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The Care and Keeping of Vascular Access for Home Hemodialysis Patients

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Implementing Hemodialysis in the Home
A Global Perspective

ISHD
International Society for Hemodialysis

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Vascular Access in Home Hemodialysis

Abstract

Creating and maintaining a healthy vascular access is a critical factor in successful home hemodialysis (HD). This module aims to serve as a "how-to manual" regarding vascular access issues for both patients and healthcare providers in a home HD program. This module outlines cannulation options for patients with arteriovenous access and describes troubleshooting techniques for potential complications; strategies are suggested to help patients overcome fear of cannulation and address problems associated with difficult cannulation. Technical aspects of central venous catheter care, as well as a guide to troubleshooting catheter complications, are covered in detail. Monitoring for access-related complications of stenosis, infection, and thrombosis is a key part of every home HD program. Key performance and quality indicators are important mechanisms to ensure patient safety in home HD and should be used during routine clinic visits.

Useful Resources

» La Société Française de l'Abord Vasculaire. History of Buttonhole Technique

» End Stage Renal Disease Network, Cannulation of the AV Fistula

Arteriovenous Fistula

Arteriovenous Fistula Cannulation Options

Cannulation of the arteriovenous fistula (AVF), even when done properly, causes pain and local trauma; repeated cannulation can weaken blood vessel walls and promote wall dilation and the formation of aneurysms.[1, 2] Unsuccessful cannulation can result in needle infiltration (swelling that happens when the needle goes through the fistula wall), which in turn causes localized bruising and increases the risk of thrombosis and loss of AVF patency.[3]

Two methods of needling are commonly used: rotating sites/rope ladder (RL) technique, and buttonhole (BH) technique. The standard is RL, wherein the needling site is alternated along the length of the AVF, resulting in minimal scar tissue formation. Many patients are trained on this method of cannulation when beginning home dialysis. While discouraged, some patients prefer particular sites (ie, use the "area wall technique"), which increases the potential for damage to the AVF wall and dilation of the fistula, and can result in the development of an aneurysm.[4-6]

The BH technique, also known as constant site needling, is a cannulation method that uses the same location, angle, and depth repeatedly.[1, 2] Sharp needles are used to form a tract of scar tissue for entry into the fistula over time. Once this tract is formed, the patient can begin cannulating using a blunt needle, which is theoretically less traumatizing to the vascular structure and should improve survival of the access.[1]

To date, there are no high-quality clinical trials comparing AVF outcomes with RL vs BH cannulation in home HD patients or other self-needler patients (Table 1). The majority of the evidence supporting the use of the BH technique was generated through observational studies, and the generalizability of the existing observational and clinical trial data to the self-needling patient is unknown.

Table 1. Advantages and Disadvantages of BH Cannulation Technique

Advantages for the Patient	• Reduced needling attempts[1, 2] • Fewer hematomas[7] • Reduced number of infiltrations[5, 7, 8] • Reduced number of aneurysms and aneurysm size[8, 9] • Prevents "area" cannulation • Reduced pain (shown in observational studies only)[5, 6, 10-13] • Beneficial for individuals with needle phobia (opinion only)
Disadvantages for the Patient	• Increased risk of infection[7-14] • Need for meticulous hygiene • Possibility of introducing sharps into tunnel when confronted with difficult needling • If tract moves, BH may require re-siting

Buttonhole Cannulation Technique

In each unit, specialized, highly trained clinic staff are responsible for teaching BH tract creation. Ideally, there should only be 1 cannulator for the BH, and it is best if that cannulator is the patient himself; however, there are cases where a dedicated helper can be taught to cannulate. It is very important that the angle, position of the arm, and tourniquet placement are kept constant with each cannulation in order to create and maintain the BH tract. Previous teachings have suggested that the angle of entry should be 45 degrees for all BH cannulations, but in fact, the angle of entry depends on the depth and the anatomy of the fistula, and, thus, varies with each patient. To provide consistency for the angle of needle insertion, the touch cannulation technique can be taught. This technique refers to the placement of the thumb and forefingers on the needle tubing (and not the wings) while the other fingers rest upon the arm to provide stabilization (for more information and cannulation images, see **End Stage Renal Disease Network, Cannulation of the AV Fistula**).

Many clinics recommend that 2 separate BH sites (ie, 2 arterial and 2 venous) be created, each 6 to 8 cm apart. Ideally, patients should alternate between these sites and if there is ongoing difficulty with accessing a site or if it becomes infected (see section Increased Risk of Infection with Buttonhole Cannulation), that site should be abandoned.

