

PAC use is indicated in clinical scenarios where the benefits derived from therapy guiding haemodynamic data (not available through less invasive means) are thought to outweigh the risks associated with PAC use, with the aim of improving individual patient outcomes.

A meta-analysis estimating the impact of PAC in critically ill patients was unable to demonstrate improved outcomes, nor increased mortality or hospital length of stay. The treating ICU Consultant must approve the decision to utilise a PAC on a case by case basis.

CONTRA-INDICATIONS

- Patients with prosthetic tricuspid and/or pulmonary valves.
- Tricuspid and/or pulmonary valve vegetations.
- Right-sided cardiac thrombus.

COMPLICATIONS

PAC insertion is an invasive procedure with risk of significant complications including those associated with central venous catheterisation. Complications include:

- Damage to nearby structures – vessels, nerves, lung
- Infection – local and systemic
- Bleeding
- Thrombosis
- Air embolus
- Elevated intracranial pressure during insertion

Additional complications specific to PAC insertion include:

- Arrhythmia
- Pulmonary artery rupture
- Pulmonary infarction
- Valve damage
- Catheter knotting/kinking

PAC use in patients with pulmonary hypertension is associated with a small but significant increase in adverse events.
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Title

INSERTION OF PAC

Insertion and supervision of a PAC should only be performed by Medical Consultants or Registrars accredited in this procedure.

SITES
Subclavian vein (preferred due to lower infection risk), or Internal Jugular vein.

Equipment
Utilise the Line Insertion Trolley for insertion of the PAC
Ensure the following items are available:

- CVC non-tunelled insertion pack
- Full body length sterile drape
- Sterile gloves
- 2% Chlorhexidine in 70% alcohol (unless contraindicated, see box below)
- 8.5Fr Arrow Percutaneous sheath introducer kit. The same introducer is used for insertion of a Paceport Swan (REF AK-09801-A).
- Local anaesthetic is pre packed in the Arrow introducer kit.
- Pulmonary artery catheter
- Transducer sets x 2, with pressure cables and modules
- Normal Saline 1000ml and pressure bag
- 3/0 silk suture
- Transparent semi-permeable dressing (e.g. Tegaderm or Opsite 10cm x 12cm)
- Chlorhexidine Impregnated sponge (Biopatch)

Contraindications for chlorhexidine as skin preparation: 2% Chlorhexidine in 70% Alcohol is recommended for skin disinfection before Central Line insertion and dressing change. However it will degrade ECMO circuits and some patients may have an allergy to Chlorhexidine solution – therefore Povidine Iodine (Betadine) should be used for disinfection before accessing and dressing procedures for patients with an ECMO circuit or an allergy.

Patient Preparation
- Informed consent – if possible
- Explain procedure to the patient in terms they will understand.
- Check coagulation profile and platelets.
- Clip (not shave) area prior to insertion.
- Place patient head down prior to prepping and draping.
- Monitoring- ECG, SpO2, Blood Pressure, ETCO2 (as appropriate)
INSERTION TECHNIQUE

