Vascular access is an essential prerequisite for HD. A permanent vascular access, preferably an AVF, should be constructed prior to first dialysis. However, a large number of patients start and sometimes continue dialysis with dialysis catheters. Comprehensive care of a vascular access involves a team approach involving the patient and several caregivers in order to obtain the best possible results. Regular monitoring, appropriate care, and timely intervention for malfunction are important for better outcomes.

Access Creation

We recommend creation of a permanent vascular access for every patient when dialysis start is anticipated in few months. The planning and placement should be done when estimated glomerular filtration rate <30 ml/min, further guided by clinical condition and rate of progression of chronic kidney disease (CKD). Native AVF is the best form of dialysis access.

We recommend the following order of preference for permanent access:
1. Radiocephalic AVF
2. Mid-forearm AVF
3. Saphenous vein forearm grafts
4. Brachiocephalic AVF
5. Brachiobasilic fistula with transposed vein
6. Upper arm autologous saphenous vein grafts
7. Polytetrafluroethylene (PTFE) grafts (straight or U) at any site.

We suggest that autologous saphenous vein grafts are preferred over PTFE grafts because of lower costs and thrombogenicity.

Preservation of peripheral and central veins

We recommend access creation in the nondominant arm. Preservation of the veins by avoiding venipuncture and IV lines is important.

• Patients with CKD IV or V should not have venipunctures or peripheral cannulae in the forearm or above the wrist once a decision to create an AVF for dialysis has been taken
• Patients admitted in hospital should be provided with bracelets labeled “No Venipuncture” to be worn during admission. Patients and clinical staff should be educated about preservation of the forearm veins.

All HD units should aim to have AVF in at least 65% of new patients and in 90% or more of prevalent patients at all times.

If an AVF is not ready for starting dialysis, we recommend that either double-lumen uncuffed nontunneled or tunneled cuffed catheters be inserted in the internal jugular vein. The choice of catheter will be guided by clinical variables, long-term plan, cost, and expertise. An AVF should be created as soon as possible. Uncuffed catheters should be avoided if the anticipated duration of use in more than 3 weeks.

We recommend that the subclavian vein should not be used for gaining temporary access unless the internal jugular is unusable and no permanent access is possible on that side. Even a single subclavian cannulation is associated with a 35% risk of stenosis, compromising the placement of future AVF in the ipsilateral arm.

We suggest that the right internal jugular vein (IJV) be the preferred site of insertion of catheters and that the length be appropriately chosen [Table 1].

Ultrasound-guided placement of dialysis catheters is suggested if available. Fluoroscopy is advised for confirming the placement of cuffed catheters.

We recommend that uncuffed catheters be retained for a period of no longer than 3 weeks.

We recommend that any catheter planned for use longer than 3 weeks should be a cuffed tunneled catheter.

In recent years, an increasing incidence of central venous stenosis is being reported. All catheters increase the risk of stenosis.

With subclavian catheters no longer used, left innominate vein stenosis is the most common central vein lesion, caused by the course of the catheter. The stenosis may be clinically silent and brought to attention when an ipsilateral AVF is created, mainly upper arm fistulae.

Stiff temporary catheters induce a higher risk of central vein stenosis both because of their composition and the frequent infections they are associated with.

We suggest that the femoral vein on the left side may be used as a temporary vascular access with rigid uncuffed catheters, in an emergency situation only. Cannulae in the femoral vein should not be retained for longer than 7 days and should never be used in the outpatient setting.

We suggest that cuffed tunneled double-luminal soft catheters inserted in the IJV with an exit site on the anterior chest wall may be utilized as a semi-permanent access. The cuff should be placed subcutaneously below the clavicle and at a distance of 3–4 cm from the exit site.

We suggest that venous grafts, both autologous and PTFE, may be used within 3 weeks of construction.

Design and performance of temporary accesses

• The diameter of the cannula and the length determine the blood flow
• We suggest that single-lumen femoral cannulae should
be at least 19 cm long to reach the inferior vena cava (IVC). Flows of >200 ml/min are not obtained with standard femoral single-lumen cannulae

- The length of a cannula in the right IJV should be 13.5 cm for an adult, whereas that of a left internal jugular cannula should be around 16–20 cm
- The cannulae should be at least 12 F to obtain flows of 300 ml/min and 14 F if higher flows are desired. For children, 8 and 10 F cannula can be used. Table 1 summarizes recommended catheter lengths and diameters.

