PG21 Guideline on safe practices for central venous access device insertion, maintenance, and removal 2026

Short title: Central venous access device (CVAD) mechanical safety

Keyword list: central venous catheter, central venous access device. arterial injury, air embolism

1. Purpose

Mechanical complications of central venous access devices (CVADs) are physical complications that may occur throughout the clinical lifespan of the device. This document describes principles and strategies that aim to reduce the incidence of mechanical complications.

2. Scope

This document applies to anaesthetists placing CVADs percutaneously, and is relevant to placement in the neck, groin or upper torso, where the tip of the device sits in a major central vein. The typical approaches are via the internal jugular, subclavian or femoral vein routes, but the principles described may apply with other approaches. There may be some overlap between principles described here and peripherally inserted Central Catheters (PICC).

This document covers mechanical complications associated with CVADs, it does not cover infectious complications, which are more appropriately dealt with in other guidelines dealing specifically with Central Line Associated Bloodstream Infections (CLABSI).

Principles outlined in this document may apply to practitioners other than anaesthetists, but some may not be relevant in cases where open surgical exposure or advanced imaging techniques (e.g. fluoroscopy or trans-oesophageal echocardiography) are used.

This document is not intended to cover surgically placed, implanted, tunnelled and cuffed CVADs.

3. Background

Mechanical complications of CVADs can have serious consequences including but not limited to death, stroke, vascular trauma, haemorrhage, arrhythmia, nerve damage, pneumothorax and embolism of air, atherosclerotic plaque or thrombus. Causes of mechanical complications include needle trauma, incorrect placement of a catheter (particularly intra-arterial placement), retention of components and failure of insertion.

These complications are described in the literature and in morbidity and mortality reports including to the WebAIRS database. Strategies to minimise mechanical complications of CVADs have been reviewed in Australian and International guidelines.[1-3]

This document describes processes and practical steps anaesthetists can take to minimise the risks of mechanical complications of CVAD insertion, maintenance and removal. There is a particular focus on avoiding intra-arterial catheter placement.

4. Definitions

4.1 Central venous access device (CVAD)

A catheter, cannula or sheath, inserted percutaneously in the neck, upper torso or groin, whose tip resides in a large central vein. (Also described as a central venous catheter).

4.2 Mechanical complications of CVADs

A physical complication occurring throughout the clinical lifetime of a CVAD which may have consequences including but not limited to death, stroke, vascular trauma, haemorrhage, arrhythmia, nerve damage, pneumothorax, component retention, and embolism of air, atherosclerotic plaque, thrombus or catheter fragment. As noted, in the context of this document, infectious complications are excluded.

4.3 Static, Dynamic and Focused Ultrasound during CVAD placement

Static ultrasound is where the vessel is visualised and the skin may be marked. It may also be used to describe the process of vessel assessment or pre-scan.

Dynamic ultrasound is used to describe the use of ultrasound in real-time during a procedure to guide a needle or cannula into its desired position with its tip in the desired target vein for subsequent wire insertion.

Focused ultrasound is separate to dynamic ultrasound during cannulation and is an advanced ultrasound modality that is used to confirm with high probability that the inserted guidewire has a venous course for a sufficient length to exclude being in another vessel or tissue space.

5. Principles

5.1 Planning

An appropriate location and assistant are required for the insertion procedure. The location must allow for aseptic insertion and electrical safety. The assistant should also act as the engaged observer ensuring compliance with asepsis and safety precautions.

The clinical indication for the CVAD must be established. This is especially relevant where insertion of the CVAD is undertaken as a procedure on behalf of another medical specialty unit. Alternative therapies such as peripheral vasopressors in lower concentrations, intraosseous access or PICC or mid-lines should be considered. In time / resource pressured situations, it may be appropriate to delay placement of a CVAD, if alternative therapeutic options are available. Careful consideration must be given to the CVAD type to be inserted, including its intended use, site of insertion, and the presence of allergens such as chlorhexidine coating.

Patient risk for the procedure must be assessed and consent obtained from the patient or legally responsible person (except for emergency situations). If the CVAD is a component of the anaesthetic, then consent may form part of the anaesthesia consent process, similarly it may form part of consent for critical care (e.g. in ICU), otherwise a specific consent form must be obtained and signed by the patient (or legally responsible person). Please refer to *PS26(A) Informed consent*.

Specific equipment requirements include an ultrasound machine suitable for dynamic imaging within a sterile field and a patient trolley or bed that is capable of head down tilt (Trendelenburg position).