1. Decontaminate hands. Open the sterile insertion pack, drop required equipment, dressings, PAC and insertion equipment, onto the aseptic field, ensuring asepsis is maintained.
2. Meticulous attention to aseptic technique – don theatre cap, protective eyewear and surgical mask. Perform a surgical hand scrub, dry with the sterile towel in the gown pack, and don sterile gown.
3. Use 2% Chlorhexidine in 70% Alcohol for skin preparation. Place a full sterile drape over the patient with the fenestration in the drape over the prepared site.
4. Allow Chlorhexidine solution to dry before skin puncture is performed.
5. Ultrasound guided access is recommended for all internal jugular lines and may be used for subclavian lines. A sterile sheath and sleeve must be used.
6. Insert sheath and suture at insertion site.
7. Place the PAC on the aseptic field, prepare and flush all lumens. A sterile primed monitoring transducer should be connected to the Pulmonary Artery (PA) distal lumen of the PAC.
8. Ensure PA distal lumen pressures are continuously transduced on the monitor to assist with floatation of the PAC.
9. Ensure the Cath Guard catheter contamination shield is placed over the PAC prior to it being inserted into the sheath.
10. Inflate and allow deflation of the balloon to assess balloon integrity prior to inserting the PAC into the sheath.
11. Once the PAC is placed into the sheath, advance the catheter to the right atrium (RA). The balloon is only inflated once RA trace is seen (PAC marking approximately 15 – 20 cm depending on insertion site).
12. With the balloon inflated, continue to advance the PAC to the right ventricle (RV), then PA. Continue to advance PAC until wedge trace occurs according to monitored pressure waveform. Open balloon gate and allow passive balloon deflation.
13. **NOTE**: If unable to float the PAC into next chamber and it has been advanced > 20 cm, consider that the PAC is coiling in the chamber and is at risk of knotting, potentially causing chamber rupture or arrhythmias. With the balloon deflated, withdraw the PAC into the RA if this occurs.
14. Take note of PAC insertion length. Secure PAC hub into the sheath hub.
15. Apply a Chlorhexidine impregnated sponge at the base of the hub at the skin insertion and secure with a single transparent semi-permeable adhesive dressing is placed over the PAC and sheath with the skin insertion point approximately in the middle of the dressing.
16. All new IV infusions are to be attached to the catheter by the Inserting Medical Officer whilst still sterile.
17. Support PAC, lines and flow adaptors by anchoring the lines to a secondary dressing on patient.

Post insertion follow-up:
- Record the insertion details in medical notes and ICU Active procedure list including the date and site of insertion, and type of PAC used.
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Place equipment serial number sticker and any sterile equipment stickers into patient history.

Confirm position and exclude complications with Chest X-Ray (CXR).

Document the length of insertion of the PAC, and volume of air required to obtain a wedge trace on ICU blue observation chart.

If IV infusion lines were not connected during insertion, connect new infusions and IV administration lines to PAC infusion ports using sterile technique.

Currently in The Alfred ICU patients with a PAC insitu are restricted to bed rest.

INFUSION LINE MANAGEMENT FOR PAC

Refer to CVC in ICU guidelines for general line management. Any accessing of the PAC lumens must be performed with aseptic non-touch technique (ANTT) and ‘Scrub the Hub’.

Perform Hand Hygiene with Chlorhexidine gluconate 4% soap or alcohol based hand rub

Suggested Lumen Use

Proximal Injectate and RA Infusion lumens - situated in the right atrium (RA)

- RA/Central Venous Pressure (CVP) monitoring
- Injectate port for Cardiac Output (CO) solution (Proximal Injectate lumen)
- Administration of fluids, electrolytes, medications, some drug infusions
- No inotropes or vasodilators on Proximal Injectate lumen
- Ideally no inotropes or vasodilators on the RA lumen

RV Infusion - situated in the right ventricle (RV)

- Administration of drug infusions
- RV pressure monitoring

PA Distal - situated in the pulmonary artery. For MONITORING purposes ONLY, not for infusions.

- Pulmonary artery pressure monitoring
- Measurement of Pulmonary Artery Occlusion Pressure (PAOP) when balloon inflated
- Drawing of mixed venous blood sampling

Side Arm of Sheath

- Administration of colloids.
- Inotropes, dilators, anti-arrhythmic drug infusions may be transferred to this lumen prior to PAC removal.
Thermistor Connector
- Measures blood temperature 4cm from the distal tip of the PAC, for monitoring only.

DRESSING MANAGEMENT

**General**
- Hands must be decontaminated immediately before touching the PAC or performing a procedure.
- The PAC sheath dressing should be changed every 7 days or when non occlusive, soiled or damp.
- “Sandwich” dressings may increase the risk of contamination during dressing change (due to the increased manipulation required to remove the dressing) and therefore must not be used.
- A Chlorhexidine impregnated sponge (Biopatch) and transparent semi-permeable dressing (Tegaderm) is the preferred dressing for a PAC.
- Clean site with 2% Chlorhexidine in 70% Alcohol unless contraindicated. Allow the site to dry by evaporation.
- Do not use topical antibiotic ointment on insertion site.
- If excessively diaphoretic or bleeding at the site, dry gauze dressing can be used. This must be changed every 48 hours, or if damp, soiled or loose.
- Ensure dressing is occlusive and covers the insertion site and that there is no tract between the site and the sheath hub. Dressing edges can be secured with Hyperfix strips to improve dressing adhesion.
- There should be no tension on the insertion site by supporting the catheter with a secondary dressing attached to the patient.
- See ‘CVC Line Management in ICU Guideline’ for further information.