### Patient preparation and evaluation for permanent access procedure

We recommend that a detailed evaluation of the suitability of creating a permanent vascular access be performed with regard to the following:

- A history should be obtained regarding past central or peripheral or venous or arterial cannulation, pacemaker insertion, previous attempted AVF, time and possible cause of access failure (if applicable), presence of cardiac disorders, malignancy, and prothrombotic tendency or anticoagulation
- Physical examination of both upper extremities to assess the feasibility of successful access creation should include:
  a. Examination of peripheral pulses
  b. Bilateral upper extremity blood pressure (BP) measurement
  c. Presence of edema
  d. Presence of collateral veins
  e. Collapsibility
  f. Allens test and Modified Allens test
  g. Ultrasound Doppler-based venous and arterial assessment can guide optimal access placement plan.

The Allen’s test assesses collateral circulation in the hand, in two steps:
  a) Step 1 occludes the radial artery for several minutes and compares the hand color to the other hand. The hand is said to have sufficient collateral circulation through the ulnar artery if there is no change in color
  b) Step 2 occludes the ulnar artery. A change in hand color means the potential for radial artery occlusion is high.

That is a positive Allen’s test, which contraindicates radial artery use for an AVF.

The modified Allen’s test may be carried out as follows:
  a) Instruct the patient to clench his/her fist, or if the patient is unable, close the hand tightly
  b) Apply occlusive pressure with the fingers to both the ulnar and radial arteries. This maneuver obstructs blood flow to the hand
  c) While applying occlusive pressure to both the arteries, have the patient relax his/her hand. Blanching of the palm and fingers should occur. If it does not, you have not completely occluded the arteries with your finger
  d) Release the occlusive pressure on the ulnar artery. Flushing of the hand should occur within 5–15 s. This denotes that the ulnar artery has good blood flow. This normal flushing of the hand is considered to be a positive modified Allen’s test. A negative modified Allen’s test is one in which the hand does not flush within the specified time period. This indicates that ulnar circulation is inadequate or nonexistent. In this case, the radial artery supplying arterial blood to that hand should not be used for an AVF.

We recommend that monitoring of all AV accesses be carried out.
- We suggest that surveillance and diagnostic testing be carried out wherever possible
- Monitoring: Physical examination of the access to detect physical signs that suggest the presence of dysfunction
- Surveillance: Periodic evaluation of the vascular access by means of specialized tests that involve special instrumentation
- Diagnostic testing: Specialized testing that is prompted by some abnormality or other medical indication and that is undertaken to diagnose the cause of the vascular access dysfunction

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**Table 1: Appropriate catheter lengths for dialysis**

| Catheter site and type                             | Length for right IJV | Length for left IJV | Length for femoral | Diameter |
|---------------------------------------------------|----------------------|---------------------|--------------------|----------|
| Temporary adult catheter (tip to hub)              | 13-16 cm             | 19-20 cm            | 19-23 cm           | 12-14 F  |
| Pediatric temporary catheter                       |                      |                     |                    |          |
| Neonates                                          |                      |                     |                    |          |
| 3-6 kg                                            | As available         | 5-7 F               |                    |          |
| 6-10 kg                                           | 11 cm can be inserted in EJV also | 8 F               |                    |          |
| 11-20 kg                                          | 11-12 cm can be inserted in EJV also | 9 F               |                    |          |
| 21-30 kg                                          | 12-13.5 cm           | 10 F                |                    |          |
| >30 kg                                            | 13-15 cm             | 11.5-12 F           |                    |          |
| Adult cuffed tunneled catheter (tip to cuff)       | 19-23 cm             | 27-33 cm            | 45-55 cm           | 11.5-14.5 F |
| Pediatric cuffed tunneled catheters (tip to cuff)  | 12-15 cm             | 19.5 cm             | Variable           | 8-12 F   |

IJV: Internal jugular vein, EJV: External jugular vein
Surveillance and monitoring are complementary. They must be combined with regular assessment of the access and dialysis adequacy and tracked within each center as part of a quality assurance and improvement program.

