

Cannulation of AV Fistulas and Grafts

(Approved May 11, 2007)

Vascular Access Guideline



BC Renal Agency
An agency of the Provincial Health Services Authority

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1.0 Scope

This guideline makes recommendations about skill levels and procedures with regard to cannulation of new AV fistulas (AVFs) and grafts (AVGs).

This guideline applies to both *pediatric* and *adult* patients. *Pediatric* patients that are most likely to have AVFs/AVGs created (and therefore to whom this guideline would be relevant) are those unlikely to receive a transplant for at least one year post access creation and/or weigh > 20 kg.

For *pediatric* patients, needle sizes are the same as for adults but initial blood pump speeds are usually lower (200 mL/min for pediatric patients vs 250 mL/min for adults or as per physician's orders). Once established, recommended pump speeds are the same for *pediatric* patients as for *adults* with actual speeds being ordered by the physician.

Related Guidelines:

- BC Provincial Renal Agency. Provincial Recommendations for VA for Patients with HD as Primary Modality, 2005.
- BC Provincial Renal Agency. Assessment of Maturation: AV Fistula and Graft, 2006 (in progress).
- Canadian Society of Nephrology Guidelines. Chapter 4: Vascular Access, *Journal of American Society of Nephrology*, 17: S16–S23, 2006.

- National Kidney Foundation. KDOQI Clinical Practice Guidelines and Clinical Practice Recommendations for 2006 Updates: Hemodialysis Adequacy, Peritoneal Dialysis Adequacy and Vascular Access. Guideline 3: Cannulation of Fistulae and Grafts and Accession of HD Catheters and Port Catheter Systems, *American Journal of Kidney Disease*, 48:S210-S209, 2006 (suppl 1).
- Canadian Association of Nephrology Nurses and Technologists (CANNT). Recommendations for New VA Management in HD Patients (recommendations 1 – 7), *CANNT Journal*, vol 16 (supp 1), July – September 2006.

2.0 Recommendations, Rationale, & Evidence

Recommendation 1: The skill level of cannulators is matched to the degree of difficulty of a specific access to cannulate (opinion).

Cannulation is a learned skill which improves with practice. Without good cannulation skills, an AVF or AVG can be damaged or destroyed. Research suggests that inexperienced dialysis staff have higher rates of access infection, infiltration, and loss.

Cannulation skills of hemodialysis (HD) RNs are assessed by advanced cannulators that have been delegated by the unit manager as “cannulator assessors.” HD RNs may be designated as novice, skilled, or advanced.

The degree of difficulty of a specific access to cannulate is assessed by two nurses (one of which is an advanced cannulator) and designated as easy, moderately complicated, or complicated.

The skill level of the cannulator is matched to the degree of difficulty of a specific access to cannulate in considering patient assignments.

Skill Level of Cannulator	Access Rating Approved to Cannulate
Novice	Easy
Skilled	Easy & moderately complicated
Advanced	Easy, moderately complicated, & complicated

Recommendation 2: Initial cannulation of an AV fistula (AVF) or graft (AVG) is attempted only after (1) the AVF has had adequate time to mature and shows signs that maturation has occurred or (2) there is no longer swelling in the AVG limb AND following confirmation by a physician, vascular access (VA) coordinator, or advanced cannulator (opinion).

Generally speaking, *AV grafts* should not be cannulated for at least 2 weeks after placement and not until the swelling has subsided enough to allow palpation along of the course of the graft. Exceptions to the 14 day guideline may apply when a patient requires hemodialysis, has no other access, and a physician's order has been obtained. Rotation of cannulation sites is necessary to avoid pseudoaneurysm formation. Cannulation of an AVG in an edematous arm may lead to hematoma formation and graft wall damage as a result of inaccurate needle insertion.

Assessing the maturation of an *AV fistula* is more difficult than an AVG. An AVF needs to be mature, ready for cannulation with minimal risk for infiltration, and able to deliver the prescribed blood flow throughout the dialysis procedure. Some AVFs may be mature enough to cannulate as early as one month post creation while others may require several months or may never be mature enough to cannulate. Premature cannulation may result in infiltration with associated compression of the vessel by hematoma and a permanent loss of the AVF.

A study conducted by Robins reported that experienced dialysis nurses were able to accurately predict the ultimate utility of an AVF 80% of the time through the use of physical assessment skills alone.¹ Venous diameters of ≥ 4 mm and flow volumes of ≥ 500 mL/min as measured by Doppler ultrasound were reported to increase the predictive power of adequate maturation to 95%.²

An AVF is more likely to be useable (or mature) when the following characteristics are present:

- Thrill palpable at the arterial anastomosis only and disappears when AVF or AVG is momentarily occluded.
- Soft, easily compressible pulse within the fistula.
- Low pitch, continuous bruit present.
- Diameter of vein is at least 0.6 cm and vein is no more than 0.6 cm deep and has discernible margins (for initial cannulation, vein diameter needs to be a minimum of 0.4 cm).
- Flow > 600 mL/min as measured by Doppler ultrasound (for initial cannulation, flow needs to be a minimum of 500 mL/min).

¹ Robbin, ML, Chamberlain NE, Lockhart ME, Gallichio MH, Young CJ, Deierhoi MH, and Allon M, HD Arteriovenous Fistula Maturity: Ultrasound Evaluation, *Radiology*, 2002, Oct; 225 (1), p.p., 59 - 64.