BH tract creation requires repeated cannulation with a sharp fistula needle, an intravenous (IV) needle, or placement of a polycarbonate peg (eg, BioHole™ Plug, Nipro Corporation, Belgium). With each of these methods (except for the peg, which has no scab formation), the scab on the BH tract is removed before cannulation to allow the access site to be viewed and permit accurate insertion of the needles. The needles are inserted using the exact location, angle, and depth for each HD treatment. Canadian guidelines suggest that topical antimicrobial prophylaxis be applied to the BH site after the dialysis treatment is completed.[15]

The most common way to create a BH tract is with any type of sharp standard HD needle. The BH is initially created after approximately 8 to 12 cannulations using this approach. Once the BH tract is developed, the needles are switched to a dull/ blunt BH needle (eg, **Medisystems**) or a dull/blunt IV needle with a plastic cannula (eg, **Nipro BioHoleTM Cath**) to cannulate the BH sites.

Intravenous needles with plastic cannulas (eg, **the Supercath™ Clampcath or angiocatheter**) have also been used to create BH tracts with repeated needling. As described above, these needles are also inserted into the exact spot, using the same angle and depth for each HD treatment; the scab on the BH is removed before cannulation. Once the BH tract is developed, the blunt version of these needles can be used to cannulate the BH sites. These types of catheters have a large enough cannula to sustain dialysis blood flow, and the plastic (instead of steel) cannula limits the potential for needle infiltration.

Of note, there are descriptions in the literature using these IV needles with plastic cannulas to create a BH by leaving the catheter indwelling for periods of time.[16] Readers should be warned that there are possible complications with these indwelling catheters, namely the chance of infection, needle dislodgement, and cannula breakage with migration into a vessel.[17] The authors have personally treated catheter breakage in patients who have used this technique and we do not recommend this approach.[18]

Polycarbonate pegs are emerging as preferred tools with which to create BHs. The peg is a small, sterile, thumbtack-shaped plug used to maintain the needle tract between cannulations. Scar tissue forms around the peg, which facilitates the development of the BH tract. The use of a polycarbonate peg may lead to improved tract creation, which may in turn improve AVF survival. A randomized trial by Vaux et al[8] used polycarbonate pegs to create BHs, and they found improved AVF survival with BH cannulation at 1 year, whereas with conventional BH tract formation, there was no difference in AVF survival in a comparison with RL needling.[19] (See "Buttonhole Tract Formation Using Polycarbonate Pegs" in the Appendix) Note that some, but not all, BH protocols include antibiotic prophylaxis.[20, 21]

Vascular Access in Home Hemodialysis

The BH technique is not recommended for all patients and is contraindicated in patients with arteriovenous grafts (AVGs). In North America and Australasia, the BH technique is considered a relative contraindication for newly created AVFs because the fistula is undergoing dynamic changes that influence the BH tracts; however, this practice is not consistent globally. In Europe, BH cannulation is performed in patients with newly created fistulae.

Indications for and against BH cannulation are summarized in Table 2, and a checklist for assisting clinicians in choosing the best cannulation method for patients can be found in "Criteria for Determining Type of Self-Cannulation" in the Appendix. Choosing a cannulation method is discussed further in the section "Tools to Determine the Best Type of Needling". Patients with limited vision should use prescription lenses or a magnifying glass during the self-cannulation evaluation.

Useful Resources

» Big D and Me. Dialysis Buttons for your Buttonholes.

» Home Dialysis Central. The Art of Teaching Buttonhole Self-Cannulation.

Table 2. Indications For or Against BH Cannulation Technique

Indications For Its Use	• AVF is short in length or has short usable segments • AVF with tortuous anatomy • AVF with aneurysmal dilatation[6] • AVF is difficult to cannulate. The patient is unable to self-cannulate using the RL technique • AVF is mature • Patient preference. Risk factors discussed and understood by patient • Needle phobia. Patient expresses considerable fear related to self-cannulation
Indications Against Its Use	• AVF is relatively straight • Patient experiences hand tremors. Unsuitable placement of needle on the BH may lead to the creation of multiple tracts within the BH • Patient reports or demonstrates difficulty visualizing the BH site. Poor vision and improper placement of needle on the BH may lead to the creation of multiple tracts within the BH • Patient has bioprosthesis (eg, mechanical heart valve, artificial joint)

Complications of Buttonhole Cannulation

Indentation/Hubbing

Over time BH sites can develop a widening and an indentation at the entry to the skin. This is commonly known as "hubbing". Hubbing occurs when the hub of the needle is buried into the skin, which can result in incomplete scab removal, patient's inability to clean the puncture site, and breakdown of the lining of the tunnel tract.[22] Hubbing can be prevented by leaving space between the hub of the needle and the puncture site.

