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Abstract

Central venous access devices (CVADs) are an essential part of patient therapy and provide a route for the delivery of intravenous medications, solutions, and blood sampling, as well as for hemodialysis. Complications such as CVAD occlusions can have a significant impact on the patient and health care system, causing suboptimal treatment, yet there is a lack of standard practices for CVAD occlusion management outside of hemodialysis. A national task force of Canadian clinicians was formed to review the published literature and develop a clinical guideline for the management of catheter occlusions – for CVADs not used specifically for hemodialysis. The recommendations are presented here. Clinical practice tools and templates that support the application of this guideline will be available to ensure safe and effective management of CVAD occlusions.

Summary of Key Recommendations

For full recommendations, please refer to the corresponding section.

1.0 ASSESSMENT OF CVAD PATENCY

Assess catheter patency and identify type of catheter occlusion (i.e., partial, withdrawal, or complete) if present. [IB]*

Flush each lumen with sterile, 0.9%, preservative-free, sodium chloride solution/normal saline (NS), and attempt to aspirate blood from each lumen to determine ease of flush and aspiration. [IB]

Document catheter patency assessment and signs and symptoms of catheter occlusion. [IB]

2.0 ASSESSMENT AND MANAGEMENT OF MECHANICAL OCCLUSION

Assess for signs of mechanical occlusion of the central venous access device (CVAD). [IB]

Resolve the mechanical obstruction accordingly. [IB]

Consider changing the dressing, ensuring no twisting/kinking of the catheter. [IB]

Consider chest x-ray to rule out internal kinking, malposition, or pinch-off syndrome [IB]

3.0 ASSESSMENT AND MANAGEMENT OF THROMBOTIC OCCLUSION

Assess catheter occlusion to identify if the occlusion is caused by a thrombotic obstruction of the CVAD. [IB]

Manage as thrombotic occlusion if unable to determine type of occlusion. [IB]

Promptly administer thrombolytic agents approved for restoring CVAD patency in catheter with partial, withdrawal, or complete occlusion suspected to be caused by blood/fibrin. [IB]

Treat all catheter lumens with partial, withdrawal, or complete occlusion. Do not leave an occluded lumen untreated because another lumen is functional. Applicable to all types of CVADs. [IB]

Let thrombolytic dwell for 30–120 minutes. [IB] Consider extending dwell to 24–72 hours (to permit longer contact time of thrombolytic with the fibrin in the catheter or around the catheter tip in the case of a mural thrombus or fibrin sheath). [IC]

Consider use of thrombolytic for CVAD occlusions in the community and long-term care settings. [IB]

4.0 ASSESSMENT AND MANAGEMENT OF CHEMICAL OCCLUSION

Assess catheter occlusion to identify if the occlusion is caused by a chemical obstruction of the CVAD. [IB]

Promptly attempt to restore patency of CVADs occluded by chemical precipitate by instillation of clearing agent(s) recognized to dissolve precipitate. [IIB]

5.0 PREVENTION OF CVAD OCCLUSION

Ensure ongoing education and competency validation of the health care professional responsible for CVAD care and management in (1) principles of catheter patency; (2) assessment, prevention, and management of catheter occlusions; and (3) CVAD type and add-on device features. [IC]

Flush CVAD lumens with normal saline (NS) solution. [IB]

Fluid lock nonvalved CVADs (after flushing with NS solution) when CVAD is not in use. [IB]

Routinely assess catheter patency, and intervene promptly at earliest signs of occlusion. [IB]

Ensure optimal CVAD tip placement. Minimizing catheter occlusions requires the tip placement for CVADs to be in the lower one-third of the superior vena cava near the junction of the right atrium. [IB]

*Please see Table 2 on page 10 for grading scale for recommendations.

Introduction

Central venous access devices (CVADs) are catheters inserted into the venous system that terminate in the central vasculature. The ideal tip position for a CVAD is in the lower one-third of the superior vena cava (SVC) near the junction of the right atrium (commonly referred to as the atrial caval or cavo-atrial junction) or in the inferior vena cava above the level of the diaphragm (for CVADs such as femoral, saphenous, or translumbar access).¹⁻⁷ CVADs with ideal tip position will have less risk for complications such as thrombosis and catheter-related occlusion.^{2,4-9}

CVADs facilitate the administration of intravenous (IV) medications, solutions, blood products, and parenteral nutrition to patients. The flow rate of blood in the SVC is approximately 2 L/min and allows for immediate hemodilution of solutions and medications.¹⁰ IV infusions flow directly through the CVAD into the SVC and are delivered more efficiently and in larger volumes than would be possible via a peripheral vascular access device. These fluids are diluted rapidly as they emerge from the catheter lumen. This allows for simultaneous administration of incompatible solutions through multilumen catheters. It also allows for the safe and efficient administration of concentrated solutions, vesicants, or irritants without pain or damage to the vessel wall and with minimal risk of extravasation and chemical phlebitis.¹¹⁻¹³ CVADs also provide an access for blood sampling.^{2,6,7} The four main types of CVADs are peripherally inserted central catheters (PICCs), nontunnelled CVADs, tunnelled CVADs, and implanted vascular access devices (IVADs). The types and features of CVADs are described in Appendix 1. CVADs such as PICCs, tunnelled CVADs, and IVADs provide a convenient access for infusion therapy in settings such as community, home, and long-term care.¹¹⁻¹⁴

CVAD occlusions are a common complication (occurring in 14–36% of patients within 1–2 years of placement) and can have a significant impact on health care.¹⁷ A study of outcomes in 50,000 patients undergoing home infusion demonstrated that occlusions lead to therapy interruption caused by loss of patency (43%), device replacement (29%), device removal (14%), emergency room

visits (9%), and unscheduled hospital visits (6%).¹⁵

Purpose

In 2012, the Canadian Vascular Access Association (CVAA) recognized a lack of standardized practice across the country for managing occlusions of CVADs not specifically used for hemodialysis. Discussions among clinicians occurred, and questions were received by the CVAA's national board of directors. The CVAA wanted to provide direction to various health care professionals (HCPs) who are involved in CVAD insertion, care, and management outside of hemodialysis. The literature review for this project was performed in 2012, and gaps were noted in the direction of clinical practice for CVAD occlusion management. Issues such as the management of multiple-lumen CVADs that are occluded and persistent CVAD occlusions are not clearly addressed in the literature, leading to inconsistent clinical practice for PICCs, nontunnelled CVADs, tunnelled CVADs, and IVADs. A recent Cochrane Review of catheter occlusion management states that there is "a piecemeal approach in the management of these complications."¹⁸

A national task force (NTF) of nurses in Canada was brought together to create a guideline, based on current evidence and clinical expert recommendations, for HCPs who are responsible for the management of occluded CVADs outside of hemodialysis. The NTF was convened by the CVAA with the goals of having representation from a group of Canadian experienced clinicians from different provinces (British Columbia, Alberta, Manitoba, Quebec, Ontario, and Nova Scotia) and covering a large scope of practice settings and specialties for this topic (acute, community, oncology, vascular access, and infusion therapy). The purpose of this guideline is to define the recommended strategies for safely and effectively managing CVAD occlusions in patients in Canada. The goal of this guideline is to standardize care and minimize variation of clinical practice to obtain positive outcomes with CVADs. The intent of this guideline is to supplement and guide clinical practice and decision-making; it is not meant to replace critical thinking and judgment based on professional training and education. Specifically, a

standardized approach to the effective management of CVAD occlusions will help achieve and maintain catheter patency and ensure optimal and appropriate delivery of therapy.

The target audience includes HCPs who are involved with CVADs outside of hemodialysis and are trained and competent in CVAD management in clinical settings such as acute, community, and long-term care.

Scope

CVAD occlusion assessment, management, and prevention shall be performed by HCPs caring for patients with CVADs as permitted by provincial relevant legislation, organizational policy, and scope of practice. HCPs include but are not limited to the following:

- Nurses
- Physicians
- Radiology technicians and technologists
- Respiratory therapists
- Pharmacists

Applicable health care settings in Canada include acute, community, and long-term care. Applicable patient populations include adult and pediatric populations with the clinical condition of CVAD occlusion.

The scope of this CVAA guideline does not include CVADs used specifically for hemodialysis. For specific information on occlusion management for hemodialysis catheters, refer to “Recommendations for Management of Vascular Access in Hemodialysis Patients” by the Canadian Association of Nephrology Nurses and Technologists.¹⁹ The scope of this CVAA guideline also does not include the neonatal population. For information on CVAD care and maintenance for the neonatal population, refer to “Best Practice Guidelines in the Care and Maintenance of Pediatric Central Venous Catheters” by the Association for Vascular Access/PEDIVAN.²⁰ The use of catheter clearance agents described in this document does not apply to midline catheters as this document refers to CVADs only.

This CVAA guideline does not address practice recommendations specific to the assessment,

prevention, and management of catheter-related bloodstream infection (CRBSI). Although the relationship between thrombosis and CRBSI is described in the literature, the latter requires a separate focus and is therefore beyond the scope of the guideline presented here.

Guideline Methodology

The NTF was composed of eleven experienced clinicians in Canada who work in acute, community, and home care settings in the fields of infusion therapy, vascular access, and oncology. Three CVAA Board liaisons were part of the NTF. The NTF was responsible for managing the project, reviewing all the publications, evaluating the quality of the evidence, developing and grading the recommendations, and creating the manuscript.