² Robbin, ML, Chamberlain NE, Lockhart ME, Gallichio MH, Young CJ, Deierhoi MH, and Allon M, HD Arteriovenous Fistula Maturity: Ultrasound Evaluation, *Radiology*, 2002, Oct; 225 (1), p.p., 59 - 64.

In addition to maturation, it is important there not be signs of infection, aneurysms, haematomas, swelling, skin breakdown, and/or cyanosis in the access limb prior to attempting cannulation. Skin temperature, grip strength (arm) and pedal movement (leg) in the access limb should also be normal.

If possible, organize a trial cannulation for a non dialysis day. This serves to eliminate potential complications associated with the administration of heparin. If this is not possible, perform the initial cannulation at the patient's midweek dialysis treatment. This helps to avoid complications such as fluid overload and elevated chemistry test results associated with weekends.

Although AVFs are associated with fewer complications than AVGs or catheters, the combined early failure/failure to mature rate is estimated to be 25% - 35% depending upon the location of the AVF.³ One study suggested the figure for AVGs is 78% higher than for AVFs.⁴ AVFs that fail to mature by 6 weeks should be investigated. AVFs or AVGs that are not usable for dialysis or that fail within 3 months of initial use are classified as early failures.

Recommendation 3: Aseptic technique is used for all cannulation procedures (evidence).

Considerable evidence exists that the use of sterile rather than clean aseptic technique for cannulation is impractical and unnecessary. The use of strict dialysis precautions and clean aseptic technique, however, has been shown to be important in the prevention and minimization of access infections. Careful handwashing and donning clean gloves just prior to disinfecting the access site and needling are the minimum accepted standards in the literature; despite general acceptance of the importance of these activities, studies show they are frequently skipped.

Recommendation 4: For arm AVFs or AVGs, regular hand-arm exercises, with or without a lightly applied tourniquet, are recommended for several weeks/months prior to and resuming 2 weeks post access creation (or after the clips or sutures have been removed) (opinion). Tourniquets are not used post-creation on AVGs.

Although there is no definitive information in the literature, any intervention that increases blood flow to the extremity has the potential to improve the chances of successful AVF and AVG creation. Therefore, regular hand-arm exercises, with or without a lightly applied tourniquet (tourniquets are not used post-creation on AVGs), are recommended for several weeks/months prior to access creation. Continuation of these

³ Lok, Charmaine and Oliver, Matthew, Overcoming Barriers to AVF Creation and Use (Toronto), *Seminars in Dialysis*, vol 16, no 3, May/June, 2003, p.p., 189 - 196

⁴ Gibson KD, Capt MT, Kohler TR, Hatsukami TS, Gillen DL, Aldassy M, Sherrard DJ, Stehman-Breen C, Assessment of a policy to reduce placement of prosthetic hemodialysis access, *Kidney Int*, vol 59, no 6, June 2001, p.p., 2335-45.

exercises starting two weeks post-creation (or after the clips or sutures have been removed) while the access matures is also recommended as it may improve muscle tone under the vascular access which may stabilize the vessel and facilitate cannulation. While such exercises are encouraged, it is important to emphasize to patients with failed accesses that not doing the exercises was not the cause of access failure.

Recommendation 5: Local anaesthetics may be helpful in relieving needle discomfort in selected patients (opinion).

Local anaesthetics may help in patients who complain of discomfort or are highly anxious about being “needled.” As side effects of local anaesthetics are possible, use should be limited to patients demonstrating significant discomfort or anxiety with needling and after full disclosure of the potential negative effects to the patient.

Topical anaesthetics: Topical anaesthetics contain lidocaine or a combination of lidocaine and prilocaine and are generally applied by the patient at home one hour prior to the dialysis treatment. A depth of 3 mm is generally achieved after 60 minutes of contact time. After application, the patient is instructed to cover the access with clear plastic wrap to ensure the medication does not wipe off prematurely.

Intradermal lidocaine: Intradermal lidocaine injections (0.2 cc minimum of 1% or 2% lidocaine solution, first to arterial and then to venous sites, using separate sterile needles) may be considered if the access is well developed and minimal swelling exists. While effective at minimizing discomfort, lidocaine injections are generally discouraged particularly in poorly developed or deep accesses because it may reduce the ability to palpate the access properly (as a vasoconstrictor, lidocaine can cause the vein to become smaller and sometimes make it a little deeper). Also, a lidocaine injection itself is painful, and there is an added risk of accidental intravenous infusion. Lidocaine injections should never be used in cases of deep or edematous accesses (the latter is often the case in newly developing AVFs and AVGs).

Recommendation 6: Consider the following principles for needle placement and size (combination of evidence & opinion):

If access is an AVF and there is a functioning central venous catheter (CVC) in place,

- Use the AVF as the arterial source only for at least the first 3 successful cannulations (i.e., 1 needle; treatments 1 through 3). Use a maximum blood pump speed of 250 mL/min (200 mL/min for children) the first time and up to 300 mL/min (250 - 300mL/min for children) the next two times.
- Use the AVF as the venous return only for at least the next 3 successful cannulations (i.e., 1 needle; treatments 4 through 6). Use a maximum blood pump speed of 250 mL/min (200 mL/min for children) the first time and up to 300 mL/min (250 - 300mL/min for children) the next two times.
- After 6 successful cannulations and assuming no complications, begin cannulating the AVF using 2 needles. Gradually increase blood pump speed.