Trampoline Effect

The trampoline effect describes the motion of a blunt needle meeting resistance and bouncing back toward the cannulator. This occurs because of a thickening of the tunnel tract or poor tract development. When this occurs, the patient's needling technique should be reassessed.

Increased Risk of Infection with Buttonhole Cannulation

Several clinical studies have demonstrated an increased risk of infection with the use of BH cannulation.[5-7, 21-26] The incidence of localized infections is increased with BH and other infectious complications have been reported. These include septic arthritis, bacterial endocarditis, and bacteremia; however, these conditions may not appear until long after the BH technique is initiated.[5, 6, 24-26] While incidence of infection varies between studies (and by patient population and locality), 1 retrospective study reported a rate of bacteremia of 0.073 per 1000 AVF days for BH patients, compared with no bacteremia for RL patients.[26] One systematic review of observational and randomized studies reported an increased risk of AVF-related infections using BH cannulation, with relative risk ranging from 3.15 to 3.34 comparing before and after changes and with RL cannulation, respectively.[27]

Patients should be informed of the increased risk of infection and receive specialized training and frequent evaluations of their cannulation techniques.[15] Strict adherence to aseptic technique in performing cannulations is essential; additional measures of infection prevention are also recommended for BH patients (Table 3).[15, 23, 28, 29] Each clinic should track and regularly review infection rates (see section **Key Performance and Quality Indicators**)

Table 3. Summary of Measures to Reduce Infection Risk

Adhere strictly to aseptic technique for access skin preparation and BH scab removal Use hand disinfectant prior to decannulation
Perform routine audit of patient cannulation technique on a quarterly basis (recommended) at clinic visits (see the "Arteriovenous Fistula/Graft Audit Tool" and the "Central Venous Catheter Audit Tool" in the Appendix)
Use face masks on the patient (and staff/ helper if applicable) to lower the theoretical risk of nasal transmission of *Staphylococcus aureus* during cannulation[28]
Discuss and provide topical prophylaxis: Patients considering BH technique require counseling regarding the increased risk of infection and the potential for devastating consequences resulting from infection. Topical prophylaxis is strongly recommended for the prevention of infection[15, 24] • Options for topical agents: » **Polysporin triple ointment:** A formulation of polymyxin B sulfate, bacitracin zinc, and gramicidin used for the treatment of infections caused by bacteria » **Povidone-iodine ointment:** A broad-spectrum antiseptic for the treatment and prevention of infection » **Mupirocin ointment:** Utilized to treat staphylococcal infections or attempt to decrease the incidence of subsequent staphylococcal infections. Note: continued use may result in antimicrobial resistance » **Polyhexamethylene biguanide (PHMB):** A dressing infused with a broad-spectrum antimicrobial for the prevention of infection and promotion of wound healing
Perform routine screening of the nares for *S aureus* and, when present, pursue an eradication program (see the "Mupirocin Protocol" in the Appendix)

Management of BH Infections

The optimal duration and choice of antibiotic therapy to treat BH-related infections has not been directly studied. The following suggestions are based on the authors' opinion. Empiric treatment should begin with a first-generation cephalosporin (eg, cefazolin) or vancomycin, depending on local methicillin-resistant *S aureus* (MRSA) colonization rates. Subsequent choice of antimicrobials should be based on culture and susceptibility results.

- Infection of BH with fever and/or bacteremia: This infection should be treated with appropriate antibiotics for a minimum of 4 weeks. Treatment should be extended to 6 weeks in the case of *S aureus* bacteremia and/or if there is a metastatic complication. If further complications exist, abort use of infected BH site and re-site the BH
- Cellulitis or exit site infection: Local infection without fever and bacteremia should be treated with appropriate antibiotics for a minimum of 2 weeks. Abort use of BH located in the vicinity of cellulitis and re-site the BH. Reevaluate the need to change the dressing type and cleansing agent
- Abscess: Abscess of BH, especially with fever, should be treated with appropriate antibiotics for a minimum of 4 weeks and extended to 6 weeks if bacteremia is present. Treatment may be extended if there is progression of serious metastatic complications. Abort use of infected AVF. The abscess may require surgical intervention[30]

