Rationale and key points
This article aims to help nurses to undertake the removal of pulmonary artery (PA) catheters in a safe manner.

- PA catheter removal is associated with several risks and complications, and nurses should be cognisant of these and take appropriate action to ensure patient safety and optimum outcomes.
- When PA catheters are no longer required, the temporary central venous catheter and its wide-bore introducer must be removed.

Preparation and equipment
- The nurse should be aware of the potential risks and complications associated with the removal of a pulmonary artery (PA) catheter. They should work under the supervision of experienced colleagues until they become competent to undertake the procedure.
- The nurse should ensure that all equipment is available, including:
  - A sterile dressing pack, containing gloves.
  - Skin cleansing preparation, 2% chlorhexidine in 70% isopropyl alcohol.
  - Bactericidal soap or alcohol hand gel.
  - A sterile transparent dressing.
  - A stitch cutter.
  - 2 pairs of sterile scissors.
  - 2 sterile specimen containers.
  - Sterile gauze.
- The nurse should explain the procedure to the patient and gain verbal consent, if possible.
- The nurse should ensure the patient is in the supine position with their head turned away from the PA catheter entry site.
- The nurse should disable the monitor alarms associated with the PA catheter, clamp the pressure monitoring line attached to the PA catheter and discontinue any fluids that are running via the introducer side arm. All other monitoring alarms should remain active.

Procedure
1. Position the cardiac monitor so that it can be seen during the procedure.
2. Ensure the balloon at the distal tip of the PA catheter is deflated, using the dedicated PA catheter syringe.
3. Check the PA waveform on the cardiac monitor to ensure there is a pulsatile PA pressure wave with appropriate PA pressure values; this confirms that the PA catheter balloon is deflated.
4. Wash your hands with bactericidal soap and water or cleanse with alcohol hand gel.
5. Open the sterile dressing pack. Open the other sterile packs, tipping their contents onto the sterile field.
6. Put on clean (non-sterile) gloves.
7. Unlock the protective PA catheter sleeve from the top of the wide-bore introducer.
8. While observing the electrocardiogram (ECG) for dysrhythmias, gently withdraw the PA catheter in a continuous smooth action until the tip emerges through the self-sealing haemostasis valve. If resistance is met during withdrawal, stop and seek assistance; resistance may indicate that the PA catheter has become entangled in the tricuspid valve.
9. Place the PA catheter onto the sterile field.
10. Remove gloves and dispose of appropriately.
11. Wash your hands with bactericidal soap and water or cleanse with alcohol hand gel.
12. Reposition the patient slightly head down, if tolerated.
13. Wash your hands with bactericidal soap and water or cleanse with alcohol hand gel.
14. Put on clean (non-sterile) gloves.
15. Remove the dressing from the PA catheter entry site and any sutures from the introducer.
16. Clean the entry site with 2% chlorhexidine in 70% isopropyl alcohol using back and forth strokes with friction. Allow the skin to dry for 30 seconds.
17. Remove gloves and dispose of appropriately.
18. Wash your hands with bactericidal soap and water or cleanse with alcohol hand gel.
19. Put on sterile gloves.
20. Using the sterile gauze, apply firm pressure to the introducer entry site and remove the introducer. If the patient is alert they can be asked to perform the Valsalva manoeuvre – the patient is asked to breathe in and then try to force air out with the mouth and nose closed. It should be noted that there is limited evidence for this technique and the nurse should follow local policy. Continue to press firmly on the entry site for at least five minutes and observe the ECG for dysrhythmias while applying pressure to the internal jugular vein entry site. The close proximity of the internal jugular vein to the carotid artery means there is an inadvertent risk of carotid sinus stimulation when applying pressure to the internal jugular vein, which can cause bradycardia.
21. Place the introducer onto the sterile field.
22. After five minutes, cautiously reduce the pressure on the entry site and check for bleeding. If bleeding continues, re-apply pressure. Once bleeding stops, cover the entry site with the sterile transparent dressing, which should remain in place for 72 hours.
23. Advise the patient that the procedure has finished.
24. If the PA catheter tip is to be sent for microbial culture, use sterile scissors to cut off the tip (approximately 5cm) and place it in a sterile specimen container. If the introducer tip is to be sent for culture, repeat this step using a new pair of sterile scissors and a new sterile specimen container.
25. Remove gloves and dispose of appropriately.
26. Wash your hands with bactericidal soap and water or cleanse with alcohol hand gel.
27. Reposition the patient comfortably.
28. Label the sterile specimen containers and send them to the laboratory for microbiological investigation.

**Evidence base**

PA catheters are long flexible multi-lumen devices incorporating a small balloon at the distal tip of the catheter (Figure 1). Once in position, the distal lumen measures the PA pressure.