- After 2 – 4 weeks of successful cannulation and assuming blood pump speeds are adequate and arterial and venous pressures within normal limits (arterial pressures not lower than -250 mmHg and venous pressures not higher than 250 mmHg), perform transonic flow measurement (if machine available); if access flow is ≥ 500 mL/min (≥ 650 mL/min/1.73m² in paediatrics), consult a physician for removal of the CVC.
- If transonic flow measurement machine is not available but blood pump speeds are adequate and arterial and venous pressures are within normal limits, consult a physician for removal of the CVC.
- If at any point the attempt at needling fails, revert back to the use of the CVC. Assess again on next dialysis date and resume use of the AVF once the swelling has subsided and the fistula is easily palpated. At that time, reinstitute the sequence at the last successful level (i.e., if initiating a new access, the level reached prior to the problem arising; if a mature fistula, continue using as before once access deemed useable).

If access is an AVF and there is not a functioning CVC in place or access is an AVG,

- Use 2 needles (one at the arterial source and one as venous return) for all cannulations.
- Use a maximum blood pump speed of 250 mL/min (200 - 250mL/min for children) the first time and up to 300 mL/min (250 – 300 mL/min for children) for next 5 times (treatments 2 through 6).
- If blood pump speeds are satisfactory with 2 needles for 6 consecutive treatments (i.e., at the end of treatment 6) and arterial and venous pressures are within normal limits (arterial pressures should never be lower than -250 mmHg and venous pressures never higher than 250 mmHg), perform transonic flow measurement (if machine available); if access flow is ≥ 500 mL/min for AVFs (≥ 650 mL/min/1.73m² in paediatrics) or ≥ 650 mL/min for AVGs (≥ 650 mL/min/1.73m² in paediatrics), gradually increase blood pump speeds.
- If transonic flow measurement machine is not available but blood pump speeds are adequate and arterial and venous pressures are within normal limits, gradually increase blood pump speeds.
- Pump speeds may be increased at a faster rate for AVGs if the arterial and venous pressures remain within normal limits.

For all AVFs and AVGs regardless of whether there is a CVC in place,

- Use small gauge needle (17 or 16 gauge) for early cannulation attempts and for two weeks after any major cannulation complication. For AVFs, start with the smallest available needle size (preferably 17 gauge).
- Use initial needle size for approximately the first week of 2 needle cannulations. Consider proceeding to next size up for the 2nd week. Gradually increase to larger size needles following successful cannulations.
- Place venous needle antegrade (with the blood flow – i.e., facing venous end of AVF or AVG). Arterial needle may be placed antegrade or retrograde (against the blood flow – i.e., facing the arterial end).

- Place needles so tips are 7.5 cm (3 inches) apart and are at least 4 – 5 cm (1.5 – 2 inches) away from the arterial or venous anastomosis. Avoid aneurysms, curves, and flat spots.
- If the needle gauge sizes and blood pump speeds listed above do not achieve the desired clinical effects (Kt/V or PRU), consult the physician re increasing the length or frequency of dialysis treatments; this strategy is recommended over attempting to use larger needles or run dialysis at higher blood pump speeds prior to the access being ready.
- Once cannulation has been established, correlate needle gauge, blood pump speed, and clinical condition (Kt/V or PRU). Use the smallest gauge needle that will achieve the desired blood pump speed with consideration to the guidelines on the next table (the larger the needle, the lower the pressures and, therefore, the higher the blood pump speed that can be achieved):

<i>Desired Blood Pump Speed</i>	<i>Recommended Needle Gauge</i>	
	<i>AVF</i>	<i>AVG</i>
<i><300 mL/min</i>	17 gauge (smallest needle)	17 gauge (smallest needle)
<i>300 – 350 mL/min</i>	16 gauge	16 gauge
<i>350 – 450 mL/min</i>	15 gauge	15 gauge
<i>>450 mL/min</i>	14 gauge (largest needle)	15 gauge (largest needle)

Note: There is no literature/research/guidelines available on the maximum needle size to use for AVGs. It is generally accepted, however, that the principle of using the smallest gauge needle that will achieve the desired blood pump speed applies.

Recommendation 7: Use the rope ladder technique (rotating sites) for cannulation of AVGs and the rope ladder or buttonhole technique (constant sites) for AVFs (evidence).

The rope ladder technique rotates needle sites upon each HD treatment while the buttonhole technique uses the same needle site, depth, and angle for each and every cannulation creating a tunnel or track. Advantages of the latter include fewer infections, infiltrations, and missed sticks, less hematoma formation and less pain. The major disadvantage of using the buttonhole technique is that it requires the same cannulator or same two cannulators until the track has been formed (usually 8 - 12 cannulations), creating logistical challenges for staffing. Once a tunnel or track has been formed, blunt needles may be used to access the AVF. The buttonhole technique is recommended for self-cannulation in patients with an AVF (see recommendation #12).

Recommendation 8: The maximum number of cannulation attempts at any one session is four (total for both arterial and venous sites) unless ordered otherwise by a physician. All levels of cannulators consult an advanced cannulator after the first unsuccessful attempt (opinion).