Tools to Determine the Best Type of Needling

For patients with AVF, the RL method of cannulation is the preferred type of needling.[15] In general, RL cannulation is used with an AVF that is of adequate length and superficial depth. In addition, the RL method is favored among patients who have poorer vision or those who have a slight tremor. However, in patients who have an AVF that is of short length, consists of tortuous anatomy, or involves aneurysmal sections, BH cannulation should be considered (see Table 2). Patients with a needle phobia can often overcome this phobia with the BH cannulation technique (see "Fear of Needles" in the Appendix). Due to the increased risk of infections with BH, this technique is not recommended for patients with a history of AVF infections, mechanical heart valves, or other prostheses.

A downloadable tool to assist clinicians in choosing the most appropriate type of self-cannulation can be found in "Criteria for Determining Type of Self-Cannulation" in the Appendix.

Additional Cannulation References

- » End Stage Renal Disease Network, Cannulation of the AV Fistula
- » BC Renal. Vascular Access Guideline, Rope Ladder Cannulation of AV Fistulas and Grafts
- » Home Dialysis Central. The Art of Teaching Buttonhole Self-Cannulation. Step-by-step PDF booklet with color photos

Fistula Cannulation Methods

Indications for Use of Standard Sharp Fistula Needles

Standard sharp fistula needles are used if the patient is unable to cannulate using the IV needle with cannula or with the dull/ blunt needle at a BH tract. If the sharp fistula needle is used, then the patient is encouraged to cannulate at a new site rather than using the established BH tract. The use of sharp fistula needles for nocturnal dialysis is not preferred due to the potential for needle infiltration during the treatment. However, if sharp fistula needles are used for nocturnal dialysis, it is imperative to ensure that these needles are secured well. See "Taping Methods for Hemodialysis Needle" and "Taping Method of Intravenous Needle with Cannula" protocols in the Appendix. For more information on nocturnal dialysis, see "Prescriptions for Home Hemodialysis".

Indications for Use of IV Needle with Cannula (Examples: Supercath Clampcath Needles, Nipro Biohole Cath)

For nocturnal dialysis, the flexible cannula is used for comfort and to prevent needle infiltration during treatment. The use of this needle system should be considered in:

- Patients who have an allergy to metals
- Restless patients who may be at risk of needle infiltration (ideal use)
- RL technique for the nocturnal HD patient

Protocols on use of IV needle with cannula can be found at:

- "Buttonhole Cannulation for Creation and Maintenance of Tract with Intravenous Needle and Cannula" in the Appendix
- **BC Renal, Vascular Access Guideline, Self-Cannulation of Buttonholes on AV Fistulas**

Indications for Use of Dull/Blunt Needle

For nocturnal dialysis the dull/blunt needle is used to prevent needle infiltration during treatment. When used with the BH technique, once the BH tract is created, a dull/ blunt needle can be inserted into that tract for the dialysis treatment. Protocols on use of dull/blunt needles can be found at:

- "Buttonhole Cannulation Technique with Dull (Blunt) Bevel" in the Appendix
- **BC Renal, Vascular Access Guideline, Self-Cannulation of Buttonholes on AV Fistulas**
- **BC Renal, Patient Teaching Tool, Self-Needling Your Fistula Using the Buttonhole Method**
- **BC Renal, Buttonhole Cannulation**

Troubleshooting Arteriovenous Fistula Complications

Centers should conduct technique review of self-needling patients every 3 months, with the patient being examined while cannulating in the clinic or during a home visit (see "Arteriovenous Fistula/Graft Audit Tool" in the Appendix). The major focus here is on prevention of infections.

Pain with Needling: Strategies

For patients who experience painful needling, a warm compress should be applied to the access site 5 to 10 minutes before needling. A topical anesthetic (preferred to a subcutaneous injection of lidocaine) should be used to numb the skin surface. Topical lidocaine preparations can be applied to the skin at the desired cannulation sites in a thick layer and then covered with an occlusive dressing or plastic wrap for 60-120 minutes prior to cannulation. Of note, the anesthetic needs to be thoroughly washed off the skin prior to cannulation. It is best to avoid injection of lidocaine into BH sites to minimize the chance for vessel and BH tract movement and potential for vasoconstriction of the blood vessel.

Cannulation Dependency Issues

Some BH patients may become fearful of cannulating using sharp needles at sites other than at the BH site. As a result, these patients can become dependent on the home HD clinic to troubleshoot access issues and reestablish the BH site.

