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Nursing Recommendations for the Management of Vascular Access in Adult Hemodialysis Patients 2023 Update

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Nursing Recommendations for the Management of Vascular Access in Adult Hemodialysis Patients: 2023 Update

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List of Acronyms and Abbreviations

A-V	Arterial–venous
AV	Arteriovenous
AVF	Arteriovenous fistula
AVG	Arteriovenous graft
BCR	British Columbia Renal
BH	Buttonhole
CNeph(C)	Canadian Nurses Association Specialty Certification – Certified in Nephrology Canada
CANNT	Canadian Association of Nephrology Nurses and Technologists
CDC	Centers for Disease Control and Prevention
CEN	Clinical Educators Network
CKD	Chronic Kidney Disease
CNNP	Canadian Nephrology Nurse Practitioners Network
CR-BSI	Catheter-related bloodstream infection
CSN-CPG	Canadian Society of Nephrology – Clinical Practice Guideline
CVAD	Central venous access device
CVC	Central venous catheter
DOPPS	Dialysis Outcomes and Practice Patterns Study
DVP	Dynamic venous pressure
EBPG	European Best Practice Guidelines
ESKD	End-Stage Kidney Disease
eGFR	Estimated Glomerular Filtration Rate
HD	Hemodialysis
IV	Intravenous
KDOQI	Kidney Disease Outcomes Quality Initiative
Kt/V	Dialysis Adequacy Calculation
LPN	Licensed Practical Nurse
MRSA	Methicillin-resistant Staphylococcus Aureus
NKF-KDOQI	National Kidney Foundation – Kidney Disease Outcomes Quality Initiative
NS	Normal saline
NP	Nurse Practitioner
ORN	Ontario Renal Network
Pa	Arterial pressure
QA	Access flow
Qb	Blood flow
RN	Registered Nurse
RPN	Registered Practical Nurse
RNAO	Registered Nurses Association of Ontario
SIAPR	Static intra-access pressure ratio
URR	Urea Reduction Ratio
VA	Vascular Access
VAC	Vascular Access Coordinators
VP	Venous pressure
V-A	Venous–arterial
V-V	Venous–venous

Message from the CANNT Vascular Access (VA) Working Group

This document represents an updated version of a project initiated in 2006 by members of the Greater Toronto Area Clinical Educators Network (CEN) and the Canadian Hemodialysis Access Coordinators Network (CHAC), and revised in 2015 by CHAC members. This year, the Canadian Association of Nephrology Nurses and Technologists (CANNT) supported the revision of this document. A CANNT working group, comprised of appointed nursing experts in vascular access, was established to ensure the validity, reliability, and utility of the revised recommendations. The opinions of the CANNT Vascular Access (VA) Working Group are listed as expert-informed opinion.

Recognizing the ongoing, commonly faced challenges in nursing practice across the country related to vascular access in the care of adult patients receiving hemodialysis, CANNT identified the need for collaboration and sharing of experiences and expertise, specifically in the management of new and established arteriovenous accesses and central venous catheters. These recommendations are offered as clinical practice guidelines rather than standards of practice, and are based on evidence and evidence-based practice where they exists. Some topics offer little or no published literature, or conflicting information and, in those instances, comments are based on evidence-informed opinion and are included in the document as clinical considerations.

CANNT hopes these guidelines will assist hemodialysis nurses in the care and management of vascular access, assist in preparing unit policies and protocols, and provide clinicians with education and documentation tools. Furthermore, CANNT supports these guidelines to encourage and inspire nursing research that will enhance the body of existing literature in the interest of improving outcomes for adult patients receiving hemodialysis.

Jovina Bachynski, MN-NP (Adult), RN(EC), CNeph(C), PhD Student, and Rosa M. Marticorena, CNS, CNeph(C), DClinEpi, PhD on behalf of the CANNT VA Working Group

PREAMBLE

CANNT collaborated with members of the former Canadian Hemodialysis Access Coordinators Network (CHAC), Clinical Renal Educators, and Canadian Nephrology Nurse Practitioners (CNNP) groups to establish nursing recommendations for the management of new and established arteriovenous (AV) accesses and hemodialysis central venous catheters (CVC). The term CANNT 'Vascular Access (VA) Working Group' refers to the abovementioned expert members. The term 'hemodialysis' and 'dialysis' will be used interchangeably throughout this document to refer to hemodialysis (HD) treatment, not peritoneal dialysis. The term 'nurse' refers to Registered Nurses (RN), Nurse Practitioners (NP), Registered Practical Nurses (RPN), and Licensed Practical Nurses (LPN) with formal theoretical and practical hemodialysis knowledge and training.

The document includes recommendations and guidelines intended to assist clinicians in the treatment and management of vascular access for individual dialysis units and nephrology programs. These guidelines apply to vascular access care and management for adult HD patients, and may not be applicable for pediatric HD patients (under the age of 18 years).

The CANNT VA Working Group recommends that these guidelines are revised and published once every five years, and suggests establishing a working group and beginning the review three years after the VA recommendations and guidelines are published.

Nursing Terminology

Clinical practice guidelines

It is the opinion of the CANNT VA working group that recommendations for the care and management of vascular accesses for adult hemodialysis patients are based on research (where it exists), published guidelines, or evidence-based practice (e.g., Canadian Society of Nephrology Clinical Practice Guidelines for vascular access, [Jindal et al., 2006]; National Kidney Foundation-Kidney Disease Outcomes Quality Initiative [NKF- KDOQI] Guidelines for vascular access update [NKF, 2019]).

Evidence-based practice

Evidence-based practice within the context of nursing is a "problem solving approach to the delivery of health care that integrates the best evidence from well-designed studies and patient care data and combines it with clinical expertise and patient preferences and values" (Melnyk, 2010, p. 51).

"Evidence-based practice means integrating the best available research evidence with information about patient preferences, clinical skill level, and available resources to make decisions about patient care" (Ciliska et al., 2001, p. 520).

The pooling of nurses' clinical expertise maximizes clinical knowledge and can support recommendation development (Benner et al., 1997). In such cases, the recommendations will be made where there is no formal evidence upon which to base the opinion of the group, and will be identified as evidence-informed opinion and included as clinical considerations.

Critical thinking:

Critical thinking is defined as the "intellectually disciplined process of actively and skillfully conceptualizing, applying, synthesizing or evaluating information" (Zunkel et al., 2004, p. 161).

"Critical thinking requires clinical reasoning that is knowledge-based and creative; however, it is also contextual and is impacted by the reality of individual client needs and the practice environment in which the nurse works" (Nelson et al., 2005, p. 170).

Clinical Governance:

"Clinical governance is a framework through which healthcare organizations are accountable for continuous quality improvement initiatives by creating an environment in which excellence in clinical care will flourish. Implementing this concept to vascular access management should enhance the quality of care, decrease clinical risks and improve clinical outcomes in hemodialysis patients." (Bajardi et al., 2009; Holey, 2006; McClellan & Goodman, 2001; Bonfant et al., 2010).

CANNT VA Working Group and Acknowledgements

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- Members of the CANNT VA Working Group 2016–2023: Rick Luscombe, BScN,[1] Linda Mills, RN, CNeph(C),[2] Kelly Sutherland, RN,[3] Latha Kumar, RN, MScN (Ed),[4] Patricia Quinan, RN,CNS, CNeph(C),[5] Carol Rivers, RN, MSN,[6] Deidra Goodacre, RN, BSN, CNeph(C),[7] Cathy Cake, RN,BN, M. Ed., CNeph(C),[8] Jovina Bachynski, MN-NP, RN(EC), CNeph(C), PhD Student, NP,[9] Cheryle Keys, RN,[10] and Rosa M. Marticorena, RN, CNS, CNeph(C), DClinEpi, PhD.[11]
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ENDORSEMENT

These guidelines are endorsed by the Canadian Association of Nephrology Nurses and Technologists (CANNT)

Chapter 1: Recommendations for new and established arteriovenous access management in adult hemodialysis patients

INTRODUCTION

CANNT supports this document which addresses the important role that nurses play in the management of new and established vascular accesses (VA) in the adult hemodialysis (HD) population. Nurses make a unique contribution to patient care by applying critical thinking to problem-solving and clinical decision-making (Nelson et al., 2005).

Kidney Disease Outcome and Quality Initiative (KDOQI), 2019 guideline statements emphasize a patient-focused approach and recommend developing an end-stage kidney disease (ESKD) Life-Plan for each patient, which incorporates each patient's needs and preferences when choosing and planning initial and future dialysis accesses.

RECOMMENDATION 1: VEIN PRESERVATION

Vein preservation should begin in patients with Chronic Kidney Disease (CKD) with known Stage 4 (eGFR 15-30 mL/min) or Stage 5 (eGFR less than 15 mL/min; also known as End Stage Kidney Disease), and continue through all stages (BC Renal, 2022; Hoggard et al., 2008; Ontario Renal Network [ORN], 2014). It should be inclusive of all patients currently on HD and peritoneal dialysis (PD), and patients with a functional kidney transplant (Hakim & Himmelfarb, 2009). It is a critical goal for patients with CKD who may require long-term VA (Bowen Santolucito, 2001).

Vein preservation primarily includes the avoidance of venipuncture and peripherally inserted central catheters (PICC) into central and peripheral veins for patients with chronic kidney disease (KDOQI, 2019), as complications resulting from venipunctures may render veins that are available for AV access creation unsuitable. PICC lines should be avoided in patients with abnormal creatinine or eGFR (Stage 3, 4 or 5) whenever possible (Hakim & Himmelfarb, 2009) as they have been shown to be associated with an increased risk of central vein stenosis and thrombosis and can cause scarring of peripheral veins. This damage to peripheral and central veins can limit possible AV access sites in the future (BC Renal, 2022. Fistula First, n.d.; Turcotte et al., 2006). Vein preservation should also include avoiding placement of subclavian vein catheters and peripherally inserted central catheter (PICC) lines in patients with Stage 4 or 5 CKD (Jindal et al., 2006; KDOQI, 2019).

Nurses play a vital role in educating patients about forearm and arm vein preservation (Banerjee, 2009). The 2006 Canadian Clinical Practice Guidelines for Vascular Access (CPG-VA) (Guideline 3.1.2) recommend preserving arm veins suitable for placement of arteriovenous (AV) access regardless of arm dominance and to instruct hospital staff and patients with developing end stage kidney disease (ESKD) to protect arms from venipuncture and intravenous catheters (Jindal et al., 2006; ORN, 2014; Pelletier et al., 2016). Patient education highlighting treatment options and eGFR thresholds for access placements are known to be associated with improved permanent AV access placement (Gill et al., 2002; Hakim & Himmelfarb, 2009; Lopez-Vargas et al., 2011). ANNA (2012) and CPG-VA (Jindal et al., 2006) support the recommendation that patients with kidney disease wear medical bracelets or wristbands to identify that they have CKD and carry a wallet card with information about vein preservation (BC Renal, 2022; Jindal et al., 2006; Fink, 2019; Hakim & Himmelfarb, 2009; Fistula First, n.d.; ORN, 2014).

Patients requiring maintenance HD should ideally have a functioning permanent VA in place prior to initiating HD. CPG-VA & EBPG (Guideline 1.3) recommend that patients with an eGFR from 15–30 mL/min per 1.73m^2 (Stage 4) are referred for fistula creation (Jindal et al., 2006; Tordoir et al., 2007). Peritoneal dialysis should be considered as a bridge to AV fistula maturation in appropriate patients in order to avoid CVC placement (American Nephrology Nurses' Association (ANNA), 2013).

See Figure 1: ORN armband, Figure 2: BC Renal wristband and Figure 3: Vein preservation sample wallet card.

Figure 1

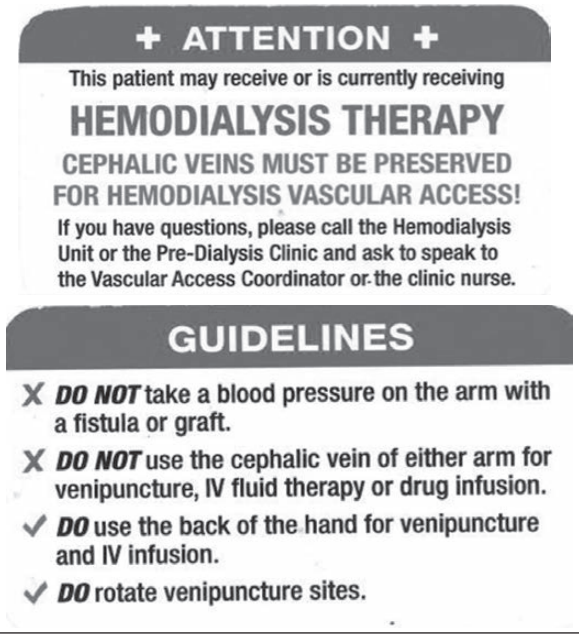
Vein preservation armband for CKD patients. Copyright Ontario Renal Network (ORN). Used with permission.

Figure 2

Vein preservation wristband for CKD patients. Copyright BC Renal. Used with permission.

Figure 3

CHAC vein preservation wallet card. Used with permission.



Early CKD care including modality selection and referral for AV access creation for suitable patients will ensure optimal start on dialysis and reduce the financial burden to the health care system (Moist, 2011). Late referral results in a greater chance of non-maturation of AVFs and need to initiate HD with a CVC (Avorn et al., 2002; Roubicek et al., 2000; Tordoir et al., 2007), and early cannulation is associated with the greatest risk of AV access failure (Ravani et al., 2004). CKD care and education should include venipunctures from the dorsum part of the hands and avoiding venipunctures, intravenous therapy, blood pressures, and saline locks in the limb planned for AV access creation or limb with a functioning VA (BC Renal, 2022; Fistula First, n.d.; Jindal et al., 2006; ORN, 2014; Tordoir et al., 2007; KDOQI, 2019). Limb restriction should be documented on the patient's chart. To avoid unnecessary venipunctures, the CANNT working group recommends that, whenever possible, blood samples are scheduled to be obtained from the VA prior to initiating dialysis treatments (BC Renal, 2022).

The National Kidney Foundation (NKF) Kidney Disease Outcomes Quality Initiative Guidelines (KDOQI) (2019) recommend that fistulae be created at least six months before the expected start of dialysis. Oliver et al. (2012) found that 81% of CKD patients with fistula creations in Ontario eventually started dialysis, suggesting that clinicians are selecting appropriate patients, but that fistula creations are occurring later in the course of CKD than most guidelines recommend. Shechter et al., (2014) examined timing for referral and AV access creation and found that referral within 12 months of estimated time to initiation of dialysis and referral at eGFR <15–20 mL/ min/1.73 m^2 (Stage 4) produced the best outcomes. The CANNT working group recommends guiding referral by individual rate of CKD progression and suggests referring elderly patients later to reduce the risk of AV fistula non-use. "Implementation of a multifaceted intervention including a vascular access nurse and an algorithm to prioritize surgery significantly increases the proportion of patients starting dialysis therapy with an AV fistula (AVF) by improving the overall coordination of the surgical waiting list" (Polkinghorne et al., 2009, p. 99).

According to 2007 Evidence-based Practice Guidelines on Vascular Access (EBPG) (Guideline 1.1), an early plan for venous preservation should be a substantial part of pre-dialysis care and education in any CKD patient regardless of choice of treatment modality (Tordoir et al., 2007); potential HD patients should ideally be referred to the Vascular Surgeon for physical examination and preparing AV access when they reach Stage 4 or earlier in case of rapidly progressive nephropathy or specific clinical conditions such as diabetes or severe peripheral vascular disease (Guideline 1.3); clinical evaluation and non-invasive ultrasonography of upper extremity arteries and veins should be performed before AV access creation (Guideline 2.1); and nurses and medical staff should be involved in vein preservation and monitoring of the AV access. Every patient with CKD should have a declared plan for preserving the AV access and potential access sites (Guideline 4.1).

Pre-operative venous mapping:

Venous mapping in addition to physical examination of arm veins may improve AVF patency (Ferring et al., 2010). The advantages of venous mapping in guiding and assessing the feasibility of AV access placement and determining optimal location have been well established in several studies (Ferring et al., 2008; Ferring et al., 2010; Gibson et al., 2001).

Doppler ultrasound vein mapping supports optimal outcomes when the vascular surgeon performs vein mapping and reviews the results to anticipate and plan the surgical approach (Allon et al., 2001; Robbin et al., 2000; Silva et al., 1998). Venous mapping has been associated with decreased primary failure, increased patency, and decreased numbers of unnecessary surgical explorations (Silva et al., 1998; Wong et al., 1996). It can also identify patients for potential primary or secondary elevation or transposition techniques with superficialization, lipectomy or liposuction of deep veins to facilitate cannulation (Bourquelot et al., 2009; Tordoir et al., 2010; Stoikes et al., 2009; Barnard et al., 2010; Causey et al, 2010; Ochoa et al., 2010; Wang & Wang, 2017; Elbarbary, 2019).

In a randomized control trial, primary AV access failure without pre-operative ultrasound imaging was 25%, compared to 6% failure rate with pre-operative ultrasound imaging (Mihmanli et al., 2001). Robbin et al. (2000) and Allon et al. (2001) suggest that a high primary fistula failure rate persists despite pre-operative mapping and, therefore, evidence does not support routine use in all patients. ANNA (2013) suggests that vessel mapping is indicated when a VA failure or impending failure occurs to determine if the patient is a candidate for a new AV fistula. KDOQI (2019) suggests selective venous mapping for patients at high risk of failure rather than routinely venous mapping for all patients.

Clinical consideration: Routine venous mapping is reported to be associated with increased fistula creation. However, a high primary fistula failure rate persists despite pre-operative venous mapping. Selective use of venous mapping is suggested in patients with high risk for failure to mature, obesity or planned upper arm access.

Point of care ultrasound to assess suitable veins for access creation is routinely used by expert vascular access nurses (communication with St. Joseph's Healthcare Hamilton, ON and St. Paul's in Vancouver, BC), this approach prevents delays in access creation, without additional appointments. Patients are referred for mapping if suitable veins are not found. Follow local unit protocols and recommendations or preferences of the vascular surgeons.

Pre-operative and post-operative hand and arm exercises:

Strengthening the forearm by using isometric exercises to increase hand grip strength (squeezing a rubber ball prior to AV access surgery) may increase blood flow, thereby enhancing vein maturation (Oder et al., 2003; Rus et al., 2003). Performing hand and arm exercises after AV access surgery were found to significantly increase clinical maturation and vessel size in distal AVFs, and potentially increase blood flow through the fistula, (Leaf et al., 2003; Lok & Oliver, 2001; Rus et al., 2005; Salimi et al., 2013; Fontsere et al., 2016). KDOQI (2019) suggests considering post-operative arm exercises to promote AVF maturation, despite some literature suggesting that there is no benefit, as arm exercises are noninvasive, result in little to no harm, and minimal to no cost. The CANNT working group recommends following local practices and protocols and recommendations from the vascular surgeon.

The CANNT working group recommends instructing patients to perform regular hand and arm exercises, with or without a lightly applied tourniquet, before and after surgery, if sufficient lead time allows. The CANNT working group recommends following unit practices and instructions from the Vascular Surgeon for use of tourniquet for performing hand and arm exercises.

Note: Hand and arm exercise alone will not turn a poorly developed fistula into a functioning fistula. Patients should be informed that despite hand and arm exercises, the fistula may fail to mature enough to be usable for dialysis.

RECOMMENDATION 2: PATIENT EDUCATION

The interdisciplinary team should ensure that patients and families have factual information related to all types of vascular access and respect the patient's right to self-determination in choice of vascular access (ANNA, 2013). It is reasonable to have an AV access (AVG or AVF) in a patient requiring HD, when consistent with their ESKD life plan and overall goals of care (NKF KDOQI Guidelines 2019 (Guideline 2: types of AV access and indication for use, expert opinion).

As previously stated, patients and their families should be educated on the importance of vein preservation (See Recommendation 1: Vein Preservation) and how to care for their vascular access (VA). Patients should also be shown how to check their AV access daily for the presence of a thrill (vibration or buzzing), the importance of rotating needle sites, and using proper compression technique for needle site hemostasis (BC Renal, 2022; Fistula First, n.d.; NKF, 2006; ORN, 2014). Patients should be instructed not to wear tight clothing or jewelry, or carry heavy objects pressing on the limb with the functioning AV access. Other strategies to prolong access function include observing good personal hygiene habits, avoiding the exposure of the access site to animal's saliva or fur and recognizing and reporting early signs of infection. Hand hygiene remains the most important way to prevent contact transmission. Health care providers should demonstrate proper hand washing techniques to patients and cleaning of the access arm prior to cannulation (NKF, 2006; O'Grady et al., 2011; Thomas-Hawkins, 1995).