**Dressing Technique**

**Equipment**
- Dressing trolley, cleaned with appropriate disinfectant solution.
- Sterile Dressing Pack
- 2% Chlorhexidine in 70% Alcohol
- Non-sterile gloves
- Sterile gloves
- Transparent semi-permeable dressing (Tegaderm) and Chlorhexidine impregnated sponge (Biopatch).

**Technique**
1. Explain procedure to patient.
2. Decontaminate hands, allow them to dry and don non-sterile gloves.
3. Remove the old dressing, taking care not to move the sheath at its insertion site or dislodge the suture.
4. Discard the gloves and decontaminate hands.
5. Open dressing pack onto clean trolley. Add cleaning solution (2% Chlorhexidine in 70% Alcohol) and dressing materials to sterile field.
6. Don sterile gloves.
7. Clean the insertion site first, then the surrounding area.
8. Allow the Chlorhexidine solution to dry by evaporation.
9. Apply Chlorhexidine impregnated sponge (Biopatch) and transparent semi-permeable dressing (Tegaderm) to site ensuring that the insertion point is covered.
10. Decontaminate hands.
11. Anchor the PAC to the patient with a secondary dressing to prevent traction on the insertion site.

**PAC MANIPULATION**

- Only ICU Consultants and Registrars accredited in PAC insertion may manipulate the PAC
- A ICU registered nurse may only remove the PAC following a documented medical order
- Patient must be adequately monitored during manipulations with ECG, SpO2, BP, ETCO2.

**Advancing PAC Forwards**

- To obtain Pulmonary artery occlusion pressure (PAOP) or following inadvertent withdrawal of the PAC
  1. Check position of PAC on CXR.
  2. Explain procedure to patient.
  4. Ensure PA waveform is continuously monitored.
  5. Note current insertion length of PAC.
  6. Decontaminate hands and don non-sterile gloves.
  7. Detach the syringe from balloon port and fill with air (~ 1.5 ml), replace syringe.
  8. Inflate the balloon slowly (stopping if any resistance is felt) and lock balloon gate into position.
     Inflation of balloon is required to aid flotation of PAC to minimise risk to pulmonary vascular damage whilst advancing.
  9. Observe the PA waveform whilst slowly advancing the catheter until a PAOP waveform is observed. DO NOT advance the PAC more than 5cm past this point.
  10. Open balloon gate and allow passive deflation of the balloon observing return of PA waveform.
      If not, the PAC may need to be withdrawn.
  11. Lock the gate; detach the syringe from the port, and empty air out. Reattach the empty syringe and leave the syringe gate open.
  12. Proceed to post PAC manipulation care.
Withdrawal of PAC

- For PAC’s inserted too far into the pulmonary vasculature (Spontaneous wedge or too deep on CXR)
  1. Check position of PAC on CXR.
  2. Explain procedure to patient.
  4. Ensure PA waveform is continuously monitored.
  5. Note current insertion length of PAC.
  6. Decontaminate hands.
  7. Don non-sterile gloves.
  8. PAC balloon **MUST BE DEFLATED** prior to manipulation to minimise damage to the PA vasculature and avoid valvular damage.
  9. Within the protective sterile sleeve, withdraw PAC to desired length or until PA waveform appears on monitor.
  10. Remove gloves and decontaminate hands.
  11. Proceed to post PAC manipulation care.

Post PAC Manipulation Care

- Assess both PA and CVP waveforms and ensure both are appropriate.
- Document new PAC insertion length and volume of air required to wedge on ICU observation chart and in patient history.
- Consider a Chest x-ray (CXR) if unsure of PAC position, or if manipulation was difficult.