Fear of Needles

Fear of needling can be a barrier to the uptake of home dialysis.[31] Needle fear should not be a contraindication to teaching self-cannulation. In fact, this fear can be overcome if a stepwise approach is followed in which the patient slowly increases his or her comfort level with needles. Patients should start off simply watching the insertion of another patient's needles, followed by watching the insertion of his or her own needles. Becoming familiar with simply holding the needles and holding needle sites after needle removal is also an important step. For more information, please see **this website** or "Fear of Needles" in the Appendix.

Strategies for Addressing Difficult Cannulation

Patients who experience difficulty with cannulation should be scheduled to return to the home HD unit as soon as possible for a review of their cannulation technique and an access assessment for a possible complication of stenosis or thrombosis (Table 4). Thus, in addition to a physical examination (see, "Physical Examination of the Fistula" approach below), an access flow assessment should be made with a subsequent plan for intervention, if needed.

Regardless of the type of cannulation, patients should be instructed to avoid flipping needles. Flipping a sharp needle can actually damage the vessel, while flipping a blunt needle may be indicative of an underlying access problem.

Some home HD programs will use heparin locks or flushes to ensure patency of the access when patients experience temporary cannulation difficulties (eg, if needling is difficult due to onset of stenosis) or in those who need extra guidance for needling. Locking involves instilling a diluted heparin solution into the cannulas (needles and tubing) of the arteriovenous access and allowing it to dwell for a specified period of time (ie, "locking" the heparin in the lumens); flushing involves passing diluted heparin through the cannula before initiating dialysis. Some programs may substitute citrate 4% for the heparin. Before using this approach, patients should be informed of the potential risk of needle dislodgement and possible sequelae, such as bleeding and infection. More information can be found in the "Heparin Flushing of Cannulas" protocol in the Appendix.

Table 4. Troubleshooting for Buttonhole Cannulation Difficulties

Monitor established sites frequently
Avoid sharp needles in an established BH site. The use of sharp needles in a BH site may lead to excessive scarring
Review AVF for possible underlying access dysfunction and/or re-site BH if patient presents with cannulation difficulties
Reposition the arm, change the angle, and slightly rotate the cannula when resistance is felt during the cannulation of BH
Check for an inflamed or infected BH site. If infection is present, do not cannulate. Cannulation in this instance increases the risk of severe hemorrhage with possible exsanguination
Check for keloid formation at the BH cannulation site
Ensure that the BH needle site aligns with the tract entrance into the AVF. A cannulation failure could occur if the BH needle site does not align properly. A new BH site may need to be created to correct the problem
Check for an enlarged BH needle site that may lead to prolonged bleeding

Appropriate Blood Pump Speeds

The ideal blood pump speed for HD is unknown. However, there are potential deleterious effects of high blood pump speeds on fistula integrity. Needle turbulence is the intense flow that is created by a needle in an arteriovenous access, and has been shown to cause endothelial dysfunction with decreased nitrous oxide formation and loss of endothelial integrity.[32, 33] The effect of higher pump speeds has not been proven, but injury to the endothelial wall from altered flow mechanics of high pump speeds is likely to occur.[34] Expert opinion recommends that lower pump speeds should be used to promote vessel integrity and maintain fistula longevity. More information on pump speeds used for different HD modalities can be found in the "Prescriptions for Home Hemodialysis" module. Regardless of the blood pump speeds utilized, most programs aim to maintain the arterial and venous pressures below -250 and 250 mm Hg, respectively; however, these pressures are not strongly evidence-based. A recent observational study of patients on in-center HD reported an increased risk of access failure with venous pressures outside the range of 100–150 mm Hg.[35]

Physical Examination of the Fistula

The access arm must be examined regularly by the patient. Routine evaluation of the arm using a "look, listen, and feel" approach may help detect access complications and subsequent intervention before the access is lost entirely. For an excellent description of the access physical examination, see Sousa et al.[36]

Monitoring for Complications of Stenosis and Thrombosis

Studies have not been performed to assess the value of access surveillance among home HD patients, but most programs recommend pursuing access flow monitoring when the patient returns for quarterly or biannual clinic visits. In addition, regular physical examination of the access by staff is suggested at these clinic visits.

Home HD patients should be taught how to perform a basic access arm examination regularly using the "look, listen, and feel" approach. Patients should be instructed to assess their access using the Arm Raise Technique. They will pump their hand to make a fist, raise their arm straight in the air, and, while standing in front of a mirror, note if the AVF collapses (normal state) or if the AVF does not collapse, which indicates an outflow obstruction.

