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NATIONAL GUIDELINE CLEARINGHOUSE

# General

## Guideline Title

ACR Appropriateness Criteria® radiologic management of central venous access.

## Bibliographic Source(s)

Shaw CM, Shah S, Kapoor BS, Cain TR, Caplin DM, Farsad K, Knuttinen MG, Lee MH, McBride JJ, Minocha J, Robilotti EV, Rochon PJ, Strax R, Teo EYL, Lorenz JM, Expert Panel on Interventional Imaging. ACR Appropriateness CriteriaÂ® radiologic management of central venous access. Reston (VA): American College of Radiology (ACR); 2017. 28 p. [152 references]

## Guideline Status

This is the current release of the guideline.

This guideline meets NGC's 2013 (revised) inclusion criteria.

# NEATS Assessment

National Guideline Clearinghouse (NGC) has assessed this guideline's adherence to standards of trustworthiness, derived from the Institute of Medicine's report Clinical Practice Guidelines We Can Trust.

= Poor = Fair = Good = Very Good = Excellent

| Assessment | Standard of Trustworthiness |
|---|---|
| YES | Disclosure of Guideline Funding Source |
| | Disclosure and Management of Financial Conflict of Interests |
| | Guideline Development Group Composition |
| YES | Multidisciplinary Group |
| YES | Methodologist Involvement |

| | |
|---|---|
| | Patient and Public Perspectives |
| | **Use of a Systematic Review of Evidence** |
| | Search Strategy |
| | Study Selection |
| | Synthesis of Evidence |
| | **Evidence Foundations for and Rating Strength of Recommendations** |
| | Grading the Quality or Strength of Evidence |
| | Benefits and Harms of Recommendations |
| | Evidence Summary Supporting Recommendations |
| | Rating the Strength of Recommendations |
| | **Specific and Unambiguous Articulation of Recommendations** |
| | **External Review** |
| | **Updating** |

# Recommendations

## Major Recommendations

ACR Appropriateness Criteria®

Radiologic Management of Central Venous Access

Variant 1: Device selection. Adult or child ≥13 years of age. Intravenous access for long-term total parenteral nutrition and intermittent intravenous antibiotics.

| Treatment/Procedure | Appropriateness Category |
|---|---|
| Chest port | Usually Appropriate |
| Arm port | May Be Appropriate |
| Single lumen PICC | Usually Not Appropriate |
| Double lumen PICC | May Be Appropriate |
| Tunneled small bore central venous catheter single lumen | May Be Appropriate |
| Tunneled small bore central venous catheter double lumen | Usually Appropriate |

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 2: Device selection. Adult or child ≥13 years of age. Sickle cell anemia requires intravenous access for the treatment of recurrent sickle cell crisis.

| Treatment/Procedure | Appropriateness Category |
|---|---|
| Chest port | Usually Appropriate |
| Arm port | May Be Appropriate |
| Single lumen PICC | May Be Appropriate |
| Double lumen PICC | May Be Appropriate |
| Tunneled central venous catheter | May Be Appropriate |
| Nontunneled central venous catheter | May Be Appropriate |

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 3: Device selection. Adult or child ≥13 years of age. Stage 3 chronic kidney disease requires central venous access for 6 weeks of antibiotic treatment.

| Treatment/Procedure | Appropriateness Category |
|---|---|
| Chest port | Usually Not Appropriate |
| Arm port | Usually Not Appropriate |
| Single lumen PICC | Usually Not Appropriate |
| Double lumen PICC | Usually Not Appropriate |
| Tunneled small bore central venous catheter single lumen | Usually Appropriate |
| Tunneled small bore central venous catheter double lumen | May Be Appropriate |

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 4: Device selection. Adult or child ≥13 years of age. Intensive care unit (ICU) patient with sepsis and acute renal insufficiency requires intravenous access for approximately 7 to 10 days.

| Treatment/Procedure | Appropriateness Category |
|---|---|
| Chest port | Usually Not Appropriate |
| PICC | May Be Appropriate |
| Tunneled small bore central venous catheter | Usually Not Appropriate |
| Nontunneled central venous catheter | Usually Appropriate |

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 5: Site selection. Adult or child ≥13 years of age. Head and neck surgery. Central venous access required for adjuvant chemotherapy.

| Treatment/Procedure | Appropriateness Category |
|---|---|
| Arm port | Usually Appropriate |
| PICC | Usually Appropriate |
| Chest port via internal jugular/subclavian vein | Usually Appropriate |
| Tunneled small bore catheter via internal jugular/subclavian vein | May Be Appropriate |

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 6: Site selection. Adult or child ≥13 years of age. Sepsis in a patient with stage 4 chronic kidney disease, requires 7 to 10 days of intravenous antibiotic therapy.

| Treatment/Procedure | Appropriateness Category |
|---|---|
| PICC | Usually Not Appropriate |
| Nontunneled central venous catheter via the left internal jugular vein | Usually Appropriate |
| Nontunneled central venous catheter via the right internal jugular vein | Usually Appropriate |
| Nontunneled central venous catheter via the subclavian vein | Usually Not Appropriate |

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 7: Site selection. Adult or child ≥13 years of age. ICU patient with sepsis. The patient receives hemodialysis via nontunneled catheter placed via the right internal jugular vein. Multilumen central venous access required.

| Treatment/Procedure | Appropriateness Category |
|---|---|
| Arm PICC | Usually Not Appropriate |
| Femoral vein nontunneled central venous catheter | May Be Appropriate |
| Right internal jugular vein nontunneled central venous catheter | Usually Appropriate |
| Subclavian vein nontunneled central venous catheter | May Be Appropriate |
| Left internal jugular vein nontunneled central venous catheter | Usually Appropriate |

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 8: Site selection for permanent hemodialysis catheter. Adult or child ≥13 years of age. End stage renal disease has undergone creation of a left arm arteriovenous fistula. The fistula has not yet matured.

| Treatment/Procedure | Appropriateness Category |
|---|---|
| Right internal jugular vein | Usually Appropriate |
| Right subclavian vein | May Be Appropriate |
| Left internal jugular vein | May Be Appropriate |
| Left subclavian vein | Usually Not Appropriate |
| Right or left femoral vein | May Be Appropriate |

Variant 9: Immunocompromised patient. Adult or child ≥13 years of age. Has a tunneled small-bore catheter placed via right internal jugular vein. Patient is pancytopenic (ANC 300/μL, PLT 32,000/μL) and presents with fevers and malaise.

| Treatment/Procedure | Appropriateness Category |
|---|---|
| Immediate removal of the tunneled catheter, culture of the catheter tip and placement of a nontunneled central venous catheter via different site | May Be Appropriate |
| Retain the catheter and commence empiric antibiotics once peripheral and central blood cultures have been drawn | May Be Appropriate |
| Catheter should be removed if positive blood cultures are confirmed | Usually Appropriate |
| Catheter salvage may be considered even after positive blood cultures are acquired | May Be Appropriate |

Variant 10: Thrombotic complications. Adult or child ≥13 years of age. Chest port placed via right internal jugular vein is being used for chemotherapy. The infusion nurse can infuse saline but is unable to aspirate blood from the catheter.

| Treatment/Procedure | Appropriateness Category |
|---|---|
| Continue to use the port for administering drugs but use peripheral access for blood draws | May Be Appropriate |
| Catheter removal and placement of alternative venous access | May Be Appropriate |
| Chest radiograph | Usually Appropriate |
| Interrogate the port with patient and/or patient arm in different positions | Usually Appropriate |
| Instill a thrombolytic agent into the port | Usually Appropriate |
| Contrast study of the catheter | Usually Appropriate |
| Catheter exchange | May Be Appropriate |
| Catheter stripping | May Be Appropriate |

Variant 11: Thrombotic complications. Adult or child ≥13 years of age. Permanent hemodialysis catheter placed via the right internal jugular vein. Poor flows are documented at hemodialysis via both lumens.

| Treatment/Procedure | Appropriateness Category |
|---|---|
| Catheter removal and placement of a new catheter from a different site | Usually Appropriate |
| Catheter exchange | Usually Appropriate |
| Contrast study of the catheter | Usually Appropriate |
| Fibrin sheath stripping | Usually Appropriate |
| Fibrin sheath disruption | Usually Appropriate |
| Attempt to perform dialysis with patient arm in a different position | Usually Appropriate |

Variant 12: Thrombotic complications. Adult or child ≥13 years of age. Arm swelling secondary to extensive thrombus surrounding a triple lumen PICC placed via left Basilic vein. The catheter is being used for long-term parenteral nutrition and intermittent intravenous antibiotics. The catheter is functioning.

| Treatment/Procedure | Appropriateness Category |
|---|---|
| Immediate catheter removal | May Be Appropriate |
| Commence anticoagulation and continue to use the catheter | Usually Appropriate |
| Catheter-directed thrombolysis | May Be Appropriate |
| Systemic thrombolysis | Usually Not Appropriate |
| SVC filter placement | Usually Not Appropriate |
| Catheter downsize for a single/double lumen PICC | Usually Not Appropriate |

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 13: Infectious complications. Adult or child ≥13 years of age. Preventive measures to reduce catheter-related bloodstream infections when placing a nontunneled central venous catheter in ICU patient.

| Treatment/Procedure | Appropriateness Category |
|---|---|
| Antibiotic impregnated catheters | May Be Appropriate |
| Upper body insertion site | Usually Appropriate |
| Heparin-bonded catheter | May Be Appropriate |
| Prophylactic antibiotics prior to catheter placement | May Be Appropriate |
| | |

| Treatment/Procedure | Appropriateness Category |
|---|---|
| Antimicrobial lock therapy (not ethanol lock) | May Be Appropriate |
| Routine guide-wire catheter exchanges | Usually Not Appropriate |

Variant 14: Infectious complications. Adult or child ≥13 years of age. Therapeutic measures to manage catheter-related bloodstream infections.

| Treatment/Procedure | Appropriateness Category |
|---|---|
| Catheter should be removed immediately | May Be Appropriate |
| Catheter should be removed in the setting of *Staphylococcus aureus* bacteremia | Usually Appropriate |
| Catheter should be preserved in clinically stable patients | May Be Appropriate |
| Catheter exchange in conjunction with systemic antibiotics can be considered in patients with coagulase-negative Staphylococcal bacteremia | May Be Appropriate |
| Exit site infections may be treated with antibiotics alone | May Be Appropriate |
| Catheter salvage and concomitant antibiotic therapy are appropriate in patients with limited venous access | Usually Appropriate |

Summary of Literature Review

Introduction/Background

Image-guided percutaneous central venous (CV) access refers to the use of real-time imaging (fluoroscopy and/or sonography) to place a catheter in a vein that leads directly to the heart. The catheter tip is positioned at the cavoatrial junction, or in the right atrium. Central venous catheters (CVC) include peripherally inserted central catheters (PICC), temporary (nontunneled) CVCs, long-term (tunneled) CVCs, and totally implantable devices. CV access may be required for diagnostic and/or therapeutic reasons. Many of the indications for CV access are not mutually exclusive to a particular device. Diagnostic indications include establishing or confirming a diagnosis, establishing a prognosis, monitoring a response to treatment, and repeated blood sampling. Therapeutic indications include administration of chemotherapy, parenteral nutrition (PN), blood products, intravenous medications or fluids, and performance of plasmapheresis or hemodialysis.