The Dialysis Outcomes and Practice Patterns Study (DOPPS) data reveal that nephrology nurses play an important role in advocating for AV access placement and encouraging and influencing patients on VA choice (Mapes, 2005).

Pre-operative AV access education should include:

- What is a fistula or graft?
- Why is access necessary?
- What are the advantages of having a fistula or graft over a central venous catheter (CVC)?
- How long will the fistula or graft last?
- The importance of vein preservation and requesting that hand veins are used for blood samples and intravenous therapy. Vein preservation also includes instructing patients to avoid wearing tight clothing or jewelry, avoid carrying heavy objects, and to consult the VA team prior to participating in contact sports.
- What does the surgery involve?
- How to know that the access is working? Describe the terms bruit and thrill and demonstrate an assessment.
- When will the fistula or graft be used?
- How are the needles inserted? Describe cannulation techniques (rope ladder, buttonhole (BH) and self-cannulation)
- What are the complications of the fistula or graft (failure to mature, steal syndrome, infection)?

Post-operative AV access education should include:

- How to take care of the fistula or graft after surgery.
- How to check that the fistula or graft is working. Demonstrate how to check the thrill (buzzing or vibration) and bruit (listening for whooshing sound). To assess the thrill, ask the patient to place the palm of their hand over the access and feel the vibration (thrill). To assess the bruit, ask the patient to raise their access limb to the opposite ear and listen for the sound (bruit) (NKF, 2006).
- How and when to perform hand and arm exercises. (Hand and arm exercises are not required for grafts).
- The importance of vein preservation and requesting that hand veins are used for blood samples and intravenous therapy. Vein preservation also includes avoiding blood pressure measurements, and constricting objects such as jewelry, tight clothing, or tightly wrapped dressings on the access arm (Jindal et al., 2006; NKF, 2006; ORN, 2014).
- Continuing with normal daily activities once the AV access has healed (as advised by the Vascular Surgeon and VAC).
- Who to call for advice or assistance.
- Strategies to prevent access loss or infection include observing good personal hygiene habits, cleaning access arm prior to needle placement, avoiding constriction of access (no jewelry or tight clothing on access arm), and the importance of rotating needle sites (Ball, 2005; BC Renal, 2022; Thomas-Hawkins, 1995).

The importance of promptly reporting:

- change in thrill or bruit (weak or absent).
- pain, fever, redness or swelling.
- bleeding.
- presence of scab.

RECOMMENDATION 3: ASSESSMENT OF THE ARTERIOVENOUS (AV) ACCESS

Assessment is key to evaluating all new and established fistulas and grafts, in order to determine patency and cannulation readiness. Staff education should include principles and hands-on cannulation training to assure optimal care of the patient's access. Staff education programs should include satisfactory demonstration of knowledge and skills prior to the staff member being allowed to independently perform cannulation (ANNA, 2013). A nurse trained in clinical assessment of the AV access should carry out the assessment and cannulation procedure.

Assessment of the AV access includes three aspects: inspection, auscultation, and palpation. Prior to each cannulation, the AV access must be assessed and evaluated using these three aspects of nursing care (Ball, 2005; Beathard, 1998, BC Renal, 2022; Asif et al., 2007; Campos et al., 2008; Coentrao et al., 2012; Leon et al., 2008; Salman & Beathard., 2013). Vachharajani (ASDIN 2014 Scientific meeting) and National Renal Network (2017) recommend performing a one-minute access exam including look (inspection), listen (auscultation), feel (palpation), arm elevation (AV fistula only) at each dialysis treatment, and augmentation test monthly and as needed. Arm elevation test is also referred to as a free fistulogram and may be useful in detecting the presence of outflow stenosis (Coentrao et al 2012). Normal collapse or flattening of the outflow vein (fistula) when the fistula arm is elevated above the level of the heart suggests absence of outflow obstruction or stenosis. Whereas observation of post-stenotic collapse of the vein (fistula) or failure of the outflow vein to collapse or remain plump after arm elevation may demonstrate hemodynamic relevance of a stenosis (Schmidli et al., 2018; Whittier, 2009). Clinical assessment, physical examination and prompt reporting of failure to mature and abnormal findings are necessary to maintaining access function and access longevity (Asif et al., 2007; Campos et al., 2008; Leon & Asif, 2008; Leon et al., 2008; McLafferty et al., 2007; Salman et al., 2013; NKF, 2006; Paulson et al., 2012; Schuman et al., 2007; Thomas-Hawkins, 1995). Surveillance should include identifying patients who are at risk for VA complications, detecting early signs of problems, implementing nursing interventions aimed at prevention of complications, and providing staff and patient education. These are all strategies that nurses should employ to preserve the function and survival of VA (KDOQI, 2019; Paulson et al., 2012; Thomas-Hawkins, 1995).

Tools and resources that may be utilized when assessing and cannulating fistulas or grafts include:

- Clinical assessment
- Physical examination
- Stethoscope (to assess bruit)
- Operative report (date of AV access creation)
- Interventional Radiology report
- Transonic access flow measurement
- Recirculation studies
- Ultrasound/portable device (to assess vein diameter, depth, course, valves, narrowing and presence of thrombus)
- Tourniquet (to stabilize and augment the outflow vein)
- Clinical Renal Educator
- Vascular Access Nurse (s)/Vascular Access Coordinator
- Charge Nurse/Team Leader/expert cannulator
- Nephrologist/NP

The assessment should be carried out as follows. The nurse should begin the assessment process through dialogue with the patient to determine:

- Patient's knowledge of the fistula or graft and how it will be used (needle insertion)
- Patient's knowledge of how to assess the thrill and bruit. Ask the patient to demonstrate the assessment and assist, as needed
- Patient's report of changes in the thrill or bruit
- Patient's experience with the access creation and any concerns or post- procedural symptoms (where applicable)
- Patient's report of pain, weakness, tingling, swelling, and temperature or color changes in the access extremity
- Emphasize with the patient the importance of needle site rotation to preserve access function and survival.

Inspection

- Expose the entire extremity (arm or leg) with the AV access
- When assessing for limb swelling always compare the access limb to the non-access limb
- Position the access limb parallel to the floor — this is critical to enable proper visualization of the access
- Observe the access limb for:
  - Signs of infection (warmth, erythema, discharge or swelling)
  - Presence of bruising, swelling, and collateral veins (visualize entire arm and upper chest)
  - For AV fistulas, an elevation test on the access limb can be used to detect outflow (venous) stenosis. In the absence of a stenosis, the entire fistula will generally collapse when the access limb is elevated. If a stenosis is present, the portion of the fistula distal to point of stenosis remains distended, while the proximal portion collapses (Beathard, 2003; Vachharanji, 2010)
  - Access-induced ischemia or steal syndrome (signs of cyanosis of the fingertips and toes and delayed capillary refill of the nail beds, hand pallor and foot pallor and decreased range of motion)
  - Location of anastomosis and evidence of healing incision lines
  - Skin integrity (rash, blisters, scabs or eroded cannulation sites)
  - Appropriateness of vessel size (depth and diameter) for cannulation suitability
  - Location for previous cannulation sites (avoid thin, white, shiny aneurysmal areas).

Clinical consideration: Arm swelling could be a result of central vein stenosis. If generalized swelling of the arm and/or collateral veins on the upper torso is identified, the possibility of central venous stenosis needs to be ruled out. Consult the Nephrologist or NP. For arm or leg swelling, instruct patients to elevate the limb as much as possible until the swelling subsides and advise patients to avoid any tight clothing, jewelry or circumferential gauze wrapping on the access arm. For patients with an AV graft, post-operative arm swelling may take as long as three to six weeks to subside. An increase in swelling requires urgent evaluation (Asif et al., 2007; NKF, 2006).

Auscultation

- Using a stethoscope, press gently and listen for the quality and duration of the bruit (continuous, low pitched whooshing sound) created by the turbulence at the anastomosis (Ball, 2005; Banerjee, 2009; BC Renal, 2022; KDOQI, 2019). A normal bruit should have a systolic and diastolic component (BC Renal, 2022; Fistula First, 2015; KDOQI, 2019). Begin at the AV anastomosis and continue along the length of the access noting any changes in pitch and amplitude of the bruit.
- A high-pitched, discontinuous bruit whistling sound (present on systole only), is abnormal and may indicate outflow stenosis at the venous end and inflow stenosis if present at the arterial end of the access (Banerjee, 2009; BC Renal, 2022; KDOQI, 2019).
- A significant increase in pitch is noted on auscultation (bruit) — suggestive of a potential stenosis.
- Absent bruit usually indicates that the access has clotted or thrombosed (BC Renal, 2022; KDOQI, 2019).
- NO BRUIT – NO NEEDLE.

Clinical consideration: If the bruit is absent, this likely indicates that the AV access is clotted or thrombosed, and therefore is not able to provide adequate dialysis. Assess the bruit by listening with a stethoscope, Doppler, or portable ultrasound and promptly report findings to the VAC, VA nurse, Nephrologist or NP.

Palpation for AV fistulas

- Feel the entire length of the AV access assessing skin temperature.
- Assess and compare temperatures in both the access and non-access limb.
- Assess the thrill by palpating the entire length of the AV fistula to determine access patency. The vein should be soft and easy to compress (KDOQI, 2019).
- A thrill is a buzzing or vibration felt as the result of turbulence of the blood flow created by the high-pressure arterial system merging with the low pressure venous system (Ball, 2005; NFK, 2006).
- A strong thrill should be palpable at the arterial anastomosis diminishing distally, closer to the venous end (BC Renal, 2022; Beathard, 1998; Beathard, 2005). A weak thrill may suggest a stenosis at or near the anastomosis.
- A pulsatile fistula is suggestive of obstruction or stenosis (BC Renal, 2022; McGuckin et al., 2005). "The strength of the pulse is directly proportional to the arterial (inflow) pressure," (Beathard, 2003, p. 6).
- Pulse augmentation is a useful test to assess the strength of the arterial inflow and is performed by complete or near occlusion of the outflow of the AV access several centimeters beyond the AV anastomosis and assessing the strength of the pulse (Asif et al., 2007; Whittier, 2009). "The fistula is said to augment well, meaning it has a very strong pulse with obstruction and by inference, a good arterial inflow at the AV anastomosis. Conversely, it may be found to augment poorly, meaning a weak or absent pulse with obstruction and by inference, a poor arterial inflow," (Beathard, 2003, p. 6).
- Use a two or three-finger approach to roll your fingers across the AV fistula to determine width and depth of access.
- For forearm fistulas, apply a tourniquet at the level of the elbow tight enough to dilate the fistula. For upper arm fistulas apply a tourniquet just below the axilla tight enough to dilate the fistula (See *Figure 4: Cannulation with tourniquet*). Always make sure you can palpate the thrill with the tourniquet in place (Ball, 2005; BC Renal, 2022).
- For upper arm fistulas use the Cushion Cannulation Technique *(See Figure 5: photos A and B)* described by Mott & Prowant (2006), or the surgical position (Moore & Mott, 2009).
- Comprehensive information on assessment of VA can be found in the *Atlas of Dialysis Vascular Access, Fistula First* (Vachharajani, 2010), at: https://cdn.ymaws.com/www.asdin.org/resource/resmgr/imported/atlas%20of%20dialysis%20access.pdf

Clinical consideration: Routine use of tourniquets for cannulating AV fistulas: The general opinion of the CANNT working group is that tourniquets should routinely be used for cannulating AV fistulas. This is also supported by Fistula First, 2015, Ball, 2005, and BC Renal, 2022. The CANNT working group recognizes that many nurses considered to be expert cannulators repeatedly achieve successful and skillful cannulation without using a tourniquet and instead stabilize the vein by placing the middle or index finger a couple of inches above the site selected for cannulation prior to needle placement. A tourniquet alone, without conducting a thorough assessment of the AV access and stabilizing the vein will not guarantee successful cannulation. Tourniquets help to engorge the vein, making it more palpable and stabilize the vein during cannulation (Banerjee, 2009; Ball, 2005; Fistula First, 2015; NKF, 2006).

Holding the needle below the wings allows visibility of flashback (brisk blood return) during needle insertion (*See Figure 4: Cannulation of AVF using a tourniquet).*

Figure 4

Cannulation of AVF using a tourniquet. Photo provided compliments of a patient at Humber River Hospital, Toronto, ON. Used with permission.

The "Cushion Cannulation Technique" includes the nurse sitting on a stool and placing a firm cushion under the patient's access arm. This positioning allows better visualization of the access, especially for upper arm accesses. The cannulator's body mechanics are improved both by the seated position and by having the access at the same level as the cannulator's hands and forearms. The arm can be easily extended to the surgical position, which will stretch and expose the entire usable length of the fistula, yet still be

comfortable for the patient and cannulator (Moore & Mott, 2009). The arm should be fully extended to the side horizontally on the cushion at, or just below shoulder level, as far as possible up under the armpit *(See Figure 5: The Cushion Cannulation Technique)*. This position limits the patient's ability to pull back during cannulation and provides additional stability for the cannulator's hands and forearm during cannulation (Mott & Prowant, 2006).

Figure 5

Cushion Cannulation Technique. Photos provided compliments of S. Mott. Used with permission.

5A: Access arm extended outwards on the cushion.

5B: Cannulator in sitting position with wrist and forearm 5B; supported by the cushion.

This position limits the patient's ability to pull back during cannulation and provides additional stability for the cannulator's hands and forearm, and access and tissue (Mott & Prowant, 2006).

Assessment of the AV Graft

In addition to the above assessment of an AV access, complete these additional steps for an AV graft.

- Assess the temperature of the skin around both the arterial and venous anastomosis and along the entire length of the graft and check for abnormalities.
- Use a two or three-finger approach to roll your fingers across the AV graft to determine width and depth of the access.
- Palpate the entire length of the AV graft, noting location, graft integrity and depth.
- A strong pulse may indicate the presence of a stenosis (Ball, 2005; BC Renal, 2022; KDOQI, 2019).
- Use of tourniquets is not recommended for standard AV grafts. HeRo graft cannulation requires application of light compression of the venous portion of the graft during cannulation. Follow unit protocols and manufacturer recommendations.

To determine direction of blood flow in a loop graft

- Review the operative and/or ultrasound report (if available) for anatomical position and direction of blood flow and document arterial and venous aspects.
- Determine the direction of blood flow by partially occluding the midpoint of the graft for a few seconds while listening to the quality and duration of the bruit on either side of this mid-point. The arterial side can usually be determined by a stronger bruit than the venous side (BC Renal, 2022; Brouwer & Peterson, 2002). Fistula First (2015) recommends occluding the graft with the tip of the finger and palpating on each side of the occlusion point for a pulse. The side without a pulse is the downstream (venous) side of the graft. The upstream (arterial) pulse will increase in intensity during the occlusion. This is known as pulse augmentation.
- Carry out access flow measurements using the dilution method (Transonic®).

Clinical consideration: Early cannulation (FlixeneTM) grafts and Hemodialysis Reliable Outflow grafts (HeRO®): Schild et al, 2011 report successful outcomes with early cannulation AV grafts (within 24–72 hours) achieving successful cannulation, while at the same time avoiding placement of CVC or limiting use of CVC. Expert-opinion suggests that thrill may not be present and to ensure that bruit is assessed and present prior to cannulation. The HeRO® graft provides an alternative long-term access for patients with limited VA options and central venous obstruction. Unlike conventional AV accesses, the HeRO® polytetrafluoroethylene graft component is connected to an artery in the arm (arterial anastomosis), but there is no venous anastomosis. The graft is subsequently tunneled under the skin and then connected to a silastic outflow catheter placed transluminally, across and beyond the central venous obstruction and the tip of the catheter is directed into the right atrium of the heart (Katzman et al., 2009; Wallace et al., 2013; Shakarchi et al., 2015). "Although typically used as a new AV access configuration, the HeRO® graft can be used in combination with an existing AVF or AVG to provide the "central vein run-off", provided that the delivery sheath for the CVC can be passed through the lesion." (From KDOQI, 2019 references include Allan et al., 2012; Davis et al., 2016).

RECOMMENDATION 4: DETERMINATION OF CANNULATION SITES

Optimal needle placement is imperative to minimize mechanical trauma with needle insertion and maximize dialysis adequacy (Donnelly & Marticorena, 2012; Marticorena et al.; 2015 & 2018).

Prior to cannulation, it is important the nurse conducts a thorough assessment of the VA to visualize where the needle tip will end up, and to determine appropriateness of the selected sites to prevent inadvertent placement of a needle tip in an area too close to the other needle, or in a narrow or tortuous portion of the AV access (BC Renal, 2022; Brouwer, 2005; NKF, 2006). The use of portable ultrasound for VA assessment and ultrasound-guided cannulations can optimize cannulation

and ensure correct needle placement. Ongoing education and training for nurses on theoretical knowledge and cannulation skills is essential to maintain competency in cannulation skills, especially for cannulation of newly created or complex AV accesses (Marticorena et al., 2015; van Loon et al., 2009; Schmidli et al., 2018; KDOQI, 2019). KDOQI, 2019 working group reviewed literature on widespread use of ultrasound guided cannulation and suggested use on select patients, for example first or new AVF cannulation, with prior infiltration injury, or to avoid cannulation complications.

Cannulation should be avoided, and the VAC, VA, nurse, clinical renal educator, NP, or Nephrologist (where appropriate) consulted when:

- Signs and symptoms of infection are present.
- Absence or poor quality of bruit and/or thrill is noted.
- A pulse is palpated instead of a thrill—suggestive of diminished blood flow or stenosis.
- Extreme edema or other abnormal findings are observed (e.g., rash, scab(s), steal or unexplained aneurysm), which, in clinical judgment would render the cannulation inappropriate (BC Renal, 2022; Vachharajani, 2010).

Clinical consideration: The general opinion of the CANNT working group is that when available a portable ultrasound be used to guide cannulation of new or complex AV accesses. This is supported by consistent results of research studies of ultrasound guided cannulation of HD AV accesses. The CANNT working group recognizes that special training is required to achieve competency in the use of ultrasound for guided cannulation and recommends competencies are obtained for its successful use following published competency guides (Marticorena et al.; 2015 and 2018; Schmidli et al., 2018; Schoch et al., 2018 & 2021).

The mechanical trauma and the biological injury to the skin and vessel wall that occur with each cannulation are directly related to the cannulation technique and, therefore, are affected by the variation in cannulation skills in clinical practice. The hemodynamic trauma is generated by blood flow disturbances at needle sites and are affected by the dialysis machine blood pump speed (Qb) during dialysis (Rosa M. Marticorena & Donnelly, 2016). Blood flow disturbances damage the endothelia triggering pathways that induce development of neointimal hyperplasia, stenotic lesions, thrombogenesis, thrombosis and, ultimately, access loss (Lee et al., 2014; Roy-Chaudhury, 2005; Roy-Chaudhury, Arend, et al., 2007; Roy-Chaudhury et al., 2012).

Metal needles and plastic cannulae have been available since the inception of HD in the 1960's. Their design and material have evolved over the years. Adjustments were made to counteract problems with increasing pressures during hemodialysis treatment and with the frequent clot formation observed at the venous needle hub, which was an important cause of early interruption of the treatment (Stewart, Manuel, & Fleming, 1972).

Plastic cannulae are generally used for the first 2–4 weeks of cannulation after which the patients are transitioned to metal needles if cannulations have progressed without complications.

Plastic cannulae have been used for over 2 decades in hemodialysis. They are generally used for the first 2-4 weeks of cannulation of new or complex accesses. Their use may be extended beyond this time if it is felt that the AV access is still maturing, if the access is fragile, or when there is an increased risk of a needle infiltration due to restlessness of the patient. Use of plastic cannula is associated with decrease burden of illness related to infiltrations and less procedures to treat complications (Marticorena et al., 2018; de Barbieri et al., 2021; Choi et.al., 2021; Smith et.al., 2022).

The primary reason to transition plastic cannulae to metal needles is cost. Plastic cannulae cost about triple the price of metal needles. However, the saving in procedural costs and more importantly savings in time, distress and pain that patient suffer while a hematoma solves should be prioritized (Marticorena et al., 2018; de Barbieri et al., 2021; Choi, et al., 2021; Smith et al., 2022).

Clinical consideration: The general opinion of the CANNT working group is that when available plastic cannulae be used for cannulating new or complex AV access. This is supported by consistent results of research studies favoring the use of plastic cannulae (Marticorena et al., 2018; de Barbieri et al., 2021; Choi et.al., 2021; Smith et al., 2022). The CANNT working group recognizes that special training is required to achieve successful and skillful cannulation with plastic cannulae and recommends practice in phantom models prior to their use in real patients (Marticorena et al., 2015).