Repetitive attempts to cannulate an infiltrated AVF or AVG carries a high risk of inaccurate cannulation, which may further exacerbate the existing swelling and possibly lead to permanent loss of the access.

If, after four unsuccessful attempts (at least 3 of which will have utilized an advanced cannulator), the physician is notified. If infiltration has occurred, consider resting the access for 1 week or until the infiltration and bruising have resolved (see recommendation 8).

Recommendation 9: If signs of infiltration are present, remove needle, apply ice, and rest the AVF or AVG until resolution of bruising and/or swelling. After 24 hours, cold and warmth may be alternated. Reinitiate treatments with smaller gauge needles (opinion).

Infiltrations can occur before dialysis, during dialysis with the blood pump running, or after dialysis with the needle removal.

If an infiltration occurs prior to the patient receiving heparin, the needle should be pulled out and digital pressure applied to the exit site by placing two fingers along the access extending over a minimum of a 1 inch span-in the area of the infiltration. If a back or side infiltration is suspected, use 2 fingers on the forearm to apply anterior pressure and the thumb on the backside of the arm to apply posterior pressure (“C-clamp” method). Unfortunately, it is difficult to control back or side wall bleeding because direct pressure to the puncture site is not possible.

If a back or side wall infiltration occurs and the patient has already received heparin, the infiltration site should be assessed to see if the needle should be pulled out or left in place with ice applied over the site until the dialysis treatment is complete. Generally speaking, if the infiltration site remains stable with no increase in the size of the hematoma, the needle can be safely left in place and pulled out at the end of the treatment. If, however, the hematoma increases in size, the needle should be removed and digital pressure applied. Never apply pressure to an infiltration site while the needle is still in the vessel, as this could cause further damage to the vessel wall.

Rather than repetitive attempts to cannulate, it is best to apply ice to infiltrated AVFs and AVGs (on 10 minutes, off 10 minutes) and allow to rest. While ice is recommended for the first 24 hours, alternating cold and warmth is recommended after 24 hours, along with resting the fistula or graft (usually 1 – 2 weeks is sufficient). If required, other accesses may be established (e.g., temporary or cuffed catheter) until the swelling and/or bruising has subsided.

Care needs to be taken with all needle cannulations in order to prevent infiltration. A severe infiltration, such as a posterior or back wall infiltration in an AVG, can lead to the formation of a large hematoma and subsequent graft compression and/or graft thrombosis.

Recommendation 10: If the AVF or AVG has problems and/or has not matured within the appropriate timeframes and/or is difficult to cannulate, a physician or VA Coordinator is consulted (evidence).

Examples in which to avoid cannulation and consult a physician or VA Coordinator include but are not limited to:

- Signs and symptoms of severe infection.
- Signs and symptoms of a localized, superficial infection that is on or near the needling site.
- Absence or poor quality of bruit and thrill.
- Extreme edema or other factors (e.g. rash or unexplained aneurysm) which would render cannulation inappropriate.

Examples in which to proceed with cannulation but consult the physician or the VA Coordinator at the earliest opportunity include but are not limited to:

- Signs and symptoms of a localized, superficial infection that is not on or near the needling site.
- A pulse is palpated instead of a thrill, and is abnormal for the access in question.
- A significant increase in pitch is noted on auscultation.
- Aneurysm (AVFs) or pseudoaneurysm formation (AVGs).
- Difficulties in cannulation, despite the use of advanced cannulators.
- Inability to achieve a blood pump speed on dialysis of >300 mL/min by week 3 or <350 mL/min for established hemodialysis (in 2 consecutive runs).
- Low arterial or high venous pressures on 3 consecutive runs.
- Unexplained, prolonged bleeding (>10 – 15 minutes) from cannulation site on 3 consecutive runs assuming appropriate positioning (may be indicative of stenosis).

Recommendation 11: To achieve hemostasis, apply mild, digital, localized, direct pressure, using two fingers over the needle sites. Never use clamps or tourniquets (aka straps or site minder) on new AVFs or AVGs or on AVFs or AVGs that show signs of infiltration, infection, or edema. Use only as a last resort on mature AVFs or established AVGs in cases where there are no signs of complications and the flow is adequate.

Hemostasis is best achieved by applying mild, digital, localized, direct pressure, using two fingers over the needle sites. If the patient is unable to do this him/herself, arrange for a family member or, in the absence of a family member, a nurse to perform this function.

Use of clamps or tourniquets on AVFs or AVGs is not recommended because of damage and/or thrombosis that can occur by applying too much pressure. New and developing AVFs and AVGs are particularly vulnerable to hematoma formation, infiltration, and bruising.

If clamps or tourniquets are used on mature AVFs or established AVGs in cases where there are no signs of complications and the flow is adequate (AVFs: ≥ 500 mL/min for in adults and ≥ 650 mL/min/1.73m² in paediatrics; AVGs: ≥ 650 mL/min in adults and ≥ 650 mL/min/1.73m² in paediatrics⁵), use only one at a time in order to prevent excessive pressure/thrombosis. Leave the clamp or tourniquet on only until the bleeding has stopped and never for more than 20 minutes. While the clamp or tourniquet is on, palpate for a thrill on both sides of the clamp or tourniquet. If not present or if only a pulse can be felt, lighten the grip on the clamp or tourniquet or remove as blood flow is being occluded. After removing the clamp or tourniquet, confirm the presence of a thrill and bruit.