An engaged observer, who may be the assistant to the anaesthetist performing the procedure, should be able to ensure relevant checklists (including those for central line associated blood stream infections (CLABSI) prevention) are undertaken, in addition to assisting with monitoring and supporting the patient.

5.2 Training, assessment and competence

Placement of CVAD should only be undertaken by, or under the direct supervision of, an appropriately trained and credentialed practitioner.

Individual institutions should develop and institute formal training and accreditation pathways, which include the ability to perform simulated practice[4] [5] (see section 7).

5.3 Procedural components

5.3.1 Monitoring

Appropriate monitoring of the patient must be available and be appropriate for a patient who is sedated. ECG monitoring is required for arrhythmias that might occur when a wire or catheter enters the atrium or ventricle.

5.3.2 Sedation

Where sedation is provided for the procedure, the principles of *PG09 Procedural sedation* should be followed.

5.3.3 Pre-procedural (Static) ultrasound scan

There should be a low threshold for using static US scanning of the venous anatomy prior to the sterile field being put in place. This technique may be helpful to identify abnormal anatomy and useful for teaching, or in a more critical context (such as ECMO cannulae insertion, or where previous CVAD cannulation has taken place). [6]

5.3.4 Asepsis

Precautions to prevent CLABSI should be implemented as described in *PG28 Infection prevention and control*. These precautions should include but are not limited to: a mask, gown and sterile gloves worn by the proceduralist; chlorhexidine and alcohol (unless allergic to chlorhexidine) to prepare the procedural site; a full body sterile drape; a sterile cover for the ultrasound probe; assistants wearing a surgical face mask.

5.4 Central venous access

5.4.1 Dynamic (real-time) ultrasound for needle guidance

Evidence supports the use of real-time (dynamic) ultrasound imaging which should be used to follow the path of the needle tip from the skin into the target vein. This is typically performed in short axis using a dynamic needle tip visualisation technique, moving the needle tip into the ultrasound field then moving the field forward and moving the needle tip into the new plane. Long axis techniques can be considered but care needs to be taken where an artery and vein lie side by side. The routine use of US in CVAD insertion has significant benefits but also has demonstrated that misinterpretation of the location of the needle or cannula tip is a common causative factor in cases of inadvertent arterial injury.

5.4.2 Choice of needle versus cannula

Options for accessing the vein include the use of a needle (Seldinger technique) or a small gauge cannula (modified Seldinger technique). An advantage of using the Seldinger technique is that some needles are designed to be more echogenic (facilitating dynamic needle tip positioning), and vein entry may be more ‘tactile’ as the needle is more rigid. The modified Seldinger technique facilitates the use of manometry by reducing the number of steps required (see below).

5.4.3 Avoiding venous air embolism during vessel puncture

Active steps should be taken to prevent a pressure gradient from the atmosphere to the intrathoracic (central venous) space. Head down positioning increases the chance of positive venous pressure when placing CVADs in the upper body. When patients are sedated for the procedure, care should be taken to avoid obstructed breathing that promotes negative intrathoracic pressure. In ventilated patients, PEEP minimises negative central venous pressure.

5.4.4 Guidewire management

Retained guidewires are at risk of embolism requiring invasive interventions to facilitate removal. Once a CVAD is placed, the wire should be promptly removed and verbal confirmation of this step made with the assistant. This step should be included where procedural checklists are used. If more than one guidewire is utilised, the wires must be 'counted off' the sterile field during /at the end of the procedure.

5.4.5 Number of attempts

As the number of attempts to access a central vein increases, patient discomfort and the probability of complications increases.[7] Institutions should recommend a maximum number of attempts at vein access before seeking help of an experienced colleague or attempting venous access at another site.

A reasonable approach is to consider that after a third failed attempt, a practitioner should seek assistance or re-think their approach.

5.4.6 Dilator management

Care should be taken with dilators, only advancing far enough to create a track for catheter insertion. Inserting dilators further than this increases the risk of perforation of the great vessels or heart.

5.4.7 Documentation

Clear documentation of the CVAD insertion process should be undertaken. A CVAD-procedure specific form is the optimal way to do this.

5.5 Confirmation of needle / cannula / wire placement before dilatation: "Critical checking"

Vessel dilatation is an **irreversible step**, which, if arterial, can lead to severe adverse outcomes including death. Before a vessel is dilated, **critical checking** should be performed to confirm that a guidewire has a solely intra-venous course. It should be noted that tests and checks all have limitations and arterial dilatation can occur regardless, but steps must be taken to minimise this risk. As this is a system vulnerability, a **systems-based approach** to minimising harm should be applied across all settings in which CVADs are inserted, regardless of operator experience.