RECOMMENDATION 5: CANNULATION PROCEDURES—AV FISTULA AND AV GRAFT

Your fingers are now an extension of the needle as you cannulate:

- Consult with the VAC, VA nurse, Vascular Surgeon, Nephrologist or expert cannulator to determine cannulation readiness (BC Renal, 2022).
- Nephrology nurses are best suited to determine cannulation readiness or maturation based on expert clinical assessment skills (Banerjee et al., 2008). Cannulation readiness should be based on clinical assessment rather than a time-bound or eight-week rule (Banerjee, 2009).
- Arteriovenous fistula (AVF) maturation is determined by suitability for cannulation, whereby the fistula develops adequate flow, wall thickness and vein diameter. The Rule of 6s includes: 6 mm diameter vein, less than 6 mm deep, 6 weeks from date of creation, and blood flow of 600 mL/min) (Barrone et al., 2007; BC Renal, 2022; Fistula First, 2015; NKF, 2006). Robbin et al., (2018) reviewed the Rule of 6s in the National Institutes of Health Hemodialysis Fistula Maturation Study. They found when using blood flow of 600 mLs, vein diameter of 6mm and depth of 2mm below the skin level, approximately 50% of AV accesses successfully matured, and a depth of 6mm (Rule of 6s) would likely be less successful if maturation was only 50% with vein depth of 2 mm. (pg S74). KDOQI (2019) reviewed Rule of 6s since 2006 guidelines to include "principles of having a vein of adequate length and diameter that is easily accessible (i.e., not too deep and properly located to allow for comfortable needle cannulation) continue to hold."

- Robbin et al., (2002) and Lee et al., (2018) reported that fistula adequacy for dialysis doubled if the minimum diameter was 0.4 cm or greater, and flow volume was 500 mL/min or greater; applying criteria of vein diameter ⩾ 4 mm and blood flow ⩾ 500 mL/min could minimize the need for unnecessary early interventions in AVFs that are likely to mature without performing an intervention, but would delay interventions in AVFs that are unlikely to mature. They suggest this criteria may be preferred in patients with a radiocephalic AVF.
- Instruct patients to wash their access arm prior to coming to the dialysis chair.
- Practice careful hand washing and wear gloves to clean the access site (BC Renal, 2022).
- When available, use a portable ultrasound machine to assess vein diameter, depth, course, valves, narrowing and presence of thrombus prior to cannulation. It is estimated that the use of ultrasound-guided cannulation adds 1–3 minutes to the time required for cannulation (Paulson et al., 2015).
- The cannulator should determine the best position for successful cannulation, *(See the Cushion Technique, Figure 5)*. Sitting during cannulation promotes cannulator comfort allowing the wrist and forearm to be supported on a cushion and helps to keep the cannulator's hand steady during cannulation.
- For fistulas only: apply a tourniquet or blood pressure (BP) cuff (pumped up to 80–90 mmHg) midpoint of the upper arm (lower arm fistula) or just below the axilla (upper arm fistula), tight enough to dilate the veins but being careful not to occlude the flow (Ball, 2005; BC Renal, 2022; Fistula First, 2015; Vachharajani, 2010). See *Clinical consideration: Routine Use of Tourniquets for Cannulating AV Fistulas* on page 14.
- Do not use tourniquet or BP cuff when cannulating standard arteriovenous grafts (AVGs) (Vachharajani, 2010). Follow unit protocols and manufacturer's recommendations for use of tourniquets on HeRO grafts.
- Identify any collateral veins and/or areas of concern such as decreased size of vessel, hard or bruised areas, or tortuosity. These areas should be avoided and not selected for needle placement.
- The areas of the vein chosen to cannulate should be at least 1 inch in length to accommodate the length of the fistula needle in order to achieve optimal needle placement. Place the needle at least 2.5 cm (~1 inch) from the anastomosis and with approximately 5 cm (~2 inches) between the tip of the arterial and venous needles (Ball, 2005; Fistula First, 2015; Schmidli et al., 2018). Consider type and length of needle used.
- For "wet" or "dry" cannulation, follow unit protocols and practices. Wet cannulation involves flushing the fistula needle with normal saline prior to insertion.
- Cannulate slowly to prevent infiltration of the vessel wall. Thread the needle down the center of the access using approximately a 25-degree angle (fistula) for superficial accesses or 45-degree (graft) angle (CPG-VA, 2006). Once flashback is seen, level the needle (flatten the angle) to the skin level and slowly advance the needle into the access (BC Renal, 2022).
- Determine needle patency by assessing quality of flashback prior to initiating dialysis treatment. Flashback should be brisk. Flush the needle with normal saline and repeat steps with a second needle. If the flashback is sluggish or absent, DO NOT FLUSH NEEDLE. Assess needle position with portable ultrasound and carefully reposition the needle as needed. See section on placement of needles and troubleshooting needle placement in Table 1: Guidelines for cannulation of AV fistulas and AV grafts.
- Ensure your angle is reflective of the depth of the access. For deeper accesses, sharpen angle of needle insertion (based on clinical exam and/or portable ultrasound evaluation). The three-point technique involves pulling back on the skin to help stabilize and immobilize the vessel (Ball, 2006; BC Renal, 2022; NKF, 2006). The "L" technique includes holding the thumb and index finger in the shape of the letter "L", the thumb is used to hold the skin taut over the fistula and the index finger is used to stabilize and engorge the fistula (Fistula First, 2015).
- BC Renal (2022) recommends leaving the last 2 mm of metal part of the needle exposed to prevent the hub of the needle from touching the entrance sites and prevent scab formation in buttonhole sites (Ball, 2012).
- The venous needle should be placed in the direction of the blood flow (antegrade) and the arterial needle can be placed in the direction of the blood flow or against the direction of blood flow (retrograde). The direction of the arterial needle should not influence the risk of recirculation unless the flow in the VA is less than the blood flow rate (Brouwer, 2005; Hartland, 1994; English, 2005; Ozmen et al., 2008).
- See Table 1: Guidelines for cannulation of AV fistulas and AV grafts and Flowchart 1: Complications of cannulation.

Clinical consideration: Infection prevention. Patients on dialysis have more Staph Aureus on their skin and in their nares than the general population, making it all the more important for them to wash their access arm prior to coming to the dialysis chair (Kaplowitz et al., 1988; O'Grady et al., 2011). The Centre for Disease Control (CDC) (2011) recommends more stringent precautions for hemodialysis units because of the increased potential for contamination with blood and pathogenic microorganisms. Infection control practices for hemodialysis units restrict the use of common supplies, instruments, medications, and prohibit the use of a common medication cart. Other potential risk factors for vascular access infections include location of the access in the lower extremity, recent access surgery, trauma, hematoma, dermatitis, scratching over the access site, poor patient hygiene, and poor needle insertion technique (CDC, 2001).

Clinical consideration: Needle placement (bevel position and direction of cannulation). A recent observational study by Parisotto et al. (2017) found that retrograde cannulation of the arterial needle with the bevel down was associated with an increased risk of access failure (18%) and formation of hematomas and aneurysms, possibly owing to the related venous return of the blood (i.e., retrograde filling). The authors suggest that antegrade puncturing of the arterial needle with bevel up may be considered fistula protective by the same reasoning—that is, tract closure through flow force. These findings are consistent with observations by Woodson and Shapiro (1974), who reported that retrograde puncturing may be associated with increased hematoma formation.

Table 1

Guidelines for cannulation of AV fistulas and AV grafts

Standard	Guideline	Reference
Cleansing of the cannulation sites	✓ Select cannulation sites ✓ Cleanse the skin using antibacterial soap ✓ Cleanse the skin using 2% Chlorhexidine gluconate solution with alcohol (drying time 30 seconds), Povidine-iodine (drying time 2–3 min), or approved facility solution, using friction and a circular motion ✓ Allow cleansing solution to dry thoroughly prior to needle insertion–do not blot area dry	Ball, 2005; Boelaert et al., 1996; Jindal et al., 2006; Kaplowitz et al., 1988; NKF, 2006; O'Grady et al., 2011; RNAO, 2005
Placement of needles	✓ 4–5 cm (1.5–2 inches) apart, hub to hub, if needles in the same direction on the same limb, as fistula length allows ✓ 2.5 cm (1 inch) apart, hub to hub, if needles in opposite direction ✓ 1.5–2 cm from the anastamosis ✓ Insertion site or needle tip once inserted, 4 cm (1.5 inches) away from the anastomosis ✓ Determine needle patency by assessing quality of flashback prior to initiating dialysis treatment. Flashback should be brisk. Gently flush needle with normal saline and repeat steps with second needle. If flashback is sluggish or absent, DO NOT FLUSH NEEDLE. Assess needle position with portable ultrasound and reposition needle as needed ✓ Cannulation techniques include rotation of cannulation sites using a rope ladder technique or constant site cannulation using BH cannulation method	Ball, 2005; Brouwer, 1995; Fistula First; 2015 Northwest Renal Network, 2006 BC Renal, 2022, Recommendation 8: Use of the BH Cannulation Method
Selection of needle gauge and type (metal versus angiocaths)	To be determined based on the following: ✓ Fistula maturation during clinical assessment— recommend 17 gauge needle for first attempts ✓ Use 17 gauge for approximately one week with two needle cannulation without complication or infiltration ✓ Increase needle gauge as successful cannulations are achieved, aiming for long-term use of 15 gauge needles (where possible) ✓ For cannulation of AV grafts, suggest using 2–16 gauge needles for initial cannulation and advancing to 15 gauge for subsequent cannulations ✓ Consideration should be given to blood pump speed and needle gauge ✓ Consider the 2:1 rule – arterial and venous pressure should not exceed 50% of the pump speed e.g., 400 mL/min blood pump speed, arterial and venous pressure should be -200/200 mm/hg respectively ✓ Arterial and venous pressure should not exceed -250 or 250 mm/hg to avoid damage to the access	BC Renal, 2022; Brouwer, 2005; Fistula First, 2015; Northwest Renal Network, 2006 BC Renal, 2022 BC Renal, 2022; NKF, 2006 BC Renal, 2022; NKF, 2006
Personal protective devices and aseptic techniques (Standard Precautions)	✓ Strict hand washing ✓ Eye protection (face shield or goggles) ✓ Mask ✓ Gloves ✓ Use according to unit standards to ensure staff protection	BC Renal, 2022; CDC, 2001; O'Grady et al., 2011
Direction of needle placement	✓ Venous needle must be placed towards the direction of blood flow (antegrade), for example facing venous outflow of AV access ✓ Arterial needle may be placed antegrade or retrograde (against the blood flow), for example facing arterial anastamosis. In a loop AV graft, if the needles both face upward, the arterial needle would then be retrograde. Increased access failure has been described with retrograde	Brouwer, 1995; Fistula First, 2015 Parisotto et al., 2017

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Standard	Guideline	Reference
Bevel position/ flipping of needle	✓ This remains a controversial issue. Increased access failure has been described with retrograde direction of the arterial needle and bevel down cannulation, and possibly improved access survival with antegrade direction of the arterial needle and bevel up cannulation ✓ Avoid flipping the needle as this can cause coring of the vessel ✓ Flipping needles should be discouraged. If flipping is necessary due to increased needle pressures, this must be done carefully to avoid damage to access; consider using fistula needles with a back-eye to prevent the need for flipping needles ✓ When available use portable ultrasound to determine optimal cannulation sites and assess needle position, prior to re-positioning the fistula needle	BC Renal, 2018; Brouwer, 2005; Fistula First, 2015; NKF, 2006; Northwest Renal Network, 2006; & Parisotto et al., 2017
Angle of insertion	✓ Fistula — 20–35 degree angle (depending on vein depth) ✓ Graft — 45 degree angle ✓ Angle of insertion is based on clinical assessment and use of portable ultrasound	BC Renal, 2018; Brouwer, 2003; Fistula First, 2015; NKF, 2006
Application of local anesthetic	✓ Reserve use in patients who are concerned/experiencing discomfort and pain/fear associated with needle insertion ✓ Obtain order from Nephrologist or NP and follow unit protocols ✓ Minimum amount of Lidocaine 1 -2 % injection should be used (0.2 mL) ✓ Lidocaine injection is painful, and there is added risk of accidental intravenous infusion ✓ Several different anesthetics are available for needle insertions (intradermal lidocaine, Ethyl Chloride spray and topical anesthetic creams such as Lidocaine 2.5% prilocaine 2.5% (EMLA®). Ethyl Chloride is not sterile and therefore must be applied prior to the antimicrobial prep. Patients should be questioned about possible allergies prior to considering anesthetic for needle insertion ✓ If topical cream is used, always remove cream and cleanse access arm prior to cannulation	BC Renal, 2018; Brouwer, 1995; Fistula First, 2015 Ball, 2005 Ball, 2005; BC Renal, 2018 Fistula First, 2015
Number of attempts	✓ When available, assessment of needle position and vein depth/diameter with portable ultrasound is recommended ✓ If cannulation is unsuccessful or infiltration occurs, seek assistance from expert cannulator, clinical educator, VAC, or VA nurse ✓ If unable to aspirate blood from needle, DO NOT INSTILL SALINE or BLOOD ✓ General rule of thumb: If in doubt that needle has infiltrated, remove the needle to minimize vessel damage. Apply ice to site. If patient has received heparin, the decision to leave the needle in place may be appropriate. Follow unit protocols and practices ✓ After an additional attempt by an expert cannulator, consider appropriateness of continuing to attempt cannulation or perform single needle dialysis (when available) ✓ If infiltration occurs, consider resting the access until infiltration and bruising has resolved. Always consult the Nephrologist or NP and follow unit protocols for adjustment of systemic heparinization during dialysis treatment ✓ Following infiltration, immediately apply ice which can help decrease the pain and size of the infiltration and may decrease bleeding time. Follow unit protocols and procedures. ✓ For number of attempts, follow unit protocols. After 1 failed attempt, consult expert cannulator, clinical educator, VAC, or VA nurse ✓ (See Flowchart 1: Complications of Cannulation)	Northwest Renal Network, 2006 BC Renal, 2013; Thomas-Hawkins, 1995; NKF, 2006 Fistula First, 2015; NKF, 2006

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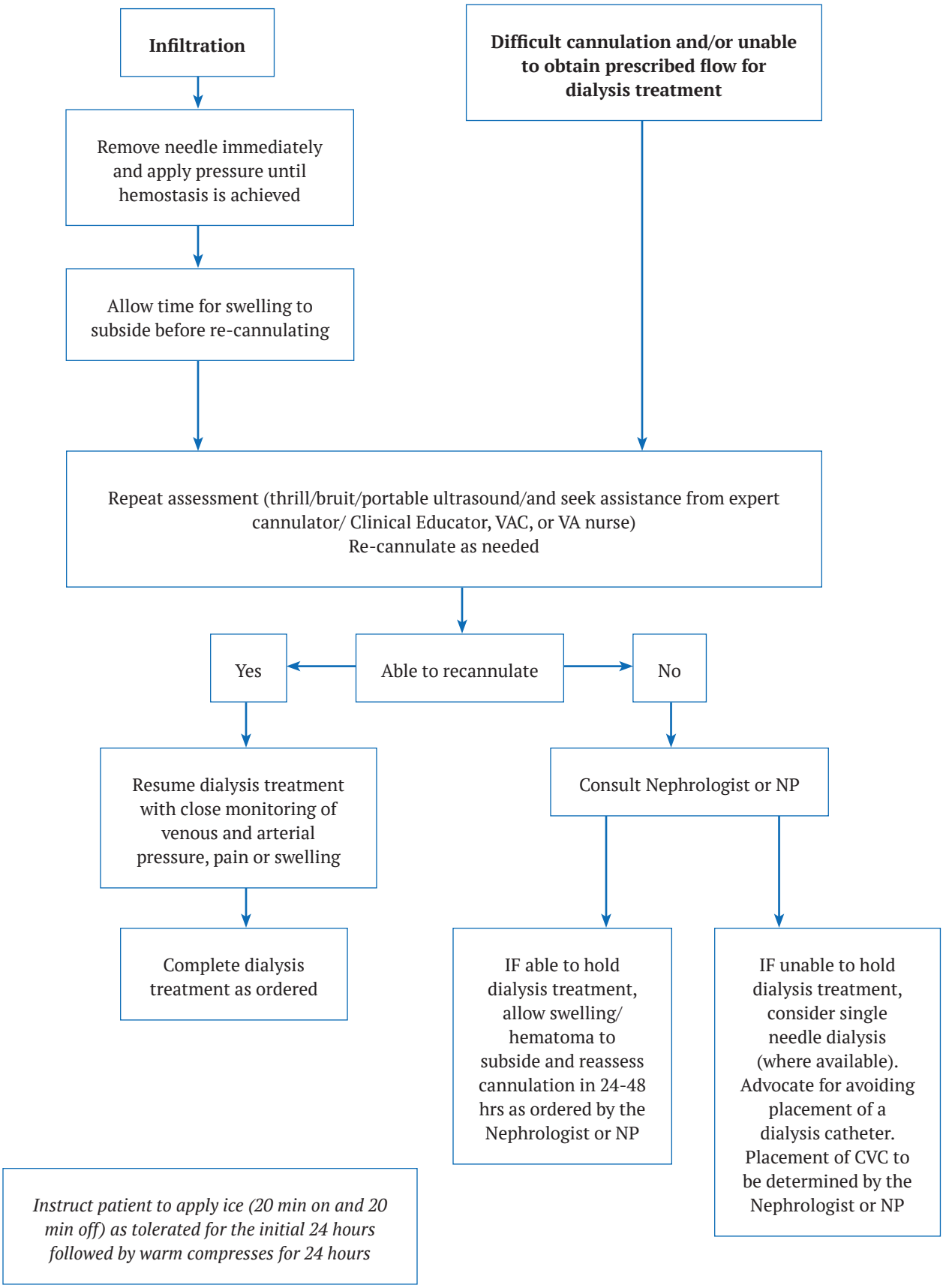
Standard	Guideline	Reference
Securing of needles	✓ Needles should be secured at the same angle of advancement to avoid change in needle position and minimize risk of infiltration ✓ Follow unit policies for taping and securement of needles ✓ Needles should be well secured during treatment to avoid accidental malposition or dislodgment of needles ✓ Access limb and connections should be visible at all times and should not be covered with blankets. Inspect needles at each patient check and follow unit policies	BC Renal, 2013; Fistula First, 2015
Needle Removal and Hemostasis	✓ Needles should be removed at the same angle of insertion ✓ Do not apply pressure while the needle is in the vein ✓ Once the needle is completely removed, use a 2-digit technique (one finger at the skin level and one at the vein level) for maximum hemostasis (see Figure 6: Two-digit technique) ✓ Dispose of the needle as per unit protocols in a sharps receptacle and follow Occupational Health standards	Fistula First, 2015; NKF, 2006; Ball, 2005; BC Renal, 2013. Fistula First, 2015; See Figure 7: 2-digit technique and Recommendation 10: Needle Removal and Hemostasis
	✓ Hold each site for a minimum of 10 min without releasing pressure. While applying pressure, ensure a thrill can be felt in the access ✓ If thrill cannot be felt, slowly ease up on digital pressure and assess thrill	Fistula First, 2015 BC Renal, 2013; Fistula First, 2015
Troubleshooting Needle Placement and increased venous and/or arterial pressures. (Follow steps in the order listed)	✓ Decrease blood pump speed or stop blood pump and assess site for infiltration ✓ Measure blood pressure and review previous clinical records to determine baseline blood pressure, venous and arterial pressures and achieved blood flow (Qb) ✓ Assess thrill and bruit and observe for infiltration (swelling) ✓ Carefully reposition access limb ✓ Always use portable ultrasound to check position of needle prior to re-positioning or adjusting needle (when available) ✓ Carefully adjust tape or place a small gauze under the needle wings (as needed), while closely monitoring venous and arterial pressures ✓ If successful, secure needle in position with tape while monitoring venous and arterial pressures. Maximize blood pump as tolerated ✓ If unsuccessful, recirculate patient's blood and recheck needle position with portable ultrasound ✓ Apply tourniquet, reassess needle patency using a 10 mL syringe of 0.9% normal saline, carefully reposition the needle as needed and confirm needle position with portable ultrasound (when available) ✓ If repositioning is unsuccessful, promptly remove fistula needle ✓ Prior to re-cannulation, seek assistance from an individual deemed to have expert cannulation skills, clinical educator, VAC, or VA nurse ✓ Repeat clinical assessment of AV access (thrill, bruit and portable ultrasound) prior to repeating cannulation. ✓ Avoid repeated cannulation and follow unit protocols and practices	Persistent intradialytic hypotension can increase risk of vascular access thrombosis (Chang et al., 2011) For BH cannulation technique, See Recommendation 9: Troubleshooting for BH Cannulation. See BC Renal, 2018; Thomas- Hawkins, 1995; and Flowchart 1: Complications of Cannulation

Flowchart 1

Complications of cannulation



Clinical consideration: The literature on treatment of infiltrations is limited. Fistula First recommends applying pressure to the site for 10–12 minutes until bleeding has stopped, followed by ice or a cold compress on site for 20 minutes on and off for the initial 24 hours to reduce swelling and pain, and a warm compress for 24 hours thereafter.