Radiologically guided percutaneous insertion is associated with higher technical success rates, fewer complications, shortened procedure times, and subsequent reduction in costs compared with other specialties.

Discussion by Variant

*Variant 1: Device Selection. Adult or Child ≥13 Years of Age. Intravenous Access for Long-term Total Parenteral Nutrition and Intermittent Intravenous Antibiotics*

*Variant 2: Device Selection. Adult or Child ≥13 Years of Age. Sickle Cell Anemia Requires Intravenous Access for the Treatment of Recurrent Sickle Cell Crisis*

*Variant 3: Device Selection. Adult or Child ≥13 Years of Age. Stage 3 Chronic Kidney Disease Requires Central Venous Access for 6 Weeks of Antibiotic Treatment*

*Variant 4: Device Selection. Adult or Child ≥13 Years of Age. Intensive Care Unit (ICU) Patient with Sepsis and Acute Renal Insufficiency Requires Intravenous Access for Approximately 7 to 10 Days*

The ideal CV access device should be radiopaque, hemo-compatible, and durable. The catheter and the vein in which it is placed should allow brisk infusion and easy aspiration of fluids. Patient comfort and mobility should not be adversely affected. There is no evidence-based guide to the selection of the most

appropriate CV access device for each clinical situation. Device selection is determined by several factors: the patient's diagnosis and clinical status; the type, frequency, and duration of therapy; the patient's history of CV access and patency of the access veins; patient preference; and operator experience.

Duration of Therapy

Short-term (1-3 weeks) CVCs are nontunneled (temporary) 20 to 30 cm–long catheters inserted into a central vein (subclavian, internal jugular, innominate, axillary, or femoral vein). They may have a single or multiple lumens and range in size from 5 to 14F. They are designed for continuous short-term (1-3 weeks) infusions, drug delivery, hemodialysis, apheresis, and CV pressure monitoring.

Intermediate (<3 months) CVCs are nontunneled devices specifically designed for prolonged intermittent use, such as PICCs and Hohn catheters. PICCs are nontunneled, central catheters inserted through a peripheral vein of the arm. They range from 2 to 7F, and may have one, two, or three lumens. The catheter extends from the puncture site to the superior vena cava (SVC). Hohn catheters are nontunneled, 20 cm long, centrally inserted catheters. They are available as either single lumen 5F or dual lumen 7F. The catheter is made of silicone and has a nontapered tip. Both PICCs and Hohn catheters can be used for prolonged continuous or intermittent infusion therapies (up to 3 months) both in hospitalized patients and in outpatients.

Long-term (>3 months) CVCs include tunneled CVC or a totally implanted port. Tunneled catheters travel through a short (8-15 cm) subcutaneous tunnel before entry into an accessed vein. Sizes range from 3.5 to 21F. The cuff induces an inflammatory reaction within the subcutaneous tunnel, leading to fibrosis and consequent catheter fixation, usually within 3 to 4 weeks after insertion. The cuff also inhibits migration of organisms into the catheter tract, thus reducing infection rates compared with temporary catheters. Totally implanted ports consist of a reservoir connected to a CVC, which may or may not be valved. The reservoir is implanted in the chest or arm. Ports have lower reported rates of catheter-related bloodstream infections (CRBSI) than both tunneled and nontunneled CVCs. Tunneled CVC is recommended for patients requiring continuous access, whereas a totally implantable access device should be reserved for patients who require long-term, intermittent vascular access.

Catheter Design

The materials used to make the catheter, and the catheter design, have undergone considerable modifications to improve function and reduce catheter-related complications.

Catheter Size and Number of Lumens

In general, the smallest diameter catheter and minimum number of lumens should be used to minimize the risk of catheter-related complications. Multilumen catheters may be used when multiple simultaneous therapies are required or when infusion of noncompatible medications and fluids require additional venous access. In patients with chest ports who require higher infusion rates, the flow through a catheter 6F or greater will be limited by the size of the accessing Huber needle used and not the catheter lumen. In patients who require PN, it is generally recommended that a single lumen be dedicated exclusively to that purpose.

Materials

The properties of the catheter material can impact device placement and performance in several ways. Almost all CVCs are now made of silicone or polyurethane. These materials have been associated with fewer infections than polyvinyl chloride or polyethylene. Silicone, a soft biocompatible rubber, is one of the least traumatic and thrombogenic materials available. Silicone catheters are more prone to compression and "pinch off." Polyurethane, on the other hand, is a tougher and stiffer material. Greater catheter stiffness and size are associated with an increased risk of mechanical phlebitis. In general, silicone is more compatible with infusates, and polyurethane is more susceptible to degradation by various drug solvents.

In an attempt to reduce catheter-related complications, catheters and cuffs that are coated or

impregnated with antimicrobial, antiseptic, or anti-thrombotic agents have been developed. The data available relates primarily to triple-lumen, temporary catheters in adult patients with catheter dwell time <30 days. Two meta-analyses of first-generation catheters coated externally with chlorhexidine/silver showed a reduced risk for CRBSI compared with standard noncoated catheters. Three prospective, randomized studies of second-generation catheters demonstrated a significant reduction in catheter colonization, but were underpowered to show a difference in CRBSI. CVCs impregnated on both the external and internal surfaces with minocycline/rifampin were associated with lower rates of CRBSI when compared with the first-generation chlorhexidine/silver sulfadiazine impregnated catheters. The beneficial effect began after day six of catheterization. Silicone minocycline/rifampin-impregnated CVCs with an average dwell time of over 60 days have been shown to be effective in reducing CRBSI. Conflicting results have been obtained from a number of prospective randomized control trials (RCTs) comparing platinum/silver impregnated catheters with nonimpregnated catheters. In 2011, the U.S. Centers for Disease Control and Prevention (CDC) recommended the use of a chlorhexidine/silver sulfadiazine or minocycline/rifampin-impregnated CVC in patients whose catheter is expected to remain in place more than five days if, after successful implementation of a comprehensive strategy to reduce rates of catheter-line–associated bloodstream infection, the infection rate is not decreasing.

Thrombolytic coatings (e.g., heparin), have been incorporated into the design of some tunneled catheters. A retrospective comparison of heparin-coated and noncoated hemodialysis catheters showed a significantly lower risk of catheter-related bacteremia among the heparin-coated catheters, but the coating did not decrease the risk of catheter malfunction. The longevity of the coatings, the risk of antibiotic resistance, and the safety of the antithrombotic coatings, particularly in patients who may be heparin-induced thrombocytopenia positive, needs to be assessed. At present, there is inadequate evidence to support the use of PICCs or tunneled catheters coated with anti-infective or antithrombotic drugs.

Catheter Tip Design

Numerous catheter tip designs exist, including end-hole, valved tip, and staggered tips. End-hole is the tip configuration in most temporary catheters and can be cut to the appropriate length. Valved-tip catheters have a closed blunt tip with valved slits just proximal to the tip. While infusion and aspiration are possible, the tip prevents blood from entering the lumen when not in use, obviating the need for heparin flushes. Since the tip cannot be modified, the catheter length is trimmed at the hub. In an RCT, they were not superior to a traditional, open-ended device in terms of catheter efficacy, and early and late complications.

Hemodialysis and apheresis require flow rates of approximately 350 and 125 cc/min, respectively. Hemodialysis catheter tip designs include a single catheter with two lumens and a central septum (e.g., Optiflow, Hickman catheters), two distinct circular lumens (e.g., PermCath catheter), two distinct catheters partially attached (e.g., Ash Split catheter), and two distinct and separate catheters (e.g., Tesio catheter). In most designs, the distal catheter tips are staggered to prevent re-circulation; typically, the venous port is more inferior. Currently, there is insufficient evidence to support one type of hemodialysis catheter design over another.

Indication for Use

Hemodialysis

The vascular access of choice for maintenance hemodialysis is the native arteriovenous fistula (AVF). Hemodialysis access of <3 weeks' duration should be obtained using a noncuffed, or a cuffed, double-lumen percutaneously inserted catheter. Noncuffed femoral catheters should not be left in place longer than 5 days and should be left in place only in bed-bound patients. Tunneled cuffed venous catheters are the method of choice for temporary access of >3 weeks' duration. Some patients who have depleted all other access options require permanent access via tunneled cuffed catheters. For patients who have a primary AVF maturing but need immediate hemodialysis, tunneled cuffed catheters are the access of choice.

The National Kidney Foundation Disease Outcomes Quality Initiative (NKF-KDOQI) Clinical Practice Guidelines for Vascular Access currently recommends restricting venous access for patients with chronic kidney disease stage 3 or worse. The NKF-KDOQI guidelines recommend the use of small-bore catheters placed via the internal jugular vein and avoidance of the subclavian vein when CV access is indicated in patients with stage 3 to 5 chronic kidney disease. In general, a PICC line should not be placed in patients at risk for future hemodialysis vascular access.

Parenteral Nutrition

CV access, which allows delivery of nutrients directly into the SVC or the right atrium, is needed in most patients who are candidates for PN. It is recommended that peripheral PN delivered via short or midline catheters should be used only for a limited period of time, and only for nutrient solutions with osmolarity of 850 mOsm/L or less. For high osmolarity PN, the tip of the catheter should be placed in the lower third of the SVC or in the upper right atrium to avoid injury to the endothelium of the veins. Both nontunneled CVCs and PICCs are suitable for short-term inpatient PN. Neither device has been shown to be superior in this patient population. For medium term or home PN, PICCs, Hohn catheters, tunneled catheters and ports are appropriate. PICCs may not be suitable for patients receiving home PN who are self-caring as the PICC effectively disables one arm. For prolonged use and home PN for >3 months, a tunneled catheter or port is advised. Venous ports have been recommended only for patients who require long-term, intermittent vascular access, while for patients requiring long-term frequent or continuous access, a tunneled CVC is preferable.