Recommendation 12: Self-cannulation is encouraged for patients who are capable and whose access is suitably positioned. The preferred self-cannulation technique for patients with AVFs is the buttonhole.

There is growing evidence that buttonhole (constant-site) cannulation may be less likely to infiltrate, may be pain free for the patient, may help preserve the integrity of the outflow vein, and may be easier for patients to self-cannulate.

3.0 Procedure

Preparation for Cannulation

1. Consult a physician, vascular access (VA) coordinator, or advanced cannulator to confirm the access is ready to cannulate.
2. If ready to cannulate and patient is on heparin, contact physician to reassess heparin orders and heparin stop times. Reassess regularly during initial cannulations.
3. Plan for “advanced” cannulators to cannulate the access for at least the first 4 weeks.
 - ▶ Key point: If the buttonhole cannulation technique is used, assign the same cannulator until the track is established (usually takes 8 – 12 treatments) (if not possible to assign one cannulator, assign two with each using their own site/hole).
4. If access is an AVF and there is a functioning CVC in place, utilize the cannulation sequence outlined in step 25 (a) of this procedure. If access is an AVF and there is no

⁵ Assumes the ability to monitor flows is available in the unit.

functioning CVC in place or if the access is an AVG, utilize the cannulation sequence outlined in step 25 (b) of this procedure.

5. Instruct the patient to wash their access with anti-bacterial soap or scrub and water using friction.
6. If patient is highly anxious re needle discomfort, discusses the option of applying/injecting a local anaesthetic prior to needling.

Pre-Cannulation Assessment

7. Assess patient and vascular access prior to cannulation (remembering that more than one abnormality may occur) :
 - *Inspection (Look):*
 - Expose and position the limb (“sleeves up” if arm access and “pants down” and “shoes/socks off” if leg access) with the access parallel to the floor. Expose the contralateral limb for comparison.
 - Observe the limb and access site for signs of infection (redness, discharge, and/or swelling), aneurysms, haematomas, swelling, and/or cyanosis in the access extremity. Compare to contralateral limb.
 - If AVF, vein should be well developed and have adequate straight areas suitable for repeated cannulations. If arm AVF, vein should partially collapse when arm is elevated above the head (slow emptying or bulging of the fistula is an indicator of stenosis at the venous end).
 - If AVF, place in dependent position and observe for collateral veins. There should not be multiple collateral veins present (may require ligation if fistula has failed to mature). It could also indicate a venous end stenosis in a mature fistula and when corrected the collaterals usually diminish in size without ligation). If not possible to get limb dependent, apply a tourniquet (or B/P cuff pumped up to 80–90 mm Hg) just below the axilla (upper arm fistula) or midpoint of the upper arm (lower arm fistula) tight enough to dilate the veins but being careful not to occlude the flow to observe for accessory veins).
 - If AVG, it should be uniform in size and in a loop or straight configuration.
 - Expose the upper chest and observe for abnormalities such as dilated neck veins, accessory veins in the arm or neck above the access, and/or the presence of edema (may indicate a central vein stenosis).
 - ▶ **Key points:**
 - Redness, discharge and/or swelling of the access limb may indicate infection.
 - Cyanosis of the access limb extremity may indicate steal syndrome.
 - Multiple collateral veins or poorly defined cannulation areas may indicate poor maturation.

- *Auscultation (Listen):*
 - Using a stethoscope, listen for several pulsations in the sound of the bruit at the anastomosis. A low pitch, continuous (i.e., present on systole and diastole) “whooshing” sound is a normal bruit.
 - Continue to auscultate along the access path, noting any changes in the pitch or amplitude of the bruit.

- ▶ Key point: A high pitched, discontinuous (i.e., present on systole only) whistling sound at the venous end may indicate outflow stenosis and at the arterial end an inflow stenosis. Absence of a bruit usually indicates clotting of the access.

- *Palpation (Feel):*
 - Assess the temperature of the skin along the access for abnormal warmth, paying particular attention to the site of the anastomosis. Compare the temperature of fingers/toes in access and non-access hands/feet.
 - Assess grip strength and hand movement (arm access) or pedal movement (leg access).
 - Using a two to three finger approach, roll fingers across the AVF to determine the diameter and depth of the access. For initial cannulation, the diameter should be at least 0.4 cm in diameter (and preferably 0.6 cm).
 - Palpate the entire length of the access. A strong thrill should be palpable only at or near the arterial anastomosis. A pulse may be felt throughout the entire outflow vein with the strength normally decreasing along the outflow vein pathway. Vein should be easy to compress.
 - For AVFs only, apply a tourniquet (or B/P cuff pumped up to 80–90 mm Hg) just below the axilla (upper arm fistula) or midpoint of the upper arm (lower arm fistula) tight enough to dilate the veins but being careful not to occlude the flow. Repeat the steps of palpation as outlined above, identifying any collateral veins and/or areas of concern such as decreased size of vessel, or decrease in flow.