5.5.1 The recommended 'two critical checks' approach

Performance of two critical checks is strongly recommended, but at least one correctly performed critical confirmatory check must be performed other than in exceptional circumstances.

- Waveform analysis
- Manometry
- Focused US
- Blood gas analysis

- Fluoroscopy

The following tests are NOT reliable enough to be confirmatory

- Dynamic US scanning used during needle guidance alone
- The assessment of pulsatility or the colour of blood

Performance of two critical checks is strongly recommended especially if a chosen critical test is ambiguous or in high-risk scenarios (see section 8). These complementary approaches allow confirmation that the tip of a cannula is intravenous, and the path followed by a wire is only venous. The use of two complimentary confirmatory methods is likely to provide the lowest overall risk of inadvertent arterial dilatation.

If ultrasound or manometry confirmation of wire position is deemed as acceptable practice, as the sole component of the critical check in an institution, the technique involved should form a part of an institutionally approved protocol that includes an assessment of the competency of practitioners.

5.5.2 Recommended “critical checking” confirmation methods.

5.5.2.1 Manometry / waveform analysis

The manometry / waveform technique is used to demonstrate that the pressure at the end of a cannula (or needle) is consistent with venous pressure. It is strongly recommended that transduction occurs through a cannula, as a small inadvertent movement of a sharp needle can lead to an anatomically significant change in position after the manometry / waveform analysis has occurred. If a needle is used to access a vein, a wire exchange to an appropriate cannula can be performed. If a cannula is not provided in the CVAD kit, it is necessary to use a sterile cannula of sufficient length to reach well into the vessel, and sufficient internal diameter to enable the wire to pass through.

If manometry using a short length of tubing is performed, the goal is to demonstrate a *falling meniscus* of blood or saline in the tubing, to a final height that rules out arterial placement. A static meniscus can be misleading as it may represent an occluded cannula or tip placement in an extra-vascular location.

If a pressure transducer is available and can be used in a sterile fashion, it can be attached to the cannula, and a pressure measurement obtained and/or wave form seen, that is consistent with venous placement. A flat line may represent occlusion of the cannula or extravascular positioning.

Manometry and waveform analysis can demonstrate that the tip of a cannula is in the venous system.

5.5.2.2 Focused ultrasound to confirm wire placement

Higher level Focused ultrasound skills are required to demonstrate that a wire lies entirely in a vein. Imaging should occur in a variety of views, in short and long axis. The wire should be followed centrally with ultrasound for as far as possible, demonstrating an intra-venous course. Focused ultrasound confirmatory indicators include:

- Ultrasound visualisation of a length of wire within the vein that is longer than the needle or cannula used to pass the wire provides a high degree of certainty.
- Identification of the wire in the brachiocephalic vein.

- Ultrasound visualisation of the tip of the wire (eg the 'J' at the end of the wire) within the vein proves the tip of the wire is intravenous, but carries the risk of wire displacement and so if attempted, should be performed with the cannula still in situ.

If ultrasound confirmation of wire position is deemed as acceptable practice, as the sole component of critical checking in an institution, the techniques involved should form a part of the assessment of competency.

If trans-oesophageal echocardiography is used simultaneously, a correctly placed wire can be visualised as it passes into the right atrium by looking at a bi-caval view. If transthoracic echocardiography is employed, a correctly placed wire can be observed passing into the right atrium.

5.5.2.3 Blood gas analysis

A blood sample for blood gas analysis can be obtained from a cannula placed in a central vein to demonstrate venous rather than arterial placement. If using a needle to access a vein, this should be exchanged to a cannula over a guidewire, before taking a blood sample, as inadvertent movement of a needle is possible following sampling. In a critically ill patient, paired blood gas analysis, with comparison to a known arterial sample may be necessary.

Precautions should be made to ensure the cannula does not allow air embolism, cause bleeding or become blocked with thrombus whilst a blood gas result is obtained.

Use of blood gas analysis is resource intensive and time consuming and may be impractical in many environments. It may be well-suited to an Intensive Care Unit environment.

5.5.2.4 Fluoroscopy

In some circumstances, fluoroscopy may be available to assess wire position before dilatation and placement of a catheter. Practitioners utilising fluoroscopy should be appropriately trained and credentialed and working in their scope of practice.

5.5.3 Indicators that do NOT reliably confirm venous placement

The following observations may support venous placement but should not be relied upon as a confirmatory component of "Critical Checking".