Two professional medical librarians (one from McGill University Health Centre, Montreal, Québec, and one from Northern Health Library Services, University Hospital of Northern British Columbia, Prince George, British Columbia) conducted the literature searches. The following databases were searched between 2000 and 2012: Cumulative Index to Nursing and Allied Health Literature, Medline, PubMed, Science Direct, Ovid Nursing and the Cochrane Database of Systematic Reviews. Languages included both English and French. The key search terms used were “central venous catheter,” “central venous access device,” “central venous line,” and “catheter,” associated with “clearance,” “patency,” “occlusion,” “obstruction,” “dysfunction,” and “catheter-related thrombosis,” “thrombolytics,” “fibrinolytic,” “tpa,” “alteplase,” “r-tpa,” “fluid lock(s),” “locking solutions,” “Heparin,” “EDTA,” “ethanol,” and “sodium citrate.” The search terms were used in different combinations. Reference lists were also examined for any additional relevant literature not identified through the searches. In total, 68 articles were retrieved.

Inclusion criteria for literature included (1) mechanical occlusion in CVADs, (2) chemical occlusion in CVADs, (3) thrombotic occlusion in CVADs, (4) use of thrombolytics for CVAD occlusion, (5) use of agents for chemical occlusion in CVADs, (6) other fluid lock for CVAD management, (7) adult patient population, and (8) pediatric patient population.

Table 1. Grading Scale for Recommendations

Strength of Recommendation	Level of Evidence
I: Strong: Strongly recommended for implementation into practice.	A: Strongly supported by evidence obtained from well-designed experimental, clinical, or epidemiologic studies.
II: Weak: Suggested for implementation when deemed appropriate.	B: Supported by some experimental, clinical, or epidemiologic studies, or an accepted practice supported by limited evidence and a strong theoretical rationale. The theoretical benefits are clear and the theoretical risks are marginal.
Unresolved issue: No recommendation made due to an unresolved issue for which evidence is insufficient or no consensus is reached.	C: Supported by accepted practice based on opinions and clinical experience, expertise, and clinical practice of consensus panel, with minimal or no scientific evidence but strong theoretical rationale. The theoretical benefits are clear and the theoretical risks are marginal.

Additional literature was sourced (based on hand searches, clinical expertise, and knowledge base) and included research studies, review articles, policy papers, and opinion articles. Some articles dated before 2000 were included because of the foundational knowledge they contribute to the literature on this topic. Due to the nature of the topic and the lack of high-level research studies, all types of literature (such as case reports and retrospective reviews as well as literature about hemodialysis CVADs) were included. With CVADs being defined specifically by tip location, literature about hemodialysis CVADs was included on the basis of their close relationship with and relevance to other CVADs. These search strategies generated 84 publications appropriate for inclusion as selected by the NTF. Other cited references relate to supporting theory (such as for CVAD tip location), catheter-related thrombosis, CRBSI, and product-specific monographs or instructions for use.

Excluded were articles discussing heparin for deep vein thrombosis, other catheters that are not CVADs (chest tube, urinary), high-dose anticoagulants, and thrombolytics for other clinical indications such as myocardial infarction and stroke.

Recommendations for practice are based on published evidence with references cited. Practice strategies to support the implementation of the recommendation are described after each recommendation where applicable. The grading of recommendations is described in Tables 1 and 2.

The strength of each recommendation is categorized as strong (I) or weak (II). The quality of evidence is classed as high to moderately high (A), low to very low (B), or evidence obtained by consensus (C). Consensus statements by the NTF are presented as a separate level of evidence when the quality of evidence is minimal or is poor but supported by NTF clinical experience, expertise, and clinical practice. Clinical expertise is a core component of evidence-based practice, particularly in the absence of clinically relevant research.²¹ Consensus on the assignment of the grade of recommendation was achieved through the Modified Delphi Technique. Consensus was based on a threshold of 8 of 11 NTF members or 73%.

The Cochrane Review¹⁸ described the overall quality of studies in relation to this topic as “low” to “very low,” and therefore the NTF did not grade the level of evidence of each individual study reference based on limited relevant research. The overall body of evidence for each recommendation was graded.

Upon completion of a draft of this guideline, the NTF evaluated it with the AGREE II tool²² and amended the content in the document accordingly. External review of the guideline was then performed by a group of multidisciplinary clinicians (i.e., nurses, pharmacist, and physician) selected from different regions across the country. External reviewers were given instructions on how to use the AGREE II tool in their review. The draft guideline

Table 2. Summary of Categories of Recommendations

Category	Description
IA: Strong recommendation with high to moderate quality evidence.	Strongly recommended for implementation and strongly supported by evidence obtained from well-designed experimental, clinical, or epidemiologic studies.
IB: Strong recommendation with low to very low quality evidence.	Strongly recommended for implementation and supported by some experimental, clinical, or epidemiologic studies, or an accepted practice supported by limited evidence and a strong theoretical rationale. The theoretical benefits are clear and the theoretical risks are marginal.
IC: Strong recommendation with national task force/panel consensus.	Strongly recommended for implementation and supported by accepted practice based on opinions and clinical experience, expertise, and clinical practice of consensus panel, with minimal or no scientific evidence but strong theoretical rationale. The theoretical benefits are clear and the theoretical risks are marginal.
IIA: Weak recommendation with high to moderate quality evidence.	Suggested for implementation when deemed appropriate. Strongly supported by evidence obtained from well-designed experimental, clinical, or epidemiologic studies.
IIB: Weak recommendation with low to very low quality evidence.	Suggested for implementation when deemed appropriate. Supported by some experimental, clinical, or epidemiologic studies, or an accepted practice supported by limited evidence and a strong theoretical rationale. The theoretical benefits are clear and the theoretical risks are marginal.
IIC: Weak recommendation with minimal or no scientific evidence.	Suggested for implementation when deemed appropriate. Supported by accepted practice based on opinions and clinical experience, expertise, and clinical practice of consensus panel, with minimal or no scientific evidence. The theoretical benefits are clear and the theoretical risks are marginal.

Grading scale adapted from grading system used for Centers for Disease Control and Prevention (CDC) and Healthcare Infection Control Practices Advisory Committee (HICPAC) guidelines.²

was revised, incorporating external review feedback, edited by the NTF, and subsequently approved by the CVAA Board of Directors. The process for feedback from reviewers was systematic by email and teleconference calls, and the collated results were then taken into consideration in the editing and revision process. This CVAA Occlusion Management Guideline will be published in the CVAA journal, *Vascular Access*, and will be available on the CVAA website (www.cvaa.info). The CVAA will be responsible for reviewing, revising, and updating the guideline every 5 years under the direction of the board of directors and the chair for professional practice. The revision and update may be in full, partial, or none (based on new evidence and considering the

impact on the guideline's content) and will be communicated and distributed through the CVAA on the CVAA website and in the CVAA journal.

Disclosures

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Table 3. Degrees/Types of Occlusion

Degree/Type of Occlusion	Symptoms/Signs	Causes
Partial	Decreased ability to infuse fluids into the CVAD; resistance with flushing and aspiration Sluggish flow through the catheter	Mechanical, chemical, or thrombotic occlusion
Withdrawal	Inability to aspirate blood but ability to infuse without any resistance Lack of free-flowing blood return	Mechanical or thrombotic occlusion
Complete	Inability to infuse or withdraw blood or fluid into the CVAD	Mechanical, chemical, or thrombotic occlusion

CVAD = central venous access device.

Source: Data from Baskin et al.²³ and Cummings-Winfield and Mushani-Kanji.²⁸

Table 4. Types of Thrombotic Occlusions

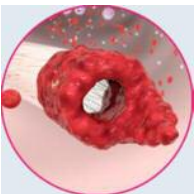
Intraluminal



An intraluminal thrombus often causes complete catheter obstruction. Intraluminal thrombi account for 5–25% of catheter occlusions.²³

- Forms within the lumen of the catheter and may result in a partial or complete occlusion.²⁶
- Develops from blood buildup within the lumen of a catheter as the result of insufficient flushing, inadequate flow through the lumen of the catheter, or frequent withdrawals of blood via the catheter.³⁹
- May also be due to blood reflux caused by cough, change in intrathoracic pressure, and improper disconnection with negative displacement devices.²⁸

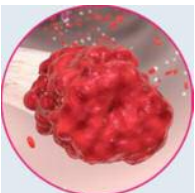
Fibrin Tail



A fibrin tail occurs when fibrin adheres to the end of the catheter. As the tail attaches to the catheter and “sticks out” or extends into the bloodstream, more cells and other blood products become deposited onto the tail. Fibrin tails can become quite long.³⁹

- Acts as a one-way valve that permits infusion but not withdrawal of fluid from the catheter.²⁶
- Gets “sucked back” over the opening when blood aspiration is attempted. The fibrin tail gets pushed aside by the positive pressure of injecting or infusing through the device.³²

Fibrin Sheath



A fibrin sheath forms when fibrin adheres to the external surface of the catheter, creating a “sock” over the end of the catheter or its whole length.²⁶ Fibrin sheaths can cover a catheter within 1 week or sooner after placement.^{17,30,33–35}

- Occasionally the sheath or sleeve covers the end-hole of the catheter and causes occlusion. Fluid can usually be injected, but blood cannot be aspirated.³⁰
- Serious infiltration/extravasation complications can result when medications are prevented from entering the bloodstream by the fibrin sheath. As a result, medications will infuse “up” the fibrin sheath back to the insertion site.³⁹
- May cause mixing of incompatible solutions.³⁶

Mural



A mural thrombus forms when fibrin from a vessel wall injury binds to fibrin covering the catheter surface.²⁶ Vessel wall injury may be due to the catheter rubbing in the vessel with motion, a traumatic insertion, poor blood flow, aberrant vasculature, or a high catheter-to-vein ratio.^{37,38}

- May occlude the tip of the catheter and cause partial venous obstruction or progress into a venous thrombosis that leads to complete occlusion of the vein.²³

Source: Images courtesy of A. Questell. Used with permission.