- ▶ Key points:
 - **Tourniquets should normally not be used on AVGs to assess the veins** due to the risk of thrombosis. The only exception might be the use of a light tourniquet applied to the arm of a “mushy” graft (“mushy” grafts are grafts that have been cannulated repeatedly for several years).
 - Abnormal warmth along the graft may indicate infection.
 - Abnormal temperature, grip strength, range of motion, and/or complaints of pain may indicate steal syndrome.
 - Strong thrill and/or water-hammer pulse may indicate an area of stenosis.
 - Multiple collateral veins or poorly defined cannulation areas may indicate poor maturation.
 - If an AVG, a “mushy” or irregularly shaped graft may be the site of a pseudoaneurysm.

8. If any of the following are noted during the assessment, *avoid cannulation* and consult the physician or the VA Coordinator or *proceed with cannulation* but consult the physician, VA Coordinator at the earliest opportunity (if the physician is consulted, please notify the VA Coordinator of the problem and plan to ensure facilitate continued follow-up):

Avoid cannulation and consult:

- Signs and symptoms of severe infection.
- Signs and symptoms of a localized, superficial infection that is on or near the needling site.
- Signs and symptoms of a localized, superficial infection.
- Absence or poor quality of bruit and thrill.
- Extreme edema or other factors (e.g. rash or unexplained aneurysm) which would render cannulation inappropriate.

Proceed with cannulation but consult at the earliest opportunity:

- Signs and symptoms of a localized, superficial infection that is not on or near the needling site.
- A pulse is palpated instead of a thrill.
- A significant increase in pitch is noted on auscultation.
- Aneurysm (AVFs) or pseudoaneurysm formation (AVGs).
- Difficulties in cannulation, despite the use of advanced cannulators.
- Inability to achieve a blood pump speed on dialysis of >300 mL/min by week 3 or <350 mL/min for established hemodialysis (in 2 consecutive runs).
- Low arterial or high venous pressures on 3 consecutive runs.
- Low access flow rate.
- Unexplained, prolonged bleeding (>10 – 15 minutes) from cannulation site on 3 consecutive runs (may be indicative of stenosis) assuming appropriate positioning (may be indicative of stenosis).

Cannulation

9. Identify the direction of blood flow at the access site.
- AVFs:
 - Locate the arterial anastomosis engorgement prior to placement of the tourniquet.
 - Most AVFs flow from the distal end of the limb toward the venous return.
 - AVGs:
 - Review the operative note for anatomical position.
 - Listen to the bruit and palpate for the thrill at both ends of the AVG – the end with a stronger bruit and thrill is assumed to be the arterial limb. To confirm

this assumption, lightly compress the mid-graft area to impede the blood flow for a few seconds and listen and palpate on both sides of this mid-point; again the stronger bruit and thrill can be considered to be the arterial limb.

10. Visualize the site(s) and plan for needle placement taking into account the following:
 - Plan for alternate sites in case unable to thread needle or infiltration occurs.
 - Place venous needle antegrade (with the blood flow – i.e., facing venous end of AVF or AVG). Place arterial needle antegrade or retrograde (against the blood flow – i.e., facing the arterial end).
 - Place needles so tips are 7.5 cm (3 inches) apart and are at least 4 – 5 cm (1.5 – 2 inches) away from the arterial or venous anastomosis.
11. Ensure clean gloves prior to cleansing and cannulating the site. Change gloves if contaminated at any time during the cannulation procedure.
12. Cleanse the site with a cleansing solution using a circular motion inside to outside. Allow skin to dry thoroughly.
 - ▶ Key point: If the buttonhole cannulation technique is used, cleanse the site and soak to soften the scab(s) using (1) 2x2s with sterile saline; (2) 2x2s with alcohol-based gel; or (3) an alcohol wipe prior to dialysis. Remove the scab(s) using the sterile gauze and, if necessary, aseptic tweezers, being careful to maintain the integrity of the buttonhole. After removing the scab(s), cleanse the site with a cleansing solution using friction and a back and forth or rubbing motion.
13. For AVFs, apply a tourniquet (or B/P cuff pumped up to 80–90 mm Hg) to the access arm just below the axilla (upper arm fistula) or midpoint of the upper arm (lower arm fistula) tight enough to dilate the veins but being careful not to occlude the flow.
14. If desired by the patient, apply/inject the local anaesthetic (if using topical anaesthetic, may have already been applied by patient at home).
15. Taking the needle in one hand, place the thumb and forefinger of the other hand on either side of the AVF or AVG and thread the needle down the center of the AVF or AVG using approximately a 25 degree (AVF) or 45 degree (AVG) angle. Use either the pinky or ring finger of the needle holding hand to pull the skin taut in the opposite direction of needle insertion. Assess the depth of the access and adjust the cannulation angle accordingly. Cannulation techniques for stabilizing accesses may vary depending upon the cannulator skill level.
 - ▶ Key point: If the buttonhole cannulation technique is used, use the same site, angle, and depth of needle insertion for each cannulation (to enable formation of a tunnel or track).

16. Once the needle has been advanced through the skin, subcutaneous tissue, and the wall of the AVF or AVG, blood flashback should be visible. Once flashback is visible, level the needle to skin level and slowly insert the needle to the hub. Flipping needles is not recommended (needles being manufactured today have back eyes; flipping needles can cause tearing of the AVF).

If blood flashback is not seen, confirm needle placement by assessing blood flow into the tubing. Some AVFs will have less flashback than others. If no blood returns, carefully adjust needle.