The skill of cannulation:

Cannulation is a learned skill that generally improves with practice and years of experience (Wilson et al., 2010), and an essential skill for hemodialysis nurses (Harwood et al., 2017). Developing and improving expertise in cannulation is critical to the viability of the AV access and to the patient's experience (Moore & Mott, 2009; Schmidli et al., 2018; Harwood et al., 2017). Lack of knowledge and skills can lead to unsuccessful cannulation and have a major implication for patients (van Loon, 2015), resulting in an inability to provide HD treatment and potentially necessitate the need for placement of a CVC (Harwood et al., 2016; Wilson et al., 2010).

Cannulation complications include hematomas, aneurysmal formations, infection, infiltrations, missed cannulation, central venous catheter placement, prolonged catheter dependency, numerous procedures, and access loss (BC Renal, 2022; Lee et al., 2006; van Loon et al., 2009; Schmidli et al., 2018). According to Harwood et al., (2016), "the nurses' approach, attitude and skill with cannulation impacts greatly on the patient experience." (p. 30).

Pifer et al., 2002 and van Loon et al., 2010 reported an 11% decrease in AVF and AVG failure with each 20% increase in the percentage of experienced HD staff. Experience was defined as a nurse with more than three years of experience. van Loon et al, 2010 recommend "careful consideration of individual AV accesses and patient awareness and skills of the dialysis nurse, frequent monitoring, and a continued evaluation and education of cannulation technique." Harwood and Wilson, 2017 examined patients' perspective in defining cannulation success and identified the following themes: pain and anxiety; a friendly nurse/patient relationship; nurses technical skills during cannulation; and the impact of the environment.

Nephrology nurses have the primary responsibility to assure the highest quality cannulation to preserve vascular access integrity, prevent access complications and improve patient outcomes. This responsibility includes incorporating best practices for AV access cannulation by promotion of expert cannulators and formal cannulation protocols (ANNA, 2013). Bay et al., (1998) found that nurses ranked difficult cannulation as their main concern associated with the dialysis treatment. Wilson et al., (2015) report some nurses remain in a state of perpetual novice. It takes experience and skill development for HD nurses to successfully cannulate AVFs (Robbin et al., 2002). Tordoir et al. (2007) report that any staff involved in handling or cannulating AV accesses should be adequately trained and be in a continuous training scheme for access management (Guideline 4.2). Pile (2004) suggests the need for education, protocols and procedures, and mentoring of staff that care for AV access as being critical to successful patient outcomes. KDOQI (2019) state that "ideally all nurses, technicians, patients and physicians cannulating an AV access should have a level of proficiency such that all new and established AV accesses can be cannulated with the same degree of comfort, reliability, and success." (pg S74).

Clinical consideration: The CANNT working group recognizes that cannulation experience and expertise varies from centre to centre and that expertise in the skill of cannulation is not always related to years of dialysis experience. Cannulation expertise and improvement of cannulation skill requires opportunity and a commitment by the nurse to advance and improve his or her skills; conducting a thorough assessment using a portable ultrasound to guide cannulation (when available); identifying learning needs and seeking assistance from staff responsible for skills training; and meeting established competencies as outlined by the centre. It is the opinion of the CANNT working group that cannulation competency is best determined by the clinical educator, vascular access coordinator or vascular access nurse, and that incorporating these recommendations and developing local strategies to improve cannulation skills for nurses will lead to more successful cannulations and fewer missed cannulations and, ultimately, improve patients' and nurses' experiences. (See Table 2)

Table 2

Rating levels for cannulation
Matching Skills of Cannulators and Vascular Access (Adapted from the BC Renal, 2013)

Classification	Types of Accesses (AVF and AVG)
Novice (less than 2 years)	Easy, complication-free accesses. Does not cannulate new accesses or initiate BH tracks
Skilled (2 years +)	Easy or moderately complicated accesses. New accesses deemed easy. Does not initiate BH tracks
Expert (3 years +)	Easy, moderately complicated or complicated accesses. All new accesses and observes cannulation skills of colleagues and offers feedback/ troubleshoots. Forms/creates/ and initiates BH tracks

Rating Levels (Northwest Renal Network, n.d.)

Employee Description	Rating Level for Cannulating
New employee with no previous cannulation experience	1
New employee with previous experience, or current employee advancing their rating	2–3
Most experienced cannulator	4

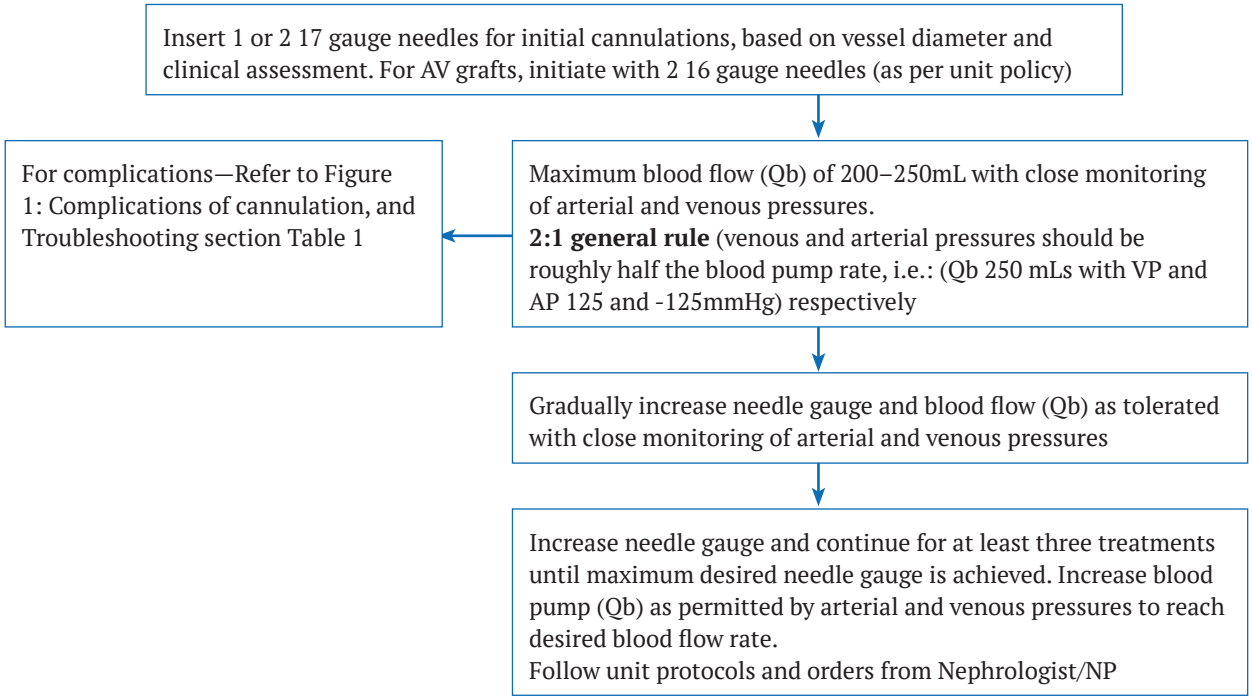
RECOMMENDATION 6: CANNULATION OF A NEW AV FISTULA AND GRAFTS WITH NO EXISTING CENTRAL VENOUS CATHETER

Cannulation should be approached according to Recommendation 3, 4 and 5 and as follows:

- Schedule the first dialysis treatment during a non-rush/low patient turnover time to allow for a relaxed atmosphere/environment (BC Renal, 2022; NKF, 2006).
- For AV fistulae, cannulation readiness or fistula maturation is best determined by dialysis nurse's expert assessment. Timing for initial cannulation should be based on clinical assessment, rather than a time-bound, eight-week rule (Banerjee et al., 2008; Banerjee, 2009).
- For AV grafts, cannulation is not recommended during the first two weeks after surgery. Discuss timing for initial cannulation with the Vascular Surgeon and follow unit protocols and manufacturer's recommendations regarding timing for first cannulation and needle gauge.
- For AV grafts, initial cannulation for the first two weeks should be performed by nurses with recognized expertise in cannulation of AV grafts to minimize the risk of infiltration, trauma and backwall punctures of the graft.
- For AV fistulae, initial cannulation for the first two weeks should be performed by nurses with recognized expertise in cannulation to minimize risk of infiltration and trauma to the fistula, and placement of a central venous catheter (Ball, 2005; BC Renal, 2022; Fistula First, 2015; NKF, 2006; Harwood et al., 2016; Thomas-Hawkins, 1995). (See Flowchart 2: Cannulation of New Fistula - No Central Venous Catheter).
- For AV fistulae, start Qb at 50 mL/min and slowly increase blood flow by 50 mL/min while closely monitoring the venous and arterial pressures. Qb should be set at a maximum of 200-250 mL/min. Follow unit protocol and practices and orders from the Nurse Practitioner or Nephrologist. For subsequent cannulation, increase Qb slowly over the next two weeks, not exceeding Qb of 300 mL/min (BC Renal, 2022; expert-informed opinion).
- For all new and challenging AV accesses, cannulation should be performed by nurses with an advanced level of expertise in successful cannulation (Ball, 2005; BC Renal, 2022; Fistula First, 2015; Hakim & Himmelfarb, 2009; NKF, 2006). Selection of skilled cannnulators can reduce the incidence of trauma, improve cannulation success, and may help to reduce early fistula failures (Hakim & Himmelfarb, 2009; Pifer et al., 2002), *(See table 2)*.
- Positioning the patient's access arm prior to cannulation will enhance their comfort and minimize malposition of needles that can occur with arm movement. For upper arm accesses, extend the access arm horizontally on a pillow to allow better visualization of the entire access, thereby optimizing needle placement and limiting patient's ability to pull arm back during needle insertion using site rotation or BH cannulation technique (Fistula First, 2015; Mott & Prowant, 2006). *See Figure 5: The Cushion Cannulation Technique.*
- Instruct the patient not to move their access arm during cannulation and while needles are in place. Monitor the patient closely to ensure that the patient is comfortable at all times and avoid any sudden movement or adjustments of the access arm.
- If available, set up for single needle dialysis for the first two weeks, especially for AV fistulas (Wilson et al., 2009).
- If cannulation with two needles is unsuccessful, perform single needle dialysis (Wilson et al., 2009).
- Always consult the VAC, VA nurse, clinical educator, NP or Nephrologist and follow unit practices and protocols.

Flowchart 2

Cannulation of New AV Fistula – No Central Venous Catheter



RECOMMENDATION 7: CANNULATION OF A NEW AV FISTULA WITH AN EXISTING CENTRAL VENOUS CATHETER

Although the preferred VA for hemodialysis (HD) is an AV access (AVF or AVG), patients who require urgent or acute HD therapy prior to AV access creation or maturation will require placement of a central venous catheter (CVC). For risks of long-term CVC use, see Chapter 2: Recommendations for central venous catheter management in HD patients.

Recommendation 1: Long-term use of CVC.

For patients with dual accesses (CVC and AVF or CVC and AVG), see Flowchart 3: Cannulation of a new AV fistula with an existing CVC, which outlines an approach to cannulation with the goal to achieve successful cannulation, minimize trauma to the AV access, nurture a positive experience for the patient and the nurse/cannulator, and ensure safe and timely removal of the CVC. According to DOPPS data, delayed cannulation may inadvertently act as a barrier to AVF use and promote CVC use and exposure to catheter-related risks (Mendelssohn et al., 2006).

All steps in this procedure should be completed over no less than a two-week timeframe (expert-informed opinion).

Step 1

The first time the AV fistula is cannulated, the decision to use one or two needles should be based on the vessel size and clinical assessment of the AV access (expert-informed opinion). If one needle is used, it is recommended that the first cannulation is used for arterial supply (BC Renal, 2022). Hold circuit anticoagulation until successful cannulation is achieved (expert-informed opinion). If cannulation is unsuccessful, consult with a Nephrologist and/or NP to determine if anticoagulation should be initiated or blood flow rate adjusted (BC Renal, 2022).

This will allow for:

- ✓ Assessment of maturity of the AV access and sufficient arterial inflow to the AV access
- ✓ Decreased risk of infiltration (and therefore a more positive experience for the patient and the nurse/cannulator)
- ✓ Set initial Qb at 200–250 mL/min with close monitoring of venous and arterial pressures. Maximum venous and arterial pressure limits are 250 mm Hg and -250 mm Hg respectively (BC Renal, 2022; NKF, 2006).
- ✓ If infiltration occurs or cannulation is unsuccessful, hold cannulation until swelling or hematoma resolves and then reassess cannulation at the next scheduled dialysis treatment.

Follow unit protocols and consult the Nephrologist or NP (See Flowchart 3: Cannulation of a new fistula with an existing CVC) and follow Recommendation 3: Assessment of the AV access.

Step 2

Monitor and documenting dynamic venous pressures (DVP) with Qb of 200 mL/min during the first two to five minutes of each hemodialysis treatment provides trending of usual venous pressures for each individual patient in order to provide a standard method for identifying VA dysfunction (Jindal et al., 2006; Whittier, 2009). A baseline value and changes three times in succession from baseline has been shown to significantly predict presence of stenosis in the VA (Schwab et al., 1989).

Arterial and venous pressure limits should be roughly half of blood pump speed 2:1 rule (100-125 mm/hg) (evidence-informed opinion).

Step 3

The techniques for cannulating AV fistulas include rope ladder (site rotation and optimizing the entire length of the fistula) or BH. For BH cannulation technique, see Recommendation 8: Use of the BH cannulation method, and follow unit protocols and practices. BH cannulation technique is not recommended for cannulating AVG. Always follow unit protocols and manufacturer's recommendations.

Step 4

The AV fistula should be cannulated successfully with two needles for six consecutive treatments (with no infiltrations) prior to removing the CVC (Fistula First, 2015; NKF, 2006; National Renal Network, 2006). For removal of CVC for patients with AVG, follow unit protocols and consult with the VAC, VA, Nephrologist or NP.

NKF-KDOQI Guidelines (2019) suggest obtaining baseline access flow measurements and incorporating Transonic® flow measurements as part of your program's AV access surveillance program.

Step 5

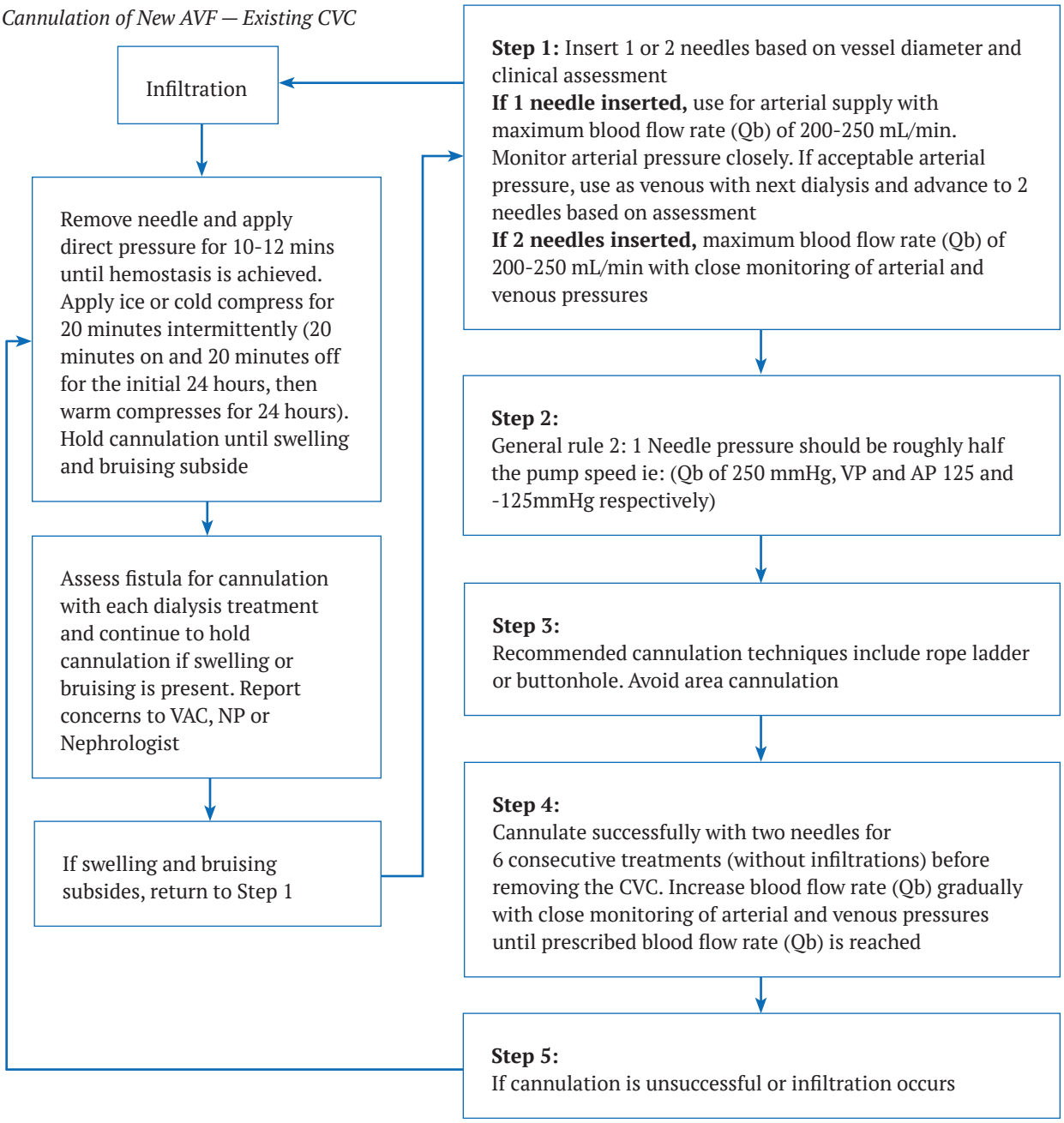
If cannulation is unsuccessful or infiltration occurs, cannulation should be held to avoid trauma or damage to the AV access. If infiltration occurs or bruising or swelling is noted, follow unit protocols regarding systemic heparinization during dialysis treatment and consult the Nephrologist or NP. Cannulation of the AV access should be assessed with each dialysis treatment based on clinical assessment of the AV access (See Recommendation 3, 4, 5 and Flowchart 3: Cannulation of a new fistula or AV graft – Existing CVC).

RECOMMENDATION 8: USE OF THE BUTTONHOLE (BH) CANNULATION METHOD FOR AV FISTULAS

Buttonhole cannulation (BH) technique involves insertion of arterial and venous needles by a single cannulator in the same site, at the same depth and angle for each HD treatment, thereby creating a tunnel track (Ball, 2005; Ball, 2012; Fistula First, 2015; MacRae et al., 2012; Twardowski & Kubar, 1979; Twardowski, 2011; Zimmerman & Lok, 2012). BH cannulation sites should be selected carefully in areas without aneurysmal formation. BH is a cannulation technique that may prolong the use of an AV fistula, salvage a fistula not deemed useable due to short length (< 2 inches or 5 cm) or severe tortuosity (Wong & Storie et al., 2014; Ball, 2006; Ball, 2010; Besarab & Brouwer, 2004). Ease of needle insertion, fewer infiltrations, reduced aneurysmal size, and reduced pain have been suggested as benefits of BH cannulation technique (Marticorena et al., 2006; Toma et al., 2003; Twardowski & Kubar, 1979; Verhallen et al., 2007; Twardowski, 2011). Zimmerman & Lok, (2012) reported no reduction of pain with needle insertion, however, Chow et al., (2011), van Loon et al., (2010), & Tordoir, (2010), report that patients experienced more pain.

Flowchart 3

Cannulation of New AVF — Existing CVC



Clinical consideration: BH cannulation is not recommended for use with AV grafts. Avoid multiple cannulators or cannulators who are inexperienced with BH cannulation technique. Follow unit protocols and manufacturer's recommendations.