CARE OF PAC EACH SHIFT

- Record PAC insertion length on ICU blue observation chart.
- Review daily CXR to confirm PAC placement.
- Ensure PAC pressure waveform is continuously transduced – observe the PA waveform for proper placement. Dampening or loss of clarity of the PA waveform may indicate the PAC position has changed.
- Inspect insertion site each shift / daily and record in patient history signs of:
  - Erythema / purulence (swab wound, discuss with ICU round medical staff)
  - Dressing integrity (redress if required), ensure Chlorhexidine Gluconate impregnated sponge (Biopatch) is in situ (unless the patient has a Chlorhexidine allergy).
- Currently patients in The Alfred ICU are restricted to bed rest if a PAC is in situ.
PAC MONITORING

- **Monitored Pressures include:**
  - Pulmonary artery Systolic/ Diastolic/ Mean
  - Pulmonary Capillary Occlusion Pressure
  - Central Venous Pressure

- **Other Measurements:**
  - Cardiac Output Measurements
  - Core Body Temperature
  - Systemic/ Pulmonary Vascular Resistance
  - Mixed venous oxygen saturation (SvO2)

MONITORING OF PULMONARY ARTERY Pressures

1. Position patient supine, head of bed may be elevated up to 45 degrees
2. Locate reference point for pressure transducer (4th Intercostal space, phelbostatic axis)
3. Reading should be measured at end expiration
4. Observe pressure waveform on monitor to ensure reading is true
5. Document PA systolic and diastolic pressures on ICU observation chart
6. Return patient to position of comfort.

If measurement difficult, consider:
- Check PAC position on CXR.
- Pressure transducer level - relevel.
- Transducer malfunction – rezero or replace.
- Assess for changes in patients condition / addition of inotropes, dilators.

OBTAINING A PULMONARY ARTERY OCCLUSION PRESSURE (PAOP)

- Also known as Pulmonary Capillary Wedge Pressure
- Used to estimate LA pressure and calculate Transpulmonary Pressure Gradient (TPG)
- To be performed by accredited medical staff only

Perform Hand Hygiene with Chlorhexidine gluconate 4% soap or alcohol based hand rub

1. Decontaminate hands.
2. Explain the procedure to the patient.
3. Locate reference point, and position patient supine with head of bed may be elevated up to 45 degrees.
4. Select the Wedge screen from the menu at the bottom of the monitor screen.
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5. Decontaminate hands, allow them to dry and don non sterile gloves.
6. Remove syringe and draw up 1.5mls of air, replace syringe.
7. Inflate balloon slowly until a wedge waveform is obtained (Do not inflate against resistance, or keep inflated for more than 2 respiratory cycles).
8. Allow syringe to deflate passively.
9. Remove syringe and expel air, reconnect syringe to port. The gate valve is left in an unlocked position once the empty syringe is attached.
10. Using cursor, select PAOP waveform at end expiration and confirm measurement.
11. Exit wedge screen.
12. Return patient to position of comfort.

**Note:** The balloon gate must never be closed except during advancement of the PAC. The balloon syringe must never be manually withdrawn. The syringe gate remains open, syringe attached.

**Monitoring For Spontaneous Wedging**

Occurs due to:
- Migration of the PAC from softening post insertion.
- Pulmonary vasoconstriction due to increased dose of inotropes, or decreased dose of dilators or inhaled nitric oxide.
- Improving RV function (less dilated)

**The PA waveform must be continuously monitored at all times** - Observe PA waveform for spontaneous wedging. If the waveform becomes dampened and the numerical readout becomes a single number, spontaneous wedging must be assumed.

- Set narrow PAP systolic, diastolic and mean alarm settings within expected range to alert the Clinician's to a spontaneous wedge, or change in patient status.
- If a PAOP is performed, set alarms so clinicians will be alerted to spontaneous wedging of PAC.
- Alarms should be activated only if the PAC spontaneously wedges or a PAOP is performed by an accredited person.
Troubleshooting Spontaneous Wedge

Suspected spontaneous wedge requires medical staff notification and attendance ASAP. Failure to recognise and respond to spontaneous wedge risks PA rupture or pulmonary infarction with associated morbidity/mortality.

1. Explain procedure to patient.
2. Decontaminate hands, and once dry, don non-sterile gloves.

3. Troubleshooting PA waveform:
   Check waveform for transducer position, dampened trace and ensure the appropriate scale is in use to visualise the PA pressure waveform.
   Ensure balloon is deflated.