► Key points:

- If resistance is felt at any time during needle advancement or needle position change, pull the needle back and redirect the angle. When in doubt, seek assistance from a colleague.
 - If the first cannulation attempt at any session is unsuccessful, consult an(other) advanced cannulator. Cannulation should never be attempted more than four times (total for both arterial and venous sites) in a session unless ordered otherwise by a physician.
17. Assess carefully for signs of infiltration (i.e., pain, swelling, or discoloration). Infiltrations can occur before dialysis, during dialysis with the blood pump running, or after dialysis with the needle removal.

If signs of infiltration are present:

- If patient *has not received heparin*, shut off pump, remove needle, apply digital pressure to the exit site by placing two fingers along the access extending over at least 1 inch span in the area of the infiltration.
- If patient *has received heparin*, assess infiltration site to see if needle should be pulled out or left in place with ice applied over the site until the dialysis treatment is complete.
 - If the size of the hematoma is stable, it is acceptable to leave the needle in until the end of the treatment.
 - If the hematoma is increasing in size during the treatment, shut off pump, remove the needle and apply digital pressure. Never apply pressure until the needle is completely out.
- If a back or side infiltration is suspected, use 2 fingers on the forearm to apply anterior pressure and the thumb on the backside of the arm to apply posterior pressure (“C-clamp” method).
- Apply ice to infiltrated AVF or AVG (on 10 minutes, off 10 minutes) and instruct patient to continue for 24 hours at home. After 24 hours, instruct patient to alternate cold and warmth, along with resting the fistula or graft (usually 1 – 2 weeks is sufficient).
- Assess infiltration on next dialysis date and resume use once the swelling has subsided and the AVF or AVG is easily palpated. At that time, reinstitute the sequence at the last successful level (i.e., if initiating a new access, the level

reached prior to the problem arising; if a mature fistula, continue using as before once access deemed useable).

- ▶ Key point: Accessing an infiltrated AVF or AVG, it is not recommended. If required, other accesses may be established (e.g., temporary or cuffed catheter) until the swelling and/or bruising has subsided. If the latter is not possible and the AVF or AVG must be used, the next cannulation should be as distant from the site of the infiltration as feasible.

18. Secure the wings of the needle at the same angle of advancement. Apply adhesive device to prevent any movement of the needles during the dialysis treatment. If required, a 2x2 gauze pad may be placed under the needle wings to correct the angle of the needle.

19. Repeat steps 14 – 17 for the second needle.

20. Once cannulation has been established, match needle gauge to blood pump speed (refer to step 25).

Needle Removal

21. Remove adhesive device and then remove the needle slowly and at the same angle that was used for insertion. To prevent damage to the vessel wall, **never apply pressure until the needle is completely out.**

22. After the needle is completely out, apply mild, localized, digital, direct pressure for 10 – 15 minutes to the needle exit sites of both the skin and graft or vessel wall, using a two digit technique over a haemostatic dressing (for better site control, pressure is best applied over each needle site in turn).

- One finger at the vein or graft puncture site (internal)
- One finger at the skin exit site (external)

▶ Key points:

- To ensure that compression is not excessive, check that a pulse is palpable above and below the compression site. If not, reduce the digital pressure (there is a fine balance between enough pressure to prevent needle hold bleeding and excessive compression which may lead to access thrombosis).
- Excessive bleeding post dialysis can be a sign of venous outflow stenosis in a patient with normal bleeding times. If prolonged hemostasis is ongoing, reassess heparinization, review dynamic venous pressure readings, and perform access flow studies to rule out stenosis as a cause.

23. Place an adhesive or gauze pad on the cannulation site or ensure dressing used is secure.

Cannulation of AV Fistulas and Grafts

24. Prior to the patient leaving the unit, assess and document the quality of the bruit and thrill.

25. When initiating a new AVF or AVG, utilize the appropriate cannulation sequence:

- (a) AVF with functioning CVC in place; or
- (b) AVF with no functioning CVC in place and all AVGs.

(a) *Cannulation sequence for AVF with functioning CVC in place:*

Treatment	1	2	3	4	5	6	7	8	9	10
Needle location	Arterial (CVC for venous)	Arterial (CVC for venous)	Arterial (CVC for venous)	Venous (CVC for arterial)	Venous (CVC for arterial)	Venous (CVC for arterial)	Arterial & venous	Arterial & venous	Arterial & venous	Arterial & venous
Needles	1	1	1	1	1	1	2	2	2	2
Needle gauge	17 or 16 g	Same as tx #1	Same as tx #1	Same as tx #1	Same as tx #1	Same as tx #1	Same as tx #1	Same as tx #1	Same as tx #1	Larger by 1 gauge & inc gradually to desired size
Max blood pump speed	250 (200 for children) See note below	300 (250 for children)	300	250 (200 for children) See note below)	300 (250 for children)	300	Increase gradually to desired speed	Increase gradually to desired speed	Increase gradually to desired speed	Increase gradually to desired speed
<ul style="list-style-type: none"> • For the first run, start with slow pump (50 ml/min) and increase 50 ml/min every 30 sec to 250 mL/min; if pump speed is not tolerated, reduce to 200 mL/min. • Do not exceed rate of 300 ml/min for the first two weeks. • Arterial pressures should never be lower than -250 mmHg and venous pressures never higher than 250 mmHg. 										