Chemotherapy

Oncology patients often require indefinite venous access that will serve them through all phases of their disease. There are very limited data to guide clinicians when selecting a device for their oncologic patient. CV access is recommended for the administration of boluses of vesicant drugs, but is essential for continuous infusion of these agents. While many clinical factors may impact the choice of device, patient involvement has been shown to result in greater patient satisfaction, fewer delays in therapy related to loss of vascular access, fewer device complications, preservation of peripheral veins, less nursing time spent attempting to gain vascular access, shorter hospital stays, fewer emergency room visits, and decreased infusion therapy costs.

Ports have been shown to have the lowest reported rates of CRBSI compared with either tunneled or nontunneled CVC. The only study to randomize patients with solid tumors commencing chemotherapy to surgical port placement versus standard peripheral venous access showed low port complication rates (0.23/1,000 days of use) and significantly less access-related anxiety and pain with 27% of the control group ultimately requiring CV access. Costs were considerably higher in the port group compared with controls. While overall quality of life scores was comparable in the two groups, the study had limited power to detect significant differences in the subscale sores.

Single lumen ports are ideally suited to patients with solid tumors receiving long-term intermittent bolus chemotherapy. Double lumen ports may be required in oncologic patients who require regular blood transfusions or bone marrow transplantation, or for the administration of noncompatible infusates. Port implantation in brachial veins is associated with easy vascular access and a lower risk of complications at insertion. They may be preferable in patients with tracheostomy, head and neck tumors, and anatomic deformities in the chest that may make access and nursing care more difficult. One study reported more frequent thrombogenic complications in arm ports than in chest ports (11.4% versus 4.8% respectively).

Although medium- and long-term access devices are both acceptable in outpatients, PICCs have been associated with a higher incidence of thrombosis in patients with hematological and nonhematological malignancies. This is an important consideration in patients who have had previous thromboses, and in those who are receiving therapy, which may increase the thrombotic tendency. The risk of PICC-related venous thrombosis can be reduced by avoiding PICCs with calibers greater than 4F and by using ultrasound guidance for placement. A systematic review and meta-analysis including 5 RCTs and 25 observational studies comparing centrally inserted external catheters with totally implantable ports in patients undergoing chemotherapy showed a 3- to 4-fold increased risk of infections, noninfections

complications, and device removal, compared to implantable ports.

Hospitalized Patients

Nontunneled CVCs are used for short-term venous access in the majority of hospitalized patients. A multicenter study analyzing 2,101 CVCs inserted in critically ill patients showed PICCs were associated with a significantly lower rate of bloodstream infection than standard CVC. No RCT has yet proven this. A meta-analysis from consisting of 48 papers published between 1979 and 2004, did not find clear evidence that PICC is superior to CVC in acute care settings. In this meta-analysis, infectious complications did not significantly differ between PICC and CVC; however, all PICC placements were performed without ultrasound guidance. In relation to PN in hospitalized patients, PICCs should be considered in patients with tracheostomy, and in patients where insertion-related complications are increased (e.g., patients with coagulation abnormalities).

*Variant 5: Site Selection. Adult or Child ≥13 Years of Age. Head and Neck Surgery. Central Venous Access Required for Adjuvant Chemotherapy*

*Variant 6: Site Selection. Adult or Child ≥13 Years of Age. Sepsis in a Patient with Stage 4 Chronic Kidney Disease, Requires 7 to 10 Days of Intravenous Antibiotic Therapy*

*Variant 7: Site Selection. Adult or Child ≥13 Years of Age. ICU Patient with Sepsis. The Patient Receives Hemodialysis via Nontunneled Catheter Placed via the Right Internal Jugular Vein. Multilumen Central Venous Access Required*

*Variant 8: Site selection for Permanent Hemodialysis Catheter. Adult or Child ≥13 Years of Age. End Stage Renal Disease Has Undergone Creation of a Left Arm Arteriovenous Fistula. The Fistula Has Not Yet Matured*

The risk of catheter-related complications varies according to the site of catheter insertion. Factors to consider when selecting the optimal insertion site include the presence of acute or chronic thrombus in the target vein, CV access history, and integrity of the surrounding soft tissues.

Peripheral Veins

CV access via peripheral vein may be preferable in a patient with a tracheostomy, severe anatomical abnormalities of neck and thorax, marked thrombocytopenia, and in patients who require home PN for limited periods of time.

In the upper limb, PICCs and subcutaneous arm ports are usually placed via the basilic, brachial, or cephalic veins when image-guidance is employed. The basilic vein is the access vein of choice as it is superficial and is usually the largest vein in the arm. Access via the cephalic vein has a higher incidence of thrombosis. This is due to its smaller size and catheter susceptibility to movement and kinking as it overlies the biceps muscle. Brachial vein access carries a greater risk of injury to the brachial artery and median nerve.

Conventional Central Veins

Determination of the optimal site for CV access can be complex. The decision should be based on a careful evaluation of the relative risks and benefits of each site.

The femoral route is often preferred in emergency or high-risk situations (e.g., severe thrombocytopenia or coagulopathy), where insertion complications are lower and hemostasis is easier to achieve. In patients in whom the internal jugular and subclavian veins are occluded or otherwise unavailable for puncture, or in the event of SVC obstruction, femoral vein access may also be considered. In 2011, the CDC advised against using femoral vein for CV access in adult patients. This recommendation was based on studies that demonstrated high femoral catheter colonization rates compared with subclavian and internal jugular sites in adults and, in some studies, higher rates of CRBSI. Femoral catheters were also associated with a higher risk of deep venous thrombosis (DVT) than internal jugular or subclavian catheters. Femoral venous access should be avoided in patients with aorto-bifemoral bypass grafts or a

femoral-distal bypass graft due to the risk of infection. The femoral vein is relatively contraindicated for PN due to the high risk of contamination at the groin exit site and the high risk of venous thrombosis. Tunneling onto the anterior abdominal wall can take the exit site out of the groin, thus facilitating access and nursing care. In 2012, a Cochrane review of CV access sites for prevention of thrombosis stenosis and infection reported lower risks of catheter colonization and thrombotic complication attributed to subclavian CV access compared to femoral CV access in short-term catheterizations. A single randomized study of short-term hemodialysis catheterization in 293 critically ill patients reported higher risks of mechanical complications but equivalent infection risks from internal jugular CV access routes compared with femoral access. Clinical interpretation of these results is limited due to the lack of ultrasound guidance used for the internal jugular vein access cases. Based on evidence from a number of observational studies in which nontunneled CVCs placed via jugular route were associated with higher colonization rates or CRBSI than those inserted into a subclavian vein, the CDC 2011 guidelines recommend placing nontunneled CVCs in adults at subclavian rather than jugular or femoral sites. This recommendation is supported by similar findings from a multicenter RCT involving 3,027 intensive care unit (ICU) patients.

Long-term catheterization data comparing subclavian and internal jugular CV access routes amongst 268 cancer patients showed similar risks for catheter-related complications. Radiologists have used both the subclavian and internal jugular veins for chest port insertion. Using ultrasound guidance, the internal jugular vein is easier to puncture than the subclavian vein, and is the vessel of choice for CV access by interventional radiologists. The right internal jugular is preferred to the left because it has a relatively straight course, facilitating catheterization and has a negligible risk of symptomatic CV stenosis and thrombosis. The incidence of CV thrombosis or stenosis for nontunneled catheters has been reported at 40% to 50% with the subclavian route versus 0% to 10% with the right internal jugular route. Subclavian vein thrombosis can result in painful arm swelling that may necessitate catheter removal, anticoagulation therapy, or thrombolysis. Other disadvantages of subclavian vein access include the higher risk of pneumothorax, catheter fatigue, pinch-off, and possibly fracture due to compression by the costoclavicular ligaments and subclavius muscle.

There is inadequate data relating to nonhemodialysis tunneled catheter placement to recommend a preferred site for access. In relation to long-term hemodialysis catheter placement, the NKF-KDOQI guidelines strongly recommend avoidance of the subclavian vein unless no other option exists or unless the ipsilateral extremity can no longer be used for permanent dialysis access. The right internal jugular vein is the preferred access site as it has a more direct trajectory to the cavoatrial junction and is associated with a lower risk of complications compared to other insertion sites. Furthermore, placement via the left internal jugular vein may jeopardize the venous return from the left arm and rule out future fistula formation on that side. Catheter placement in the left internal jugular vein is associated with poor blood flow rates and high rates of stenosis and thrombosis. If possible, the tunneled catheter should be placed on the contralateral side to a maturing fistula.

Unconventional Venous Access

The loss of CV access options in a patient requiring long-term hemodialysis or PN can be life-threatening. Alternative means of obtaining CV access include recanalization of occluded vein segments, use of collateral neck or chest veins, catheter placement in the inferior vena cava via infra-umbilical, trans-lumbar or trans-hepatic approaches, and right atrial catheter placement via trans-hepatic venous approach.

Collateral neck or chest wall veins develop in response to chronic CV narrowing and occlusion. In patients with a well-established collateral network via mediastinal, intercostal, paraspinal, or azygos veins, access via these vessels is unlikely to result in symptomatic CV obstruction. Procedure-related complication rates are comparable to those via conventional venous access sites.

When all options for permanent catheter placement in the chest have been exhausted, femoral venous access or trans-lumbar inferior vena cava access may be considered. Femoral vein access should not be used without first considering lower extremity fistula formation. Permanent femoral catheters are associated with a higher rate of infection and occlusion, resulting in more frequent interventions for

catheter maintenance. Trans-lumbar cava access is technically more challenging and time consuming. Infection rates for tunneled catheters are comparable with chest veins, but the risk of catheter malfunction is greater. Trans-hepatic CV access is associated with a high risk of catheter malfunction due to constant catheter tip movement with respiration. In a review of 36 transhepatic CV access catheterizations, catheter occlusion was reported at 2.4/100 catheter-days.

*Variant 9: Immunocompromised Patient. Adult or Child ≥13 Years of Age. Has a Tunneled Small-bore Catheter Placed via Right Internal Jugular Vein. Patient Is Pancytopenic (ANC 300/μL, PLT 32,000/μL) and Presents with Fevers and Malaise*

AIDS

Increased susceptibility to opportunistic infections amongst AIDS patients is due to defective cell-mediated immunity, impaired B-cell antibody response, neutropenia (20% to 25% of AIDS sufferers), and neutrophil dysfunction. One study found a higher rate of catheter-related infections in AIDS patients compared with oncology patients. A high prevalence of catheter-related infections due to gram-positive organisms has been demonstrated in AIDS patients. Immune function at the time of CV access insertion has not been shown to predict infectious complications. Colonization of the skin, oral mucosa, and intestinal and respiratory tracts has been identified as a risk factor for systemic infections. Catheter manipulation can lead to fungal contamination of catheters, resulting in fungemia due to impaired clearance of fungal elements. Fungemia can also occur during antifungal therapy for oral or esophageal candidiasis, which affects 70% to 100% of AIDS patients. Empiric broad spectrum antibiotics including staphylococcus prophylaxis should be initiated until culture results become available.