We recommend the following steps for preparing the access for cannulation:

Box 2 shows a detailed examination of a functioning or malfunctioning vascular access:

1. Access should be examined at each session prior to starting dialysis
   a. Fistulae should be examined to confirm a low-pitched continuous bruit and a thrill, absence of edema, normal limb temperature, absence of ischemia, steal, and large collateral veins
   b. Fistulae should not have a water hammer pulse on examination
   c. Veins should collapse upon raising the arm above the level of the heart.

2. Wash (or ask the patient to wash) the access site with antimicrobial or plain soap and water

3. Wash hands

4. Cleanse the skin by applying any one of the following:
   a. 0.5–2% chlorhexidine gluconate in 70% ethyl or isopropyl alcohol
   b. Alcoholic chlorhexidine (0.5–2% chlorhexidine gluconate in 70% ethyl or isopropyl alcohol)
   c. 70% isopropyl alcohol using sterile swabs.

5. Cleanse in a circular, rubbing motion from the center outward, for 1 min immediately prior to cannulation. Do not use a backward and forward movement

6. Wear sterile gloves for cannulation if the skin needs to be re-palpatated

7. Gloves should be changed if contaminated. The antiseptic should be allowed to dry on the skin prior to cannulation. This takes about 40 s for the above antiseptics.

8. The skin at the site of puncture should be infiltrated with 2% xylocaine using a 26G needle. Alternatively, lignocaine-prilocaine gel should be applied over the region 30 min prior to puncture.

9. Initial cannulation of the AVF should be with 17G needles equipped with a “back eye.” Flows of up to 200 ml/min can be obtained with a 17G needle. Subsequent cannulation should be with a 16G needle to obtain flows of 300 ml/min and with a 15G needle to obtain flows of >300 ml/min.

10. We recommend railroading technique rather than a buttonhole technique should be followed for cannulation, unless blunt needles are being used.
   a. Railroading – At each dialysis session, puncture of the fistula should be done 1–2 mm away from the previous point and a return to the original site should occur after 6–7 sessions.
   b. Buttonhole – Every puncture is done through an identical point. This eventually leads to decreased pain sensation at the site but also to weakening of the vein wall and aneurysmal dilatation.

11. The “arterial needle” should point toward the anastomosis and the “venous needle” should point away from the anastomosis.
   - We suggest that the two needles be sited at least 5 cm away from each other
   - We suggest that removal of the needles following dialysis should be done after confirming the post dialysis weight, BP, and absence of symptoms
   - We recommend that digital pressure be applied to the puncture site for 10 min after removal of the needles. Pressure should not be applied until the needle has been completely withdrawn.
   - We recommend that the puncture site be inspected for persistent bleeding after 10 min of pressure and that this be recorded and informed to the nephrologist in charge.

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**Box 2: Examination of an arteriovenous fistula**

A detailed examination of the vascular access should include inspection, palpation, auscultation, augmentation, and the arm-raising test

Normal inspection should reveal the number, position, and character of scars; the character of the fistula vein according to the Rule of 6; and the presence of accessory vein comparison with the contralateral extremity. Normal capillary refill should be <2-3 s

Present or past catheter marks, pacemaker, or prior line should be visible on the ipsilateral side

Abnormal inspection includes presence of pseudoanuerysm, thinning of skin, purulent discharge indicating inflammation, arm swelling, visible collaterals, and ischemic spots on finger tips, swelling or nonhealing ulcers of the hand, discolored fingers - Steal syndrome

Redness, discharge, or swelling indicates infection. Altered skin color, edema, or blue-black dilated veins indicate central or venous outflow stenosis

Palpation includes presence of a continuous thrill, springy feel of the vein, absence of a water hammer pulsation, a flat segment and accessory thrill, coldness or excessive warmth. Auscultation should reveal a continuous low-pitched bruit. Auscultate the entire length of the outflow vein for change in amplitude or pitch. Stenosis is revealed by a high-pitched systolic bruit

Augmentation - One finger palpates the pulse on the arterial side, one occludes venous outflow strength of the pulse without occlusion corresponding to outflow and with occlusion as a measure of inflow. In the presence of a water hammer pulse, lack of augmentation indicates severe stenosis, whereas moderate augmentation indicates moderate stenosis (<450 ml/min flow). Arm raising test:- Collapse of the AVF downstream of a lesion when extremity elevated and a dilated and pulsatile segment upstream, is characteristic of a venous stenosis.
We recommend that an antiseptic powder and a dry gauze with a sticking plaster be applied to the venipuncture site after the above maneuvers.