Canada. No other relevant disclosures for conflict of interests were identified. The NTF received honoraria for their time and extensive work on this project.

Background: CVAD Occlusion

CVAD occlusions can be categorized as mechanical, chemical, or thrombotic. Mechanical occlusions are related to internal or external problems with the catheter. They can be the result of issues such as catheter or tubing kinks, CVAD dislodgement or tip migration, a clogged cap/needleless connector or filter, and incorrect placement of a non-coring needle in an implanted vascular access device (IVAD). Chemical occlusions are related to medication or drug precipitate and can specifically be the result of precipitate from the mixing of incompatible drugs and solutions or lipid residue.^{18,23,24} It is estimated that mechanical and chemical occlusions account for 42% of CVAD occlusions.²⁵

Thrombotic occlusions account for the remaining 58% of CVAD occlusions²⁵ and are related to the formation of thrombus within or around the CVAD or in a surrounding vessel.^{26,27} The degree of CVAD occlusion can be categorized as partial, withdrawal, or complete, as shown in Table 3.

The types of thrombotic occlusions that are associated with CVADs are intraluminal thrombus, fibrin tail or flap, fibrin sheath or sleeve, and mural thrombus. These types are shown and described in Table 4.^{17,23,26,28–39}

Immediately after a CVAD is inserted into a vessel, the coagulation cascade begins. Thrombus formation may occur within 24 hours of the insertion of a device.³⁹ Platelets and white blood cells attach to the catheter surface. As the platelets begin to aggregate, fibrin strands form to cover the foreign object, resulting in catheter dysfunction due to

partial or complete occlusion of the catheter lumen.³⁹

In addition to causing catheter dysfunction, CVAD thrombotic occlusions can lead to catheter-related thrombosis (CRT). This refers to a thrombus that has attached to the catheter and has also adhered to the vessel wall. CRT is associated with catheter-related bloodstream infection (CRBSI), a serious and potentially life-threatening complication. A broad body of literature demonstrates that CRT increases the risk and incidence of CRBSI and (conversely) that the presence of CRBSI can increase the risk and incidence of CRT.^{40–45}

Catheter salvage is the preferred approach to the management of CVAD occlusions.^{14,24,26–28,46} Restoring patency to the CVAD (rather than device removal) is less time consuming, is more convenient, and ensures limited interruption of therapy, reduced trauma and psychological stress to the patient, reduced risk of complications, and decreased costs.^{24,26,28} A CVAD remains in situ as long as the device is functional and required. Restoration of catheter patency supports the longevity of the device's lifespan, as many CVADs can have a lifespan of multiple years.²⁸ The cost of device replacement can be an estimated \$200 to \$1,500 and far exceeds the cost of thrombolysis (which has a drug cost of approximately \$65) as well as the costs of supplies, nursing time, and clinic time.^{28,47}

The use of an algorithm to guide clinical practice is recommended as it may lead to improved patient outcomes and resource use.⁴⁸ Key recommendations in this guideline are summarized in Appendix 2, "Algorithm for Management of CVAD Occlusions." This tool is designed to facilitate prompt assessment and interventions related to occlusions because early assessment and management are crucial to the successful restoration of catheter patency.⁴⁹

1.0 Assessment of CVAD Patency

1.0 Recommendations

- 1.1 Assess catheter patency and identify type of catheter occlusion (i.e., partial, withdrawal, or complete) if present.^{26,28} [IB]
 - 1.1.1 Flush each lumen with sterile 0.9% preservative-free sodium chloride solution/normal saline (NS) and attempt to aspirate blood from each lumen to determine ease of flush and aspiration.^{28,50,51} [IB]
- 1.2 Document catheter patency assessment and signs and symptoms of catheter occlusion (see Table 5).^{6,7,52} [IB]
- 1.3 Ensure a dysfunctional catheter lumen is promptly investigated to identify type of occlusion (i.e., partial, withdrawal, or complete occlusion) for appropriate management.²⁴ [IB]
 - 1.3.1 Do not leave a catheter lumen with a partial, withdrawal, or complete occlusion untreated.²⁴ [IB]

Background

Catheter patency refers to the ability to easily aspirate blood from a catheter lumen and to easily infuse or flush fluid through a lumen.^{17,18} Catheter patency can be compromised by any one type of

Table 5. Signs and Symptoms of CVAD Occlusions

Upon Infusion or Flushing

- (1) Resistance when flushing⁵⁵
- (2) Sluggish flow^{27,28,39,53}
- (3) Inability to infuse fluids^{26,27,53,56}
- (4) Frequent occlusion alarm on infusion pump^{27,39,57}
- (5) Infiltration or extravasation or swelling or leaking at the insertion site^{36,39}

Upon Aspiration of Blood

- (1) Inability to withdraw blood^{26,27,28,30,39,55–57}
- (2) Sluggish blood return²⁸

occlusion: partial, withdrawal, or complete (see Table 3). This compromise leads to catheter dysfunction and can put patients at risk for delayed treatment, suboptimal therapy, thrombosis, and infection. An assessment of catheter patency must be carried out by a health care professional (HCP) with competency in CVAD use and maintenance, identification of potential complications, and appropriate nursing interventions.^{6,7,53} The HCP must have a knowledge of the factors contributing to catheter occlusion in order to ensure catheter patency for the duration of the therapy.^{6,7,48,53,54} Signs and symptoms of CVAD occlusions are shown in Table 5.^{26,27,28,30,36,39,53,55–57}

2.0 Assessment and Management of Mechanical Occlusion

2.0 Recommendations

- 2.1 Assess for signs of mechanical occlusion of the central venous access device (CVAD).⁵³ [IB]
- 2.1.1 Assess administration set for kinks, closed clamps, or clogged filter.⁵⁸ [IIB]
- 2.1.2 Assess for clogged cap or needleless connector.^{21,24} [IB]
- 2.1.3 Assess catheter for kinks, closed clamps, tight sutures, or change in external length.^{21,24,53} [IB]
- 2.1.4 Assess for positional CVAD catheter (internal or external)^{17,24,32,36,53,59,60} [IB]:
- Reposition the patient or extremity where the CVAD is located. Turn the patient onto the side. Raise the ipsilateral arm. Roll the ipsilateral shoulder backward.³⁴
 - Have the patient sit or stand or lie with foot of the bed tipped up (Trendelenburg position).
 - Ask the patient to cough, deep-breathe, or perform Valsalva's manoeuvre (to attempt to move a catheter tip that may be blocked by the blood vessel wall).
 - Assess for pinch-off syndrome (for CVADs inserted in subclavian vein only).^{36,61,62}
- 2.1.5 Assess by visual inspection and palpation for damaged catheter as evidenced by the following^{18,57} [IB]:
- Swelling along the catheter pathway
 - Catheter material bulging
 - Leaking from catheter
- 2.1.6 Assess for subjective complaints by patient that may indicate catheter tip malposition (i.e., hearing gurgling/swishing sound or pain during infusion, altered sensation during infusion).³⁰ [IB]
- 2.2 Resolve the mechanical obstruction accordingly.
- 2.2.1 Remove any add-on devices such as cap/needleless connectors, and attempt to aspirate and flush the catheter directly at the hub with normal saline (NS).²⁴ [IB]
- 2.2.2 Consider changing the dressing, ensuring no twisting/kinking of the catheter. [IC]
- 2.2.3 Verify correct placement of non-coring needle in implanted vascular access device (IVAD). Replace non-coring needle if malpositioned or occluded needle suspected.^{6,7,17,18,24,53,57,59} [IB]
- 2.2.4 Replace a clogged in-line filter.^{50,51} [IB]
- 2.2.5 If suture is tight, consider removing or replacing the retaining suture at the exit site.^{14,28,53} [IB]
- 2.2.6 Repair or replace damaged catheter.^{50,51} [IB]
- 2.2.7 Follow hospital policy, medical directive, or prescriber's orders. [IIC]
- 2.3 Consider radiographic study (such as chest x-ray) to check proper tip location if change in external catheter length, for internal kinking of catheter and for possible pinch-off syndrome.^{21,24,63} [IB]
- 2.3.1 Consider stopping intravenous infusion if catheter tip malposition is suspected until tip placement is confirmed.³⁶ [IB]
- 2.3.2 If pinch-off syndrome is confirmed by x-ray, remove CVAD; if replacement is required, ensure new CVAD is inserted appropriately (i.e., jugular vein insertion).³⁶ [IB]
- 2.5 Document assessment findings, related interventions, and response to intervention. [IC]
- 2.6 Amend patient's care plan to reflect any occlusion-preventative strategies to ensure catheter patency, considering causative factors of catheter occlusion. [IC]