4. Inappropriate PAC position (too far advanced):
   Accredited medical staff to withdraw PAC approximately 2cm.
   Reassess waveform. If spontaneous wedge trace continues, notify Registrar. Consider further withdrawal PAC.

5. Blocked lumen: Consider aspirating and flushing the lumen using sterile technique.

PERFORMING A CARDIAC OUTPUT

The patient’s height and weight need to be entered into the monitor admission screen to allow for calculation of BSA and C.O studies.

Indications
- Cardiac output (CO) measurements should be performed at least on admission and with each shift. Also consider doing a measurement following titration of inotropes or dilators.
- During haemodynamic instability.
- Post any onset of stable arrhythmias.
- Post resolution of arrhythmias.

Perform Hand Hygiene with Chlorhexidine gluconate 4% soap or alcohol based hand rub

Equipment
- Sterile dressing pack, sterile gloves, sterile huck towels (if injectate syringe not yet attached)
- Edward Lifesciences Cardiac Output set and closed injectate delivery system REF:93610
- Cardiac output module
- Cardiac output cable
- 500 ml 5% dextrose
- Sterile dressing pack
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- 2% Chlorhexidine in 70% Alcohol solution, if contraindicated use Povidine Iodine (Betadine)

**Procedure**

1. Decontaminate hands.
2. Place patient in supine position, head of bed may be elevated up to 20 degrees.
3. Explain procedure to patient.
4. Decontaminate hands.
5. Open the sterile dressing pack and add 2% Chlorhexidine in 70% alcohol. Open sterile gloves, maintaining sterility of the inner pack.
6. Decontaminate hands, and once they are dry don sterile gloves.
7. An assistant who has decontaminated their hands to open and hang the 500ml 5% Dextrose bag. Hand off the spike for the injectate delivery system to your assistant, while maintaining your asepsis. They can spike the 500ml bag of 5% Dextrose using aseptic non-touch technique. Prime the injectate syringe, eliminating all air bubbles.
8. Place sterile towel or huck towel under proximal injectate port using forceps to maintain sterility. Clean the **Proximal Injectate** port thoroughly with 2% Chlorhexidine in 70% Alcohol soaked gauze, allow it to dry over 30 seconds, and then connect the primed injectate syringe.
9. Connect cardiac output cable (probe) to injectate syringe and module.
10. Connect the core body temperature cable to the Thermistor connection on the PAC, and ensure it is reading accurately.
11. Take note of the CVP and Pulmonary Diastolic pressure (the estimated PCOP/PCWP used in calculations is the Pulmonary Diastolic pressure minus 2mmHg)
12. Select C.O. option on the bedside monitor menu.
13. Identify PAC type (on the flange of catheter) to ensure correct computation constant is programmed. Draw up 10ml 5% Dextrose solution into the injectate syringe.
14. Follow monitor prompts.
15. Press Start CO when ready.
16. Inject fluid at end expiration of the patient's respiratory cycle once the monitor prompts “inject now”. Inject in a continuous manner over 4-6 seconds avoiding any hesitation during injection.
17. Repeat above until at least three C.O recordings are obtained that are approximately within 10% of the average value.
18. Follow monitor prompts to Select/Delete CO waveform. Press Confirm to store selected mean result.
19. Calculate SVR, PVR and CI via monitor prompts or calculator. Record CO/CI, PVR, SVR and fluid used on ICU observation chart.
20. Return patient to position of comfort.
TAKING A MIXED VENOUS BLOOD SAMPLE

Mixed venous blood results can be used to assess the balance between oxygen supply and demand.

NORMAL VALUES

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>SvO2</td>
<td>70 – 75 %</td>
</tr>
<tr>
<td>PH</td>
<td>7.34 – 7.42</td>
</tr>
<tr>
<td>O2</td>
<td>37 – 42</td>
</tr>
<tr>
<td>CO2</td>
<td>40 – 50</td>
</tr>
</tbody>
</table>

- The PAC is to be used only to take mixed venous blood samples from the PA distal port.
- Routine blood samples should not be taken from a PAC.
- Mixed venous blood samples should be taken in consultation with the medical officer.