BH cannulation technique is associated with an increased risk of infection (Chow et al., 2011; MacRae et al., 2012; Nesrallah et al., 2010; O'Brien et al., 2012; Zimerman & Lok, 2012). Meticulous cleaning techniques and scab removal is imperative. Programs should develop strict inclusion and exclusion patient selection criteria, incorporate selective use of BH cannulation technique (Zimmerman & Lok, 2012), and give careful consideration when implementing BH cannulation techniques for in-centre HD patients (Marticorena et al., 2006) to include HD nurses who are specially trained in BH technique (MacRae et al., 2012).

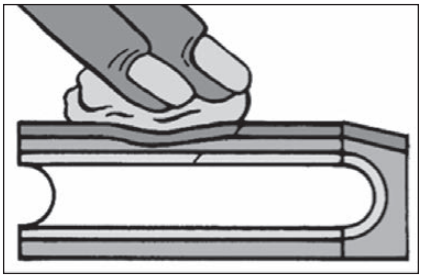
Routine prophylaxis use of topical mupirocin or Polysporin® triple antibiotic ointment at the BH sites after needle removal is recommended with favorable results (BC Renal, 2022; Fistula First, 2015; Marticorena et al., 2006; Nesrallah et al., 2010; Birchenough et al, 2010). O'Brien et al. (2012) recommend routine audits and tracking of infection rates. A recent study by Ludlow (2010) reported that although BH cannulation did provide significant improvements (patients reported decreased pain with venous and arterial needle placement), there was an increase in the infection

rate and additional cost of BH procedure related to supplies. Due to the associated increased risk of infection and adverse consequences with BH cannulation, KDOQI, 2019 suggest it reasonable to limit its use to patients with special circumstances.

Parisotto et al. (2014 & 2017) recommends that when considering BH cannulation, it is important to take into consideration that BH cannulation is a practice performed in centres with highly trained personnel who work with strict protocols and that it may also be used for fistulas with only short segments available for cannulation.

Figure 6

Two-digit technique. Image copyright BC Renal, 2022. Used with permission.



Inclusion and exclusion patient selection criteria for BH cannulation technique include the following: (St. Joseph's Hospital, 2009; Verhallen et al., 2007).

Inclusion:
- Limited cannulation sites due to short fistula segment (<2 inches or 5 cm) or tortuous fistula
- Difficult cannulation
- Frequent infiltration
- Daily dialysis
- Self-cannulators
- Aneurysm development
- Patient refusal to random needle techniques

Exclusion:
- Thin subcutaneous tissue
- Valvular heart disease including mechanical heart valve, rheumatic heart disease, and history of previous endocarditis
- Recurrent staphylococcus infection
- Persistent skin irritation or local infection along access arm
- Other prosthetic material which could cause serious problems if infected (for example permanent pacemaker)
- Immune suppression such as lupus, patients on prednisone or failed transplants
- AV grafts (follow manufacturer's recommendations and unit protocols)
- If the patient has one or more exclusion criteria, the use of BH cannulation technique should be determined in consultation with the Nephrologist, with risks discussed with the patient, and outcomes documented in the patient's chart.

Programs are encouraged to offer self-cannulation opportunities to patients who are interested and who demonstrate ability (ANNA, 2013; Fistula First, 2015).

Criteria for discontinuing BH cannulation technique include:
- Skin irritation seen at BH sites
- Patient non-adherence with established care of BH sites
- Development of any of the exclusion criteria.

A tunnel or track is a pathway that is created by the needle between the skin surface and the AVF lumen. The track collapses once the needle is removed at the end of the HD treatment and a scab forms on the skin surface.

Step 1: Guidelines for establishing BH tunnel track:
- Assign one primary cannulator for up to eight treatments or until a tunnel track is established. If one cannulator is not possible, a maximum of two cannulators is recommended. BH cannulation technique requires the primary cannulator to insert the needle at the same angle, site and depth of penetration with every cannulation in order to properly form the tunnel track and reduce damage to the track.
- Use a tourniquet for every cannulation even after the BH tunnel tracks are established.
- Approximately six to 10 cannulations with a sharp needle are necessary in order to establish a tunnel track (Fistula First, 2015, NKF, 2006). For diabetic patients or patients with poor wound healing, it may take 12–14 cannulations to establish a tunnel track (Ball, 2010).
- Primary cannulator(s) should continue until the patient successfully transitions to dull (blunt) needles.

Once a tunnel track is established, never use a sharp needle, unless a Nephrologist or NP has been consulted (BC Renal, 2022). This opinion is supported by Staaf and Uhlin (2019).They compared complications with blunt and sharp needles and found the patients cannulated with sharp needles experienced increased bleeding in between dialysis treatments, infiltrations, oozing, large scabs and major complications. However, an earlier study by Morcelli C. et al., (2015) demonstrated an increased incidence of failed cannulation using a blunt needle compared with using a sharp needle, although this was not significant, and found the use of a sharp needle did not result in any increase in complications. Patience, persistence and troubleshooting may be all that is required when difficulty is encountered. If the BH cannulation is not successful, then insertion of a sharp needle at least 20 mm away from the BH will facilitate access for the treatment (Ball, 2010).
- Create BH sites with ultrasound guidance (if available) to ensure entry into the centre of the vessel with each cannulation.
- For new AV fistulae, initiate cannulation with 17-gauge sharp needles for two treatments, then advance to 16 gauge sharp needles for two treatments, then 15 gauge sharp needles.
- For more established fistulae, use the same needle gauge that was used with previous cannulations.
- Use the same needle gauge when transitioning from sharp to dull needles (Fistula First, 2015).

Clinical consideration: The CANNT working group suggests that if unable to insert a dull needle into an established tunnel track a sharp needle may be inserted, and should be used only when necessary. Marticorena et al. (2006) describes a modified method for BH track creation that may be implemented in a busy hemodialysis unit.

Step 2: Creating and maintaining the BH sites:

- Have the patient wash both hands and the access arm with antibacterial soap upon arrival to the dialysis unit. This cannot be emphasized enough for all patients and, in particular, patients who are using the BH cannulation technique (Marticorena et al., 2006; Nesrallah et al, 2010).
- Strict adherence to contact times with the antiseptic agent aids to prevent infections (Fistula First, 2015; O'Grady et al., 2011).
- Cleanse the BH sites with Chlorhexidine 2% with 70% alcohol swab using a circular motion for 10 seconds, leave alcohol swab on BH site for additional 20 seconds with a total contact time of 30 seconds (St. Joseph's Hospital, 2007). BC Renal (2022) suggests never over-soaking the scab, as this may cause the scab to become mushy creating a challenge for removal.
- Remove scabs according to unit protocol being careful to maintain the integrity of the BH site.
- Never use the fistula needle or a sharp needle to remove scabs (Ball, 2010; BC Renal, 2022; Fistula First, 2015).
- Cleanse the BH sites again thoroughly with Chlorhexidine 2% with alcohol 70% (O'Grady et al., 2011) in a circular motion, as in surgical preparation, allowing for drying time. Ensure the entire scab is removed prior to cannulation.
- Each site must be treated separately for disinfection and scab removal.
- TIP – If scab removal is difficult or scab is deep, suggest stretching the skin in both directions to facilitate scab removal, instruct patient to tape alcohol swabs over BH sites or soak two 2x2 with normal saline or alcohol-based gel (Ball, 2010; Fistula First, 2015).
- Once the scab is completely removed, a second skin preparation is vitally important in order to kill any bacteria present following scab disturbance (Flynn & Linton, 2011).
- Use blunt needles once the tunnel track is established to access the fistula. Avoid using sharp needles once the tunnel track has been established, as sharp needles may damage the tunnel track by continued cutting of the BH tunnel track and create a new entry site to the vessel. Long-term use of sharp needles will cut adjacent tissues, enlarge the hole and result in bleeding along the needle path (Ball, 2010, Fistula First, 2015). See RECOMMENDATION 8: Use of the BH cannulation method and references.
- Use of antibiotic ointment to BH sites after each dialysis is strongly recommended and this practice should be routinely incorporated into unit BH cannulation procedure (BC Renal, 2022; Marticorena et al., 2006; Nesrallah et al., 2010).

Clinical consideration: Several authors have reported inflammation and infection in their BH patient population and recommend stringent cleansing of the BH sites both before cannulation and after needle removal (Ball, 2006; Marticorena et al., 2006; Twardowski & Kubara, 1979; Van Waeleghem et al., 2004). Twardowski and Kubara, (1979) recommend the use of a dressing after dialysis for 12 hours, and Marticorena et al. (2006) suggest the use of antibiotic ointment at the BH sites after dialysis for a period of six hours as prophylaxis against infection. A study by Nesrallah et al. (2010) suggests the use of a topical Mupirocin prophylaxis routinely after needle removal for all patients using BH cannulation technique. Patients should be assessed for other potential causes of BH site infection, such as MRSA nasal carriage, observation of cleansing and cannulation technique, skin colonization, and loss of skin integrity.

Contact dermatitis, also called eczema, is defined as an inflammation of the skin resulting from exposure to a hazardous agent (CDC, 2012). Contact dermatitis is a common occurrence in BH sites due to the antiseptic agent and prolonged contact with the skin in the same area. This can lead to serious infection and skin breakdown if not monitored regularly and promptly reported and addressed.

Common symptoms include:

- Dryness, flaking or scaly skin that is prone to breakdown and may develop cracks
- Erythema
- Pain or swelling
- Scaling
- Itching
- Visible skin breakdown or redness
- Formation of blisters or wheals (itchy, red circles, white centres)

CDC (2012) http://www.cdc.gov/niosh/topics/skin/#contact

Assess for contact dermatitis and infection and attempt to rule out the offending agent (e.g., tape, cleaning solution, fistula needles, and ointment). Always select an alternate site where skin is intact until the area is healed and consult the Nephrologist, NP, or dermatologist (when applicable).

RECOMMENDATION 9: TROUBLESHOOTING FOR BUTTONHOLE (BH) CANNULATION

Follow Troubleshooting Needle Placement in Table 1: Guidelines for cannulation of AV fistulas and AV grafts and steps in order listed below.

1. Re-positioning the access arm and re-applying tourniquet may change the position of the tunnel track.
2. Pull the skin behind the needle to try to straighten the tunnel track.
3. Use a portable ultrasound to assess needle position.
4. DO NOT manipulate the needle in and out of the tunnel track. This may create a false tunnel track.
5. If unsuccessful, remove the needle, wait 20 seconds.
6. Re-apply tourniquet and use a new dull needle, recannulate the BH site.
7. Cannulate slowly following the tunnel track. Place hands below the wings and use a gentle turning motion, side to side, NOT in and out of the tunnel track.
8. If unsuccessful, remove the needle and seek assistance from the primary cannulator or nurse with experience in BH cannulation.

9. Choose a new site away from the previous BH site. Cannulate slowly using a sharp needle.
10. If the patient does not have any other sites and the creator of the established site is not available, seek assistance from an experienced BH cannulator.

RECOMMENDATION 10: NEEDLE REMOVAL AND HEMOSTASIS

- Needle removal technique is important to protect the AV access from damage and to promote hemostasis.
- Needle removal should be performed at the same angle as the needle insertion.
- Pressure should not be applied to the needle insertion site until the needle is completely removed from both the vessel and the skin.
- Flipping the fistula needle after insertion or during treatment is strongly discouraged as this may cause coring or tearing of the vessel wall (BC Renal, 2022; Fistula First, 2015). Fistula First (2015) and NKF, (2006) recommend using fistula needles with a back-eye for both arterial and venous cannulation, which allows blood to enter from the bevel and the back-eye opening, thereby preventing the need for flipping the needle due to increased pre-pump arterial pressure. Follow unit protocols and practices.
- If the needle has been flipped after insertion, the needle should be flipped back before withdrawal to avoid coring of the vessel.
- To promote hemostasis, use a two-digit technique by placing one finger at the vein or graft puncture site (internal) and one finger at the skin exit site (external) (Ball, 2005). *See Figure 6: Two-digit technique.*
- Apply constant digital, localized, and direct pressure with two fingers (BC Renal, 2022; Fistula First, 2015).
- After needle removal, stabilize bleeding from needle site prior to holding site(s). If the patient, family member or caregiver is unable to hold the needle site(s), the nurse can perform this function.
- Gentle direct pressure should be applied to the needle site for a minimum of 10 minutes without releasing pressure. While applying pressure, ensure a thrill can be felt in the access. If a thrill cannot be felt, ease up on pressure and assess thrill (Brouwer, 1994).
- Once hemostasis is achieved, cover needle sites with gauze and tape or adhesive bandages (plain or specialty) with or without hemostatic agent. Follow unit protocols and practices.
- If gauze and tape are used, care must be taken not to wrap tape or dressing material circumferentially around the arm to avoid constricting blood flow to the AV access (Schmidli et al, 2018).
- Assess thrill prior to discharging the patient.
- The patient should be instructed to remove the dressing material four to six hours after their dialysis treatment (BC Renal, 2022). If bleeding occurs, instruct patients to apply firm, direct pressure for 15 minutes. If bleeding continues, patients should continue applying pressure and immediately seek emergency medical attention.
- *See Table 1: Guidelines for cannulation of AV fistulas and AV grafts; Needle removal and hemostasis.*
- *See Chapter 1: Recommendation 2: Patient education re: teaching patients to assess thrill and bruit daily.*

Compression devices:

If digital pressure to the needle site(s) is not possible, compression devices may be used. Always adhere to unit protocols and practices and follow Recommendation 10: Needle removal and hemostasis. Compression devices include fistula clamps, tourniquets, or straps. BC Renal (2022). Fistula First (2015) recommends not using compression devices on new and underdeveloped fistulas, apply one clamp at a time, assess bruit and thrill while clamp is in use, and suggests restricting use to include established fistulas with confirmed adequate flow volume, as measured with access flow (Qa) or duplex Doppler studies in ultrasound (Schmidtli et al, 2018). Adhere to infection control practices when cleaning compression devices and do not share compression devices between patients.

Tips to shorten hemostasis:

- Rotate cannulation sites – avoid repeated needling of one area (area cannulation).
- Avoid cannulation in aneurysmal areas (Schmidli et al, 2018).
- Avoid flipping needles (BC Renal, 2022; Fistula First, 2015; NKF, 2006). Review blood work to ensure dialysis adequacy and evaluate anticoagulation and bleeding times.

Clinical consideration: Prolonged hemostasis time may be a sign of venous outflow stenosis in a patient with normal bleeding times. If prolonged bleeding occurs, consult with the Nephrologist, NP, VAC, Clinical Renal Educator

RECOMMENDATION 11: SURVEILLANCE AND MONITORING OF THE AV ACCESS

The goal of surveillance and monitoring is to accurately identify AV accesses at risk of thrombosis and VA loss to identify patients' that most likely benefit from a pre-emptive intervention with angioplasty or surgical revision, while avoiding procedures that are unlikely to provide benefit (Schmidtli, 2018). "Stenosis in VA is the most common cause of thrombosis, the hallmark of stenosis is decreased blood flow in the access, and approximately 80% of VA fail due to thrombosis" (Tessitore et al., 2019; Allon, 2007; Miller et al., 2019; Miller et al., 2019. Access surveillance and management is an interdisciplinary team function (van Loon, 2015). The patient, Nephrologist, NP, nephrology nurse, VA coordinator, VA nurse, technician, Interventional Radiologist, Vascular Surgeon, and primary care physician should all be participants of the team (ANNA, 2013, Whittier 2009. All of this should be considered when assessing access concerns. This certainly can be a team approach and include the patient to note changes.

According to Polkinghorne (2013), it is important to emphasize the distinction between surveillance and monitoring. Surveillance refers to the practice of systematic monthly screening with diagnostic tests to diagnose VA dysfunction during or outside of HD treatments, for example, access blood flow (Qa) measurement, arterial static intra-access pressure ratio (SIAPR) and duplex Doppler ultrasound. An ideal surveillance method should quickly, accurately,

non-invasively, and economically evaluate access anatomy (e.g., stenosis) and function, and is intended to supplement clinical monitoring (Whittier, 2009; Allon et al., 2016a; KDOQI, 2019); Schwab et al, 1989 (in 2019); Beathard, 1992 (in 2019); Windus et al., 1990 (not in 2019); Schwab et al., 1987 (not in 2019); Collins et al., 1992 (not in 2019).

Monitoring is the regular review of the VA, primarily with regular physical examination and other ancillary tests or clinical findings of signs of access dysfunction during HD treatments, to provide a tailored approach for each individual patient Polkinghorne, 2013; Tessitore et al, 2014; (Schmidli et al., 2018). Physical examination and clinical monitoring and assessment are the keys to AV access maintenance and should be a part of the standard care of dialysis patients by nurses, caregivers, and patients (Asif et al., 2019; Campos et al., 2019; McLafferty et al., 2019; Leon & Asif, 2019; Leon et al., 2019; Paulson et al., 2019; Schuman et al., 2019; Tessitore et al., 2019).

Access blood flow measurement (Qa) is the most well-known surveillance method of indirectly measuring blood flow in the AV access (Krivitski, 1995a, KDOQI, 2000). Inaccuracy of Qa measurements can result from mixing during saline dilution, cardiopulmonary recirculation, and reversal of blood lines (Krivitski, 1998, Krivitski & Schneditz, 2004). "Although a decrease or low Qa is associated with increased risk of AV access thrombosis, this association does not have accuracy in predicting thrombosis. In fact, Qa and VP surveillances for AVGs were found to be inaccurate predictors of thrombosis and lead to unnecessary interventional procedures (Paulson et al., 1999; Dember et al., 2002; McDougal & Agarwal., 2001; Paulson et al., 2000; Ram et al., 2008). Qa by dilution method should be repeated two to three times to validate and confirm the results as there is a 5% expected variability between consecutive measurements (Depner & Krivitski, 1995; Krivitiski, 1995b). Muchayi Salman et al., (2015) reported that there is no consensus about the utility of Qa monitoring to predict stenosis of VA.

DVP monitoring is measured in the venous drip chamber and recorded during the first two to five minutes of HD treatment with QB rate set at 200 mLs/min. SIAPR is the pressure in the VA in the absence of extracorporeal blood flow prior to initiating HD treatment (Whittier, 2009). DVP is affected by needle gauge, length, and thickness and therefore, the utility of DVP in detecting or predicting stenosis is limited. Frinak et al., (2019) suggest that DVP, although easier to perform and record is considered less reliable than SIAPR and less sensitive and specific for assessing outlet stenosis, however, if measurements are averaged and trended with each HD treatment, DVPs have been found to be predictive of VA thrombosis.

KDOQI, 2019

"New and more rigorous evidence has reshaped some prior recommendations. For example, there is a de-emphasis on the need for AV access surveillance but a greater emphasis on the need for improved training and application of vascular access monitoring." (pg S17). See Guideline 13 AV access flow dysfunction - Monitoring/Surveillance (KDOQI, 2019 pg S28). KDOQI (2019) defines AV access dysfunction as "clinically significant abnormalities in AV access (AVF/AVG) flow or patency due to underlying stenosis, thrombosis or pathology." (S28).

Summary: Monitoring: KDOQI (2019) states that monitoring of AV access is primary and recommends regular physical examinations or checks of the AV access (AVF/AVG) by knowledgeable and experienced health care practitioners who have been trained to detect clinical indicators of flow dysfunction." (S28).

Summary: Surveillance: KDOQI (2019) states that there is inadequate evidence to recommend routine AV access surveillance by measuring access flow (Qa), pressure monitoring or duplex Doppler ultrasound, and action should not be based solely on surveillance findings."

KDOQI (2019) "does not recommend pre-emptive endovascular angioplasty of AV access stenosis in the absence of clinical findings, to improve access patency." KDOQI (2019) considers it reasonable for patients with consistently persistent clinical indications and underlying stenosis to undergo pre-emptive angioplasty to reduce the risk of AV access thrombosis and loss." (S28). KDOQI (2019) also considers it reasonable that when clinical monitoring suspects clinically significant AV access lesion (stenosis), further timely and confirmatory evaluation should proceed, including imaging of the dialysis access circuit. KDOQI (2019) defines dialysis access circuit as the continuum from the heart and the arterial inflow through the AV access to the outflow vein and back to the heart." (S29).

Whittier (2009) suggests that the percentage of access recirculation is useful in evaluating dialysis adequacy and clearance, however, it is less helpful in determining presence of stenosis. According to Smits et al., (2001) and Beathard (1994) if recirculation is measured at > 10%, stenosis should be suspected and prompt further evaluation.