Oncology Patient

Chemotherapy and radiotherapy can cause neutropenia and thrombocytopenia. Over 60% of catheter-related sepsis occur during periods of neutropenia (absolute count of <500/mm$^3$). Bone marrow transplant recipients are particularly susceptible to fungal and nocosomial bacterial infections during and after "conditioning" therapy. The neutropenia can last from 4 to 58 days until engraftment. In profound neutropenia (absolute count <200/mm$^3$), the patient remains susceptible to these infections until after a successful engraftment has occurred. After engraftment, infections may be related to immunosuppressant therapy or graft versus host disease. While fever is the most common sign of infection, immunosuppressed patients may demonstrate little other evidence of infection. Empiric antibiotics should be commenced while waiting for cultures. In cases where the mechanism for neutropenia and thrombocytopenia is neoplastic bone marrow replacement (e.g., hematologic malignancies) and depending on the organism isolated, infection may be managed without removal of the catheter. One study demonstrated that catheter salvage was possible in 78% of hematologic-oncologic pediatric population who were septicemic and neutropenic. In a prospective study of 966 CV access devices (93.4% subcutaneous venous ports) implanted in 933 cancer patients (70.4% solid tumors) in which patients were followed until device removal, death, or transfer of care to another facility; surgical reintervention, neutropenia at implantation, in-hospital implantation, cuffed CV access device use, and implantation for a purpose other than chemotherapy were statistically significant risk factors for device-related bloodstream infection and pocket infection. A multidisciplinary group responsible for CV access device care and the creation of a CV access device management protocol enabled them to reduce their catheter related infection rates from 2.2 to 0.24 per 1,000 catheter days (P<.001) during the study period.

Four prospective studies of catheter-associated thrombosis in patients with solid tumors and hematological malignancies report rates of thromboembolic events between 37% and 66%. Thus far, routine anticoagulant prophylaxis in patients with permanent venous access devices cannot be recommended.

Parenteral Nutrition Recipients

PN recipients are often immunocompromised and/or critically ill. CRBSI are major complications of PN. Although the PN itself and, in particular, the fat emulsions are well suited to bacterial and fungal growth, the majority of PN-related infections are due to contamination of the catheter rather than the infusate.

Coagulase-negative staphylococci and *Staphylococcus aureus* are the primary pathogens. PN has been associated with fungemia in the pediatric and ICU populations. Increased infection rates have been noted when a lumen used for PN is used for other purposes. If a multilumen catheter is needed, a single lumen should be used exclusively for PN.

Cystic Fibrosis

Sufferers of cystic fibrosis may require CV access for repeated courses of intravenous antibiotics and/or prolonged access for PN administration. Catheter-related septicemia has been reported in up to 10% of cystic fibrosis patients, with a relatively high percentage of infections due to atypical organisms and fungi. Diabetes mellitus, corticosteroid therapy, PN, and extended courses of broad spectrum antibiotics contribute to catheter colonization. The choice of device depends on the duration and frequency of treatment. In the outpatient setting, implanted ports may be appropriate for patients who require chronic intermittent therapy, whereas tunneled catheters may be best for those requiring more frequent access. Antifungal prophylaxis has been recommended in those with implanted ports who have impaired glucose tolerance or are undergoing corticosteroid administration. While ports do not appear to be at increased risk of infection in this group compared to other devices, one study reported SVC syndrome and DVT in up to 13.6% of these patients. Given these findings, aspirin may be prescribed.

*Variant 10: Thrombotic Complications. Adult or Child ≥13 Years of Age. Chest Port Placed via Right Internal Jugular Vein Is Being Used for Chemotherapy. The Infusion Nurse Can Infuse Saline But Is Unable to Aspirate Blood from the Catheter.*

*Variant 11: Thrombotic Complications. Adult or Child ≥13 Years of Age. Permanent Hemodialysis Catheter Placed via the Right Internal Jugular Vein. Poor Flows Are Documented at Hemodialysis via Both Lumens.*

*Variant 12: Thrombotic Complications. Adult or Child ≥13 Years of Age. Arm Swelling Secondary to Extensive Thrombus Surrounding a Triple Lumen PICC Placed via Left Basilic Vein. The Catheter Is Being Used for Long-term Parenteral Nutrition and Intermittent Intravenous Antibiotics. The Catheter Is Functioning.*

Thrombotic complications of CV access manifest as catheter malfunction and/or symptoms of DVT. The overall incidence of asymptomatic and symptomatic catheter-related DVT has been reported to be between 27% to 66%, and 0.3% to 28.3%, respectively. CVC lumen occlusion affects up to 25% of CVCs placed and may be partial or complete. It is defined as an inability to infuse solutions into or withdraw solutions from a CV access device. Causes include drug precipitation and lipid residue, anatomical or mechanical obstructions, and thrombotic occlusion. Anatomical or mechanical obstructions may be due to catheter malposition or dislocation, catheter kinking or fracture, and increased intra-luminal pressures. Thrombotic occlusion is caused by the buildup of fibrin within and around the catheter. Catheter-related thrombosis can take a number of different forms: fibrin sheath, intraluminal thrombosis, and mural thrombosis. The latter refers to thrombus extending from the catheter into the lumen of a vessel, and leading to partial or total catheter occlusion with or without clinical symptoms. Complications of upper extremity venous thrombosis include pulmonary embolus (incidence range 5%-14%), DVT recurrence (2%-5%), and post-phlebitic syndrome (incidence range 10%-28%). It is incumbent on the interventional radiologist to implement preventive measures into the CV access practice and be equipped to deal with thrombotic complications as they arise.

Preventive Measures

- Device type and placement
  - Use catheters made from less thrombogenic materials (e.g., silicone, second- and third-generation polyurethane).
  - Use a catheter with the least number of lumens required. The risk of thrombosis increases with the number of catheter lumens used.
  - Catheter tip should be placed in the caudal SVC. Venous thrombosis is more common in catheters inserted from the left side with the tip in the subclavian or innominate veins compared with tip placement in the SVC or right atrium.

A greater vessel length exposed to a catheter appears to increase the risk of thrombosis. Left-sided placements are associated with higher incidence of DVT than right-sided catheters. A prospective RCT in post-critical care patients observed a substantially higher risk of thrombotic complications (27.2%) in PICCS compared to short-term centrally placed CVCs (9.6%). Higher rates of symptomatic thrombosis (5.8% versus 1.7%; P=.003) were also reported in hemato-oncology patients who underwent PICC placement (346 patients) compared with tunneled CVC (247 patients), respectively.

Catheters impregnated with antithrombotic substances including heparin-antithrombin III are available, but given the lack of long-term data relating to the safety and efficacy of these catheters, there is inadequate evidence to support their use in routine practice.

Ultrasound-guided placement minimizes endothelial damage and reduces the risk of catheter-associated thrombosis at the puncture site. Two meta-analyses have shown a substantial reduction in mechanical complications, the number of attempts at required cannulation, and the number of failed attempts at cannulation compared with the standard landmark placement when real-time 2-D ultrasound was used for placement. Given these findings, it is likely that ultrasound guidance also reduces the risk of catheter-related thrombosis. Ultrasound guidance by an appropriately trained operator is now recommended for all nonemergent CV-access procedures by several scientific bodies.

Catheter flushing

Flushing of the catheter ports is routinely performed to maintain patency, reducing fibrin sheath, and clot formation. Since thrombosis is a major risk factor for CVC infection, catheter flushing is also performed to reduce the risk of CRBSI. The ideal flush solution, concentration, and the flushing interval have not been defined.

Saline and unfractionated heparin are equally effective to prevent thrombotic complications. Heparin at doses of 500 to 5,000 units has been the most commonly used agent. While long-term CVCs are usually flushed at least once a month, a recent retrospective study showed that CVCs flushed less frequently were not associated with an increased rate of catheter complications.

Recombinant tissue plasminogen activator (rTPA) (1 mg in each lumen) applied weekly as a locking solution lowered the risk of catheter dysfunction and infection in hemodialysis patients. A decrease in the number of catheter-related infections has been reported with the use of rTPA in patients with hemophilia.

Urokinase has similar efficacy as a locking solution for CVCs.

Gentamicin-citrate solution was compared with heparin in a prospective multicenter study involving 555 patients with tunneled hemodialysis catheters. CRBSI in the antibiotic lock period (0.45/1,000 catheter-days) was 73% less than that for the heparin period (1.68/1,000 catheter-days) (P=.001). The antibiotic lock solution was the first to demonstrate a reduction in mortality in this patient population. A systematic review and meta-analysis of 13 RCTs comparing sodium citrate versus heparin in hemodialysis patients showed antimicrobial-containing citrate locks (citrate + gentamicin, citrate + taurolidine, citrate + methylene blue + methylparaben + propylparaben) to be superior in the prevention of CRBSI (P<.001, P=.003, P=.008, respectively). Citrate alone was less effective. The incidence of bleeding episodes was significantly lower in patients receiving citrate locks. Exit site infections, catheter removal for poor flow, thrombolytic treatment, all-cause death, catheter thrombosis, mean catheter duration, CRBSI-free catheter survival, and catheter-related readmission were similar among the two groups.

Low-dose systemic prophylactic anticoagulation/thrombolytics

There is inadequate evidence to support the routine use of low molecular weight heparin (LMWH), low dose vitamin K antagonists (warfarin 1 mg daily), or vitamin K antagonists to maintain an INR between 1.5 and 2, continuous intravenous unfractionated heparin, or fibrinolytics to prevent symptomatic catheter-related thrombosis in comparison to no prophylaxis.

## Management of Catheter Occlusion

Rule out mechanical problems

Attempt to aspirate blood with the patient in a supine, sitting, or standing position, with the ipsilateral arm raised.

Radiograph to exclude an internal kink, fracture, or dislocation of the catheter.

Chemical intervention

Precipitation of drugs with low or high pH or parenteral infusions with lipid-rich emulsions may be treated with sodium bicarbonate, hydrochloric acid, and ethanol respectively. A volume equal to the catheter fill volume should be instilled for up to 20 min.

Thrombotic occlusion

Contrast study of the catheter should be performed if a thrombotic complication is suspected. Drug interventions for intraluminal thrombus or thrombus at the catheter tip include:

Partial occlusion: Unfractionated heparin 5,000–25,000 units over 6 to 24 hours.

Complete occlusion: 1 to 2 doses of urokinase or rTPA may be administered. In one study using rTPA (2 mg/2 mL), function was reported within 2 hours in 90% of cases. Similar results for rTPA were later confirmed in a large RCT including over 1,000 patients. Where thrombolysis is the indication for use, 1 mg rTPA is equivalent to 36,000 units of urokinase.