We recommend that tourniquets not be applied to the AVF limb after needle removal.

A detailed examination of the vascular access should include inspection, palpation, auscultation, augmentation, and the arm-raising test.

Normal inspection should reveal the number, position, and character of scars; the character of the fistula vein according to the Rule of 6; and the presence of accessory vein comparison with the contralateral extremity. Normal capillary refill should be < 2–3 s.

Present or past catheter marks, pacemaker, or prior line should be visible on the ipsilateral side.

Abnormal inspection includes presence of pseudoaneurysm, thinning of skin, purulent discharge indicating inflammation, arm swelling, visible collaterals, and ischemic spots on finger tips, swelling or nonhealing ulcers of the hand, discolored fingers – Steal syndrome.

Redness, discharge, or swelling indicates infection. Altered skin color, edema, or blue-black dilated veins indicate central or venous outflow stenosis.

Palpation includes presence of a continuous thrill, springy feel of the vein, absence of a water hammer pulsation, a flat segment and accessory thrills, coldness or excessive warmth. Auscultation should reveal a continuous low-pitched bruit. Auscultate the entire length of the outflow vein for change in amplitude or pitch. Stenosis is revealed by a high-pitched systolic bruit.

Augmentation – One finger palpates the pulse on the arterial side, one occludes venous outflow strength of the pulse without occlusion corresponding to outflow and with occlusion as a measure of inflow. In the presence of a water hammer pulse, lack of augmentation indicates severe stenosis, whereas moderate augmentation indicates moderate stenosis (<450 ml/min flow) Arm raising test Collapse of the AVF downstream of a lesion when extremity elevated and a dilated and pulsatile segment upstream is characteristic of a venous stenosis.

We recommend the following for care of a catheter:

1. Dressings of a vascular access should be transparent, occlusive, and strong enough to resist the weight of the dialysis cannulae. Micropore or Tegaderm or OPsite is a useful dressing.

2. The skin around the exit site of the access site should be clipped of hair, and tincture benzoin should be applied to the area prior to application of the dressing.

3. Triple antibiotic (triple sporin) ointment should be applied to the exit site of both cuffed and uncuffed cannulae. The Centers for Disease Control and Prevention (CDC) guidelines recommend this rather than Mupirocin following the demonstration that Gram-negative organisms, rather than Staphylococci predominate in the colonization of dialysis cannulae. With a predominance of Gram-negative organisms such as Stenotrophomonas and Ralstonia in Indian dialysis units and an overall higher incidence of Gram-negative organisms in blood cultures in Indian studies, it seems reasonable to use this preparation, which contains neomycin, bacitracin, and polymixin B.

4. For the same reason, we recommend not using empirical vancomycin for the treatment of suspected catheter-related bloodstream infection (CRBSI).

5. We recommend that dialysis units should maintain a record of the organisms isolated from blood cultures in their patients, practice antibiotic stewardship, and suggest that there is an urgent need for this information to be published.

6. Patients and attendants should wear a disposable surgical mask during any manipulation of access needle/catheter, dressing changes, and connection and disconnection to the dialysis machine.

7. Dressings should be changed weekly and whenever wet, visibly soiled, or stained with blood or other material. Cannulae should not be unnecessarily manipulated.

8. The hubs of the cannulae should be cleaned with sterile swabs soaked in 2% alcoholic chlorhexidine, the connection to blood tubings should be done without touching the hubs or connectors, and the joint should be wrapped with a swab soaked in 2% alcoholic chlorhexidine or 10% povidone-iodine for 10 min.

9. The cannulae should be flushed with sterile saline till free of blood prior to anticoagulant instillation after each dialysis. Pressure on the piston of the syringe should be maintained continuously while clamping the catheter to prevent the backflow of blood.

We recommend that the CDC “Scrub the Hub” protocol be followed when connecting and disconnecting patients with catheters from dialysis. Box 3 contains the protocol while the procedure can be viewed on the CDC site or on YouTube at https://www.youtube.com/watch?v=fjVHV8J68O.