Equipment required:
- Clean Procedure trolley
- Sterile dressing pack
- Sterile gloves
- 2% Chlorhexidine in 70% Alcohol solution (unless contraindicated, then use Povidine Iodine)
- 10ml syringe
- 2ml syringe
- Blood gas syringe
- Red sterile cap
- Personal protective eyewear

Procedure
1. Explain procedure to patient.
2. Decontaminate hands.
3. Open sterile dressing pack onto the trolley. Open outside pack of the sterile gloves, maintaining sterility of the inner pack.
4. Add 2% Chlorhexidine in 70% solution to gauze, and add syringes and caps onto the dressing pack, maintaining sterility of the pack.
5. Place protective eyewear on and decontaminate hands, and once dry don sterile gloves.
6. Isolate PA distal port. Clean the 3-way tap attached to the PA distal port thoroughly with Chlorhexidine soaked gauze, and allow it to dry over 30 seconds.
7. Attach 10ml syringe to the tap and slowly aspirate 5-10 ml of blood and discard.
8. Aspirate blood sample into blood gas syringe. Expel air from the syringe once detached from the port.
9. Attach a 2ml syringe to the 3-way tap, turn tap off to the patient, and flush to remove blood. Attach sterile cap.

Perform Hand Hygiene with Chlorhexidine gluconate 4% soap or alcohol based hand rub
10. Gently flush the PA distal lumen until clear of blood.
11. Decontaminate hands.

**REMOVAL OF PULMONARY ARTERY CATHETER**

The removal of the PAC should be considered as soon as it is no longer required, preferably by day 3, with the sheath to be removed by day 7 to reduce the risk of local infection and central line associated bloodstream infection (CLABSI).

The PAC should be removed if there is evidence of infection at the insertion site, or unexplained systemic sepsis.

The PAC is to be removed prior to discharge to the general wards. Removal of the PAC may be performed once the Senior Registrar or ICU Consultant has given the order to do so.

The removal of the PAC can be performed by an appropriately trained CCRN. A GRN or CCC student may remove the PAC with supervision and assessment of the procedure by a Clinical Nurse Educator or accredited CCRN.

**Equipment for preparation and removal of the PAC:**
- Sterile dressing packs
- 2% Chlorhexidine in 70% Alcohol (unless contraindicated – then use Povidine Iodine)
- Sterile Gloves
- Non-sterile Gloves
- Protective eyewear
- Sterile PAC sheath cap – to secure to the PAC sheath, once the PAC is removed
- Transparent semi-permeable dressing (Tegaderm)
- Chlorhexidine impregnated sponge (Biopatch)

If you are also removing the sheath you will require the additional equipment:
- Stitch cutter
- If the sheath is to be sent for culture you will require sterile scissors and a sterile container.

**Patient Preparation**
- Check the position of the PAC on the CXR to ensure there are no kinks in the catheter, or loops in the RV.
- Check coagulation profile and platelets.
- Notify your pod Resource Nurse (ANM) and neighbouring staff member that you are removing the PAC in case of VT or VF, requiring ACLS intervention.
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- Explain the procedure to the patient.
- Monitoring- ECG, SpO2, Blood Pressure, ETCO2 (as appropriate)
- Decontaminate hands.
- Open a sterile dressing pack and add Chlorhexidine in 70% Alcohol solution. Open a pair of sterile gloves, maintaining sterility of the gloves.
- Decontaminate hands, allow them to dry and apply sterile gloves.
- Remove excess lines, unwanted infusions and CO set from the PAC, using gauze soaked with 2% Chlorhexidine in 70% Alcohol solution to scrub each hub prior to disconnection. Place a sterile cap on the end of each hub that has been disconnected.
- Consider transferring infusions to the side sheath port if continuous and uninterrupted flow is required (i.e. inotropes).
- Leave the CVP and PA transducers intact.
- Position the patient flat, to decrease the risk of air embolus during removal.
- Ask the patient to practice holding his/her breath which also decreases the risk of air embolus during removal.