Management of fibrin sheath

Fibrin sheath formation is seen in up to 76% of short- or long-term CVC by pull-back venography. The sheath can form as early as 24 hours after catheter insertion, and encase its entire length within 5 to 7 days. Mechanical treatment options for dealing with a fibrin sheath include catheter exchange, disruption using a wire or angioplasty balloon, and fibrin sheath stripping. Such interventions are indicated when pharmacologic therapy fails to restore catheter tip patency. A retrospective review of 66 procedures performed in patients with poor flow through tunneled hemodialysis catheters, despite rTPA administration, showed similar cumulative catheter patency rates at 1 month, 3 months, and 6 months among the three groups: catheter exchange, fibrin sheath stripping, and fibrin sheath disruption. The results were similar to those reported elsewhere for fibrin sheath stripping and catheter exchange; cumulative patency rates of 31% to 93% at one month and 45% to 56% at 3 months.

## Management of Catheter-related DVT

Anticoagulation

There is insufficient evidence in cancer patients to support the routine use of LMWH and a vitamin K antagonist or long-term LMWH for the treatment of CVC-related thrombosis. Based on good evidence supporting the use of LMWH in lower limb DVT or pulmonary embolism in cancer patients, the International Society on Thrombosis and Hemostasis recommend the use of LMWH alone for a minimum of 3 months for the treatment of catheter-related thrombosis, depending on the clinical status of the patient. To date, there have been no published data regarding the use of newer anticoagulants, such as fondaparinux, dabigatran, or rivaroxaban in the treatment of patients with upper extremity or catheter-related DVT.

Catheter removal

A catheter that is no longer required should be removed. If the catheter is functioning and CV access is needed then the device should be left in place and anticoagulation commenced. If the risk of pulmonary embolus is high, the catheter should be removed several days after commencing anticoagulation therapy, otherwise the catheter can be removed immediately. The patient should remain on anticoagulation for at least 3 months or as long as the CVC remains in place.

Catheter or systemic thrombolysis

In patients with upper extremity DVT, these therapeutic strategies have been studied only in small, retrospective case series. In the largest retrospective cohort study of systemic thrombolysis in upper extremity-DVT, the rates of DVT recurrence were similar between patients treated with thrombolysis or standard anticoagulation. However, systemic thrombolysis significantly increases the risk for major bleeding (15% versus 0%). Catheter-directed thrombolysis may be safer, but data are limited.

A thrombolytic or surgical approach is often considered in patients with extensive or massive thrombosis, but there is no evidence that such a strategy is superior over anticoagulant therapy alone in reducing the risk of recurrent thrombosis, pulmonary embolism, or post-thrombotic syndrome in patients with upper extremity DVT.

SVC filter placement
SVC filter placement should be limited to patients with a contraindication to anticoagulation therapy and to those with thrombus progression of symptomatic pulmonary embolism despite adequate treatment with anticoagulants. Placement of a SVC filter is technically more difficult than an inferior vena cava filter because of the shorter length of the SVC. In a review that included 209 patients treated with SVC filters, 3.8% had severe complications, including cardiac tamponade, aortic perforation, and recurrent pneumothorax. While mortality rates reported after filter placement are high, mortality is almost always related to the underlying disease.

*Variant 13: Infectious Complications. Adult or Child ≥13 Years of Age. Preventive Measures to Reduce Catheter-related Bloodstream Infections When Placing a Nontunneled Central Venous Catheter in ICU Patient*

*Variant 14: Infectious Complications. Adult or Child ≥13 Years of Age. Therapeutic Measures to Manage Catheter-related Bloodstream Infections*

A CRBSI is defined as at least two blood cultures positive with the same organism, obtained from at least two separate sites at different times, in association with evidence of colonization of the catheter with the same organism. A central-line-associated bloodstream infection (CLABSI) is a term used by CDCs National Healthcare Safety Network. It is defined as a primary bloodstream infection in a patient that had a central line within the 48-hour period before the development of the bloodstream infection and is not related to an infection at another site. Since bloodstream infections may be due to sources other than a central line, this definition may overestimate the true incidence of CRBSI. A tunnel infection is characterized by pain and induration along the track of the catheter. An insertion site infection (ISI) is characterized by erythema, tenderness, and occasionally a discharge.

Infectious complications of CVCs present a significant health care burden and impose a great cost to hospitals for their management. In the United States, approximately 80,000 cases of CRBSI occur in ICUs each year. Every new episode of CRBSI increases the risk of death, in addition to prolonging ICU stay. Management of CRBSI requires a multidisciplinary approach. As such, recommendations from diverse fields such as infectious disease, critical care, and interventional radiology should be implemented for optimal management of CRBSI and ISI.

The primary source of catheter-related infections in acute CV access devices is the patient's own skin (65%); the second most common source is the hub of the catheter (30%), and other pathways (5%). In long-term catheters, the primary source is the hub. The most commonly identified organisms in catheter-related infections are coagulase-negative staphylococcus, *S aureus*, Candida species, enteric gram-negative bacilli, and pseudomonas aeruginosa. Broadly speaking, the management of CRBSI/ISIs can be divided into prophylaxis/prevention and therapeutic intervention. In 2011, the CDC and Healthcare Infection Control Practices Advisory Committee (HICPAC) published evidence-based guidelines for the prevention of intravascular catheter related infections.

<u>Prevention</u>

Predisposing factors
Factors predisposing to CRBSI include length of ICU stay before catheter insertion, insertion in the jugular or femoral vein, and utilization of the catheter to deliver PN. Conversely, the use of a CVC to deliver antibiotics decreased the risk of CRBSI. Additionally, duration of device retention has been shown to increase the risk of CRBSI. It was found that the use of a chest port for more than 33 days and a nontunneled CVC for more than 10 days carried an increased risk of CRBSI. Chest ports carried a BSI rate of 2.81 cases per 1,000 days of use and nontunneled central lines carried a BSI rate of 5.60 cases of BSI per 1,000 days of use. One study found that the only predictor of CRBSI infection

was the duration the line was in place. Of the lines studied, infected and noninfected CVCs were in place a mean of 25 and 16 days, respectively. The single infected PICC was in place for 19 days, whereas the remaining catheters were in place a mean of 14 days. Other factors that may impact the rate of CRBSI include heavy microbial colonization at the insertion site or the catheter hub, and neutropenia.

Education and training

Those responsible for the placement of CV access must ensure that healthcare personnel are educated and trained regarding the indications for intravascular catheter use, proper procedures for the insertion and maintenance of intravascular catheters, and appropriate infection control measures to prevent intravascular catheter-related infections. Knowledge of and adherence to guidelines by all personnel involved in the CV access service should be evaluated periodically.

Insertion technique and maintenance

The compilation of recommendations for placement technique is a multimodal undertaking spanning nurses, physicians, and other providers. Numerous studies and guidelines are in concordance regarding sterile technique and barrier precautions during placement. Little controversy exists regarding this issue. The 2011 CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections include step-by-step, evidence-based recommendations relating to the prevention of catheter-related infection when inserting and maintaining these devices.

Hand-hygiene procedures including washing hands with conventional soap and water or alcohol-based hand rubs, should be performed before and after all catheter-related interventions and palpation of the catheter insertion site. Sterile gloves should be worn when inserting CVCs, exchanging catheters over a guide-wire, and for dressing changes.

Maximum sterile barrier precautions including cap, mask, sterile gown, sterile gloves, and a sterile full-body drape should be used for insertion of CVCs, PICCs, or guide-wire exchange.

Antiseptic skin preparation prior to CVC insertion and during dressing changes should be performed with >0.5% chlorhexidine preparation with alcohol.

Catheter skin site should be covered with either sterile gauze or sterile transparent semipermeable dressing. For short-term CVC sites, dressings should be changed every second day for gauze dressings, and weekly for transparent dressings. Transparent dressings on tunneled or implanted CVC sites should be changed weekly until the insertion site has healed. There are no recommendations relating to the need for a dressing on well-healed exit sites of long-term cuffed and tunneled CVCs. Chlorhexidine-impregnated sponge dressings are only recommended for temporary short-term catheters if the CLABSI rate persists despite adherence to routine preventive measures. Patients should be encouraged to monitor the catheter skin sites and report any new symptoms suggestive of a local or bloodstream infection.

Daily skin cleansing with a 2% chlorhexidine-impregnated wash cloth is aimed at reducing the incidence of multidrug resistant CRBSI in those with short-term catheters. In a study of 836 ICU patients, the authors reported a significant reduction in the risk of bloodstream infections amongst patients cleansed with chlorhexidine wash compared to soap and water (4.1 versus 10.4 infections per 1,000 patient days, 95% confidence interval 1.2-11.0). In a prospective single arm study involving 1,787 medical ICU patients bathed with soap and water baths, chlorhexidine saturated cloth baths, or nonmedicated cloth baths, the risk of vancomycin-resistant enterococcus (VRE) colonization on patient's skin was 2.5log10 less for those cleansed with the chlorhexidine mix. The incidence of VRE acquisition decreased from 26 colonizations per 1,000 patient-days to 9 per 1,000 patient-days (risk ratio, 0.4; 95% confidence interval 0.1-0.9). The relative risk of VRE contamination of health care workers hands was 0.6 (95% confidence interval 0.4-0.8) and environmental surfaces was 0.3 (95% confidence interval 0.2-0.5). More recently, further support for chlorhexidine baths came from a multicenter cluster-randomized non-blinded crossover trial in which the acquisition of multidrug resistant organisms and the incidence of hospital-acquired bloodstream infections were compared in patients cleansed with chlorhexidine-impregnated washcloths or non-antimicrobial washcloths. A total of 7,727 study patients were enrolled over a 1- to 2-month period. The overall rate of multidrug

resistant organism acquisition was 5.10 cases per 1,000 patient-days with chlorhexidine bathing versus 6.60 cases per 1,000 patient-days with non-antimicrobial washcloths (*P*=.03) (23% lower with chlorhexidine bathing). The overall rate of hospital-acquired bloodstream infections was 4.78 cases per 1,000 patient-days with chlorhexidine bathing versus 6.60 cases per 1,000 patient-days with non-antimicrobial washcloths (*P*=.007), (28% lower with chlorhexidine-impregnated washcloths). While the study supported earlier findings of a significant reduction in gram-positive bacteremias, it also demonstrated a lower rate of CVC-related fungemia.
Other targeted interventions that may reduce CVC-related infections include the use of a sutureless securement device the use of a needleless infusion system, disinfection of the needleless connector devices with chlorhexidine/alcohol solutions, and the use of antiseptic barrier caps for needleless connectors.