Table 2 summarizes the CDC information on the compatibility of catheter materials and antiseptic solutions and skin ointments.
Box 3: CDC “Scrub the Hub” Protocol

Connection steps:
1. Perform hand hygiene and don new clean gloves
2. Clamp the catheter (Note: Always clamp the catheter before removing the cap. Never leave an uncapped catheter unattended)
3. Disinfect the hub with caps removed using an appropriate antiseptic [Table 2]
   a) (Optional) Prior to cap removal, disinfect the caps and the part of the hub that is accessible and discard the antiseptic pad (i.e., use a separate antiseptic pad for the next step)
   b) Remove the caps and disinfect the hub with a new antiseptic pad for each hub. Scrub the sides (threads) and end of the hub thoroughly with friction, making sure to remove any residue (e.g., blood)
   c) Using the same antiseptic pad, apply antiseptic with friction to the catheter, moving from the hub at least several centimeters toward the body. Hold the limb while allowing the antiseptic to dry
   d) Use a separate antiseptic pad for each hub/catheter limb. Leave hubs “open” (i.e., uncapped and disconnected) for the shortest time possible.
4. Always handle the catheter hubs aseptically. Once disinfected, do not allow the catheter hubs to touch nonsterile surfaces
5. Attach sterile syringe, unclamp the catheter, withdraw blood, and flush with sterile 0.9% saline
6. Repeat for other limb (this might occur in parallel)
7. Connect the ends of the blood lines to the catheter aseptically
8. Remove gloves and perform hand hygiene.

Disconnection steps:
1. Perform hand hygiene and don new clean gloves
2. Clamp the catheter (Note: Always clamp the catheter before disconnecting. Never leave an uncapped catheter unattended)
3. Disinfect the catheter hub before applying the new cap using an appropriate antiseptic (as above):
   a) (Optional) Disinfect the connection prior to disconnection. If this is done, use a separate antiseptic pad for the subsequent disinfection of the hub
   b) Disconnect the blood line from the catheter and disinfect the hub with a new antiseptic pad. Scrub the sides (threads) and end of the hub thoroughly with friction, making sure to remove any residue (e.g., blood)
   c) Use a separate antiseptic pad for each hub. Leave hubs “open” (i.e., uncapped and disconnected) for the shortest time possible
Always handle the catheter hubs aseptically. Once disinfected, do not allow the catheter hubs to touch nonsterile surfaces. Hold the catheter until the antiseptic has dried
5. Attach the new sterile caps to the catheter aseptically. Use caution if tape is used to secure caps to the catheter
6. Ensure that catheter is still clamped
7. Remove gloves and perform hand hygiene.

Table 2: Catheter and antiseptic compatibility

| Catheter material | Catheter       | Skin antiseptics                        | Antimicrobial ointments                      |
|-------------------|----------------|----------------------------------------|---------------------------------------------|
| Durathane         | DuraFlow       | Alcohol and iodine-based solutions      | Bacitracin/gramicidin/polymyxin B, povidone-iodine ointment, bacitracin/neomycin/polymyxin B, mupirocin |
| Polyurethane      | Equistream Hemosplit | Chlorhexidine with alcohol, alcohol, chlorhexidine, povidone-iodine, sodium hypochlorite | Povidone-iodine ointment, bacitracin/polymyxin B, bacitracin, mupirocin |
| Silicone          | Maxid & Permcath | Chlorhexidine with alcohol, alcohol, chlorhexidine, povidone-iodine, sodium hypochlorite | Bacitracin/neomycin/polymyxin B               |
| Carbothane        | Palindrome     | Chlorhexidine with alcohol, alcohol, chlorhexidine, povidone-iodine, sodium hypochlorite | Bacitracin/neomycin/polymyxin B               |
| Silicone          | Medcomp Hemocath | Alcohol, chlorhexidine, povidone-iodine, sodium hypochlorite | Mupirocin                                     |
| Polyurethane      | Splitcath, SplitStream Bioflex, Tesio, Hemoflow | Alcohol, chlorhexidine, povidone-iodine, sodium hypochlorite | Mupirocin                                     |

We recommend the following steps for monitoring and detection of complications:
1. The maximum blood flow obtained from the access should be documented at each dialysis
2. A progressive drop in the flow obtained with properly positioned needles of the same gauge should prompt further investigation of the access for stenosis
3. Venous pressure should not be used to monitor stenosis
in an AVF vein. However, it may be used to monitor stenosis in an AV graft.