Procedure

1. Decontaminate hands, allow them to dry and don non-sterile gloves. Remove the dressing.
2. Decontaminate hands and open sterile procedure pack onto the dressing trolley. Pour 2% Chlorhexidine in 70% alcohol solution onto gauze.
3. Open your gloves outer pack, maintaining sterility of the contents. Secure your protective eyewear.
4. Decontaminate your hands, allow them to dry and apply sterile gloves.
5. Prepare the patient’s skin and the catheter hub with 2% Chlorhexidine in 70% Alcohol, using sterile forceps to hold gauze. Place sterile towel from dressing pack over PAC lumens to maintain a sterile field.
6. When dry loosen the sheath guard from the PAC.
7. Observe the PA trace on the monitor. Withdraw the PAC observing the change in the trace from PA to RV to RA. Note any compromise to the patient’s rhythm and blood pressure when the PAC passes through the RV.
8. When an RA trace is noted, ask the patient to hold their breath, and remove the PAC from the sheath.
9. Place your thumb over the sheath end. Check for blood leaks when the patient is exhaling. If no blood is seen, remove your thumb totally.
10. Secure the sheath cap to the top of the sheath, ensuring it is locked into place.
11. Apply the Chlorhexidine impregnated sponge (Biopatch) to the sheath base at the skin insertion site, and dress the site with a transparent semi-permeable dressing (Tegaderm), unless you are removing the sheath.
12. If you are also removing the sheath, maintain your sterility and continue as per the instructions below.

Perform Hand Hygiene with Chlorhexidine gluconate 4% soap or alcohol based hand rub

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Authors: Ruth Dellabarca (ICU ANM) & Dr. Russell Laver (ICU Senior Registrar)
Review & Update by: October 2014

The hard copy of this document may be out of date. To ensure you are reading the current version, check the policy and guideline site on the Alfred Health Intranet.
REMOVAL OF THE SHEATH FOLLOWING PAC REMOVAL

1. Ensure the patient remains in a supine position. Remove the stitch securing the sheath.
2. Ask the patient to take a deep breath and hold it.
3. Hold gauze over the insertion site and firmly but gently remove the sheath, and place the sheath on your sterile field with one hand while maintaining pressure to the removal site. Tell the patient he/she can breathe normally.
4. Apply pressure to the site until bleeding has ceased. Cover site with gauze and a transparent semi-permeable dressing (Tegaderm).
5. If the tip is to be cultured, cut the tip off with sterile scissors approximately 3cm from the end and place the tip in a sterile container.

CAPPING OF THE SHEATH FOLLOWING PAC REMOVAL

Insertion of an obturator or triple lumen CVC into the PAC sheath is no longer recommended following PAC removal.

Immediately post PAC removal, while maintaining sterility, the sheath may be capped and the side-arm used for short term (<24 hours) access if:

- The sheath has been insitu < 72 hours, and
- There is no suspicion of CLABSI, and
- The line was inserted with strict adherence to aseptic technique.

Strict aseptic technique must be adhered to for capping of the PAC sheath to avoid contamination and bacterial colonisation.

If central access beyond 24 hours is required, a new CVC should be sited and the PAC sheath removed.
Appendix: NORMAL PULMONARY ARTERY CATHETER VALUES