Site selection

While there remains some discussion regarding subclavian versus internal jugular placement of CVCs, there is general consensus that selection of an upper body insertion site should be considered to minimize the risk of infection in adult patients. While one study found that insertion of nontunneled CVCs in the jugular or femoral vein prolonged ICU stay compared with subclavian vein access, this must be weighed against certain increased risks associated with subclavian line insertion such as pneumothorax. Catheters should be placed as far away as possible from open wounds. A multicenter trial in which the placement of nontunneled CVCs in 3,027 ICU patients were randomly assigned to the subclavian, jugular, or femoral veins reported lower risk of bloodstream infection and symptomatic thrombosis, but higher rates of pneumothorax among patients who underwent subclavian vein catheterization compared with those who underwent jugular vein or femoral vein catheterization. This finding supports the CDC 2011 recommendation to place nontunneled CVC in adult patients at a subclavian site rather than jugular or femoral venous sites to minimize infection risk. No recommendation can be made for a preferred site of insertion to minimize infection risk for a tunneled CVC.

Device selection

The daily infection rate with CVCs is about 20 times higher than with peripheral catheters. The most serious CRBSI occur in the setting of short-term nontunneled catheters placed via central vein. The infection rate increases exponentially over time with their use. Rates of bacteremia are extremely high in nontunneled catheters within 2 to 4 weeks after placement In general, a lower rate of infection is documented with totally implantable devices. Long-term catheters that are tunneled (e.g., Hickman, Broviac, or Groshong catheters) appear to have one-quarter of the daily risk associated with nontunneled central lines, but still pose a much higher risk than peripheral catheters. In one study, implanted ports had the lowest incidence of CRBSI (0.1 per 1,000 catheter days). In this same study, the incidence of CRBSI among tunneled and nontunneled CVCs were 1.6 per 1,000 catheter days, and 2.7 per 1,000 catheter days respectively. One study found that CRBSI related to ports was only 5.1% at 0.15 per 1,000 catheter days.

There is no consensus regarding infectious complications of PICCs. Another study found that PICCs seem to have a similar risk of infection to central lines in ICUs. In another study, PICCs were associated with fewer CRBSIs in long term surgical ICU patients (allowing for the fact that CVCs were in place somewhat longer than PICCs). In this study, there were 263 CVCs and 37 PICCs placed. Of the CVCs, 4.9% became infected, an infection rate of 6.0 per 1,000 catheter-days. Of the 37 PICCs placed, 2.7% became infected, a rate of 2.2 infections per 1,000 catheter-days.

The use of catheters for hemodialysis is the most common factor contributing to bacteremia in dialysis patients. The relative risk for bacteremia in patients with dialysis catheters is 7-fold the risk for patients with AVF. If temporary access is needed for dialysis, a tunneled cuffed catheter is preferable to a noncuffed catheter, even in the ICU setting, if the catheter is expected to stay in place for >3 weeks.

Polytetrafluoroethylene (Teflon®, The Chemours Company, Wilmington, DE, USA) or polyurethane catheters have been associated with fewer infectious complications than catheters made of polyvinyl chloride or polyethylene. The use of anti-infective agents (aside from antibiotics) in conjunction with

CVCs has been shown to reduce the rates of CRBSI for durations of between 5 and 12 days and greater than 20 days when CVCs are inserted in the femoral or jugular veins. Studies report the best clinical effect when CVCs are treated with a combination of minocycline and rifampin, or internally and externally treated with silver or chlorhexidine and silver sulfadiazine. Current evidence suggests that anti-infectives are cost effective for high-risk patients compared with standard CVCs. Additional anti-infective agents demonstrated to have variable levels of efficacy include carbon and platinum, cuffs impregnated with silver, and benzalkonium chloride.

Catheter-related thrombosis is closely linked to CRBSI. Thrombus can serve as a nidus for infection. To this end, one group analyzed 45 trials with 12,085 enrolled CVCs. It was found that adjusted heparin-bonded catheters and minocycline/rifampicin catheters were associated with a significantly lower rate of CRBSI than standard catheters. It was concluded that rifampicin-based impregnated catheters were better for prevention of catheter-related infection compared with the other catheters. They also found that for prevention of CVC colonization, adjusted silver iontophoretic catheters, chlorhexidine and silver sulfadiazine catheters, chlorhexidine and silver sulfadiazine blue plus catheters, minocycline/rifampicin catheters, and miconazole/rifampicin catheters were associated with a significantly lower rate of catheter colonization compared with standard catheters. The ultimate conclusion of this large scale meta-analysis was that rifampicin-based impregnated CVC was the only type of CVC that reduced both catheter colonization and CRBSI compared with standard CVCs, and that rifampicin-based impregnated catheters seem to be more effective for prevention of catheter-related infection.

Other impregnated compounds have also been investigated. In critically ill patients, the use of silver-nanoparticle-impregnated CVCs had no significant effect on CVC colonization, CRBSI incidence, or ICU mortality.

Prophylactic antibiotics
Use of prophylactic antibiotics prior to CV access placement remains controversial and poorly studied. In one study that examined the use of prophylactic antibiotics in 404 patients before chest port placement, the authors found that 1 g of cefazolin given pre-procedure had no significant impact on the already low rate of postoperative infectious complications (overall rate of surgical site infection was 2.7%). No difference in the incidence of infectious complications was found in either group. Another group reached a similar conclusion in that the rate of early infection without antibiotic prophylaxis before chest port placement in the interventional radiology suite was only 1%. Based on their data, use of prophylactic antibiotics for implanted devices was not recommended. Additionally, there was no significant difference between the rates of device removal because of infections in patients who received antibiotics before the procedure versus patients who did not receive antibiotics. The CDC recommends against the routine administration of systemic antimicrobial prophylaxis before insertion or during use of an intravascular catheter to prevent catheter colonization or CRBSI. In nononcology patients, no benefit was associated with vancomycin administration prior to catheter insertion in 55 patients undergoing catheterization for PN. Extending perioperative prophylactic antibiotics in cardiovascular surgery patients did not reduce CVC colonization. For immunocompromised patients, administration of intravenous antibiotic prophylaxis should be considered on a case-by-case basis.

Topical applications
Several antibiotic and anti-infective agents have been tested at the surgical insertion site in an attempt to reduce catheter-related infection. In three RCTs involving hemodialysis patients, the use of 10% povidone iodine was associated with a significant decrease in colonization, exit-site infection, or bloodstream infection. The beneficial effect was most prominent in subjects with nasal colonization by *S aureus*. Mupirocin ointment applied either at the catheter insertion site or nasally has been shown to reduce the risk of CRBSI; however, this has been offset by an increase in mupirocin resistance in some centers and the potential for the drug to degrade polyurethane catheters.

Catheter locking solutions (covered under "Thrombotic complications")

## Management

### Diagnosis of CRBSI

Numerous studies and guidelines exist in the critical care and infectious disease literature regarding the methodology of diagnosing CRBSI. This is an important issue, as it was found in one study that more than 70% of the suspected CRBSIs yielded negative blood culture results (no growth), meaning that the catheter was unnecessarily removed. In that same study, there was no statistically significant difference between the standard and conservative methods of diagnosing CRBSI, with regards to in-hospital mortality. The standard method consisted of culturing the catheter tip, plus a culture of a peripheral blood sample. A differential time to positivity of 2 hours (cut-off limit) is a very sensitive and specific predictor of catheter-related bacteremia. The conservative method consisted of obtaining peripheral and catheter blood samples at different times with analysis of the number of colonies. Of the 29 deaths occurring in the ICU, 17 (58.6%) were from the conservative method group and 12 (41.3%) from the standard method group. The study showed no difference in mortality rates of patients with CRBSI when the two methods of diagnosis were compared. However, there was noted to be a difference in mortality when the standard method was compared to the conservative method in cases where the catheter is kept in place for more than 24 hours (56% versus 100%). One study reported a much higher rate of false-positives with blood cultures obtained from catheters compared with peripheral sites due to catheter hub contamination.

In relation to the hematology/oncology patient population, certain aspects of diagnosing CRBSI are similar to those of the general population. At least two of the following three symptoms are required to diagnose local infection: redness, induration, or tenderness within 2 cm of the venipuncture site. In patients with suspected or local infection without signs of systemic infection, two pairs of blood cultures should be taken— one from a peripheral vein and one from the CVC. The difference in time between positivity of results of catheter culture and peripheral blood culture has been found be an important diagnostic indicator (differential time to positivity).

### Catheter removal or retention

Convention has long dictated that after CRBSI has been demonstrated, the catheter is to be removed. However, in patients with limited access, this is often not feasible. In general, a catheter should be removed if the patient has unexplained sepsis or erythema overlying the catheter insertion site, purulence at the catheter insertion site, or if the CRBSI is associated with supportive thrombophlebitis, endocarditis, or osteomyelitis. Additionally, catheter removal is necessary if *S aureus* is isolated from blood cultures of a patient with an indwelling CVC. It has been shown that attempts for catheter preservation in subjects with catheter-related infection due to *S aureus* have no more than a 20% chance of success. Preservation of the catheter may be attempted in clinically stable patients, in whom coagulase-negative staphylococci, *Corynebacterium jeikeium*, *Acinetobacter baumannii*, *Stenotrophomonas maltophilia*, *Pseudomonas aeruginosa*, and bacillus species have been detected as infections. In clinically stable patients with fever of unknown origin, the catheter should not routinely be removed without microbiological evidence of catheter-related infection.

One group stated that long-term CVC or ports should be removed from patients with CRBSI associated with any of the following conditions: severe sepsis, supportive thrombophlebitis, endocarditis, bloodstream infection that continues despite 72 hours of antimicrobial therapy to which the infecting microbes are susceptible, or if a port abscess is diagnosed. Salvage therapy can be considered in uncomplicated CRBSI where patients have limited access options and long-term intravascular access is required. Both systemic and antimicrobial lock therapy should be used, repeated blood cultures obtained and the catheter removed if blood cultures remain positive for a microorganism when drawn 72 hours after initiation of appropriate therapy.

Routine replacement of CVCs, PICCs, and hemodialysis catheters to prevent infection should be avoided in adults and children. Routine guide-wire exchanges of nontunneled CVCs in an effort to prevent CRBSI should be avoided. In select patients with tunneled hemodialysis catheters and bacteremia, catheter exchange over a guide-wire, in combination with antibiotic therapy, is an alternative as a salvage strategy in patients with limited venous access.

Treatment recommendations

The microbes that colonize catheter hubs and the skin surrounding the insertion site are the source of most CRBSIs. The microorganisms involved in CRBSI have been shown, via electron microscopy, to be embedded in a biofilm matrix. Additionally, the number of organisms on the catheter tip is related to the occurrence of CRBSI. The microorganisms most often isolated from intravascular catheters are coagulase-negative staphylococci, followed by candida, *S aureus*, enterococcus, pseudomonas, and acinetobacter. For infections localized to the exit site, treatment with antibiotics alone may be adequate.