Background

Mechanical obstruction of the CVAD can be either internal or external. External occlusions can be caused by issues such as clamped or kinked

tubing. Internal occlusions can be caused by improper catheter tip placement, kinking or compression of the catheter inside the vein or body, and the catheter tip's abutting or adhering to the vessel wall.^{23,30,53} Additional etiologies of catheter mechanical occlusion include implanted port reservoir detachment (for IVAD) and defective catheter material.^{18,30} Chest radiography (chest x-ray [CXR]) can show malpositioned catheters and catheters of incorrect length, tip placement, looping, kinking, or an implanted port reservoir detached from its catheter.⁵²

A rare cause of mechanical obstruction is pinch-off syndrome.^{18,23,28,62} CVADs (excluding PICCs) can become compressed between the first rib and clavicle (associated only with a subclavian insertion approach). In 2011, Health Canada released a safety notice reminding HCPs to remain vigilant for early identification of catheter pinch-off.^{61,62} Up to 40% of these cases may develop catheter fragmentation and embolization of catheter fragments in the pulmonary artery or the heart. Catheter pinch-off can present as the intermittent or

constant inability to aspirate blood from a catheter line. It can occasionally present as chest pain or cardiac arrhythmias during infusion procedures⁶¹ or if the patient has to maintain an unnatural position (i.e., a raised arm or a shoulder rolled forward) to infuse solution. The signs and symptoms of problems related to catheter pinch-off are variable, and some patients with a fractured catheter can remain asymptomatic.⁶¹ Pinch-off syndrome may be suspected if the requirement of repositioning the upper extremity on the catheter side (such as raising the arm or pulling the shoulder backward) is required to enable the flushing or aspiration of blood through the CVAD. The periclavicular site should be assessed for redness, swelling, or crepitus.³⁶ To identify pinch-off syndrome, specific positioning for the CXR is required (patient arms kept down at sides).^{21,32,36}

If pinch-off syndrome is causing catheter compression, the CVAD should be removed and replaced with insertion from the jugular vein or lateral to the midclavicular line to prevent extravasation injury and catheter embolus.³⁶

3.0 Assessment and Management of Thrombotic Occlusion

3.0 Recommendations

- 3.1 Assess the catheter occlusion to identify if the occlusion is caused by a thrombotic obstruction. [IB]
- 3.1.1 Assess for visible blood in catheter or add-on devices. [IC]
- 3.1.2 If no blood return on aspiration, may alternate gently drawing back and then gently infusing small amounts of saline.⁶⁴ [IIB]
- 3.1.3 Consider using a small-barrel syringe to aspirate blood if no blood return obtained but able to flush catheter. A smaller-barrel syringe exerts less negative pressure when withdrawing blood and may result in more success. Do NOT flush with small-barrel syringe (i.e., 1 mL or 3 mL syringe) because of high pressures generated.⁴⁸ [IIB]
- 3.2 Manage as thrombotic occlusion if unable to determine type of occlusion.^{14,24,28,29,46,48} [IB]
- 3.3 Promptly administer thrombolytic agent approved for restoring central venous access device (CVAD) patency in catheter lumens that are suspected to be occluded by blood/fibrin.^{14,24,28,29,46,48} [IB]
- 3.3.1 Follow hospital policy, medical directive, or prescriber's orders. [IIC]
- 3.3.2 Discuss risks and benefits of these agents with the licensed prescriber and patient/family, and obtain order from licensed prescriber for thrombolytic agent.^{6,7,36} [IB]
- 3.3.3 Ensure that the health care professionals (HCPs) administering a thrombolytic agent have knowledge of the agent, dosage, contraindications, adverse effects, administration methods, potential complications, and patient/caregiver education. Validation of competency is recommended.^{6,7} [IB]
- 3.3.4 Administer thrombolytic agent as soon as signs of thrombotic occlusion are identified to increase the efficacy of thrombolysis and thereby avoid or at least delay the need for catheter replacement.^{14,28,29,31,46,48,65} [IB]
- 3.3.5 Treat occlusions of unknown onset in the absence of other signs of complications.⁴⁹ [IC]
- 3.3.6 Instill thrombolytic agent into occluded lumens of CVADs, including tunneled, peripherally inserted central catheters (PICCs) and implanted vascular access devices (IVADs). [1B] Instill thrombolytic agent into occluded lumens on nontunneled, short-term, single, and multi-lumen CVADs. [1C]
- 3.3.7 Use the direct instillation method when the CVAD can be flushed (partial or withdrawal occlusions).^{26,28} [IB]
- 3.3.8 Use negative pressure technique, with either a single syringe or three-way stopcock method, for complete occlusions.^{6,7,26,28,66} [IB]
- 3.3.9 Use a syringe no smaller than 10 mL for administration of thrombolytic agent.^{6,7} [IB]
- 3.3.10 Perform a risk and benefit analysis for treatment of double- and triple-lumen catheters when all lumens are occluded. Instillation of alteplase may exceed the recommended maximum dose of 4 mg. Understand that risks may be mitigated by the safety profile of the thrombolytic. [IIC]
- 3.3.11 Treat all catheter lumens with partial, withdrawal, or complete occlusion. Do not leave an occluded lumen untreated because another lumen is functional.²⁴ [IB] Instillation of thrombolytic agent into a patent lumen of a multilumen catheter where other lumens are occluded is an unresolved issue.
- 3.3.12 Stop all infusions if possible (particularly if treating a suspected fibrin tail/sheath) for optimal thrombolysis during dwell time and to facilitate maximum contact between

- thrombolytic and the thrombus/fibrin on the internal and external surface of the catheter. [IIC]
- 3.3.13 Let thrombolytic dwell for 30–120 minutes. [IB] Consider extending dwell to 24–72 hours to permit longer contact time of thrombolytic with the fibrin in the catheter or around the catheter tip in the case of a fibrin sheath or mural thrombus. [IC]
- 3.4 Consider alternative methods to deal with persistent/recurring CVAD occlusions not resolved by direct-instillation method of previous doses of thrombolytic:
- Push method over 30 minutes [IB]
 - Low-dose infusion over 30 minutes to 3 hours [IB]
- 3.4.1 Consider low-dose thrombolytic infusion for treatment of a large fibrin tail/sheath that is confirmed by dye study or other radiographic studies and is causing persistent catheter occlusion not responsive to thrombolytic by direct instillation and a dwell time of 24–72 hours. [IIC]
- 3.5 Consider instillation of thrombolytic (using single-syringe or negative pressure technique) for CVAD occlusions in community and long-term care settings.^{14,67} [IB]
- 3.6 If catheter patency is not restored, notify the licensed prescriber. Consider alternative actions such as radiography (to rule out catheter tip malposition) and/or a referral to interventional radiology (for dye study). Catheter removal may be necessary, with an alternative plan for vascular access.^{6,7,26} [IB]
- 3.7 Document assessment findings, related interventions, and response to intervention. [IC]
- 3.8 Amend the patient’s care plan to reflect any occlusion preventative strategies to ensure catheter patency, considering the causative factors of catheter occlusion. [IC]

Background

Once a mechanical obstruction has been ruled out, further assessment should be done to determine if

the obstruction is the result of a thrombotic occlusion.^{24,28,53} Assessment for thrombotic occlusion should include consideration of possible venous thrombosis. The HCP should assess for signs and symptoms of venous thrombosis such as pain and swelling on the chest wall, neck, and jaw on the side of catheter insertion/upper extremity; engorged peripheral veins on the extremity or chest wall on the side of catheter insertion; paresthesia or discoloration of the extremity; and loss of function in the extremity. If venous thrombosis is suspected, the responsible physician should be notified for further investigation and accurate diagnosis.³⁶

CVADs are used for delivering various infusions and treatments, and catheter patency is important for optimal therapy delivery as well as for the prevention of serious complications resulting from thrombotic occlusion. Complications include extravasation of vesicant medication and infusates¹³; thrombosis external to the catheter and into the vessel, leading to deep vein thrombosis; infection; and general treatment delays.⁶⁸ Restoration of catheter patency is defined as the ability to easily aspirate blood from and infuse fluids through the CVAD.^{18,69,70}

The recommendations for thrombolytics in this guideline section refer to alteplase. At the time of this guideline’s publication, Alteplase (Cathflo) is the only Health Canada–approved thrombolytic agent proven to be safe, effective, and appropriate for restoring catheter patency in the adult and pediatric (older than 2 years) population.^{6,7,17,23,49,65,71–74} The Cathflo Activase (Alteplase) Pediatric Study demonstrated the safety and efficacy of alteplase in the pediatric population, including children younger than 2 years.⁷⁰ Recommendations that are outside the Cathflo product monograph are rated as level C recommendations as they are obtained through NTF consensus.

As per the Cathflo product monograph, the recommended dose for persons weighing more than 30 kg is 2 mg with a dose volume of 2 mL.⁶⁵ The NTF recognizes that this dosing may be insufficient for larger-volume catheter systems. Consideration should be given to the total fill volume of IVADs when instilling thrombolytic or

other agents. This includes the catheter, the port body, and add-on devices, including the non-coring needle, the extension set, and any ports or connectors used. The required volume will vary depending on the specific products used, and the total volume required may exceed the recommended single dose (i.e., 2 mg/2 mL of alteplase). The practice of instilling extra volume to provide an “overflow” of thrombolytic to facilitate exposure of the thrombolytic agent to the external catheter thrombus varies among HCPs in Canada and the NTF. Some HCPs routinely administer 2–4 mg in 2–4 mL of thrombolytic (i.e., alteplase) into an occluded CVAD and immediately follow this with 1 mL of NS. This allows for the “overflow” and contact of the thrombolytic with a thrombus that extends past the CVAD lumen end and will encompass the external surface of the CVAD lumen.