**FIGURE 1**

Pulmonary artery catheter with protective sleeve, which permits manipulation of the catheter post insertion

**FIGURE 2**

Wide-bore introducer with self-sealing haemostasis valve
To insert a PA catheter, the clinician must first insert a wide-bore introducer with a self-sealing haemostasis valve (Figure 2). The PA catheter is connected to a haemodynamic monitoring system attached to the cardiac monitor. Using a sterile technique and full barrier precautions (Loveday et al 2014), the PA catheter is fed through the introducer into the superior vena cava. The PA catheter is advanced into the right atrium through the tricuspid valve and down into the right ventricle (Figure 3a). The balloon at the tip of the catheter is inflated (Figure 3b), which causes the tip of the catheter to become buoyant and to turn upwards, and the balloon-tipped catheter then ‘floats’ through the pulmonary valve into the PA (Figure 3c). PA pressure should now be displayed on the cardiac monitor. Catheter advancement through the heart can be seen on the monitor by observing the changes in pressure that occur (Figure 3). With the balloon inflated, the catheter is further advanced until it becomes wedged in a smaller branch of the PA. This interrupts the blood flow and the pulsatile PA pressure wave changes to a non-pulsatile wave (Figure 3d). The tip of the PA catheter detects the pressure of blood in the pulmonary capillary bed, which is in continuance with the pulmonary veins and the left atrium. The pulmonary capillary wedge pressure (PCWP) is an interpretation of the pressure in the left side of the heart (Figure 4). The balloon is then deflated to prevent this section of the pulmonary capillary bed from becoming ischaemic.

Ventricular contraction can cause the PA catheter to migrate and to wedge in a small pulmonary branch; this is identified by the PA wave becoming a PCWP wave. This is resolved by withdrawing the catheter slightly. To prevent contamination during catheter manipulation, the PA catheter is enclosed in a protective sleeve (Figure 1). The nurse must be able to recognise PA and PCWP pressures on the cardiac monitor to detect when the catheter has become unintentionally wedged.

Before PA catheter removal the nurse should explain the procedure to the patient and gain consent, if possible (Nursing and Midwifery Council 2015). The nurse must check that the distal balloon is deflated before removing the PA catheter and confirm this by observing for a pulsatile PA pressure wave on the cardiac monitor. Should the PA catheter be withdrawn with the balloon inflated, the pulmonary and tricuspid valves could be damaged, causing acute valvular heart failure.

Dysrhythmias are the most commonly reported complication of PA catheter removal (Baldwin and Heland 2000), but are usually transient and cease

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**FIGURE 3**

**Individual pressure waveforms seen as the pulmonary artery (PA) catheter is advanced through the heart**

a) **Right atrial pressure waveform**

b) **Right ventricular pressure waveform**

c) **Pulmonary artery pressure waveform**

d) **Pulmonary occlusion or ‘wedged’ pressure waveform**

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**FIGURE 4**

**Pulmonary artery (PA) catheter with inflated balloon wedged in a branch of the PA**

Static column of blood from distal tip of catheter to left atrium
when the catheter exits the heart. By observing the ECG during catheter removal, the nurse is alerted to any dysrhythmias. Sustained dysrhythmias should be managed according to advanced life support algorithms (Resuscitation Council (UK) 2015).

PA catheters can become entangled or knotted in the chordae tendineae of the tricuspid valve. Catheter removal should be abandoned if resistance is felt because forcible removal could cause valve damage or papillary muscle rupture (Arnaout et al. 2001).

Central venous catheter removal carries a risk of air embolism because the central vein is exposed to the atmosphere as the catheter exits the vein. Supine or head-down positioning of the patient reduces the risk of air embolism by increasing the pressure in the great veins (Scales 2008). Air embolism remains a risk for up to 72 hours following catheter removal; therefore, it is recommended that the dressing remains in place for 72 hours (Royal College of Nursing 2010).

The wide-bore introducer creates a significant defect in the vein wall. Sustained pressure is required for several minutes to prevent haemorrhage during device removal (Scales 2008). High-risk patients may benefit from correction of clotting abnormalities before the PA catheter is removed.

The advent of less invasive methods to measure cardiac output has meant that PA catheters are now used less frequently. However, they are still the device of choice for measuring cardiac output for patients with complex comorbidities, for whom the clinical benefits outweigh the associated risks NS.

Disclaimer: please note that information provided by Nursing Standard is not sufficient to make the reader competent to perform the task. All clinical skills should be formally assessed at the bedside by a nurse educator or mentor. It is the nurses’ responsibility to ensure their practice remains up to date and reflects the latest evidence.

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References