Paulson & Work (2010) state that surveillance by measuring Qa and SIAPR is only useful as an ancillary method to help confirm clinical suspicion of stenosis or access dysfunction and should be used in combination with information obtained from clinical assessment and monitoring. According to Spergel (2004), there is no correlation between access flow (Qa) and SIAPR in AVFs or in AVGs. Access flow (Qa) and VP are, however, surrogates for stenosis rather than direct measurements. Although these tests are associated with thrombosis, they lack the predictive accuracy needed to be the sole basis for intervention referrals. Duplex ultrasound has the advantage of directly visualizing a stenosis while providing flow and velocity measurements that help determine the physiological significance of the stenosis. Thus, ultrasound may avoid inaccuracies inherent in surrogate measurements. Tonelli et al. (2019), reported that surveillance of AVFs was associated with a reduced risk of thrombosis but no improvement in AVF survival. For AVGs, there was no evidence that AVG surveillance by Qa or Duplex ultrasound reduced the occurrence of thrombosis and improved AVG patency or survival.

Clinical monitoring with physical assessment of the VA has an acceptable level of accuracy in detecting and locating stenosis, and the advantage of being inexpensive, quick, and easy to perform at the bedside for screening purposes, does

not require additional equipment, can be performed by multiple staff, and is applicable to all VAs (Salman & Beathard, 2013; Allon et al., 2019b).

"Many of the problems that occur in association with the patient's VA such as stenosis, can be detected by an accurate physical examination and clinical evaluation at each HD treatment" (Tessitore et al, 2014; Besarab et al., (1995). The Kidney Disease Outcomes Quality Initiative working group stated that "physical examination and clinical evaluation are skills that can be as valuable as any surveillance method" (CPG, 2006).

Monitoring should include clinical findings that have been associated with AV access dysfunction such as assessment of physical findings of persistent swelling of the arm, presence of collateral veins, prolonged bleeding after needle withdrawal, cannulation difficulties, clot aspiration, altered characteristics of pulse or thrill in outflow vein or graft; inability to achieve the prescribed dialysis blood pump flow rate (Qb); DVP; SIAPR, review of dialysis runs looking for trending changes in AV/VP, routine review of laboratory tests, or unexplained decrease in dialysis dose delivered (Kt/V) (Paulson et al., 2019; Tessitore et al., 2019 ; KDOQI, 2019; Kumbar et al., 2019; Schwab et al., 1989. Physical examination to detect stenosis has a positive predictive value of 70-80% in AVGs and specificity of 93% in AVF (Malik et al., 2002; Asif et al., 2007; Leon et al., 2019; Campos et al., 2019; Coentrao et al., 2019; Robbin et al., 2019. Changes in clinical findings should be documented and promptly investigated by means of duplex Doppler or angiography (Asif et al., 2019; Campos et al., 2019; Coentrao et al., 2019; Leon et al., 2019.

A randomized, controlled trial by Robbin et al (2019) found the "positive predictive value was 76% for prolonged bleeding from the needle puncture site, 58% for difficulty in cannulation, but only 30% for aspiration of clots". In addition, abnormalities detected by clinical monitoring had a 70% positive predictive value for hemodynamically significant AV graft stenosis compared with Duplex ultrasound, which had an 80% predictive value". Multiple studies report that "hemodynamically significant stenosis of > 50% is present in approximately 70-90% of patients who are identified to have abnormalities of clinical monitoring'" (Robbin et al., 2006; Maya et al., 2019; Cayco et al., 1998; Robbin et al.,1998; Safa et al.,1996.

There is a growing body of evidence that monthly or bi-monthly surveillance with Qa measurement with subsequent angioplasty in the AV access with low blood flows may not improve access outcomes, is costly, and may even be harmful (Abreo et al., 2010; Allon, 2019; Allon & Robbin, 2019; Paulson & White, 2019; Paulson, 2010; Paulson & Work, 2010; Tonelli et al., 2019. Paulson et al., (2019) emphasize the importance of physical examination and clinical assessment of VA using Qa and VP measurements. "The low yield of VA surveillance in predicting AV access thrombosis and improved AV access survival has led researchers to suggest that the current surveillance paradigm might be false and that perhaps there should be a search for a new paradigm." Allon, 2019a report that there is not enough evidence to support complex surveillance programs, and there is general agreement that simple clinical monitoring of fistula performance by dialysis center personnel is preferred and recommend that routine clinical assessment should be supplemented with non-invasive testing prior to angiography.

This complex, controversial subject is best discussed by answering the following questions:

1. *Does surveillance detect VA access stenosis?* The answer is yes. In fact, both an accurate physical exam and surveillance methods including lower access flows are associated with increased stenosis within the vascular access, particularly when the stenosis is at the venous anastomosis. Doppler ultrasound provides information about the anatomy and physiology of the patient's vascular access and is noninvasive and, therefore, is an attractive option for evaluating and monitoring HD VA (Sands, 2002). Furthermore, Sands et al., (2002) reported that Duplex Doppler ultrasound accuracy for identifying stenosis was 81% in AVFs, 86% for in-graft stenosis, and 96% for outflow stenosis in AVGs.
2. *Does surveillance predict thrombosis or clotting of the AV graft?* The answer is most probably no for grafts and maybe for fistulas. Access flow and VP surveillances were found to be inaccurate predictors of graft thrombosis (Dember, Holmberg & Kaufman, 2002; McDougal, & Agarwal, 2001; Paulson et al., 1999; Paulson et al., 2019; Ram et al., 2008. For example, Ram et al. (2008) studied 176 patients who underwent a total of 1,957 monthly Qa measurements over six years. They evaluated the accuracy of monthly Qa measurements, or percentage decrease in Qa, in predicting thrombosis within the next month. They found that Qa had a sensitivity of 80% at a false positive rate of 60%. The mean Qa in grafts that did not thrombose the next month was 1,345 mL/min (range 90–4000), and the mean in grafts that did thrombose was 895 mL/min (range 105– 2115). Hence, values overlapped widely. Moreover, the majority of thromboses were not preceded by a decrease in Qa measurement, usually because thrombosis occurred before a second measurement could be taken. The authors concluded that they did not support the routine application of Qa surveillance to predict AV graft thrombosis.
3. *Does surveillance predict thrombosis in the fistula?* The answer is probably yes. Qa surveillance of fistulae was associated with a significantly reduced relative risk of thrombosis, but no significant improvement in fistula survival (Tonelli et al., 2008). The positive result for fistula thrombosis should be considered tentative given that it is based upon only four studies of 360 subjects.
4. *Does intervention with angioplasty improve AV access function and survival?* It should be recognized that unnecessary angioplasty of a stable or slowly growing stenotic lesion may impair access survival. For example, Chang et al. (2004) demonstrated that angioplasty causes an increase in cellular proliferation that is associated with neointimal hyperplasia contributing to further stenosis, which is more common at the venous outflow (Lilly et al., 2001) and found more often in AVG (Maya et al., 2004 (in 2019); Beathard, 2005 (in 2019).

Allon (2019b) peer review process found that the evidence suggests that surveillance with pre-emptive angioplasty does not have a significant benefit in decreasing the frequency of graft thrombosis or achieving long-term graft patency. Allon (2019b) recommends clinical monitoring with routine physical examination of the graft weekly and noting any abnormalities during the dialysis session and/or unexplained decreases in the delivered dialysis dose (Kt/V). Abnormalities include problems with cannulation, aspiration of clots, inability to achieve the target dialysis blood flow, or prolonged bleeding from the needle puncture sites. Allon (2019b) recommends that abnormalities should be confirmed before proceeding to a fistulogram and preemptively identifying and treating stenosis necessarily results in a substantial number of superfluous angioplasties.

Malik et al., (2005) found that duplex Doppler ultrasound screening for AV access stenosis had more interventions and longer graft patency. Although there are several studies regarding AV access surveillance, according to Whittier (2009), "significant debate still exists in the literature regarding whether access surveillance is useful" and more evidence is needed to determining if screening is useful to detect and prevent thrombosis, especially in AVGs (Ram et al., 2008; Allon,(2019); Besarab, 2006; Paulson, 2005; Sands, (2019); and White et al., 2005, Ravani et al., 2016. The use of surveillance with fistulas is more encouraging, but does require individualization of patients and understanding of the trends in the access flow and the associated clinical findings (Tessitore et al., 2003; Tessitore et al., 2004; Ravani et al., 2016; Allon, 2019a; Allon, 2019b.

Further investigation of AV access function and dialysis adequacy should be prompted when:

- AV fistula access flow less than 500 mL/min or drop of more than 20% from previous value.
- AV graft access flow less than 650 mL/min or drop of 20% from previous value.
- Although less predictable the following tests have also been used. Percent of urea reduction (URR) on dialysis is less than 65% or Kt/V less than 1.2 (Jindal et al., 2006; NKF, 2006).
- Access recirculation is identified (Beathard, 2002; Jindal et al., 2006; Whittier, 2009).
- Trend analysis (three consecutive treatments) demonstrates needling difficulties, increase in venous or arterial pressure or episodes of prolonged bleeding.
- Post angioplasty and post embolectomy (within two weeks of intervention).

Access surveillance can assist with decisions around CVC removal. For patients with dual accesses (CVC and AVF or AVG), assess AV access function, dialysis adequacy and trend analysis to guide decision for timing of CVC removal.

Chapter 2: Recommendations for central venous catheter management in hemodialysis patients

INTRODUCTION

This section addresses the nurse's role in establishing and maintaining a functional central venous catheter (CVC). Management of other catheter-related complications such as infection, stenosis or catheter displacement is beyond the scope of these guidelines.

Nurses assess and evaluate catheter dysfunction in order to facilitate HD treatment and improve patient outcomes and play an important role in providing patient education about the risk associated with CVC and limiting access of the CVC to reduce the risk of infection and nosocomial infections (RNAO Guidelines, 2005). The intraluminal pathway of the catheter provides a route for the transfer of organisms by contact from the hands of individuals accessing the catheter, patient's skin, or contact with catheter hubs or caps from surrounding clothing resulting in the contamination of the internal catheter surface (Lok & Mokrzycki, 2011; O'Grady et al., 2011).

Eggimann et al. (2000) and Armstrong et al. (1986) suggest that maintenance of intravascular catheters by inexperienced staff may increase catheter colonization and catheter-related bloodstream infections (CR-BSI). O'Grady et al. (2011) recommend limiting access of vascular access to personnel who are adequately trained, continuous training is provided (Guideline 4.2) (Infusion Nurses Standard of Practice, 2011; Jindal et al., 2006; Tordoir et al., 2007), and accessing is restricted to the provision of HD treatment unless in emergency situations.

KDOQI (2019) recommend during CVC care (accessing, de-accessing, hub care and dressing changes) that all staff, trained personal support workers, and self-care patients perform hand washing before and after CVC care, practice aseptic technique and that staff and patents wear a surgical mask. and clean or sterile gloves (Infusion Nursing Standards of Practice, 2011; Jindal et al., 2006; O'Grady et al., 2011; CDC, 2016). Programs should incorporate regular patient and staff education on the importance of vein preservation (BC Renal, 2017; Jindal et al., 2006; ORN, 2014; Tordoir et al., 2007). Vein preservation includes avoiding use of arm veins for intravenous (IV) placement and routine blood work, using the dorsal aspect of the hand veins for drawing blood and for immediate short-term access when possible (Schmidli et al., 2018).

RECOMMENDATION 1: LONG-TERM USE OF CVC

When compared to AV access, CVCs are associated with higher mortality and morbidity, a 10-fold higher estimated relative risk of bacteremia, a two-to three-fold higher risk of infection-related hospitalization, increased costs related to hospitalizations for catheter-related complications, catheter dysfunction, central vein stenosis, thrombosis, and poor survival (Allon et al., 2003; Allon et al., 2006; Al-Solaiman et al., 2011; Charra et al, 2001; Engemann et al., 2005; Ethier et al., 2008; Lok & Mokrzycki, 2011; Maki et al., 2006; Manns et al., 2005; Mermel et al., 2009; Moist et al., 2008; Nassar & Ayus, 2001; NKF, 2006; Polkinghorne et al., 2004; Taylor et al., 2004; Wasse, 2008; Xue et al., 2003; Vachharajani, 2010). Despite these risks, CVCs continue to be widely used in Canada. In fact, in 2001 to 2004, the use of CVCs in both incident (79.1%) and prevalent (51.7%) dialysis patients was higher in Canada than in Europe and the United States (Ethier et al., 2008; Moist et al., 2008; Mendelssohn et al., 2006). Mendelssohn et al., 2006 reported that 70% of patients in Canada initiate HD with a CVC despite 85% of patients seeing a Nephrologist for more than one month before initiating HD and 79% more than four months.

KDOQI (2019) considers it reasonable to limit use of temporary non-cuffed CVC for patients requiring emergent access and due to the risk of infection, limit use to a maximum of 2 weeks.

- CVCs should be restricted to patients requiring acute or emergency dialysis, as a bridge to AV access creation or maturation or peritoneal dialysis (PD), PD patients manifesting modality failure without a functioning AV access, expected renal transplantation within six months, shortened life expectancy, and patients otherwise deemed medically or surgically unsuitable or refusal for AV access creation (Battistella et al., 2011; Jindal et al., 2006; KDOQI 2019, O'Grady et al., 2011; Rehman et al., 2009; Quinan et al., 2011; Tordoir et al., 2007).
- All catheter-dependent patients should routinely be assessed for appropriate vascular access by the Nephrologist, NP, VAC and Vascular Surgeon (Harland, 1994; ORN, 2014; Quinan et al., 2011). KDOQI 2019 guidelines promote and support an approach to vascular access that attempts to achieve "the right access, in the right patient, at the right time, for the right reasons." KDOQI (2019) considers it reasonable for all patients who had an unplanned start with a CVC, to develop and document an ESKD Life-Plan for dialysis access plan within 30 days. Battistella et al. (2011) and Bhola and Lok (2008) recommend that programs develop multidisciplinary continuous improvement teams to monitor and manage catheter-related infections. Jindal et al. (2006) and Lok and Mokrzycki (2011) recommend that programs establish a quality assurance program to monitor vascular access and track catheter-related bacteremias.

RECOMMENDATION 2: CARE OF CENTRAL VENOUS CATHETERS AND PATIENT EDUCATION

The exit site should be monitored frequently for bleeding and the dressing changed weekly and as needed. If bleeding is observed, apply firm and direct pressure at the source of the bleeding. In most cases, this will stop the bleeding.

Application of a hemostatic agent such as Gelfoam® should be used according to individual institute policy. Gelfoam® sponge is only useful if bleeding is observed. Hemostatic agents should not be left on after the bleeding has stopped, as these are potential sources of infection if they are left on for a prolonged period of time (Pharmacia & Upjohn, 2012). Follow unit protocols and practices. Prolonged bleeding that is not controlled by applying firm, direct pressure should be reported promptly to the Nephrologist or NP. Prolonged bleeding may require further investigation and management by an Interventional Radiologist or Vascular Surgeon.

Prior to discharge from the dialysis unit, patient teaching and instructions should include:

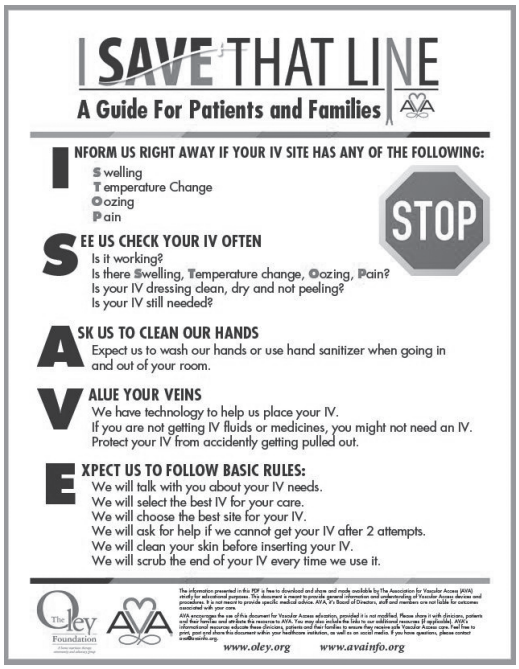
- The importance of frequent hand washing
- To avoid pulling or tugging on the catheter
- What to do if the dressing becomes soiled or falls off
- What to do if bleeding occurs
- What to do if the catheter falls out
- What to do if a limb clamp breaks and falls off
- What to do in the case of pain, fever or chills, or redness or discharge seen at the catheter exit site
- Who to call with questions or concerns.

RECOMMENDATION 3: CENTRAL VENOUS CATHETER – HUB CARE, CLEANING AND DRESSINGS

The **I SAVE That Line** mnemonic refers to proper care and management of the CVC and vein preservation and includes: Implement insertion care and maintenance bundles; Scrupulous hand hygiene before and after contact with vascular access devices and prior to insertion; Always disinfect every needle free connector prior to each access for solution and medication administration, flushing or tube change; Vein preservation; Ensure patency (flush all lumens with adequate amount of saline to maintain patency as per institution policy); initiate thrombotic protocol according to unit policy if lack of blood return or sluggish flow is encountered (Haire & Herbst, 2000). For details, see the Association for Vascular Access at https://www.avainfo.org/page/isavethatline, see Figure 7: I SAVE That Line!

Figure 7

I Save That Line. Copyright American Vascular Access Association. Used with permission.



Catheter Hub care

Contamination of the catheter hub during accessing and de-accessing procedures is believed to be a major factor in the pathogenesis factor of CR-BSI (Liñares et al., 1985; O'Grady, 2011; Schwab & Beathard, 1999; Sitges-Serra et al.,1985; CDC, 2011). Contact of the exposed hub with a non-sterile surface, allowing the catheter hub to lie exposed to the air for a prolonged period of time, improper cleansing of the catheter hub, contact with a non-sterile object (hand), or patient or nurse breathing on the exposed catheter hub may result in an infection (Beathard, 2008; CDC, 2016). Care must be taken to reduce the time that the catheter hub is exposed and avoid contamination. Attention to catheter hub care at the time of accessing and de-accessing has been shown to result in an almost four-fold decrease in catheter-related bacteremia rates to a level approaching 1 episode/1000 catheter days (Beathard, 2003a). Adopting protocols to include vigorous scrub of the hub and protection of the catheter hub at the time of use is critically important and highly recommended (Beathard, 2003a; NKF, 2006; CDC, 2011).

Cleaning

O'Grady et al. (2011) recommends cleansing of the catheter hub during accessing and de-accessing and cleaning the catheter exit site and surrounding area during dressing change using Chlorhexidene 2% and 70% alcohol solution. Chlorhexidine 2% with 70% alcohol is considered to be superior to povidone-iodine for cutaneous antisepsis (Chaiyakunapruk et al., 2002; LeBlanc & Cobbett, 2000; Maki et al., 1991; Mimoz et al., 2007; Rosenthal, 2003). If Chlorhexidene is contraindicated, Iodophor (Povidone-iodine) 10% solution or 70% alcohol can be used as an acceptable alternative (Ishizuka et al., 2009; McCann & Moore, 2010). Always allow the cleaning solution to dry completely before applying the dressing material. This will promote adherence of the dressing material to the skin and reduce the likelihood of skin breakdown and infection. Follow unit protocols and consult the Nephrologist or NP as needed.

Dressing

All dressing materials should be applied using aseptic technique (O'Grady et al., 2011; CDC, 2016). A review of the literature on the optimal dressing material for CVCs was conducted and the findings are varied. Some studies indicate that the use of transparent, occlusive dressings increase the risk of catheter-related infections when compared to gauze dressings (Gillies et al., 2004; Hoffmann et al., 1992; Nassar & Ayus, 2001). However, Maki and Ringer (1987), Gillies et al. (2003) and Le Corre et al., (2003) found no difference in catheter-related infections, fewer dressing changes, lower total treatment costs, and no unfavourable impact on patients' quality of life. KDOQI (2019) reported that there is inadequate evidence

to suggest reduced risk of catheter-related infections based on dressing type (transparent vs non-transparent/occlusive dressing materials). CDC 2017 updated recommendations on the use of Chlorhexidine-impregnated dressings for the prevention of intravascular catheter-related infections (Talbot et al., (2017) recommend Chlorhexidine-impregnated dressings to protect insertion site for non-tunneled temporary CVC.

O'Grady et al. (2011) recommends changing dressings with each dialysis (if the exit site is not visible) and changing transparent dressings weekly and as needed. Application of Povidone-iodine ointment and gauze dressing or Polysporin® triple ointment and gauze dressings are recommended, especially in patients with Staphylococcus Aureus carriage colonization (Jindal et al., 2006; Lok & Mokrzycki, 2011; NFK, 2006; O'Grady et al., 2011). The dressing material acts as a securement device to stabilize the CVC to prevent dislodgement, migration, or catheter damage (RNAO, 2005). O' Grady et al., 2011. Follow unit protocols and practices.