Coagulase negative staph: Coagulase negative staphylococci are the most common pathogens in CRBSIs. A diagnosis of bacteremia requires at least two positive blood cultures, including one drawn from a peripheral vein. While catheter removal may be sufficient to resolve the infection, it is generally recommended that the patient also be treated with one week of intravenous antibiotics. If the CVC is to be retained, a longer duration of therapy consisting of 10 to 14 days, together with antibiotic lock therapy, is advised. In the 20% of cases that fail to respond to these measures (persistent fever and bacteremia) the catheter should be removed. Vancomycin, systemically and as a catheter lock therapy, is frequently used in institutions with a high prevalence of methicillin resistant *S aureus* (MRSA). Where MRSA isolates with vancomycin inhibitory concentration values >1 mg/mL are identified, alternative agents (e.g., daptomycin) should be considered.

*S aureus*: Catheter removal is advised if a nontunneled CVC is suspected to be the source of *S aureus* bacteremia, or in the case of a tunneled device, there is evidence of a tunnel infection or ISI. A new catheter should then be placed at a different site. Uncomplicated cases should be treated with intravenous antibiotics for a minimum of 10 to 14 days after catheter removal. Caution should be exercised when considering catheter salvage. Failure or a delay in catheter removal has been associated with increased risk of hematogenous complications and increased mortality. The risk of such complications should be taken into account when deciding on the duration of therapy. Antibiotic treatment depends on sensitivities and may include penicillin, a first-generation cephalosporin, vancomycin, daptomycin, or linezolid.

Enterococcus: The incidence of enterocccal infection associated with CVCs has increased substantially. The ability of the organisms to form a biofilm can make antimicrobial treatment more difficult. The Infectious Diseases Society of America (IDSA) guidelines for the treatment of enterocccal CRBSI caused by susceptible isolates advise either ampicillin or vancomycin alone or in combination with an aminoglycoside. If ampicillin- and vancomycin-resistant enterococci are isolated, linezolid or daptomycin may be considered. If a long-term catheter is retained in cases of uncomplicated infection, 7 to 14 days of intravenous treatment is recommended in addition to antibiotic lock therapy.

Candida CRBSI: Candida species are the second most common cause of infection in the setting of a vascular catheter and are associated with increased mortality, extended hospital stays, and high cost. Since catheter retention has been associated with poorer outcomes, catheter removal within 72 hours is advised. Of note, a study of 404 oncology patients with CVC and candidemia identified the catheter as the source of infection in only 27%. With this in mind, efforts should be made to rule out other possible sources of the fungemia. The IDSA guidelines recommend antifungal therapy with fluconazole or an echinocandin for all CRBSI due to Candida species for 2 weeks after the last positive blood culture. Data relating to antifungal lock therapies are lacking.

Gram-negative bacilli: Data concerning the management of CRBSI due to gram-negative bacilli are limited. While the incidence of CRBSI due to gram-negative bacilli has decreased, multidrug resistance has become a concern. A high frequency of treatment failure and relapse has been documented if the CVC is retained. The IDSA guidelines recommend empiric antibiotic therapy in septic, critically ill, or neutropenic patients, those with femoral catheter in place or those with known focus of infection as these patients are at higher risk for infection due to multidrug resistant gram-negative bacilli. Two different class antimicrobial agents should be commenced in critically ill patients with suspected CRBSI and recent colonization of infection with a multidrug resistant gram-negative bacillus until cultures and drug sensitivities become

available.

Summary of Recommendations

A tunneled double-lumen small-bore CVC and chest port are the best choices for intravenous access for the administration of long-term total PN and intermittent intravenous antibiotics. Chest ports are recommended as the first choice for intravenous access for the treatment of recurrent sickle cell crisis.
A tunneled small-bore single-lumen CVC provides the best central venous access option for the administration of long-term antibiotics (6 weeks or more) in patients with stage 3 chronic kidney disease. A nontunneled CVC is the most appropriate CVC to use in a patient admitted to the hospital with acute or chronic renal insufficiency requiring short-term antibiotics (approximately 7-10 days) for acute sepsis.
The contralateral internal jugular vein is the most appropriate venous access site for hemodialysis in a patient with end-stage renal disease who has undergone creation of an arteriovenous fistula and the fistula has not yet matured.
The presence of fever and malaise alone in an immunocompromised patient is not an indication for removal of a tunneled CVC. However, the catheter should be removed if positive blood cultures are confirmed.
For a patient requiring head and neck surgery for cancer, arm or chest ports and PICCs are recommended for intravenous access for chemotherapy.
Chest radiograph and contrast study of the catheter are the recommended first steps for assessing a dysfunctional chest port and other CVCs.
For suspected thrombotic complications leading to a dysfunctional tunneled dialysis catheter, catheter removal and placement of a new catheter from a different site, catheter exchange, contrast study of the catheter, and fibrin sheath stripping/disruption are excellent next steps. An attempt should be made to perform dialysis with the patient arm in a different position. Arm swelling secondary to extensive thrombus surrounding a functioning, in-use peripherally inserted CVC should be treated by anticoagulation without removal of the catheter.
Preventive measures to reduce the risk of CRBSI when placing a nontunneled CVC in ICU patients include upper body insertion site. The catheter should be removed in the setting of *S aureus* bacteremia. Catheter salvage and concomitant antibiotic therapy are appropriate in patients with limited venous access.

Abbreviation

PICC, peripherally inserted central catheter

## Clinical Algorithm(s)

Algorithms were not developed from criteria guidelines.

# Scope

## Disease/Condition(s)

Any condition requiring central venous access

## Guideline Category

Management

## Clinical Specialty

Family Practice

Hematology

Infectious Diseases

Internal Medicine

Radiology

## Intended Users

Advanced Practice Nurses

Health Care Providers

Hospitals

Managed Care Organizations

Physician Assistants

Physicians

Students

Utilization Management

## Guideline Objective(s)

To evaluate the appropriateness of imaging procedures for radiologic management of central venous access

## Target Population

Patients who need central venous access

## Interventions and Practices Considered

1. Device selection
    - Arm port
    - Chest port
    - Single or double lumen peripherally inserted central catheter (PICC)
    - Tunneled small bore single or double lumen central venous catheter (CVC)
    - Nontunneled CVC
2. Site selection
    - Right or left internal jugular vein
    - Right or left subclavian vein
    - Right or left femoral vein
    - Arm
    - Chest
3. Management of immunocompromised patients
    - Immediate removal of tunneled catheter, culture of catheter tip, and placement of tunneled CVC at a different site

    - Retention of catheter and starting empiric antibiotics
    - Catheter removal if blood cultures are positive
    - Catheter salvage
4. Management of thrombotic complications
    - Continued port use with peripheral access for blood draws
    - Catheter removal and placement of alternative access
    - Chest radiograph
    - Use of different arm positions
    - Instillation of thrombolytic agent
    - Contrast study of catheter
    - Catheter exchange
    - Catheter stripping
    - Fibrin sheath stripping
    - Fibrin sheath disruption
    - Anticoagulation
    - Catheter-directed thrombolysis
    - Systemic thrombolysis
    - Superior vena cava (SVC) filter placement
    - Catheter downsize
5. Management of infectious complications
    - Antibiotic impregnated catheters
    - Upper-body insertion site
    - Heparin-bonded catheter
    - Prophylactic antibiotics prior to catheter placement
    - Antimicrobial lock therapy
    - Routine guide-wire catheter exchanges
    - Immediate catheter removal
    - Catheter preservation in clinically stable patients
    - Catheter exchange
    - Antibiotic treatment of exit site infections
    - Catheter salvage and concomitant antibiotic patients

## Major Outcomes Considered

Infection rate

# Methodology

## Methods Used to Collect/Select the Evidence

Hand-searches of Published Literature (Primary Sources)

Hand-searches of Published Literature (Secondary Sources)

Searches of Electronic Databases

## Description of Methods Used to Collect/Select the Evidence

Literature Search Summary

A literature search was conducted in June 2015 and updated in June 2017 to identify evidence for the *ACR Appropriateness Criteria® Radiologic Management of Central Venous Access* topic. Using the search

strategies described in the literature search companion (see the "Availability of Companion Documents" field), 612 articles were found. Twenty-five articles were used in the topic. The remaining articles were not used due to either poor study design, the articles were not relevant or generalizable to the topic, or the results were unclear or biased.

The author added 127 citations from bibliographies, Web sites, or books that were not found in the literature searches, including 72 articles outside of the search date ranges.

See also the American College of Radiology (ACR) Appropriateness Criteria® literature search process document (see the "Availability of Companion Documents" field) for further information.

## Number of Source Documents

The literature search conducted in June 2015 and updated in June 2017 found 25 articles that were used in the topic. The remaining articles were not used due to either poor study design, the articles were not relevant or generalizable to the topic, or the results were unclear or biased. The author added 127 citations from bibliographies, Web sites, or books that were not found in the literature searches, including 72 articles outside of the search date ranges.

## Methods Used to Assess the Quality and Strength of the Evidence

Weighting According to a Rating Scheme (Scheme Given)

## Rating Scheme for the Strength of the Evidence

Definitions of Study Quality Categories

Category 1 - The study is well-designed and accounts for common biases.

Category 2 - The study is moderately well-designed and accounts for most common biases.

Category 3 - The study has important study design limitations.

Category 4 - The study or source is not useful as primary evidence. The article may not be a clinical study, the study design is invalid, or conclusions are based on expert consensus.

> The study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
>
> *Or*
>
> The study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
>
> *Or*
>
> The study is an expert opinion or consensus document.

Category M - Meta-analysis studies are not rated for study quality using the study element method because the method is designed to evaluate individual studies only. An "M" for the study quality will indicate that the study quality has not been evaluated for the meta-analysis study.

## Methods Used to Analyze the Evidence

Review of Published Meta-Analyses

Systematic Review with Evidence Tables

## Description of the Methods Used to Analyze the Evidence

The topic author assesses the literature then drafts or revises the narrative summarizing the evidence found in the literature. American College of Radiology (ACR) staff drafts an evidence table based on the analysis of the selected literature. These tables rate the study quality for each article included in the narrative.

The expert panel reviews the narrative, evidence table and the supporting literature for each of the topic-variant combinations and assigns an appropriateness rating for each procedure listed in the variant table(s). Each individual panel member assigns a rating based on his/her interpretation of the available evidence.

More information about the evidence table development process can be found in the ACR Appropriateness Criteria® Evidence Table Development document (see the "Availability of Companion Documents" field).