One published article looked at a total dose of 1 mg of alteplase for occlusion management of hemodialysis catheters.⁷⁵ Another small study (cited in a letter to the *Annals of Pharmacotherapy* [2004]) concluded that it was reasonable to use alteplase 1 mg as an initial dose for clearing central venous catheter occlusions.⁷⁶

The NTF recognizes that the priming volumes of some CVADs are less than 2 mL and that the recommended alteplase dose volume of 2 mL⁶⁵ may therefore lead to overflow. NTF consensus suggests that this overflow will permit the interface of the thrombolytic agent with any external fibrin; thus, common practice is to instill the full recommended dose of 2 mg/2 mL.

Considerations

Practice varies in terms of the total volume and dose of alteplase as thrombolytic used for CVAD occlusion management. A total dose of 1 mg, a total dose of 2 mg, and staggering a total dose of 2 mg with a post flush of saline are all recognized as accepted practice in some clinical settings. This is an unresolved issue, but the NTF recommends following the Cathflo drug monograph as closely as possible in clinical situations. There is ongoing controversy and debate over standard management for multi-lumen CVADs, especially CVADs with two or more lumens that are occluded. Treating all

lumens in a multi-lumen CVAD will exceed the maximum dose tested in clinical studies that used a total dose of 4 mg/4 mL.^{49,74} Consideration should be made as to the type of CVAD, whether it is for short-term or long-term duration, and the type of tip (staggered [distal, medial, or proximal] or nonstaggered), keeping in mind that catheter salvage is a priority. Performing a risk and benefit analysis is recommended when the drug product monograph is not followed and when more than one lumen in a multi-lumen CVAD requires thrombolytic.

The safety and efficacy of the procedure to use alteplase for thrombotic occlusion in CVADs have been documented in both the acute care and home care settings.^{14,15,49,70,74} With catheter salvage as a priority, thrombolytic therapy for CVAD occlusion should be done as soon as occlusion is suspected, even if it is suspected that the occlusion is not new or recent. Restoration of patency to CVADs known to be occluded and treated more than 14 days after the occlusion was identified has been shown to be successful approximately 77% of the time, compared to approximately 90% for CVADs treated right away.⁴⁹

Methods and Techniques for Instillation

For partial and withdrawal occlusions, direct instillation of the thrombolytic can be done with a single 10 mL syringe with thrombolytic (Figure 1). Instillation should be done slowly versus quickly “injecting” into the CVAD lumen; the goal is for the thrombolytic to come into contact with the thrombus or clot burden and be “soaked up.”

Instillation of thrombolytic in a completely occluded catheter requires the use of negative pressure to create a vacuum by aspirating air or dead space from within the catheter, thus allowing the thrombolytic to be drawn forward into the catheter to the clot interface.^{26,28}

There are two methods or techniques for achieving negative pressure. The single-syringe technique uses a single 10 mL syringe (with reconstituted thrombolytic) attached directly to the occluded CVAD lumen hub. When the plunger is pulled back, a vacuum is created. The plunger is then slowly



Figure 1. Direct instillation of thrombolytic with a single 10 mL syringe with thrombolytic. Ensure the syringe containing the thrombolytic remains in an upright position to prevent air entry into the catheter and vasculature. (NOTE: Demonstration only – use of non-sterile gloves during procedure is recommended.)

Source: Photos courtesy of F. Paquet. Used with permission.



Figure 2. Three-way stopcock attached to the occluded CVAD lumen with the two other ports attached to (a) an empty, sterile 10 mL syringe and (b) a 10 mL syringe with the thrombolytic.

Source: Photos courtesy of F. Paquet. Used with permission.



Figure 3. Pull back on the empty 10 mL syringe to achieve the “vacuum” with the stopcock in OFF position to the thrombolytic. (NOTE: Demonstration only – use of non-sterile gloves during procedure is recommended). Source: Photos courtesy of F. Paquet. Used with permission.



Figure 4. The port to the thrombolytic is opened to allow for the “sucking in” of the drug toward the thrombus/clot burden causing the occlusion. (NOTE: Demonstration only – use of nonsterile gloves during procedure is recommended).

Source: Photos courtesy of F. Paquet. Used with permission.

released; this allows the thrombolytic to be “pulled” back into the lumen toward the thrombus/clot burden causing the occlusion. The second technique is to use a three-way stopcock attached to the occluded CVAD lumen, with the two other ports attached to (a) an empty, sterile 10 mL syringe and (b) a 10 mL syringe with the thrombolytic (Figure 2). The plunger of the empty syringe is pulled back to create a vacuum (Figure 3), followed by turning the stopcock off to the empty syringe and open to the thrombolytic syringe to allow the drug to be “pulled” into the catheter to the occlusion (Figure 4). With both techniques, the syringe plunger will need to be pulled back several times to permit full instillation of the drug. As the thrombolytic comes into contact with the occlusion, it will slowly start to act or lyse on the thrombus/clot burden causing the occlusion. It can be challenging and time-consuming to fully instill the dose of thrombolytic. At times, the full dose does not get instilled and the procedure must be done more than once, depending on the clot burden.

For all of these methods and techniques, it is important to ensure that the syringe containing the thrombolytic remains in an upright position to prevent air entry into the catheter and vasculature. Caution must be used so that air is not forcefully pushed into the CVAD lumen.

Excessive pressure should be avoided when administering the thrombolytic as such pressure may rupture the catheter or expel the thrombus into venous circulation. Avoid vigorous suction when aspirating as this may damage the vessel wall and collapse a soft-walled catheter.²⁶

Procedures to restore catheter patency should be performed as soon as signs of occlusion (partial or complete) are identified. This will increase the efficacy of thrombolysis and thereby avoid or at least delay the

need for catheter replacement.^{14,28,29,46,48}

Radiographic studies are not always necessary but should be considered if catheter patency is not restored or if occlusion recurs.^{14,24,49,74,77} Radiographic studies were not required prior to alteplase instillation in the pivotal clinical study protocols for alteplase.^{49,74} Consider ultrasound, venography, or other diagnostic study to rule out catheter tip malposition, extensive fibrin formation, thrombosis,²⁴ or a damaged catheter. Catheter removal may be necessary if catheter patency cannot be restored, with an alternative plan developed for vascular access.²⁶

Push Method for Administration

The *push* method for administration of thrombolytics is utilized successfully with hemodialysis catheters with recurrent occlusions or pump speeds of less than 200 mL/min.⁷⁸ For other CVADs such as PICCs, IVADs and tunnelled devices that are smaller in lumen size than hemodialysis CVADs, the push method may be considered when there is a recurrence of partial and withdrawal occlusions after multiple direct instillations of thrombolytic. In the push method, alteplase is administered by direct instillation. A total amount of 2 mg/2 mL is instilled, and 0.3 mL of saline is “pushed in” every 10 minutes for 30 minutes.⁷⁸ The theory behind this method is that the thrombolytic will slowly be pushed into the CVAD lumen to interface with the thrombus or clot burden over 30 minutes and act on (or “lyse”) the thrombus causing the occlusion. The goal is restoration of catheter patency.

Low-Dose Infusion for Administration

This method of administration of thrombolytic has also been utilized successfully for thrombotic occlusion management of hemodialysis catheters in both the adult and pediatric patient populations.^{79–84} For other CVADs such as PICCs, IVADs, and tunnelled devices that are smaller in lumen size than hemodialysis CVADs, low-dose infusion of thrombolytic may be considered when there is a recurrence of partial and withdrawal occlusions after multiple direct instillations of thrombolytic, including administration by the push method. Low-dose infusion of alteplase has been demonstrated to be effective in studies with protocols ranging from 1–4 mg of alteplase (one study used 10 mg) in 0.9% sodium chloride over

Table 6. Pediatric Dosing of Alteplase

Patient Weight	Alteplase (Thrombolytic) Dose
Less than 30 kg	110% of fill volume
More than 30 kg	2 mg/2 mL

Source: Data from the Cathflo Product Monograph.⁶⁵

30–60 minutes.^{79,81–85} There is also literature to support low-dose infusion over 180 minutes or 3 hours.^{84–86}

Sample dosing includes the following^{79,81–86}:

- 1–2 mg reconstituted alteplase in 50 mL mini-bag of NS over 30 minutes
- 2–4 mg reconstituted alteplase in 100 mL mini-bag of NS over 60 minutes
- 3–5 mg reconstituted alteplase in 50–100 mL mini-bag of NS over 180 minutes

The theory behind this method is that the thrombolytic will slowly and continuously reach and act on the thrombus causing occlusions that can be located along the length of the catheter’s external surface. The goal is restoration of catheter patency.