► **Key points:**

- After 2 – 4 weeks of successful cannulation and assuming blood pump speeds are adequate and arterial and venous pressures within normal limits (arterial pressures not lower than -250 mmHg and venous pressures not higher than 250 mmHg), perform transonic flow measurement (if machine available); if access flow is ≥ 500 mL/min (>650 mL/min/ $1.73m^2$ in paediatrics), consult a physician for removal of the CVC.
- If transonic flow measurement machine is not available but blood pump speeds are adequate and arterial and venous pressures are within normal limits, consult a physician for removal of the CVC.
- If the needle gauge sizes and blood pump speeds listed above do not achieve the desired clinical effects (Kt/V or PRU), consult the physician re increasing the length or frequency of dialysis treatments; this strategy is recommended over attempting to use larger needles or run dialysis at higher blood pump speeds prior to the access being ready.

- If at any point the attempt at needling fails, revert back to the use of the CVC. Assess again on next dialysis date and resume use of the AVF once the swelling has subsided and the fistula is easily palpated. At that time, reinstitute the sequence at the last successful level (i.e., if initiating a new access, the level reached prior to the problem arising; if a mature fistula, continue using as before once access deemed useable).

(b) *Cannulation sequence for AVF with no functioning CVC in place and for AVGs:*

Treatment	1	2	3	4	5	6	7	8	9	10
Needle location	Arterial & venous	Arterial & venous	Arterial & venous	Arterial & venous	Arterial & venous	Arterial & venous	Arterial & venous	Arterial & venous	Arterial & venous	Arterial & venous
Needles	2	2	2	2	2	2	2	2	2	2
Needle gauge	17 or 16 g (2 needles)	Same as tx #1	Same as tx #1	Larger by 1 gauge	Same as tx #2	Same as tx #2	Inc gradually to desired gauge	Same as tx #7	Same as tx #7	Same as tx #7
Max blood pump speed	250 (200 for children) See note below	300 (250 for children)	300	300	300	300	Increase gradually to desired speed	Increase gradually to desired speed	Increase gradually to desired speed	Increase gradually to desired speed
	<ul style="list-style-type: none"> • For the first run, start with slow pump (50 ml/min) and increase 50 ml/min every 30 sec to 250 mL/min; if pump speed is not tolerated, reduce to 200 mL/min. • Do not exceed rate of 300 ml/min for the first two weeks. • Arterial pressures should never be lower than -250 mmHg and venous pressures never higher than 250 mmHg. 									

► **Key points:**

- If blood pump speeds are satisfactory with 2 needles for 6 consecutive treatments (i.e., at the end of treatment 6) and arterial and venous pressures are within normal limits (arterial pressures should never be lower than -250 mmHg and venous pressures never higher than 250 mmHg), perform transonic flow measurement (if machine available); if access flow is ≥ 500 mL/min for AVFs (≥ 650 mL/min/1.73m² in paediatrics) or ≥ 650 mL/min for AVGs (≥ 650 mL/min/1.73m² in paediatrics), gradually increase blood pump speeds.
- If transonic flow measurement machine is not available but blood pump speeds are adequate and arterial and venous pressures are within normal limits, gradually increase blood pump speeds.
- If the needle gauge sizes and blood pump speeds listed above do not achieve the desired clinical effects (Kt/V or PRU), consult the physician re increasing the length or frequency of dialysis treatments; this strategy is recommended over attempting to use larger needles or run dialysis at higher blood pump speeds prior to the access being ready.
- Pump speeds may be increased at a faster rate for AVGs if the arterial and venous pressures remain within normal limits.

26. Once cannulation has been established, match needle gauge to blood pump speed using the guidelines on the next table (the larger the needle, the lower the pressure, and, therefore, the higher the blood pump speed that can be achieved):

<i>Desired Blood Pump Speed</i>	<i>Recommended Needle Gauge</i>	
	<i>AVF</i>	<i>AVG</i>
<i><300 mL/min</i>	17 gauge (smallest needle)	17 gauge (smallest needle)
<i>300 – 350 mL/min</i>	16 gauge	16 gauge
<i>350 – 450 mL/min</i>	15 gauge	15 gauge
<i>>450 mL/min</i>	14 gauge (largest needle)	15 gauge (largest needle)

Note: There is no literature/research/guidelines available on the maximum needle size to use for AVGs. It is generally accepted, however, that the principle of using the smallest gauge needle that will achieve the desired blood pump speed applies.

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5.0 Sponsors

This provincial guideline was developed to support improvements in the quality of vascular access care delivered to patients with chronic kidney disease in BC. Based on the best information available at the time it was published, the guideline relies on evidence and avoids opinion-based statements where possible. When used in conjunction with pertinent clinical data, it is a tool health authorities and health professionals can use to develop local guidelines.

Developed by a Vascular Access Working Group of multidisciplinary care providers from across BC, the guideline was approved by the Provincial Vascular Access Services Team and the BC Provincial Renal Agency Medical Advisory Committee. It has been adopted by BCPRA as a provincial guideline.

6.0 Effective Date

- Effective date: May 11, 2007.
- This guideline is based on scientific evidence available at the time of the effective date; refer to www.bcrenalagency.ca for most recent version.