4. The venous pressure should be measured using 17G needles within the first 5 min of dialysis at a blood flow of 200 ml/min. Serial readings are more useful than a single one. An increase of more than 20% or an absolute value persistently >120 mmHg is indicative of a graft outflow stenosis

5. If dysfunction is suspected or observed, fistula and graft stenosis should be investigated by angiography. Ultrasonography is an alternative but is highly operator dependent and can give fallacious readings due to deep collateral veins

6. An angiogram or computed tomography (CT) angiogram should evaluate the AV anastomosis, the draining veins, and the central veins (subclavian and superior vena cava)

7. Fever or rigors during HD in patients with indwelling cannulae should prompt evaluation of the vascular access as a source of infection

8. We suggest that flow from catheters, venous pressure, and prepump arterial pressure should be monitored and documented at each dialysis. Catheters with easy inflow on flushing but poor or no backflow are indicative of a “fibrin sheath” which exerts a ball valve-like effect. Catheters with poor inflow and outflow are indicative of intraluminal obstruction possibly caused by thrombus.
   - We recommend that thrombolysis initially with a low dose and subsequently with a high dose of urokinase lock protocol be carried out for thrombosed lumens, the protocol of which is provided in Box 4
   - Alternatively, 1 mg of tissue plasminogen activator may be used in the place of urokinase
   - We suggest that a catheter malfunction due to a fibrin sheath may be treated by balloon disruption of the sheath or stripping followed by insertion of a fresh catheter over a guidewire

   • We suggest that the terminology standardized by the (NAVACS) North American Vascular Access Consortium Study be used for documenting and reporting performance; events and outcomes related to vascular access be adopted by all in order to ensure uniformity and allow comparisons
   • We recommend that an attempt be made to salvage a vascular access on all occasions prior to abandoning it and creating another
   • We suggest that percutaneous or surgical interventions may be used to salvage a failing vascular access
   • We suggest that surgical revision or percutaneous intervention should be attempted to salvage a stenosed AVF or graft before attempting to construct a new access
   • Thrombolysis or surgical thrombectomy should be attempted in case of an early acute access thrombus
   • Surgical thrombectomy is rarely successful in cases of late thrombus formation, which are usually due to an underlying stenosis
   • We suggest that the interventions may be carried out by personnel with adequate training and experience including nephrologists, interventional radiologists, cardiologists, or vascular surgeons
   • We suggest that central venous stenosis or occlusion be treated primarily by percutaneous interventions and surgery be reserved for those who fail this form of treatment
   • A complete description of the possible interventions for access salvage is beyond the scope of this guideline and the reader is referred to more detailed texts.

The following “Rule of 6” should be followed for an AVF:
   • A vein of at least 6 mm in diameter with clearly

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**Box 4: Protocol of thrombolysis of catheters**

“Push-Lock” protocol with urokinase

1. Check the volume of the lumen (this is usually marked on the line itself)
2. Calculate the priming volume of each lumen plus 3 mL
3. Use this volume of sodium chloride 0.9% to reconstitute 1 vial of urokinase 5000 U
4. Draw the reconstituted urokinase solution into two 5-mL syringes
5. Calculate the priming volume of the lumen +0.5 mL. Inject this volume of urokinase into each lumen. This will be the 1st lock. In order to positively pressure lock the lumen, clamp the line while injecting the solution
6. Wait for 10 min
7. Inject 0.5 mL of the solution and positively pressure lock each lumen (2nd lock)
8. Wait for 10 min
9. Inject 0.5 mL of solution and positively pressure lock each lumen (3rd lock)
10. Wait for 10 min
11. Aspirate each lumen and flush with normal saline
12. If successful, resume dialysis and consider low-dose (1 mg) warfarin daily

If poor flow persists, repeat the protocol using 25,000 U of urokinase instead of 5000 U.
distinguishable margins
- A cannulation length of at least 6 cm from the anastomosis
- Flow of at least 600 ml/min and a depth of not more than 6 mm from the skin
- Use 6 weeks after the time of creation
- Numerous collateral veins should not be visible and there should be no evidence of venous HTN.