Pediatric Implications

The recommendations listed in this guideline apply to the pediatric population. Patients with CVADs who are between the ages of 12 months and 18 years are included. There is evidence for the use and effectiveness of thrombolytics for CVAD occlusion management in this population.^{20,24,60,87} The dosing of thrombolytic is based on the patient’s weight and the priming volume of the catheter if the patient weighs less than 30 kg as shown in Table 6.⁶⁵ Table 7 presents estimated catheter priming volume and thrombolytic dose ranges.²⁰

Caution

The drug product monograph for Cathflo that outlines precautions, contraindications, and side effects to be aware of when using this thrombolytic for CVAD occlusion management should be used as the main reference for all precautions. Caution should be exercised with patients who have active internal bleeding, have thrombocytopenia or other hemostatic defects, are pregnant, or have a known or suspected CRBSI.⁶⁵

Table 7. CVAD Priming Volumes and Thrombolytic Dose Ranges

Types of CVCs	Priming Volume Ranges (Estimated Volumes)	Thrombolytic Dose Ranges* (Estimated Doses)
PICCs	SL 1.9F/2F	0.08–0.1 mL
	3F	0.22–0.38 mL
	4F	0.38–1.5 mL
	5F	0.82 mL
	DL 4F	0.33–0.45 mL
	5F	0.41–1 mL
Nontunnelled CVCs	SL 2.5F	0.05 mL
	3F	0.1 mL
	4F	0.1 mL
	DL 4F	0.1–0.2 mL
	5F	0.2 mL
	TL 5F	0.2–0.3 mL
	7F	0.3–0.5 mL
Tunnelled CVCs	SL 2.7F	0.15 mL
	4.2F	0.3 mL
	6.6F	0.7 mL
	DL 7F	0.6–0.9 mL
	9F	1.5–2 mL
Ports	SL 6F	1.6 mL
	6.6F	0.9–1.2 mL
	8F	1.8 mL
	DL 10F	1.8 mL

CVCs = central venous catheters; DL = double lumen; PICCs = peripherally inserted central catheters; SL = single lumen; TL = triple lumen.

*Maximum dose is 2 mL.

Source: Used with permission from the Association for Vascular Access/PEDIVAN.²⁰

Other Agents and Interventions

Additional thrombolytic agents are being investigated (i.e., reteplase, alteplase, tenecteplase, urokinase), and the results vary in terms of efficacy, dwell time, number of doses required, adverse events, and cost.^{17,88–90} More studies are needed to show the efficacy and safety of other agents for thrombolysis as well as for direct comparison with alteplase.^{17,23,89}

Surgical/interventional radiologic interventions

(such as endoluminal snare, sheath stripping, stenting with radiofrequency guidewire, catheter removal with balloon disruption of sheath, or guidewire exchange) are described in the literature as interventions to be performed if the thrombolytic agent is unsuccessful.^{29,30} However, no strong studies were found to support the efficacy and safety of these measures.¹⁸ A risk and benefit analysis is recommended as well as a full consultation with the responsible physician.

4.0 Assessment and Management of Chemical Occlusion

4.0 Recommendations

- 4.1 Assess the catheter occlusion to identify if the occlusion is caused by a chemical obstruction.^{17,49,53} [IB]
- 4.1.1 Observe the catheter or tubing for the presence of visible precipitate.²⁴ [IB]
- 4.1.2 Assess the infusion plan to identify what drugs and fluids were given.^{24,48} [IB]
- 4.1.3 Verify drug dilution properties, check drug incompatibilities, and assess types of solutions instilled (e.g., rule out lipid-related occlusion or lipid residue).⁵³ [IB]
- 4.1.4 Obtain a history of current and past infusion rate and flushing frequency.⁵⁷ [IB]
- 4.2 Promptly attempt to restore patency of central venous access devices (CVADs) occluded by chemical precipitate by instillation of catheter clearance agents recognized to dissolve precipitate.^{6,7,17,59} [IIB]
- 4.2.1 Follow hospital policy, medical directive, or prescriber's orders. [IC]
- 4.2.2 Health care professionals (HCPs) administering a CVAD clearance agent must have knowledge of the agent, dosage, contraindications, adverse effects, administration methods, potential complications, and patient/caregiver education. Validation of competency is recommended.^{6,7} [IB]
Only HCPs with specialized knowledge and extensive experience with CVAD occlusion management should be performing this procedure. [IC]
- 4.2.3 Discuss the risks and benefits of these agents with the licensed prescriber and patient/family, and obtain order from licensed prescriber for catheter clearance agent. [IC]
- 4.2.4 Instill by direct-syringe instillation method if partial or withdrawal occlusion.⁶⁶ [IB]

- 4.2.5 Instill by negative pressure using single-syringe or three-way stopcock method if complete occlusion.⁶⁶ [IB]
- 4.2.6 Instillation volume of catheter clearance agent should be fill-volume of catheter lumen only. [IC]
- 4.3 Notify the licensed prescriber if the catheter clearance procedure does not result in patency of the CVAD.^{6,7} [IIB]
- 4.4 Consider use of a thrombolytic agent if patency is not restored with a chemical clearance agent. [IC]
- 4.5 Document assessment findings, related interventions, and response to intervention. [IC]
- 4.6 Amend patient's care plan to reflect any occlusion preventative strategies to ensure catheter patency, considering causative factors of catheter occlusion. [IC]

Background

Occlusions can be caused by the infusion of crystallized medication, by preformed precipitates, or by the formation of precipitates within the CVAD lumen.^{17,18} Alteration in the pH of drugs exposed to other drugs or solutions that have an opposing pH is associated with precipitation. Drugs and infusates such as phenytoin, lipids and parenteral nutrition, and mannitol are commonly affected, and lipid solutions can produce a waxy residue that can cause CVAD occlusion.^{17,18,24} The NTF identified cloxacillin as another drug that is known to precipitate and occlude CVADs.

Instillation of catheter clearance agents recognized to dissolve precipitate may be indicated to restore catheter patency. It is worth noting that phenytoin occlusion can be permanent and requires catheter replacement. Attempts to clear CVAD lumens occluded by chemical or lipid precipitate continue to be made despite a recent Cochrane Systematic Review that concluded there are no strong studies investigating the efficacy and safety of chemical interventions for the management of chemical occlusions in CVADs.¹⁸ Catheter salvage is still a priority, and every effort is made to clear occlusions appropriately as much as possible.

The use of hydrochloric acid (HCl), sodium

Table 8. Types of Chemical Occlusion and Treatment

Precipitate	Treatment (Clearance Agent)
Lipid residue	Ethanol 70% ^{17,24,59}
Acidic drug precipitate (low pH: less than 6.0) (e.g., vancomycin, parenteral nutrition)	Hydrochloric acid (HCl) 0.1 N ^{17,59}
Alkaline (basic) drug precipitate (high pH: greater than 7.0) (e.g., imipenem, heparin)	Sodium hydroxide (NaOH) 0.1 mmol/L ^{17,91} Sodium bicarbonate (NaHCO ₃) 8.4% ^{17,59}

bicarbonate (NaHCO₃), and sodium hydroxide (NaOH) to clear drug precipitates in CVADs is noted in the literature to be effective.^{17,24,59,91} HCl is effective in treating CVAD occlusions from calcium phosphorus precipitates or precipitates of acidic (low pH) drugs such as amikacin, piperacillin, and vancomycin. It can also be effective in treating CVAD occlusion from parenteral nutrition solution (amino acids). NaHCO₃ is effective in treating CVAD occlusion from precipitates of alkaline (high pH) drugs such as ganciclovir, acyclovir, ampicillin, imipenem, and heparin. NaOH has been demonstrated in a few studies to be effective in clearing partially occluded CVADs due to parenteral nutrition (with or without lipids).^{59,91} In one study, the protocol for NaOH administration involved a long infusion (over 10 hours) followed by NS infusion and flushing through the CVAD lumen.⁹¹

HCPs should not follow NaHCO₃ with HCl as the combination could generate damage or further precipitation material – these two agents should not be mixed.⁹² There is also concern with the use of HCl because of risk of damage to the wall of the catheter.^{17,59} HCPs should be aware that direct infusion of HCl or NaHCO₃ into the venous system may cause reactions such as fever, phlebitis, and sepsis.^{59,92} These reactions may be avoided by aspirating the solution in full, rather than flushing it through the catheter and into the central venous system.^{17,59} Infusion of NaOH is not hazardous if administered slowly and was not seen to contribute to catheter material degradation like the other agents (HCl and NaHCO₃).^{59,91} Check the compatibility of other clearing agents such as HCl and NaHCO₃ with the instructions or directions for use of the catheter.^{6,7,93}

The compounding and preparation of HCl, NaHCO₃, and NaOH should be done in pharmacy by HCPs who have extensive knowledge of the

precautions required during compounding and preparation. The following should be noted for each specific agent:

- HCl: Chemical grade HCl 1 N (molar) is diluted down with 0.9% sodium chloride to get a 0.1 N (molar) solution.^{94,95}
- NaHCO₃: Sterile injectable preparations are commercially available for in an 8.4% concentration.^{94,95}
- NaOH: Commercially manufactured/prepared pellets (powder) can be dissolved with sterile water and prepared with an appropriate filter to make up approximately a 0.1 N NaOH solution.