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right Atrial Pressure / Central Venous Pressure</td>
<td>0 – 8 mmHg</td>
</tr>
<tr>
<td>Pulmonary Artery Systolic</td>
<td>15 – 30 mmHg</td>
</tr>
<tr>
<td>Pulmonary Artery Diastolic</td>
<td>6 – 12 mmHg</td>
</tr>
<tr>
<td>Pulmonary Artery Mean</td>
<td>10 – 20 mmHg</td>
</tr>
<tr>
<td>Pulmonary Artery Occlusion Pressure</td>
<td>5 – 15 mmHg</td>
</tr>
<tr>
<td>Cardiac Output</td>
<td>Stroke Volume x Heart Rate</td>
</tr>
<tr>
<td>Cardiac Output</td>
<td>4 – 8 L/min</td>
</tr>
<tr>
<td>Cardiac Index</td>
<td>2.5 – 4 L/min/m²</td>
</tr>
<tr>
<td>Systemic Vascular Resistance (SVR)</td>
<td>800 – 1200 dynes/sec/cm-5</td>
</tr>
<tr>
<td>Pulmonary Vascular Resistance</td>
<td>&lt; 250 dynes/sec/cm-5</td>
</tr>
<tr>
<td>Right Ventricular Ejection Fraction</td>
<td>40 – 60 %</td>
</tr>
<tr>
<td>Left Ventricular Ejection Fraction</td>
<td>60 – 70 %</td>
</tr>
<tr>
<td>Stroke Volume (SV)</td>
<td>CO/HR x 1000</td>
</tr>
<tr>
<td>Left Ventricular Stroke Work</td>
<td>60 – 100 ml</td>
</tr>
<tr>
<td>Left Ventricular Stroke Work Index</td>
<td>SV x (MAP – PAOP) x 0.0136</td>
</tr>
<tr>
<td>Right Ventricular Stroke Work</td>
<td>50 – 62 gm-m/beat</td>
</tr>
<tr>
<td>Right Ventricular Stroke Work Index</td>
<td>SVI x (MPAP – CVP) x 0.0136</td>
</tr>
<tr>
<td>Coronary Artery Perfusion Pressure</td>
<td>MAP – PAOP</td>
</tr>
<tr>
<td>Arterial O2 Content (CaO2)</td>
<td>60 – 80 mm Hg</td>
</tr>
<tr>
<td>Venous O2 Content (CvO2)</td>
<td>17 – 20 ml/dl</td>
</tr>
<tr>
<td>Arterial Venous O2 Content Diff.</td>
<td>4 – 6 ml/dl</td>
</tr>
<tr>
<td>Oxygen Delivery</td>
<td>CaO2 x CO x 10</td>
</tr>
<tr>
<td>Oxygen Delivery Index</td>
<td>950 – 1150 ml/min</td>
</tr>
<tr>
<td>Oxygen Consumption</td>
<td>(CaO2 – CvO2) x CO x 10</td>
</tr>
<tr>
<td>Oxygen Consumption Index</td>
<td>200 – 250 ml/min</td>
</tr>
<tr>
<td>Oxygen Extraction Ratio</td>
<td>[(CaO2 – CvO2) / CaO2] x 100</td>
</tr>
<tr>
<td>Oxygen Extraction Ratio</td>
<td>22 – 30 %</td>
</tr>
<tr>
<td>Transpulmonary Pressure Gradient (TPG)</td>
<td>&lt;12 mmHg</td>
</tr>
<tr>
<td>- Mean PAP - PAOP</td>
<td></td>
</tr>
<tr>
<td>- Elevated TPG suggests increased pulmonary vascular resistance and/or pulmonary blood flow</td>
<td></td>
</tr>
<tr>
<td>- TPG helps to differentiate between active (elevated TPG) and passive (elevated PAOP) pulmonary hypertension</td>
<td></td>
</tr>
</tbody>
</table>

PAC waveform interpretation
Guideline for Pulmonary Artery Catheter Management in ICU

KEY RELATED DOCUMENTS

1. Central Venous Catheter in ICU Guideline
2. Alfred Health Central Venous Catheter Management guideline
3. Infection Control Requirements Policy
4. Standard Precautions Guideline
5. Verification of Patient Identity Policy
6. Blood Component Administration Policy
7. Waste Management Policy
8. Alfred Health hand Hygiene Guideline
9. Alfred Health Infection Prevention during CVAD insertion guideline

REFERENCES


5. ANZICS Central Line Insertion and Maintenance Guidelines 2012.


Previous guideline:

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<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Service / Program</th>
</tr>
</thead>
<tbody>
<tr>
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<td>ICU Clinical Nurse Educator/ANM</td>
<td>July 2012</td>
</tr>
<tr>
<td>Dr Russell Laver</td>
<td>ICU Senior Registrar</td>
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<td>July 2012</td>
</tr>
<tr>
<td>Prevention team</td>
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</table>

Endorsed by: ICU Guideline committee  
Date: October 2012

Approved by: ICU Intensivist (Cardiac)  
Date: October 2012

Disclaimer: This guideline has been developed within the context of Alfred Health service delivery. Alfred Health shall not be responsible for the use of any information contained in this document by another organisation outside of Alfred Health.