Clinical consideration: Vigilant CVC care is required including adherence to flushing protocols, regular inspection of the catheter and exit site, and routine dressing changes (RNAO, 2005). Showering should be permitted only for patients who are deemed able to exercise precautions to reduce the likelihood of introducing organisms into the catheter and they should be instructed to place an impermeable covering on the catheter and the connections when showering (Howell et al., 1995; Robbins et al., 1999). BC Renal (2017) and O'Grady et al., 2011 recommend that showering should only be permitted if precautions are taken to reduce likelihood of introducing infection for CVC that have been in place for 6 months or more, exit site is well healed, and no previous or current CVC infection. Snyder et al (2019) and O'Grady et al., 2011 state that "no recommendations can be made regarding necessity for any dressing on well-healed exit sites of long-term cuffed tunneled CVC". Follow unit protocols with respect to showering techniques and mask use for exit site care and accessing and de-accessing procedures for patients and nurses. If complications arise such as bloodstream or exit site infection, preference for patient safety and well-being should dictate the course of action in that case.

CAUTION: Multidose cleansing solution bottles for facility-based patients are strongly discouraged due to the risk of cross contamination. All cleansing solutions for facility-based patients should be single use, for example, disposable swab stick or swab pad. Refer to catheter manufacturer recommendations, follow unit protocols for catheter dressings and cleansing solutions (O'Grady et al., 2011; RNAO, 2005), and consult the Nephrologist or NP as needed.

Clinical consideration: Follow unit protocols, practices and guidelines for the management and treatment of catheter-related infections and promptly report any signs of infection to the Nephrologist and NP. For exit site infections, catheters can usually be salvaged with the use of topical and oral antibiotics (Mermel et al., 2001; Schwab et al., 1988; Shusterman, 1989. O'Grady et al. (2011) and Lok (2006 and more recent articles) recommend that catheter-related infections are reported as a rate event per 1,000 catheter days and that programs incorporate standardized terminology to allow for benchmarking.

RECOMMENDATION 4: BLOOD FLOW (QB) AND CENTRAL VENOUS CATHETER DYSFUNCTION

Most CVC are designed to be able to maintain blood flow rates of 400 mL/min (Besarab & Pandey, 2011; Treotola, 2000). Blood flow (Qb) rate, unless otherwise ordered/indicated should be maximized according to arterial and venous pressure readings that should not exceed -250 mm Hg (arterial) and +250 mm Hg (venous) (BC Renal, 2017). Set Qb as ordered by the Nephrologist or NP and follow unit protocols. Close monitoring of Qb and pre-pump arterial pressures is necessary to ensure quality dialysis and to detect catheter dysfunction still amenable to pharmacologic or mechanical intervention (Besarab & Brouwer, 2004). For patients with Qb that is consistently <300 mL/min, monitor dialysis adequacy with URR or Kt/V and discuss with the Nephrologist or NP to determine if an intervention is required.

Clinical consideration: The CANNT working group and NKF-KDOQI (2006) recommend that programs establish a threshold for a minimum blood flow rate and to intervene promptly if the catheter dysfunction continues for two subsequent dialysis treatments. Program should establish that dialysis adequacy is routinely assessed for all catheter-dependent patients to ensure that dialysis clearance is adequate. A reduction in blood flow rate of more than 20% during three consecutive treatments and/or a decrease in the URR or Kt/V are potential indicators of catheter dysfunction and should be investigated.

RECOMMENDATION 5: ASSESSMENT OF CENTRAL VENOUS CATHETER PATENCY

Routine flushing with 0.9% normal saline (NS) is recommended to maintain catheter patency (Barton et al., 1998; Haire & Herbst, 2000; O'Grady et al., 2011; RNAO, 2005, CVAA, 2019), and should be incorporated into standards of practice for accessing and de-accessing CVCs. Flushing of catheter lumens prevents the mixing of incompatible medications or solutions within the catheter lumen and assists in clearing the catheter of blood or fibrin buildup (Nelson et al., 2005). Infusion Nursing Standards of Practice (2011) recommend syringe size no smaller than 10 mL for accessing and de-accessing central venous access devices (including CVCs), and suggest following manufacturer's instructions for use.

Restoring and maintaining catheter patency is imperative in order to salvage the central venous access device (CVAD), and leads to improved patient outcomes and resource utilization (Barton et al., 1998; Hadaway, 2006; add more recent references). Always practice aseptic no-touch technique when accessing and de-accessing CVCs (CDC, 2016) and access one lumen at a time to reduce the time blood remains in the lumen. "According to CDC guidelines, 2016, aseptic technique includes practices that prevent contamination of cleaned and or sterile items and surfaces. Once tasks requiring aseptic technique have been started, care must be taken to avoid contamination of gloves and other clean/sterile items that can occur when touching dirty surfaces (e.g., positioning patient, documentation by using computer, keyboard or pen and paper, and touching of HD machine)." Always follow infection control practices and guidelines.

Clinical consideration: Follow unit policies and practices when accessing and de-accessing (aspirating, irrigating, and flushing) CVCs. To maximize catheter function and dialysis adequacy, connect the CVC to bloodlines in straight position (arterial lumen to arterial bloodline and venous lumen to venous bloodline (A-A and V-V). If line reversal is necessary (e.g., A-V or V-A), follow unit protocols and practices regarding lytic therapy and notify the Nephrologist or NP, as needed.

RECOMMENDATION 6: ASSESSING CENTRAL VENOUS CATHETER FUNCTION AND DYNAMIC VENOUS PRESSURE MONITORING

The criteria for determining catheter dysfunction includes Qb < 300 mL and is qualified by the pre-pump arterial pressure (Pa) (Depner, 2001; Dutka & Brickel, 2010), which factors in the length and lumen diameter of the catheter (Little et al., 2000; Twardowski & Haynie, 2002). Resistance in achieving desired blood flow is indicated by arterial and venous pressure readings during HD (LeBlanc et al., 1997). Pa monitoring is essential to ensure valid blood flows and adequacy is determined largely by the amount of blood pumped to and through the dialyzer (Canaud et al, 2002; Webb et al., 2002; Weijmer & ter Wee, 2004). Besarab and Pandey (2011) recommend recording measures of Qb at a preset pre-pump pressure (-250 +/- 10 mm Hg) at each HD session five minutes after the start with trending over time. A decline of > 10% at the same negative pre-pump pressure, particularly if progressive, suggests access dysfunction and may warrant an intervention.

Trends in venous and arterial pressure readings should be reviewed:

- Monthly or with each dialysis treatment
- Whenever reversal of dialysis catheter lumens is necessary to initiate or achieve an adequate blood flow rate for a dialysis treatment
- When arterial and/or venous pressures exceed –250 mmHg and 250 mmHg respectively and result in the reduction of a blood pump speed to more than 20% of the usual value. For example, the usual blood pump rate is 400 mL/min. However, maximum achievable blood pump rate the following treatment is 300 mL/min due to an increase in venous or arterial pressure limits.

Clinical consideration: "Early catheter failure occurs immediately after placement and is caused by catheter position or technical problems that should be corrected at the time of catheter placement. Late dysfunction occurs in a catheter that initially functioned well and is generally the result of extrinsic or intrinsic thrombosis. Although catheter dysfunction can occur in long-term catheters that previously functioned well, catheter dysfunction which occurs after two weeks of catheter insertion or exchange is more likely due to progressive occlusion of the catheter tip by fibrin or thrombus (CPG 7.1) (NKF, 2006). Early identification of catheter dysfunction allows for prompt intervention with lytic therapy and catheter salvage (Besarab & Pandey, 2011; Deitcher et al., 2002. ***Follow unit policies and practices and consult the Nephrologist or NP.***

Clinical consideration: Although trending of DVP is commonly recommended and performed for AV accesses, its utility for determining CVC dysfunction could also be applied to CVC (expert-informed opinion).

RECOMMENDATION 7: MANAGEMENT OF CENTRAL VENOUS CATHETER DYSFUNCTION

The NKF-KDOQI Guidelines (2006) define access dysfunction as the inability to achieve a Qb of 300 mL or greater during the first hour of dialysis despite at least one attempt to improve flow. CPG-VA defines catheter dysfunction as inability to attain and maintain an extracorporeal blood flow of 300 mL/min or greater at a pre-pump arterial pressure more negative than -250 mm Hg (BC Renal, 2017; Jindal, 2006). Moist et al., (2006) suggests that setting a single blood flow rate of < 300 mL/min to define dialysis inadequacy and need for intervention will result in unnecessary interventions and associated increased costs. The authors recommend expanding the definition of catheter dysfunction beyond blood flow rates.

The four main signs of catheter occlusion are (1) lack of brisk or free-flowing blood return on aspiration from catheter lumens, (2) inability to infuse fluids, (3) increased resistance when flushing, and (4) sluggish flow through the catheter (Hadaway, 2005; McKnight, 2004). Catheter dysfunction manifests as an increase in venous and/or arterial pressure that limit the achievable blood flow rate and can be caused by thrombus, fibrin sheath, central vein stenosis, or catheter malposition (Carson et al., 2005; Oliver et al., 2007; Vachharajani, 2010. The fibrin sheath acts as a nidus for thrombus and biofilm formation (Jindal et al., 2006). Signs of access dysfunction include inadequate dialysis dose (Kt/V less than 1.2) and may lead to increased morbidity and mortality (Owen et al., 1998; Segal et al., 2001; USRDS, 2013), decline in Qb during the last 30 min of a HD session and pre-pump negative arterial pressure >250 mmHg (Beserab et al., 2006; Besarab & Pandey, 2011). Catheter dysfunction can be caused by thrombosis, fibrin sheath, infections associated with thrombotic occlusion or malposition, and result in interruption of therapy due to cancelled or delayed treatment, and unnecessary line replacement (Hadaway, 2005; Little et al., 2001; McKnight, 2004; National Institute of Health, 1999; NKF, 2006). Catheter dysfunction also results in an increase in resource utilization and health care costs (Kokotis, 2005; Manns et al., 2005; Rocco et al., 1996).

Early detection of catheter occlusion or dysfunction should promote prompt lytic therapy to salvage the indwelling catheter and minimize the extent of inadequacy of dialysis as the result of low Qb, thereby avoiding or delaying the need for catheter replacement (Besarab & Pandey, 2011; Deitcher, et al., 2002; Jindal et al., 2006). Patients who frequently experience catheter dysfunction (changes in Qb and/or unable to achieve prescribed Qb) and require alteplase (Cathflo®) to restore line patency should be assessed by the Nephrologist or NP to review anticoagulation agents, and further investigate for hypercoagulability or malignancy. In some cases, the Nephrologist or NP will request a line change, disruption of fibrin sheath, or angioplasty of central veins in interventional radiology.

RECOMMENDATION 8: RECIRCULATION

NKF-KDOQI Guidelines (2006) suggest that any recirculation is abnormal and a relatively late predictor of catheter dysfunction, and that line reversal should be used as a temporary method to allow for dialysis treatment for patients requiring urgent dialysis. Recirculation and lack of treatment with thrombolytic agents are two reasons why line reversal is discouraged. The percentage of recirculation in a functional catheter (non-reversed position) is estimated at less than 5% and 13% in a non-functional catheter when in reversed position (Atherikul et al., 1998; Canaud et al, 2002; Crespo et al., 1999; Hassan et al., 2002; Sefer et al., 2003). NKF- See Chapter 2: Recommendation 7: Management of central venous catheter dysfunction and Recommendation 8: Recirculation, and follow unit protocols and practices.

In clinical practice, the inability to withdraw sufficient blood from the arterial lumen only results in line reversal (inversion of inlet and outlet catheter lumens). Although line reversal may increase urea clearance by allowing increase of blood flow temporarily (Atherikul et al., 1998), it usually is at a blood flow rate less than 300 mL/min and should never be used except temporarily until the problem is definitively corrected (NKF, 2006).

Traditional catheter tip design is staggered tip where the distal tip is the arterial lumen (red) and the proximal tip is the venous lumen (blue). In the last decade, symmetrical tip catheters have been used for HD (Palindrome, Telliflex (Arrow), Glidepath by Bard) who all report < 1% recirculation. The working group suggest further studies to confirm these findings and if in fact symmetrical tip design catheters demonstrate < 5% with non-reversed position 5% and 13% when in reversed position, as found in earlier studies with staggered tip catheters.

Recirculation with line reversal in femoral HD catheters is significantly greater than in internal jugular CVC (13.1% versus 0.4%) (Level et al., 2002). Carson et al. (2005) demonstrate that it is possible to achieve acceptable urea clearance in dysfunctional catheters with line reversal if Qb is greater than 300 mL/min.

Follow unit policies and protocols regarding line reversal and treatment of thrombus with thrombolytics.

Clinical consideration: Regular assessment of dialysis performance is strongly recommended to ensure dialysis adequacy (Canaud et al., 2002; Henning, 2007). Dialysis adequacy includes review of URR or K/t/V, serum potassium, Qb, presence of clotting in circuit or dialyzer, and patient's clinical presentation/symptoms. Catheter dysfunction should prompt a thorough reevaluation including thrombolytics, imaging with routine chest x-ray to assess tip position (Dutka & Brickel, 2010; NKF, 2006), and potentially catheter exchange (Carson et al., 2005). A protocolized approach is recommended for the management of dysfunctional HDs catheters (BC Renal, 2017; Jindal et al., 2006).

See Figure 8: Approach to dysfunctional HD central venous catheters.

RECOMMENDATION 9: THROMBOLYTIC AGENT

Thrombolytic therapy directed at catheter salvage should be considered before access replacement because it is the least invasive and least costly of all catheter salvage techniques (Beserab et al., 2006; Beserab & Pandey, 2011; Jindal et al., 2006; Haire & Herbst, 2000; Haymond et al., 2005; O'Mara et al., 2003; Savader et al., 2001).

Thrombolysis can be carried out at the bedside using an appropriate thrombolytic agent such as alteplase. Cathflo Activase (Alteplase) is a tissue plasminogen activator (t-PA) for the treatment of CVC dysfunction at a concentration of 1 mg/1 mL. As per manufacturer's recommendations, each vial contains 2.2 mg of alteplase (which includes a 10% overfill) and each reconstituted vial will deliver 2 mg of alteplase per catheter lumen for patients weighing over or equal to 30 kg (Canadian Product Monograph, 2003). For catheter lumen volume that exceeds 2 mL, additional lumen volume may be filled through the instillation of 0.9% NS solution *behind* the thrombolytic in the amount required to fill the lumen in order to ensure that the alteplase reaches the catheter tip (Semba et al., 2000). KDOQI, 2019 and Jindal et al. (2006) recommend treating both lumens with alteplase. Always follow unit protocols, practices and manufacturer's instructions as overfill volumes vary.

The terms "dwell", "push", "infusion", and "lock" or "extended dwell" are defined as follows:

Dwell: Instillation of thrombolytic agent (as per unit protocol) into catheter lumen for a specified time interval to allow lysis to occur, then removal of drug, assessment of catheter patency and initiation of dialysis.

Push or Advancing Protocol: Instillation of thrombolytic agent (as per unit protocol) into catheter lumens, attach syringe filled with 0.9% NS and subsequent advancement of the drug by pushing or advancing with 2 mL of 0.9% NS into catheter lumens at 10-minute intervals. KDOQI, 2019 suggest dwell or push method to treat CVC dysfunction.

Infusion: Infusion can be intradialytic or interdialytic, and involves administration of thrombolytic agent via infusion pump over a period of time via the HD circuit or directly into the catheter lumens.

Lock or extended dwell: Instillation of thrombolytic agent into catheter lumens in replacement of Citrate or Heparin lock to ensure catheter patency during the interdialytic period.

Short dwell (30 min – sample protocol)

For CVC lumen with a volume less than or equal to 2 mL, instill alteplase 2 mg (1 mg/mL) into each lumen.

For CVC lumen with a volume greater than 2 mL, instill alteplase 2 mg (1 mg/mL) then add 0.9% sodium chloride in a separate syringe to fill the internal volume of each CVC lumen (plus 0.1 mL overfill). Post dwell, aspirate solution and clot(s). If unable to withdraw, slowly instill alteplase.

Administer a second dose for 30 min if the first dose is not effective in restoring line patency (Dutka & Brickel, 2010; Jindal et al., 1999).

See Flowchart 4: Approach to dysfunctional HD central venous catheters.

Infusion method (60 min – Sample protocol)

Jindal et al. (2006) recommend adding alteplase 4mg (1 mg/mL) to 100 mL 0.9% sodium chloride mini bag and infuse over one hour. Reverse bloodlines and infuse via venous medication port. If both limbs of the catheter are sluggish, lines can be reversed after 30 minutes.

Choose one:

1. If both lumens are sluggish, infuse 50 mL of alteplase solution (via venous medication port) into one lumen and then attempt to reverse bloodlines and infuse the remaining 50 mL of the alteplase solution into the other lumen.
2. If unable to reserve bloodlines or only one lumen is sluggish, infuse 100 mL of the alteplase solution via venous medication port over 60 minutes.

Infusion method (3 hours – Sample protocol)

Use of 2.5 mg of alteplase infusion through each port over a three-hour period (Savader et al., 2001; Dowling et al., 2004; Jindal et al., 2006) or 4 mg over one hour. Reverse bloodlines and infuse alteplase via infusion pump into the venous drip chamber. If both limbs are sluggish, reverse lines after 30 minutes (Jindal et al., 2006).

RECOMMENDATION 10: INTERDIALYTIC CATHETER LOCKING

The purpose of capping or locking catheter lumens with an anticoagulant agent is to restore and maintain catheter patency, reduce the risk of clot formation and prevent blood from backing up into the catheter lumens during the interdialytic period (Nelson et al., 2005; RNAO, 2005). To optimize catheter function and maintain patency, ensure that accessing and de-accessing protocols are followed (See Table 3: Steps for accessing and de-accessing CVC).

Various types of catheter locking agents, thrombolytics and methods of administration are available and local protocols vary. It is the recommendation of the working group that individual programs periodically review efficacy of unit protocols and methods of administration to optimize patient outcomes.

Criteria for selecting the type and method of administration of anticoagulant agents should include:

✓ Administer the lowest possible dose to achieve optimal catheter function and dialysis adequacy (Table 4: Interdialytic catheter locking solutions and protocols).

✓ Adequate dosing without increasing risks of bleeding.

Clinical consideration: A fraction of locking solution will leak into the systemic circulation (Bayes et al., 1999; Karaaslan et al., 2001) and the specific gravity of the locking solution likely influences the rate of leak (Polaschegg & Shah, 2003).

Clinical consideration: 0.9% Normal Saline and needle free system: Krishnan et al. (2012) report that locking with normal saline 0.9% and needle free closed system (neutral displacement) connectors demonstrate efficacy and cost benefits, as compared to traditional locking solutions. Brunelli et al., (2014) report that Tego connectors may reduce the incidence of CR-BSI, and use of thrombolytics and IV antibiotics in HD patients.

Clinical consideration: Trisodium Citrate: Studies by Grudzinski et al., 2007, Lok et al., 2007, and Pierce and Rocco, 2010, using 4% Trisodium Citrate as a catheter locking solution report the following advantages: increased accuracy of international normalized ratio (INR) measurements from central venous catheters; decreased risks of incidental bleeding and comparable patency to Heparin without an increased use of thrombolytics. The volume of Citrate instilled is variable depending on unit protocols, but anecdotal evidence suggests that 2.5 mL instilled in each lumen regardless of lumen volume is not associated with increased risk of bleeding.

Clinical consideration: Anticoagulant and Thrombotic Agents and Anticoagulant and Antibiotic Combinations

Although several studies indicate a reduction in the rate of bacteremia and need for catheter replacement with the use of topical and intraluminal antibiotic locking solution, use should be reserved for patients with recurrent episodes of CR-BSI, balanced by the potential for side effects, toxicity, allergic reactions, or emergence of resistance associated with the antimicrobial agent (James et al., 2008; Onder et al., 2008).

Recommendations by O'Grady et al. (2011), and James et al. (2008), include using prophylactic antimicrobial locking solution in patients with long term catheters who have a history of multiple CR-BSI despite optimal maximal adherence to aseptic technique. Quality improvement approaches to reducing central venous catheter-related infections involving a Failure Modes Effects Analysis (FMEA) has proven to be an effective method in reducing infection rates and improving patient outcomes (Strong & Mukai, 2010).