There is literature to support the use of 70% ethanol to treat occlusions caused by lipid residue.^{17,59} The safety of ethanol in the laboratory setting has been demonstrated,^{36,96} and side effects of ethanol administration include dizziness, headaches, nausea, fatigue, and light-headedness.¹⁷ Precautions for the use of 70% ethanol for CVAD occlusion management include ensuring there is no patient sensitivity to ethanol and informing the patient (or caregiver for pediatric patients) that the instillation of ethanol may affect blood levels. This agent must be used with caution with polyurethane CVADs as ethanol may damage catheter materials. Check the compatibility of ethanol with the instructions or directions for use of the catheter.^{6,7,93} The compounding and preparation of ethyl alcohol 70% should be done by pharmacy, as follows:

- Ethyl alcohol 100% is diluted with sterile water to make a 70% concentration.^{94,95,97}

The procedure for the instillation of a catheter clearance agent is similar to that for the instillation of a thrombolytic by using the direct instillation method for partial occlusions and using negative pressure

either with the single-syringe or three-way stopcock method for complete occlusions.^{17,23,53,98–100} There is no evidence to support the strategy of “overfill” of the CVAD lumen for chemical occlusions, and the recommendation in this guideline is to instill the clearance agent to the fill volume of the lumen only. Table 8 outlines precipitates and treatments. Refer to Table 7 for estimated CVAD volumes and instill amount to fill the catheter lumen.

The following basic procedure is recommended (refer to “Methods and Techniques for Instillation” on page 18):

1. Instill sufficient volume to fill the catheter lumen, using negative pressure if the CVAD is completely occluded.
2. Allow to dwell for 20–60 minutes.
3. After dwell time, attempt to aspirate 3–5 mL of blood and contents.
4. Instillation may be repeated once if patency is not restored after the first attempt or dose.

For pediatric patients, a dose of 0.55 mL/kg of 70% ethanol (to a maximum of 3 mL) may be used to treat occlusions related to lipid administration.^{24,59} Successful clearance with HCl has been reported in the pediatric population; one study protocol used up to three doses of 0.1 N HCl (0.2–0.5 mL) with a 20-minute dwell and up to 1 mL in patients between 1 and 3 kg and up to 3 mL in patients greater than 3 kg.^{24,59}

5.0 Prevention of CVAD Occlusion

5.0 Recommendations

- 5.1 Ensure ongoing education and competency validation of health care professional responsible for central venous access device (CVAD) care and management in the following:
- Principles of catheter patency
 - Assessment, prevention, and management of catheter occlusions
 - CVAD type and add-on device features^{6,7,48,101} [IB]
- 5.2 Flush CVAD lumens with normal saline (NS) prior to and after blood sampling, administration of medications/solutions, and changing add-on devices.^{6,7,24} [IB]
- 5.2.1 Use the turbulent or “start-stop” technique.^{24,28} [IIB]
- 5.2.2 Use flush routine and frequency according to manufacturer’s recommendations specific to CVAD.^{6,7,48,50} [IB]
- 5.2.3 Flush enough NS to clear blood or medication from the cap or needleless connector and CVAD lumen.^{6,7,102,103} [IB]
- Flush with a minimum volume of twice the internal volume of the catheter system; however, a larger volume may be needed after blood sampling or blood transfusion procedures.^{6,7}
 - Change the cap/needleless connector if there is visible blood or drug.^{6,7}
- 5.2.4 Flush between incompatible medications.^{28,69} [IB]
- 5.3 Fluid lock nonvalved CVADs (after flushing with NS solution) when CVAD is not in use.⁴⁸ [IB]
- 5.3.1 Follow hospital policy, medical directive, or prescriber’s orders. [IC]
- 5.3.2 Lock CVAD lumen with at least two times the catheter volume. Use the lowest concentration of heparin (i.e., 10 units/mL or 100 units/mL) needed to maintain patency.^{6,7,20,29} [IB]
- 5.3.3 Clamp the CVAD (if clamp present) using correct clamping sequence to prevent reflux of blood into the tip of the catheter^{24,48,69,103} [IA]:
- Negative displacement connector requires clamping before the syringe is removed.
 - Positive displacement connector requires clamping after the syringe is removed.
 - Neutral displacement connector does not require a specific clamping sequence.
- 5.3.4 Consider fluid-lock solutions other than NS to maintain patency.^{104,105} Lock solutions other than low-dose heparin should be withdrawn and discarded with approximately 3 mL blood prior to accessing or flushing CVAD.¹⁰⁶ [IB]
- 5.4 Prevent reflux of blood into the tip of the catheter using other strategies [IB]
- 5.4.1 Do not let intravenous bags run dry. [IC]
- 5.4.2 Prevent syringe plunger reflux by using pre-filled syringes with NS designed to prevent the rebound effect that occurs when the plunger is released, or prevent the plunger from rebounding against the bottom of the syringe by stopping at the 0.5 mL mark when flushing.⁶⁹ [IB]
- 5.4.3 Promptly respond to pump alarms.²⁴ [IB]
- 5.4.4 Consider increasing the infusion rate to keep the catheter patent with recurrent occlusions [unresolved issue]
- 5.5 Consider the use of technology designed to prevent CVAD occlusions.^{48,59} [IIB]
- 5.6 Routinely assess catheter patency, and intervene promptly at earliest signs of occlusion.^{24,48} [IB]

- 5.7 Understand the potential for drug incompatibilities and properties to prevent precipitate occlusions.¹⁸ [IB]
- 5.8 Utilize strategies to prevent mechanical occlusions. [IB]
- 5.9 Ensure optimal CVAD tip placement. Minimizing catheter occlusions requires the tip placement for a CVAD to be in the lower one-third of the superior vena cava (SVC) near the junction of the right atrium.^{1,3,5-8} [IB]

Background

Strategies to prevent CVAD occlusion should occur routinely. HCPs should consider flushing routinely with an appropriate amount of flush solution and minimizing the number of times the CVAD is being accessed. It is important to flush with NS solution in between the administration of incompatible medications or solutions to prevent CVAD occlusions due to precipitation or crystallization. Medications incompatible with NS require flushing first with 5% dextrose in water, followed by a NS flush.⁶⁹ At a minimum, CVAD flushing and patency assessment should be done with every change of tubing or cap/needleless connector.^{59,69}

NS solution is commonly used for CVAD flushing to maintain patency.⁶⁹ The use of lock solutions such as heparin and sodium citrate after NS flushing is also common practice for fluid locking CVADs to maintain patency. For heparin, the concentration should be the lowest available (i.e., 10 units/mL or 100 units/mL) to maintain CVAD catheter patency.^{6,7,20,29} The risk for heparin-induced thrombocytopenia is associated with any heparin exposure; other flush solutions such as ethylenediaminetetraacetic acid (EDTA), are being studied for their anticoagulant and antimicrobial properties.¹⁰⁷⁻¹⁰⁹

The use of thrombolytic prophylaxis has been studied in various clinical settings.^{45,110-112} Based on the observation that catheter-related thrombosis and catheter-related infection are closely associated, several of these studies reported that the use of a thrombolytic catheter locking solution (urokinase or alteplase) resulted in a reduced incidence of both catheter-related thrombosis and infection.^{45,110-112}

Monitoring and Auditing Criteria for CVAD Occlusion

There are no data addressing acceptable benchmarks for CVAD occlusion rates in Canada. It is important to consider the complexity of CVADs in terms of their varied types and features as well as the different types of occlusions. Applying the recommendations in this guideline can help manage, treat, and prevent occlusions, but it is important for the HCP to measure outcomes in addition to using these strategies as a way to validate work and efforts toward positive patient outcomes. Outcome data should be used to guide quality improvement measures to reduce CVAD occlusion rates and related complications. Recommendations for outcome measurement related to CVAD occlusions include monitoring the following:

- CVAD type, location, number of lumens, insertion date, tip location
- Patient gender, age, diagnosis
- Patient location in health care setting (acute, community, home care, long-term care)
- Therapies administered through CVAD
- Date occlusion identified; which lumen
- Type of occlusion identified (partial, withdrawal, or complete)
- Number of doses of thrombolytic instilled
- Method of instillation for administration of thrombolytic
- Outcomes:
 - Success of catheter clearance
 - Lack of success of catheter clearance (leading to catheter removal or catheter replacement)
 - Upper-extremity deep vein thrombosis
 - Catheter-related bloodstream infection

Implementation Strategies

A goal for the NTF was to identify barriers to and facilitators for implementing the recommendations outlined in this guideline. Barriers identified include the following:

- Knowledge gaps
- Diverse practice settings
- Diversity in current practices; lack of standardization

- Advances in technology; labour-intensive nature of updating education, policies, and procedures
- Complexity and cumbersomeness of change processes
- Financial and human resource shortages

Because there are a variety of barriers to implementing the recommendations outlined in this guideline, the following strategies that may help HCPs implement the occlusion management guideline have been compiled and are summarized below ^{48,113}:

- Identify and secure the required resources at your facility to assist with the implementation.
- Ensure that HCPs are oriented to specific technology and to specialized equipment and materials and that there is ongoing assessment of knowledge to allow for consistency and sustainability of practice standards.
- Enlist a dedicated occlusion management resource person who can provide clinical expertise, leadership, and support.
- Provide educational sessions and ongoing support for the implementation of the occlusion management guideline. This might include the following:
 - Direct in-servicing and sessions with staff (consider the use of technologies such as videos, mobile applications, etc.)
 - Case studies – presentation and discussion for problem solving
 - Handouts – “cheat sheets”
 - Pocket cards
- Identify, develop, and support occlusion management “champions” on designated clinical units to promote and support the guideline implementation. Champions can train and mentor other HCPs within the facility to ensure knowledge transfer and sustainability.
- Ensure that sufficient numbers of staff are trained to perform CVAD clearance procedures to facilitate prompt management of thrombotic or chemical occlusions.
- Provide ongoing supports and resources such as policies, procedures, algorithms, competency assessment checklists, and

- documentation tools.
- Develop and provide a range of self-learning, group learning, mentorship, and reinforcement strategies that will build the knowledge and confidence of HCPs in implementing this guideline.
 - Utilize the clinical practice tools that complement this guideline for procedures, tools, and resources designed to assist with the implementation of the recommendations outlined in this guideline.