We suggest not using prophylactic antibiotic catheter locks for dialysis catheters. This represents a change from the earlier guidelines and is based on the review of studies published. Prior to 2005, studies using antibiotic catheter locks appeared to have a benefit in infection episodes per catheter years. Studies since 2006 have not shown a similar benefit and have shown an overall reduction in the number of infective episodes, probably attributable to greater attention to hand hygiene and overall catheter care. As emphasized earlier, the increasing development of multidrug resistance with extended spectrum beta-lactamase and metallo-beta-lactamasases production by Gram-negative organisms is a cause of grave concern and hence prophylactic antibiotics should be avoided.

We suggest that the use of therapeutic antibiotic locks along with systemic antibiotic therapy be considered in the treatment of CRBSI as the concentration achieved by appropriate antibiotic locks may be 1000-fold higher than blood levels of the same antibiotic.

**Preparation of antibiotic cannulae locks**
- Trisodium citrate is commercially available as a 46% solution. This may be diluted ten times with sterile water for injection to produce a 4.5% solution
- Gentamicin–citrate Lock solution: 46% trisodium citrate is diluted with sterile water 1:5 to produce a 9.2% solution
- One milliliter of this solution is mixed with 0.5 ml of 10 mg/ml gentamicin injection and the resulting 1.5 ml is injected into each limb of the cannulae. The final solution containing 6.1% citrate and 3.3 mg/ml of gentamicin can be used as a therapeutic lock solution
- Gentamicin–heparin solution: One mL of gentamicin injection containing 10 mg is mixed with 4 ml of heparin containing 1000 U/ml. Up to 1.5 ml of the solution should be instilled into each limb of the cannulae. The final solution contains 800 U/ml of heparin and 2 mg/ml of gentamicin. Stronger concentrations should not be used and care should be taken not to exceed the volume of the cannulae to avoid systemic toxicity.

If flow is still not restored, proceed for Alteplase infusion as follows:
1. Add 10-mL water for injection to a 10-mg vial of Alteplase
2. Draw up 10 mL of the Alteplase solution into two 10-mL syringes
3. Use two syringe pumps to infuse the Alteplase solution at 2 mg/h (2 mL/h) for 2 h. Higher doses have been infused over 12 h in case reports

We recommend that CRBSI should be suspected and ruled out by blood cultures in the following conditions:
- Fever (>38.0°C before dialysis and >37.7°C during dialysis)
- Chills, rigors, and hypotension
- New unexplained malaise and absence of alternative site of infection
- Even if a vascular catheter is being removed, we recommend collection of blood for culture from the hub rather than culturing the tip
- We recommend that a total of at least 30 ml of blood (60 ml if aerobic and anaerobic are required) should be obtained for culture in adults and in children aged >10 years and weighing >30 kg and inoculated in three blood culture bottles
- 10 ml should be obtained from each of the catheter lumens and 10 ml may be obtained either from a peripheral vein or from the HD circuit.
- We suggest that in children aged <10 years, 2–10 ml of blood from two sites should be cultured in two bottles. Where possible, at least 6 ml should be inoculated in one bottle. Care should be taken to use the appropriately sized bottle.

Multiple studies have proven that the culture positivity rate is proportional to the amount of blood cultured, ranging from 15% with 10 ml to 60% with 30 ml.

We recommend that in CKD patients where venipunctures are to be avoided, the dialysis circuit provides an alternative source for drawing large volumes of blood for culture. Pelletier et al. showed that the sensitivity, specificity, and accuracy of such samples were 93.5%, 100%, and 95%, respectively.

We do not recommend culturing catheter tips.

We recommend that the diagnosis of CRBSI be based on positive cultures obtained either from the HD circuit or the catheter.

We suggest that strict adherence to the Infectious Diseases Society of America criteria for quantitative cultures and differential time to positivity may not be required for diagnosis as the dialysis circuit is unique.

Because the symptoms of CRBSI frequently occur during HD, necessitating blood collection, unlike unidirectional use of catheters as in central venous catheters or ports, dialysis catheters become part of a dynamic closed circuit that both receives and delivers blood during HD. Blood circulating through an infected catheter during dialysis before cultures are obtained may dilute the density of microorganisms in the catheter, interfering with the quantitative blood cultures and differential time to positivity criterion of CRBSI in
We recommend that units follow a strict aseptic protocol when collecting blood for culture. A sample protocol is provided in Box 5.