It is recommended that patients perform trend analysis by recording the venous and arterial pressures at onset of each run at a blood pump speed of 200 mL/min, and reviewing the changes/trends in these numbers. During dialysis, the maximum arterial pressure should not exceed -250 mm Hg and the maximum venous pressure should not exceed 250 mm Hg. When these pressures are exceeded, the needle should be repositioned and/or the blood pump speed should be decreased. Patients should report to their clinician any changes noted in their routine access arm examination, trend of pressures, or cannulation, and the time of onset of cannulation difficulty.

Recent onset of increased difficulty of needling or prolonged bleeding from the access site after dialysis may be signs of an underlying stenosis and should be investigated. It is important to remember that as the AVF matures, BH tracts may change and new sites may be required, which may lead to difficulties needling. In addition, large fluctuations in body weight or size can alter the BH tracts. Patients and staff should be aware that any new onset of cannulation difficulty can also be due to a hemodynamically significant stenosis or impending thrombosis of the access.

Access flow monitoring is suggested at a frequency of every 4 to 6 months, with the same flow thresholds for intervention as are used with in-center conventional HD patients. The same guidelines have been extrapolated for home HD patients.

Vascular Access in Home Hemodialysis

Readers should note that there is considerable variability in the frequency of screening AVF/AVG. Some centers assess access flow every 6 months, while others screen more frequently (every 3 months) in cases of AVF with access issues. Other centers only investigate when cannulation difficulties are reported. Screening options include, but are not limited to, formal ultrasound study, Doppler assessment, clinical screening of needling complications, and review of technique quarterly (see "Arteriovenous Fistula/ Graft Audit Tool" in the Appendix). Additional information can be found at:

- » **Caring for Australians with Renal Impairment (CARI) Guidelines, Chapter 4: Vascular Access Surveillance**
- » **Canadian Society of Nephrology, Clinical Practice Guidelines for the Treatment of Patients with Chronic Kidney Disease, Chapter 4: Vascular Access:**

Thrombosis

Often, the first sign of impending thrombosis is what is mistaken for cellulitis, with signs of erythema over the AVF and tenderness to palpation. This is a medical emergency and the patient should be brought in for *immediate physical and ultrasound examination of the AVF*, with arrangements for radiology or surgical thrombolysis made as required. Every effort should be made to salvage the access and avoid catheter placement.

Fistula Hemorrhage

Hemorrhage from fistula has been reported in the in-center HD population,[38, 39] but the incidence of this occurring among home patients is unknown. All patients should be instructed to apply pressure to their site in the event of bleeding and to call for emergency assistance (eg, 911, 991, 999, 112, or 000 as appropriate). For additional information on fistula hemorrhage and patient safety during home HD, please see the module titled, "Ensuring Patient Safety During Home Hemodialysis".

Specific risks for home HD patients include needle dislodgement, or improper threading of the dialyzer, which may lead to significant hemorrhage. Water or enuresis alarms strategically placed under the dialysis machine and dialyzer, as well as under the access arm, help prevent these serious adverse events. Some popular alarms include the following:

- Redsense Venous Needle Dislodgement alarm
  - » **Training the Trainer**
  - » **Self-Use Instructions**
- **Zircon Leak Alert™ Electronic Water Detector**
- **HEMOdialert™ blood leak detector**

An aneurysmal fistula that is rapidly enlarging in size could indicate possible rupture and hemorrhage.[40] Thus, aneurismal fistula should be routinely monitored and the diameter of the aneurysms should be noted at each clinical visit. Fistula with necrotic skin as a result of infection can also lead to increased risk of rupture, especially in the case of BH cannulation.

The use of a single needle to minimize bleeding risk has been used in some programs; however, this results in a reduction in clearance and an increase in noise from the double pump system. The routine use of single needle in home HD has fallen out of favor, but it can be a useful technique to provide rest (and avoid a catheter placement) after AVF complications. Programs should have a standardized management plan for patients and caregivers to follow to manage hemorrhage, if it occurs in the home. For more detailed information, please see **Home Dialysis Central, The Art of Making Your Fistula or Graft Last** or the "Ensuring Patient Safety During Home Hemodialysis" module.