5.5.3.1 Observation of colour / pulsatility of blood

Observation of blood colour and pulsatility has traditionally formed a part of the assessment of catheter / needle tip position. When trying to distinguish between venous and arterial placement it is of low specificity and may be falsely reassuring, so should not be used as a method of confirmation of safe venous cannula/needle position.

5.5.3.2 Reliance only on dynamic US imaging used during needle guidance.

Real time (dynamic) US is recommended to facilitate needle or cannula placement within a vein (see 5.4.1) however this should **not** be regarded as confirmatory evidence of venous wire placement prior to dilatation, as misinterpretation of ultrasound images has led to arterial injury, morbidity and mortality.

5.6 Securing and assessing the CVAD

CVADs should be secured to minimise the chance of becoming dislodged and to minimise the chance of infective complications. Institutions should standardise the way lines are secured and promote this as a component of credentialing. A formal assessment of CVAD position, following placement, should be undertaken before use (see 5.6.2).

5.6.1 Securing CVADs

CVADs should be secured with sutures or specific devices. A clear plastic dressing in combination with a mechanism to minimise infection may be used that is consistent with institutional policy. Examples include a Biopatch® or chlorhexidine gel-impregnated dressing.

5.6.2 Assessment of line position (subsequent to placement)

If a CVAD is placed in the operating theatre as part of anaesthetic management, confirmation of correct placement should be made by pressure waveform analysis, blood gas analysis, or for IJV and subclavian routes, by cardiac ultrasound if available. The use of Transthoracic Echocardiography (TTE)to assess CVAD tip position has been described, which is a diagnostic level ultrasound skill.

A radiographic assessment of line position should be made before an internal jugular or subclavian vein CVAD is used in a ward environment or for haemodialysis. An erect chest x-ray should be performed to assess the position of the CVAD, and exclude complications such as pneumothorax, when lines are placed in the chest or neck. The ideal location for the tip of the CVAD is at the junction of the superior vena cava and the right atrium. On an erect chest x-ray the tip of a CVC should below the level of the carina, but not by more than 2 vertebral bodies. A CVAD placed on the left should be inserted far enough that the tip is vertical in the SVC. Assessment of femoral central venous lines should be performed according to institutional guidelines.

Intravascular ECG (IVECG) may be used to confirm tip position if available. Real-time changes in P-wave amplitude from the catheter or guidewire can aid detection of the right atrium boundary.

5.7 CVAD maintenance

Institutions should have policies describing the care and use of CVAD. These policies should specifically address regular assessment of the CVAD, insertion site and dressing, processes around drug and infusion delivery, flushing and locking of CVAD lumen as appropriate and appropriate duration of insertion.

5.8 CVAD removal

CVAD removal is a time of higher risk for mechanical complications and there should be institutional policies designed particularly to minimise the probability of venous air embolism, and to ensure an intact CVAD is removed.

5.8.1 Assessment of coagulopathy

Before removal of a CVAD, the risk of coagulopathy should be assessed and if necessary appropriate blood tests should be performed and any coagulopathy treated appropriately.

5.8.2 Venous air embolism

Manoeuvres that increase venous pressure during device removal include positioning the patient in the supine or head down position, and removal at end inspiration or during a breath hold

(Valsalva). An airtight dressing should be placed over the CVAD access site immediately following removal.

5.8.3 Device integrity

If there is any resistance on removal of a CVAD, advice should be sought and radiological assessment/intervention considered. Once the device is removed it should be assessed to ensure it is complete and that no component has been retained.

In open heart surgery, device integrity should be confirmed if there is a possibility the line may have been damaged or sutured (hence retained) inadvertently.

6. Management of complications

6.1 Arterial puncture

Arterial puncture with a needle or cannula (16G or smaller (21G in paediatrics)) in an externally compressible area (e.g., distal common carotid or common femoral artery) can usually be treated with application of moderate pressure for 10-15 minutes in a patient with normal coagulation. The level of pressure applied should not be enough to occlude the underlying artery, especially in the neck. Observation for haematoma development and ultrasound review of the puncture site should be undertaken, especially if anticoagulation is planned (eg for cardiac surgery).

6.2 Arterial dilation / Arterial placement of a CVAD

This is a serious complication. If an arterial puncture is made with a device >16G, or if an accidental arterial catheterisation occurs in a non-compressible area (e.g., subclavian artery) regardless of catheter size, the device should be left in situ and a vascular surgeon should be consulted immediately. Options for treatment may range from removal of the device and application of pressure, to endovascular approaches to vessel repair or open surgical repair. Early advice on anticoagulation should be sought as the intra-arterial component of the device will be thrombogenic and emboli may occur. Regular assessment of the limb / organ distal to the site of injury should be undertaken. If damage is to the carotid or subclavian, regular neurological observations should be made, if damage is to the subclavian or femoral vessels the affected limb should be observed.[8]

In paediatric patients, multidisciplinary advice should be sought if an artery is dilated.