Please refer to the Canadian Vascular Access Association website (<http://www.cvaa.info/>) for clinical practice tools, strategies, and templates to facilitate catheter occlusion management. The clinical practice tools include the following:

- Pre-printed orders
- Procedure templates
- Medical directives
- Competency assessments
- Patient education and information
- Outcome measurement tools (data collection tools)

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Glossary

Term	Definition
Cavo-atrial (atrial caval) junction	The point at which the superior vena cava meets and melds into the superior wall of the cardiac right atrium. Both the superior vena cava and inferior vena cava enter the right atrium, but only the superior entry is called the cavo-atrial junction (or atrial caval junction). This junction marks the inferior end of the superior vena cava, the continuation below that point being considered part of the heart.
Chemical occlusion	CVAD occlusion resulting from the mixing of two incompatible medications and/or solutions or from the buildup of lipid within the lumen. ⁶⁶
Complete occlusion	Inability to infuse fluid into the CVAD lumen or withdraw blood or fluid from the CVAD lumen.
CVAD patency	Ability to easily aspirate blood from and easily infuse fluid through the CVAD lumen(s). ¹⁸
Mechanical occlusion	Occlusion of a CVAD involving a component of the infusion system. An external occlusion may include a filter, a needleless connector, a malpositioned or blocked non-coring needle, or a closed clamp. An internal occlusion results from pinch-off syndrome or from a kinked or malpositioned CVAD. ⁶⁶
Occlusion	Obstruction of a CVAD lumen, preventing or limiting the ability to flush, withdraw blood, and/or administer solutions or medications. ⁶⁶
Partial occlusion	Decreased ability to infuse fluid into the CVAD lumen or withdraw blood from the CVAD lumen.
Persistent occlusion	Catheter patency is not achieved after two to three doses of catheter clearance agent.
Recurrent occlusion	Catheter patency is not maintained, requiring repeated doses of catheter clearance agent.
Thrombotic occlusion	CVAD occlusion resulting from fibrin buildup (i.e., fibrin sheath or fibrin tail) or a blood clot within the catheter and/or vessel lumen. ⁶⁶
Thrombolytic	A drug that dissolves or lyses blood clots; activates plasminogen and breaks down fibrin.
Withdrawal occlusion	Blood return is sluggish or absent, yet the CVAD flushes or infuses without difficulty.

Appendix 1. Types and Features of CVADs

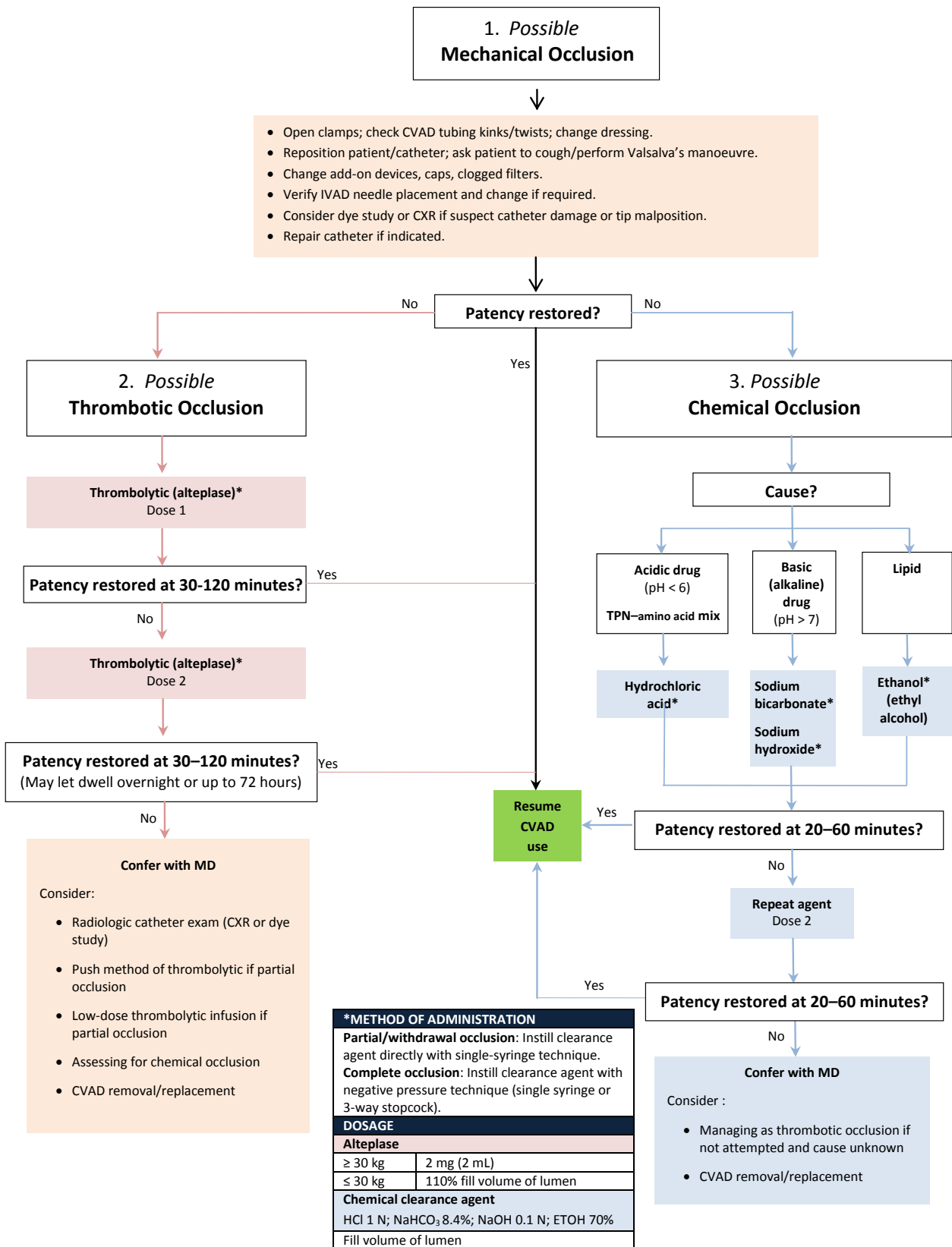
Type of Central Venous Access Device (CVAD)	Features
Nontunnelled CVAD ^{2,16,114}	<ul style="list-style-type: none"> • Percutaneous insertion of catheter into the internal jugular, subclavian, or femoral veins. • Associated with high risk of catheter-related infections due to skin exit point of catheter in close proximity to the entry point of the vein used. • Temporary or short-term devices; generally not used in community, home care, or long-term care settings. • Available with single, double, triple, or quadruple lumen.
Peripherally inserted central catheter (PICC) ^{2,16,114}	<ul style="list-style-type: none"> • Can be used in community, home care, and long-term care settings. • Inserted into peripheral vein (e.g., basilic, brachial, cephalic, saphenous, temporal scalp) and advanced to the superior or inferior vena cava. • Less risk of complications such as pneumothorax on insertion than other CVADs due to peripheral vein access on upper arm (compared to accessing of jugular or subclavian vein). • For short to intermediate duration of therapy. • Available with single, double, or triple lumen.
Tunnelled CVAD ^{2,16,114}	<ul style="list-style-type: none"> • Can be used in community, home care, and long-term care settings. • Catheters are “tunneled” through a subcutaneous tract after accessing vein on insertion (i.e., subclavian or jugular) and before exiting the skin. • Cuffs are on the catheter to adhere to the subcutaneous tissue within 10–14 days. They function to stabilize the catheter under the skin or can have antimicrobial properties and can reduce the risk of infection by creating an antimicrobial barrier from the exit site to the vein. • For long-term access and long duration of therapy. • Available with single, double or triple lumen.
Implanted vascular access device (IVAD) (also known as a port or dome) ^{16,114}	<ul style="list-style-type: none"> • Can be used in community, home care, and long-term care settings. • Tunnelled CVADs with proximal end terminating in a subcutaneous pocket with a self-sealing reservoir implanted under the skin. • Associated with a low risk of infection because the device is a closed system until accessed. • Ideal for long-term, intermittent infusion. • Must be accessed with a non-coring needle inserted into the port septum. • Available with single or double port.

A CVAD can be valved or nonvalved.

A **nonvalved CVAD** is a catheter that is open at the tip and at the lumen hub, with a clamp on the external portion of the catheter to stop blood from coming into the catheter and out of the hub. In regard to an IVAD, the term refers to the catheter’s or device’s not having an integrated valve.

A **valved CVAD** is a catheter with an integrated valve that can be located at the catheter tip (distal) or in the catheter hub (proximal). The valve will open with infusion and flushing into the catheter and also when pressure is exerted for aspiration such as for blood sampling or when checking for blood return. The valve is neutral or remains closed when no pressure is applied and will prevent blood from coming into the catheter.^{115–117}

Appendix 2. Algorithm for Management of CVAD Occlusion



CVAD = central vascular access device; CXR = chest radiography; IVAD = implanted vascular access device; TPN = total parenteral nutrition.

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