Fistula Infection

AVF infections can manifest as cellulitis, BH exit site infection, or bacteremia. Cellulitis is infrequent in mature AVF without skin lesions, but signs of redness and swelling should be evaluated to rule out thrombophlebitis. With a BH exit site infection, pus and erythema may be present at the needling site. It is important to obtain a swab for culture and sensitivity and 2 sets of blood culture specimens to rule out bacteremia (particularly *S aureus* bacteremia), which is very common with BH sites. See "Increased Risk of Infection with Buttonhole Cannulation" for details.

Two sets of blood culture specimens should be drawn from any HD patient with an unexplained fever. Some units initiate empiric therapy against both gram-positive and gram-negative bacteria, depending on the usual types of infection in that unit. The planned duration of therapy for bacteremia is 4 to 6 weeks, depending on the organism.

Arteriovenous Graft

AVGs do not have the option of BH needling; only the RL and site rotation technique is recommended. Needle options include standard AVF/AVG needles (sharp) or the needle with cannula (angiocatheter) in which a blunt cannula remains in the AVG for dialysis. With the exception of AVG infection (see below), all other sections of the AVF apply to AVG.

AVG Infection

- Often requires surgical intervention, including graft resection
- Treatment requires 6 weeks of antibiotics with double coverage of gram-positive and gram-negative organisms

Central Venous Catheter

Technical Aspects of Catheter Care

Routine placement of catheters in the subclavian vein (central venous catheters [CVCs]) is not recommended because they create a higher risk for central vein stenosis. In general, the internal jugular site is preferred.[41] There are many different catheters available; however, there is no evidence to guide selection of 1 device over another.

Catheter Care Protocols

There are many catheter care protocols available (see "Central Venous Catheter Audit Tool" in the Appendix). In general, donning clean gloves and mask are a requirement when accessing the catheter.[39]

LOCKING

After dialysis, catheters are most commonly locked with citrate 4% and heparin at a concentration of 1000 or 5000 units/mL; however the following should be considered in selecting a lock solution:

- Bleeding risks have been noted with higher heparin concentrations[42] (see "Heparin Locking of Central Venous Catheters" in the Appendix)
- Locking with 30% ethanol/4% trisodium citrate has been demonstrated to prevent the formation of biofilms in catheters in vitro,[43] and weekly 70% ethanol locks have been

successfully used for infection prophylaxis (in vivo) in a proof-of-concept study,[44] but ethanol locking is not yet widely used in clinical practice

- Tissue plasminogen activator (TPA) is also used to treat episodes of catheter dysfunction. Please see the following protocols for details:
- "Alteplase Use in Hemodialysis Central Venous Catheters" in the Appendix
- **BC Renal. Vascular Access Guideline: Alteplase Use for Occluded Hemodialysis Catheters**

DRESSINGS

- Either gauze dressings[41] or nonocclusive transparent dressings can be used at the exit site of catheters[45]
- The lack of a dressing is a potential option for patients with severe skin breakdown or rash at the exit site; however, the evidence for this practice comes from a nondialysis patient population[46]
- Sample guidelines for dressing change and exit site care can be found on the **BC Renal website**

CLOSED-CONNECTOR DEVICES

A closed-connector device is a device that is designed to decrease the risk of unintentional disconnection examples of which include:

- **InterLink (BD)**
- **Tego Needlefree Hemodialysis Connector (ICU Medical, Inc)**
- **Swan-Lock (Codan Medical Inc)**

As published in the most recent Canadian Society of Nephrology Intensive HD guidelines, a closed-connector device is recommended for patients receiving intensive (home) HD.[15] These closed-connector devices are ideal for home HD patients with a CVC who perform HD without any assistance, as there is less risk for air embolism or chance of inadvertent bleeding. Depending on the device, these closed connectors can be changed under sterile conditions either weekly by the patient at home or monthly by the nurse at the home HD unit. To decrease concerns of air embolism at the time of exchange of a closed-connector device, the patient can be taught to double clamp (ie, use the catheter clamp and another separate clamp on the catheter tubing).

EXIT SITE PROPHYLAXIS

The use of exit site prophylaxis (polysporin, mupirocin/bactroban, medi-honey, povidone-iodone, etc) is very center dependent and not used at every center.[41]

SHOWERING PROTOCOLS

Attached is an example of a protocol for patients from an established home HD program (see the "Showering Protocol" in the Appendix). Remember that the shower and shower head are potential sources of bacteria; therefore, regular cleaning of both is recommended.

Troubleshooting Catheter Complications

Infections

Catheters have a higher rate of infectious complications than arteriovenous accesses, a risk which appears to vary over time according to the length of time the access is in place.[47] Catheter-related infections can be either local (as an exit site or tunnel infection) or systemic (bacteremia).