Table 3

Steps for Accessing and De-accessing CVC

Flush Schedule	Method	Comments
Accessing a CVC for the initiation of dialysis treatment	Step 1: Remove the luer-lock cap and clean the hub. If closed system, high flow needleless style caps are used, follow manufacturer's recommendations and unit protocols and practices for cleaning and changing of caps.	Optional: prior to removing the luer-lock cap, disinfect the caps and part of the hub with antiseptic pad using a separate antiseptic pad for each hub or catheter limb. Always handle the catheter hubs aseptically. After removing the luer-lock cap, clean the hub and ensure that the disinfected hub does not touch nonsterile surfaces. Follow the " Scrub-the-hub protocol" (Association of Vascular Access, 2014; Haire & Herbst, 2000; O'Grady et al., 2011).
	Step 2: Aspirate 3–5 mL of blood and anticoagulant (locking) solution from lumen. Discard the syringe.	Aspiration ensures removal of anticoagulant (locking) solution (or potential blood clot) while assessing patency.
	Step 3: If no resistance is felt with aspiration of blood and anticoagulant solution, attach a 10 mL syringe of 0.9% normal saline (NS) and flush lumen using turbulent flushing technique.	Turbulent flush clears the catheter walls, eliminates debris adhering to the catheter's internal wall and prepares catheter for instillation of anticoagulant (locking) solution (Hadaway, 2006).
	Step 4: Repeat steps with second lumen and initiate dialysis.	Limbs should flush and aspirate freely prior to initiating dialysis.
	Step 5: If resistance is felt with aspiration of blood and anticoagulant solution with either lumen, attach a 10 mL syringe of 0.9% NS, flush and aspirate (irrigate) lumen(s) repeatedly while assessing patency.	Always rule-out external causes of resistance (kink in catheter limb or patient position). Resistance on aspiration or flushing of catheter lumen may indicate fibrin (clot) formation or position of catheter tip. Flushing lumen with NS is necessary to determine if catheter dysfunction is due to position or clot (Dutka & Brikel, 2010); this avoids clot formation and promotes catheter patency (Nelson et al., 2005). Back and forth motion (irrigation) may promote catheter patency. After irrigating lumen to establish line patency, always flush lumen with 10 mL of NS, using turbulent flushing technique to ensure that blood is cleared from the catheter lumen (optimize line patency).
	Step 6: If patency is established, initiate dialysis.	
	Step 7: If unable to aspirate from lumen, gently flush lumen with 10 mL syringe of 0.9% NS. Aim to connect lumens of CVC in the straight position (arterial limb to arterial blood line and venous limb to venous blood line (A-A and V-V).	Observe for bleeding if unable to aspirate anticoagulant (locking) solution. If line reversal is necessary in order to initiate dialysis treatment (A-V), follow unit protocols and practices with use of thrombolytic therapy for line reversal and notifying the nephrologist or NP. See Recommendation 7: Management of Central Venous Catheter Dysfunction; Recommendation 8: Recirculation and Recommendation 9: Thrombolytic agent.
	Step 8: If no resistance felt with flushing, initiate dialysis.	
	Step 9: If unable to aspirate from both lumens and flushing of lumens is sluggish, treat with lytic therapy.	Follow unit protocols and practices with use of lytic therapy and notifying the nephrologist or NP. See Recommendation 9: Thrombolytic agent.
De-accessing CVC at the end of dialysis treatment	Step 1: Retransfuse patient's blood as per unit protocol.	
	Step 2: Close the clamp on the catheter lumens and bloodlines. Disconnect one bloodline from one catheter lumen and clean the hub.	Follow 'Scrub-the-hub protocol' (Association of Vascular Access, 2014; Haire & Herbst, 2000; O'Grady et al., 2011).
	Step 3: Attach 10 mL syringe of 0.9% NS to catheter lumen and flush lumen using flushing technique. Note: some high flow catheter manufacturers recommend flushing with 20 mL of NS.	Turbulent flushing technique clears the catheter walls, eliminates debris adhering to the internal wall of the catheter, and prepares catheter for instillation of anticoagulant (locking) solution (Hadaway, 2006). Follow manufacturer's recommendations.
	Step 4: Repeat steps with second lumen.	
	Step 5: Remove 0.9% NS syringe from lumen, attach syringe with anticoagulant (locking) solution to lumen and instill anticoagulant volume as per unit protocols.	Locking solutions may include anticoagulants (sodium citrate, heparin, or alteplase) or antibiotic locks. See Recommendation 10: Interdialytic Catheter Locking and Table 4: Interdialytic Catheter Locking Solutions and Protocol. Follow unit protocols.
	Step 6: Close clamp on lumen, remove syringe, clean the hub and apply sterile luer-lock cap.	Sterile luer-lock single-use caps must be replaced every time the catheter is accessed and de-accessed. If closed system, high flow needleless caps are used, follow unit protocols and manufacturer's recommendations.
	Step 7: Repeat steps with second lumen.	

Box 1

Signs of CVC Dysfunction: Assessment Phase

Blood flow rates less than 300 mL/min
Arterial pressure ↑ (less than 250 mm Hg)
Venous pressure ↑ (greater than 250 mm Hg)
Conductance ↓ (less than 1.2): the ratio of blood pump flow to the absolute value of prepump pressure
URR progressively less than 65% (or Kt/V less than 1.2)
Unable to aspirate blood freely (late manifestation)
Frequent pressure alarms – not responsive to patient reposition or catheter flushing
Trend analysis of changes in access flow is the best predictor of access patency and risk of thrombosis

(Henning, 2007; Jindal et al., 2006; NKF, 2006)

Table 4

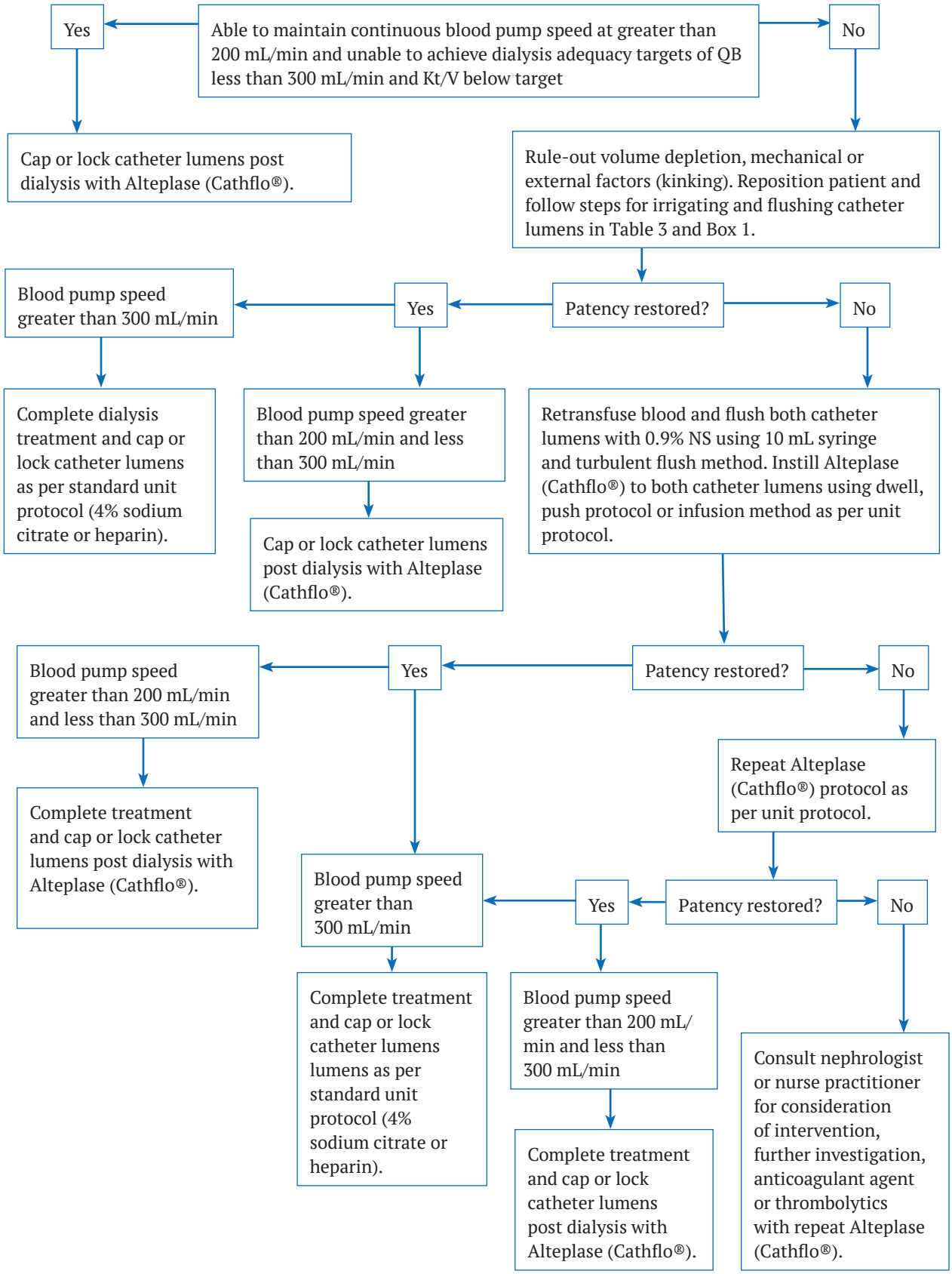
Interdialytic Catheter Locking Agents and Protocols

Locking Agents	Dose
4% Trisodium Citrate Solution	Exact volume to fill each catheter lumen or 2.5 mL in each lumen, (Grudzinski et al., 2007; Lok et al., 2007; MacRae et al., 2008; Pierce & Rocco, 2010; Polaschegg & Shah, 2003)
Heparin 1,000 units/mL	Exact volume to fill each catheter lumen (Daugirdas et al., 2007; Moran & Ash, 2008)
Alteplase or Cathflo®	Exact volume to fill catheter lumen or 2.5 mL in each lumen (Hemmelgarn et al, 2011; Savader et al., 2001; Schenk et al., 2000) or 1 mg in each lumen once weekly as a locking solution (Hemmelgarn et al., 2011; O'Mara et al., 2003). Follow unit protocol and consult with the nephrologist or NP.
Anticoagulant + Antibiotic	Variable — follow unit guidelines. Antibiotic lock is indicated for patients with CR-BSI with no sign of exit site or tunnel infection. Early treatment with antibiotics lock along with IV antibiotics can resolve symptoms and need for catheter exchange (Onder et al., 2008). For CR-BSI, antibiotic lock should not be used alone but in conjunction with systemic antimicrobial therapy, with both regimens administered for 7–14 days (Mermel et al., 2009). Examples include Gentamicin and Heparin (Allon, 2004; Allon, 2005; McIntyre et al., 2006) and antiseptics in the form of Ethanol combined with unfractionated heparin (O'Grady et al., 2011).

**Follow unit-specific protocols at all times unless otherwise indicated by the Nephrologist or NP*

Figure 8

Approach to Dysfunctional Hemodialysis Central Venous Catheters



IDENTIFICATION OF RESEARCH OPPORTUNITIES

During the review of these vascular access guidelines, opportunities for further research education were identified that may have the potential to benefit nurses and patients.

Monitoring

- Impact of implementing expert cannulators model to improve success of cannulating new fistulas, difficult accesses and or grafts
- Use of tourniquets versus no tourniquet for cannulation of AV fistula among expert cannulators
- Routine use of ultrasound-guided cannulation (proactive vs reactive) utilization model
- Metal versus plastic cannula in a new fistula, advantages/disadvantages
- Clinical experience with use of early cannulation grafts (Flixene) cannulation within 24–72 hours
- Management of needle infiltrations (ice versus cold compresses versus warmth)
- Definition of catheter dysfunction from a nursing perspective.
- Examine pace, patient turnover in hemodialysis units and its impact on the use of bedside ultrasound for VA assessment and guided cannulation
- Efficacy of using various locking solutions to improve catheter patency and treat HD catheter dysfunction
- Optimal use (dosing/dwell time/frequency) of thrombolytics to treat catheter dysfunction to achieve long-term patency
- Performance of staggered versus symmetrical tip CVC (thrombotic events/use of thrombolytic treatment and recirculation)

Monitoring/evaluation

- Access monitoring — approaches to scheduling and workload; efficacy in maintaining access patency; when to intervene
- Development and validation of evaluation tools for identifying and quantifying expert cannulators

Education

- Effectiveness of a targeted patient education program on the prevalence of AV fistulae in a HD unit
- Effectiveness of a patient-specific self-monitoring tool used to monitor access performance in maintenance of access patency and function
- Development of vascular access provincial mentorship programs for novice nurses to advance skills, enhance and foster learning opportunities and facilitate knowledge-transfer
- Certification of cannulation skill levels (novice to expert)
- Encourage engagement by patients, families, management, provincial strategies to improve VA outcomes for patients

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CONTINUING EDUCATION STUDY QUESTIONS

CONTACT HOUR: 3.0 HRS

CASE 1

Ms. Best is a 60-year-old female who arrived in the dialysis unit for her first hemodialysis treatment. The team in the Chronic Kidney Disease Clinic has followed her for the past few years and her vascular access is a left arm radio-cephalic arterio-venous (AV) fistula, which was created three months ago.

Questions 1–4 refer to this case

1. After introducing yourself to Ms. Best and orienting her to the dialysis treatment, the nephrology nurse's *first* step towards cannulation of Ms. Best's new AV fistula should be to:
   a) cleanse the forearm using 10% povidone-iodine solution or 2% Chlorhexidine solution, according to unit policy
   b) gather the cannulation supplies, taking into consideration the need for small-sized (17-gauge) fistula needles
   c) carefully and thoroughly assess the AV fistula by performing inspection, auscultation, and palpation procedures
   d) explain the cannulation procedure to the patient and ask where she would like the needles placed

2. In order to maximize the longevity of the fistula, the nephrology nurse cannulating Ms. Best's fistula should:
   a) always cannulate in the same areas to ensure that cannulation is successful and to promote the nurses confidence
   b) rotate cannulation sites using the rope ladder cannulation technique
   c) always place the arterial needle retrograde towards the flow of the fistula
   d) only cannulate with 17-gauge needle for the first 6 months that the fistula is in use

3. The nephrology nurse should teach Ms. Best to examine her fistula:
   a) daily
   b) weekly
   c) monthly
   d) bi-monthly

4. Buttonhole cannulation (BH) technique has been described as a method that may prolong the use of the fistula and result in less painful cannulation. BH cannulation involves placement of the fistula needles in the exact same site until the tunnel tracks are developed. An important component of tunnel track creation that the nephrology nurse needs to be aware of is that:
   a) tunnel tracks can be created by many nurses for a single patient
   b) BH tunnel tracks can be created in as few as three or four treatments but often take six to 10 treatments
   c) tunnel track creation requires the same angle, depth and site of needle insertion
   d) after the first sharp cannulation, dull BH needles should be used for cannulation

End of Case 1

CASE 2

Mr. Jones is a 65-year-old male with diabetic nephropathy who has missed several appointments at the Chronic Kidney Disease Clinic. Three months ago, Mr. Jones needed to start on hemodialysis urgently and a central venous catheter was inserted by interventional radiologist. Mr. Jones had an arterio-venous fistula created in his left forearm four weeks ago and the Nephrologist has orders for initiation of cannulation. Today, the nephrology nurse is planning on cannulating the fistula of Mr. Jones for the first time.

Questions 5–7 refer to this case

5. When a new arteriovenous (AV) fistula is cannulated in the presence of an existing central venous catheter, the approach to cannulation should include:
   a) the same protocol as for use of a new AV access without an existing central venous catheter (based on clinical assessment of fistula maturation)
   b) the insertion of only one needle at the first cannulation, should always be used for venous supply
   c) the insertion of only one needle at the first cannulation, should always be used for arterial supply
   d) the insertion of two needles, with a blood flow rate of 400 mL/min for the first two treatments

6. Four weeks later, the nephrology nurse has been able to cannulate the fistula of Mr. Jones with two needles on a regular basis and obtain prescribed blood flow rates. The recommended *fistula* flow rates for Mr. Jones, as measured by access flow technology are:
   a) > 200 mL/min
   b) > 300 mL/min
   c) > 400 mL/min
   d) > 500 mL/min

7. The risk of bacteremia is highest for patients on hemodialysis who have:
   a) a lower arm arteriovenous fistula
   b) a central venous catheter
   c) an upper arm arteriovenous graft
   d) a loop arteriovenous graft

End of Case 2

CASE 3

Mr. Smith is a 25-year-old male with end stage renal disease secondary to focal segmental glomerulosclerosis (FSGS), and had a deceased donor renal transplant two years ago. Recently, his original kidney disease has recurred in the transplanted kidney and he is now requiring dialysis thrice weekly. His vascular access is a right tunneled central venous HD catheter (CVC).

Questions 8–15 refer to this case

8. After the CVC insertion, a small amount of fresh blood was noted by the nurse on the dressing material. The nephrology nurse should *first*:
   a) reinforce the existing dressing
   b) identify the source of bleeding
   c) order an international normalized ratio (INR)
   d) call radiology immediately

9. Mr. Smith's CVC should be considered:
   a) a bridge to a permanent arteriovenous (AV) access, preferably a fistula
   b) the only vascular access he will need as he will go back on the transplant list
   c) a good, long-term vascular access with a low complication rate
   d) an issue of low importance, as he is having difficulty accepting his return to HD

10. Mr. Smith's catheter usually delivers blood flow (Qb) of 400 mL/min and his urea reduction ratio (URR) or per cent reduction of urea (PRU) is >70%. The nephrology nurse should be *first* concerned about Mr. Smith's CVC performance when:
    a) the maximum achievable Qb is <300 mL/min for more than three consecutive treatments with frequent venous and arterial pressure alarms
    b) the maximum achievable Qb is <250 mL/min for more than three consecutive treatments with frequent venous and arterial pressure alarms
    c) the maximum achievable Qb is <200 mL/min for more than three consecutive treatments with frequent venous and arterial pressure alarms
    d) there has been a decrease in the URR or PRU by >20% over the last month

11. Mr. Smith's CVC is functioning poorly with a maximum achievable Qb of <250 mL/min and frequent arterial and venous pressure alarms. The Nephrologist/ NP orders instillation of alteplase (Cathflo®) to restore line patency using a push protocol. Prior to initiating the algorithm, the Nephrolgist/NP should:
    a) check to see if the patient has a therapeutic international normalized ratio (INR)
    b) check whether or not the patient has a heparin or citrate lock protocol ordered
    c) determine if this is a new central venous catheter, inserted less than one week ago
    d) determine if the patient has fluid volume overload

12. If a thrombolytic agent, for example alteplase (Cathflo®), is ordered by the physician to *"lock"* or *"cap"* the catheter, the nephrology nurse would instill alteplase to fill the catheter lumens:
    a) for one hour, then resume the dialysis treatment
    b) for two hours, then resume the dialysis treatment
    c) for 24 hours and schedule a treatment on a non-dialysis day
    d) for 48 hours, until the next dialysis treatment

13. To assist in maintenance of CVC patency, the Canadian Vascular Access Association (CVAA) recommends:
    a) gentle flushes with 5 mL of normal saline solution when accessing the catheter for initiation of dialysis treatment
    b) turbulent flushes with 5 mL of normal saline solution when accessing the catheter for initiation of dialysis treatment
    c) gentle flushes with 10 mL of normal saline solution prior to instilling the catheter locking solution after the dialysis treatment has been completed
    d) turbulent flushes with 10 mL of normal saline solution both before and after dialysis treatment

14. In order to identify catheter dysfunction, the nephrology nurse should document arterial and venous pressures at the beginning of every dialysis treatment with the blood pump speed set at:
    a) 100 mL/min
    b) 200 mL/min
    c) 300 mL/min
    d) 400 mL/min

15. Trends in dynamic venous pressure monitoring should be reviewed for Mr. Smith by the nephrology team at least:
    a) monthly
    b) bimonthly
    c) six monthly
    d) yearly

End of Case 3

CONTINUING EDUCATION STUDY ANSWER FORM

CE: 3.0 HRS CONTINUING EDUCATION

Nursing Recommendations for the Management of Vascular Access in Adult Hemodialysis Patients: 2023 Update

Post-test instructions:
CANNT members:
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Please circle your answer choice:

1.	a	b	c	d
2.	a	b	c	d
3.	a	b	c	d
4.	a	b	c	d
5.	a	b	c	d
6.	a	b	c	d
7.	a	b	c	d
8.	a	b	c	d
9.	a	b	c	d
10.	a	b	c	d
11.	a	b	c	d
12.	a	b	c	d
13.	a	b	c	d
14.	a	b	c	d
15.	a	b	c	d

EVALUATION

	Strongly disagree				Strongly agree
1. The offering met the stated objectives.	1	2	3	4	5
2. The content was related to the objectives.	1	2	3	4	5
3. This study format was effective for the content.	1	2	3	4	5
4. Minutes required to read and complete:	50	75	100	125	150

Comments: _____

_____

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