6.3 Retained guidewire

If a guidewire has been retained and is not removable with simple procedures (eg removing the whole CVAD with wire), prompt help should be sought from an interventional radiologist or vascular surgeon.

6.4 Other complications

Recommendations regarding the management of other complications have been published but are beyond the scope of this document.[8]

7. Training and maintenance of competence

The general process for placing a CVAD should be familiar to all anaesthetists. Individual institutions should have specific policies describing who places CVAD, how they are placed, assessment of CVAD placement, maintenance of CVAD and safe removal. As these policies will vary between institutions, institution level training and credentialing is recommended to ensure consistent safe practice.

Trainees learning to place CVADs should undertake theoretical learning, followed by simulated insertion, then be supervised whilst undertaking insertion until a consistent level of competence is demonstrated, at which point they can be deemed competent to undertake unsupervised practice.[7]

8. High risk situations

Special consideration should be given to situations which may require additional expertise, training or assistance, or situations where optimal resources are not available for urgent support in a reasonable timeframe. Such situations include:

Patient factors

- Paediatric patients, especially in a non-tertiary setting [9, 10] (see also *PG29 Anaesthesia in children*)
- Congenital heart disease (new or repaired)
- Cardiac arrest where a patient is undergoing CPR (consider intraosseous access)
- Agitated or restless patients
- Abnormal anatomy (Obesity, fixed neck deformity)
- History of difficult CVAD insertion
- Previous CVAD or port in vicinity
- Coagulopathy

Procedural factors

- Lack of availability of a functional ultrasound machine
- Insertion of large cannulae or sheath
- Time pressured insertion / critical circumstances

This document is accompanied by a background paper (PG21BP) which provides more detailed information regarding the rationale and interpretation of the Guideline.

Related ANZCA documents

PG09(G) Procedural sedation

PS26(A) Position statement on informed consent for anaesthesia or sedation

PG28 Guideline on infection prevention and control in anaesthesia

PG29 Guideline for the provision of anaesthesia care to children

PG69 Guideline on the prevention, investigation and follow up of perioperative hypersensitivity reactions and anaphylaxis

References

1. American Society of Anesthesiologists. Practice Guidelines for Central Venous Access 2020: An Updated Report by the American Society of Anesthesiologists Task Force on Central Venous Access. Anesthesiology. 2020;132(1):8–43.
2. Johnston AJ, Simpson MJ, McCormack V, Barton A, Bennett J, Chalisey A, et al. Association of Anaesthetists guidelines: safe vascular access 2025. Anaesthesia. 2025;80(11):1381–96.
3. NSW Agency for Clinical Innovation. Central venous access devices (CVAD): Clinical practice guide Sydney2021. Available from: https://aci.health.nsw.gov.au/networks/icnsw/clinicians/cvad. Accessed: 7 Nov 2025

4. Soffler MI, Hayes MM, Smith CC. Central venous catheterization training: current perspectives on the role of simulation. Advances in medical education and practice. 2018;9:395–403.
5. Tokumine J, Yorozu T, Moriyama K, Suzuki T, Okada C. Outcome-based simulation training for ultrasound-guided central venous catheter placement: clinical impact on preventing mechanical complications. BMC medical education. 2025;25(1):131.
6. Spencer TR, Pittiruti M. Rapid Central Vein Assessment (RaCeVA): A systematic, standardized approach for ultrasound assessment before central venous catheterization. J Vasc Access. 2019;20(3):239–49.
7. Vegas A, Wells B, Braum P, Denault A, Miller Hance WC, Kaufman C, et al. Guidelines for Performing Ultrasound-Guided Vascular Cannulation: Recommendations of the American Society of Echocardiography. J Am Soc Echocardiogr. 2025;38(2):57–91.
8. Woodfall K, van Zundert A. Central Venous Access: An Update on Modern Techniques to Avoid Complications. Healthcare (Basel). 2025;13(10).
9. Ullman AJ, Marsh N, Mihala G, Cooke M, Rickard CM. Complications of Central Venous Access Devices: A Systematic Review. Pediatrics. 2015;136(5):e1331–44.
10. Zhang JJ, Nataraja RM, Lynch A, Barnes R, Ferguson P, Pacilli M. Factors affecting mechanical complications of central venous access devices in children. Pediatr Surg Int. 2022;38(7):1067–73.

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