Exit site infections are defined according to a purulent discharge at the exit site with 2 of the following features:

- Erythema
- Tenderness
- Induration at the exit site
- Sampling of the discharge that results in a culture positive for infection[48]

If left untreated, exit site infections can lead to catheter-related bacteremia. An exit site infection is generally treated with a 2-week regimen of either topical or oral antibiotics.

Vascular Access in Home Hemodialysis

A tunnel infection should be suspected in a patient who presents with pain or tenderness at the catheter exit site; the tunnel site should be palpated with the intention of expressing a discharge. A tunnel infection is defined as a purulent discharge or aspirate from a tunnel site not contiguous with the exit site and includes 2 of the following features:

- Erythema
- Tenderness
- Induration at a tunnel site
- A culture of serous discharge or aspirate from that site that is positive for infection[48]

Tunnel infections should be treated with a 3-week course of IV antibiotics.

Most HD units use the definition of a probable catheter-related bacteremia, which is 2 or more blood culture specimens that are positive for infection with no evidence for a source other than the catheter. When a patient first presents with a fever and suspected catheter-related bacteremia, start empiric antibiotics that cover both gram-positive and gram-negative organisms. The choice and duration of antibiotics, as well as the decision to remove the catheter, depend on the bacterial organism isolated.[41] An example of a center protocol is included (see "Central Venous Catheter Antibiotic Treatment Protocol" in the Appendix) and detailed treatment guidelines can be found on the **CARI website**.

Catheter Dysfunction

Catheter dysfunction is a common problem for catheter-dependent patients and results in decreased dialysis efficiency. Definitions of catheter dysfunction vary, but in general they relate to the inability to achieve a certain blood pump speed (from 200 to 300 mL/min) within the venous and arterial pressure limits of 250 and -250 mm Hg, respectively, while dialyzing. Many HD units have developed treatment algorithms for decreased flow, which include checking patient positioning and flushing the lumens with normal saline prior to administering TPA. Home HD units that have adopted these protocols and will either instruct the patient to administer TPA at home or to come back to the unit to have staff administer the thrombolytic. Sample protocols can be found here:

- **BC Renal. Alteplase Use for Occluded Hemodialysis Catheters**
- "Alteplase Use in Hemodialysis Central Venous Catheters" in the Appendix

Catheter Malfunctions

At times, an HD catheter may develop a crack in the line; generally, these lines will need to be replaced. If the crack develops distal to the "Y" portion, some lines can be repaired. Sample guidelines for determining when a catheter line can be repaired can be found at:

- **BC Renal, Vascular Access Guideline: Central Venous Catheter – Repair of Cracked Catheter Adapter, Limb or Clamp**

Embolism

There have been reports of air embolism occurring in home HD patients using catheters.[49] Prevention of air embolism by using a closed-connector device, such as those mentioned previously, is recommended.[15] In a survey of Canadian Home HD programs, near misses have been reported in some patients who use connector devices when the device is not applied firmly.

Hemorrhage

Although the closed-connector devices may prevent air emboli, there have been cases of hemorrhage that have occurred in patients because the devices have been used improperly or the membranes in these devices have failed.[15] Wetness detectors can be applied to the catheter for overnight dialysis (see "Ensuring Patient Safety During Home Hemodialysis" module).

Key Performance and Quality Indicators

Key indicators are important operating mechanisms to ensure patient safety in home HD (see "Ensuring Patient Safety During Home Hemodialysis" module). Ensure these key indicators are used and followed during routine clinic visits for home HD patients to minimize complications of infection and to determine access failure:

Performance Measures

1. Use an audit tool quarterly
2. Verify that a form of access screening is occurring (eg, patient reporting the usual venous and arterial pressures at a standardized pump speed)

Quality Indicators

1. What is the infection (local/systemic) rate, according to vascular access type (events per 1000 access days)?
2. What is the rate of access interventions, according to vascular access type (events per 1000 access days)?
3. What is the rate of bleeding (actual or "near misses") from the access site, according to vascular access type (events per 1000 access days)?

Summary

Vascular access is associated with the development of potential complications that can lead to significant morbidity. Thus, the care and keeping of vascular access is a skill that is of utmost importance for home dialysis patients. Teaching patients their cannulation options as well as encouraging them to be vigilant for possible access complications should be a large part of every home dialysis program. Furthermore, routine access screening and review of quality indicators should be instituted on a regular basis to minimize access failure.

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