We recommend that a tunnel or exit-site infection alone should be treated by catheter removal and antibiotic treatment for 7 days.

We suggest that nontunneled uncuffed catheters always be removed in case of CRBSI.

We recommend that tunneled cuffed catheters be removed in the following situations:

- Blood culture grows *Staphylococcus aureus*, *Klebsiella*, *Mycobacteria*, *Pseudomonas* or fungal organisms such as *Candida*.
- Presence of complications such as septic thrombosis, septic shock, endocarditis, or osteomyelitis.

Co-existing tunnel infection/abscess

Persistent positive blood cultures after 72 h of treatment with appropriate antibiotics.

We suggest that in infections of lower virulence such as ralstonia, systemic antibiotics, antibiotic locks, or exchange over a guidewire may be tried, once symptoms subside.

We suggest that in children, the benefits of catheter removal must be weighed against the difficulty of obtaining alternate venous access, unless there is

### Box 5: Procedure for collection of blood culture in suspected catheter-related bloodstream infection

Place all equipment required (including personal protection equipment) on a trolley cleaned with alcohol-based wipes and bring to the patient zone: this should include sterile gloves, small dressing pack, cotton swabs, tape, tourniquet (s), alcohol 70%, or alcohol 70% with chlorhexidine.

Check expiry date for each blood culture bottle and mark 10 mL above the broth for fill level.

Perform hand hygiene (moment 1).

Check patient identification and inform patient of the procedure and its purpose.

Remove the cap of each blood culture bottle and scrub the vial stoppers well using alcohol 70%, or alcohol 70% with chlorhexidine, and allow to dry completely.

Position patient appropriately, apply tourniquet to palpate, and identify appropriate vein.

Put on sterile gloves (essential if re-palpation occurs post cleansing of the venepuncture site).

Using alcohol 70%, or alcohol 70% with chlorhexidine, disinfect the venepuncture site using a scrubbing motion. Use a fresh swab for each scrub. Use 2-3 scrubs and do this for a total of 1-2 min, allowing the site to dry.

Perform venepuncture (release tourniquet during procedure where appropriate, this will contaminate the gloved hand and using a sterile towel or the nondominant hand is advised).

Place 10-mL blood per bottle, keeping blood culture bottle upright.

Always collect/inoculate the blood culture bottles FIRST (inoculating the aerobic bottle first) then, if required, collect additional blood pathology tubes at this point.

Apply cotton swab and pressure to site (where possible obtain patient assistance to hold and apply pressure); repeat procedure for the 2nd set of blood cultures at a different peripheral site, maintaining aseptic technique. Invert bottles gently several times to prevent clotting.

Discard sharps, collect all rubbish/dirty items, and dispose of appropriately.

Label each bottle with patient name, (PRN) permanent registration number, date/time for collection of blood, and location of site used for each set. Do not cover any bar codes or the bottom of the bottle.

Place bottles into a biohazard bag and arrange to send to the laboratory with request form.

Transport bottles at room temperature. Never refrigerate a blood culture bottle after inoculation.

Remove gloves and perform hand hygiene (Moment 3) after the procedure.

Administer the first doses of antibiotics.

Note: In the case of collection of blood from the cathether hub or dialysis circuit, the same precautions are to be followed as when connecting a patient for HD.

We recommend that dialysis units document all episodes of CRBSI and calculate the rate of CRBSI episodes as a part of quality assurance.

We suggest that the rates of CRBSI be included as part of an annual audit and graded according to Table 3 [after Lok (2017)].
clinical deterioration or persistent or recurrent CRBSI

• We recommend that a new cuffed tunneled catheter be placed after blood cultures are negative, following removal of an infected catheter and antibiotic treatment.

• We recommend that all episodes of CRBSI be treated with IV antibiotics for a minimum period of 14 days

• We recommend that infections with *S. aureus* be treated for a period of 21 days

• We recommend that complications such as endocarditis and osteomyelitis be treated for 6 weeks

• We recommend not using empirical vancomycin for the treatment of suspected CRBSI.