## Methods Used to Formulate the Recommendations

Expert Consensus (Delphi)

## Description of Methods Used to Formulate the Recommendations

Overview

The purpose of the rating rounds is to systematically and transparently determine the panels' recommendations while mitigating any undue influence of one or more panel members on another individual panel members' interpretation of the evidence. The panel member's rating is determined by reviewing the evidence presented in the Summary of Literature Review and assessing the risks or harms of performing the procedure or treatment balanced with the benefits of performing the procedure or treatment. The individual panel member ratings are used to calculate the median rating, which determines the panel's rating. The assessment of the amount of deviation of individual ratings from the panel rating determines whether there is disagreement among the panel about the rating.

The process used in the rating rounds is a modified Delphi method based on the methodology described in the RAND/UCLA Appropriateness Method User Manual.

The appropriateness is rated on an ordinal scale that uses integers from 1 to 9 grouped into three categories (see the "Rating Scheme for the Strength of the Recommendations" field).

Determining the Panel's Recommendation

> Ratings represent an individual's assessment of the risks and benefits of performing a specific procedure for a specific clinical scenario on an ordinal scale. The recommendation is the appropriateness category (i.e., "Usually appropriate", "May be appropriate", or "Usually not appropriate").
> The appropriateness category for a procedure and clinical scenario is determined by the panel's median rating without disagreement (see below for definition of disagreement). The panel's median rating is calculated after each rating round. If there is disagreement after the second rating round, the rating category is "May be appropriate (Disagreement)" with a rating of "5" so users understand the group disagreed on the final recommendation. The actual panel median rating is documented to provide additional context.
> Disagreement is defined as excessive dispersion of the individual ratings from the group (in this case, an Appropriateness Criteria [AC] panel) median as determined by comparison of the interpercentile range (IPR) and the interpercentile range adjusted for symmetry (IPRAS). In those instances when the IPR is greater than the IPRAS, there is disagreement. For a complete discussion, please refer to chapter 8 of the RAND/UCLA Appropriateness Method User Manual.
> Once the final recommendations have been determined, the panel reviews the document. If two

thirds of the panel feel a final recommendation is wrong (e.g., does not accurately reflect the evidence, may negatively impact patient health, has unintended consequences that may harm health care, etc.) and the process must be started again from the beginning.

For additional information on the ratings process see the Rating Round Information document (see the "Availability of Companion Documents" field).

Additional methodology documents, including a more detailed explanation of the complete topic development process and all ACR AC topics can be found on the ACR Web site (see also the "Availability of Companion Documents" field).

## Rating Scheme for the Strength of the Recommendations

Appropriateness Category Names and Definitions

| Appropriateness Category Name | Appropriateness Rating | Appropriateness Category Definition |
|---|---|---|
| Usually Appropriate | 7, 8, or 9 | The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients. |
| May Be Appropriate | 4, 5, or 6 | The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal. |
| May Be Appropriate (Disagreement) | 5 | The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned. |
| Usually Not Appropriate | 1, 2, or 3 | The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable. |

## Cost Analysis

The guideline developers reviewed published cost analyses.

## Method of Guideline Validation

Internal Peer Review

## Description of Method of Guideline Validation

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

# Evidence Supporting the Recommendations

## Type of Evidence Supporting the Recommendations

The recommendations are based on analysis of the current medical evidence literature and the application of the RAND/UCLA appropriateness method and expert panel consensus.

Summary of Evidence

Of the 152 references cited in the *ACR Appropriateness Criteria® Radiologic Management of Central Venous Access* document, 133 are categorized as therapeutic references including 47 well-designed studies, 43 good-quality studies, and 2 quality studies that may have design limitations. Additionally, 5 references are categorized as diagnostic references including 1 good-quality study. There are 45 references that may not be useful as primary evidence. There are 14 references that are meta-analysis studies.

Although there are references that report on studies with design limitations, 91 well-designed or good-quality studies provide good evidence.

# Benefits/Harms of Implementing the Guideline Recommendations

## Potential Benefits

Radiologically guided percutaneous insertion is associated with higher technical success rates, fewer complications, shortened procedure times, and subsequent reduction in costs compared with other specialties.

## Potential Harms

- Thrombotic complications of central venous (CV) access manifest as catheter malfunction and/or symptoms of deep vein thrombosis (DVT). The overall incidence of asymptomatic and symptomatic catheter-related DVT has been reported to be between 27% to 66%, and 0.3% to 28.3%, respectively. Central venous catheter (CVC) lumen occlusion affects up to 25% of CVCs placed and may be partial or complete. It is defined as an inability to infuse solutions into or withdraw solutions from a CV access device. Causes include drug precipitation and lipid residue, anatomical or mechanical obstructions, and thrombotic occlusion. Anatomical or mechanical obstructions may be due to catheter malposition or dislocation, catheter kinking or fracture, and increased intra-luminal pressures. Thrombotic occlusion is caused by the buildup of fibrin within and around the catheter. Catheter-related thrombosis can take a number of different forms: fibrin sheath, intraluminal thrombosis, and mural thrombosis. The latter refers to thrombus extending from the catheter into the lumen of a vessel, and leading to partial or total catheter occlusion with or without clinical symptoms. Complications of upper extremity venous thrombosis include pulmonary embolus (incidence range 5%-14%), DVT recurrence (2%-5%), and post-phlebitic syndrome (incidence range 10%-28%). It is incumbent on the interventional radiologist to implement preventive measures into the CV access practice and be equipped to deal with thrombotic complications as they arise.
- A catheter-related bloodstream infection (CRBSI) is defined as at least two blood cultures positive with the same organism, obtained from at least two separate sites at different times, in association with evidence of colonization of the catheter with the same organism. Infectious complications of CVCs present a significant health care burden and impose a great cost to hospitals for their management. In the United States, approximately 80,000 cases of CRBSI occur in intensive care units (ICUs) each year. Every new episode of CRBSI increases the risk of death, in addition to prolonging ICU stay. Management of CRBSI requires a multidisciplinary approach. As such, recommendations from diverse fields such as infectious disease, critical care, and interventional radiology should be implemented for optimal management of CRBSI and insertion site infection (ISI).

# Contraindications

## Contraindications

The femoral vein is relatively contraindicated for parenteral nutrition (PN) due to the high risk of contamination at the groin exit site and the high risk of venous thrombosis.

# Qualifying Statements

## Qualifying Statements

- The American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists, and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.
- ACR seeks and encourages collaboration with other organizations on the development of the ACR Appropriateness Criteria through society representation on expert panels. Participation by representatives from collaborating societies on the expert panel does not necessarily imply society endorsement of the final document.

# Implementation of the Guideline

## Description of Implementation Strategy

An implementation strategy was not provided.

# Institute of Medicine (IOM) National Healthcare Quality Report Categories

## IOM Care Need

Getting Better

## IOM Domain

Effectiveness

# Identifying Information and Availability

## Bibliographic Source(s)

## Bibliographic Source(s)

Shaw CM, Shah S, Kapoor BS, Cain TR, Caplin DM, Farsad K, Knuttinen MG, Lee MH, McBride JJ, Minocha J, Robilotti EV, Rochon PJ, Strax R, Teo EYL, Lorenz JM, Expert Panel on Interventional Imaging. ACR AppropriatenessÂ® radiologic management of central venous access. Reston (VA): American College of Radiology (ACR); 2017. 28 p. [152 references]

## Adaptation

Not applicable: The guideline was not adapted from another source.

## Date Released

2017

## Guideline Developer(s)

American College of Radiology - Medical Specialty Society

## Source(s) of Funding

The funding for the process is assumed entirely by the American College of Radiology (ACR). ACR staff support the expert panels through the conduct of literature searches, acquisition of scientific articles, drafting of evidence tables, dissemination of materials for the Delphi process, collation of results, conference calls, document processing, and general assistance to the panelists.

## Guideline Committee

Committee on Appropriateness Criteria, Expert Panel on Interventional Radiology

## Composition of Group That Authored the Guideline

*Panel Members*: Colette M. Shaw, MB (*Principal Author*); Shrenik Shah, MD (*Research Author*); Baljendra S. Kapoor, MD (*Panel Chair*); Thomas R. Cain, MD; Drew M. Caplin, MD; Khashayar Farsad, MD, PhD; M-Grace Knuttinen, MD, PhD; Margaret H. Lee, MD; Joseph J. McBride, MD; Jeet Minocha MD; Elizabeth V. Robilotti, MD, MPH; Paul J. Rochon, MD; Richard Strax, MD; Elrond Y. L. Teo, MD; Jonathan M. Lorenz, MD (*Specialty Chair*)

## Financial Disclosures/Conflicts of Interest

Disclosing Potential Conflicts of Interest and Management of Conflicts of Interest

An important aspect of committee operations is the disclosure and management of potential conflicts of interest. In 2016, the American College of Radiology (ACR) began an organization-wide review of its conflict of interest (COI) policies. The current ACR COI policy is available on its Web site . The Appropriateness Criteria (AC) program's COI process varies from the organization's current policy to accommodate the requirements for qualified provider-led entities as designated by the Centers for Medicare and Medicaid Services' Appropriate Use Criteria (AUC) program.

When physicians become participants in the AC program, welcome letters are sent to inform them of their panel roles and responsibilities, including a link to complete the COI form . The

COI form requires disclosure of all potential conflicts of interest. ACR staff oversees the COI evaluation process, coordinating with review panels consisting of ACR staff and members, who determine when there is a conflict of interest and what action, if any, is appropriate. In addition to making the information publicly available, management may include exclusion from some topic processes, exclusion from a topic, or exclusion from the panel.

Besides potential COI disclosure, AC staff begins every committee call with the conflict of interest disclosure statement listed below reminding members to update their COI forms. If any updates to their COI information have not been submitted, they are instructed not to participate in discussion where an undisclosed conflict may exist.

Finally, all ACR AC are published as part of the Journal of the American College of Radiology (JACR) electronic supplement. Those who participated on the document and are listed as authors must complete the JACR process that includes completing the International Committee of Medical Journal Editors (ICMJE) COI form which is reviewed by the journal's staff/publisher.

Dr. Farsad reports personal fees from Cook Medical, personal fees from Neuvave Medical, personal fees from Bayer, grants from Terumo, grants from Guerbet, outside the submitted work.

## Guideline Status

This is the current release of the guideline.

This guideline meets NGC's 2013 (revised) inclusion criteria.

## Guideline Availability

Available from the American College of Radiology (ACR) Web site .

## Availability of Companion Documents

The following are available:

ACR Appropriateness Criteria®. Overview. Reston (VA): American College of Radiology; 2017. Available from the American College of Radiology (ACR) Web site .

ACR Appropriateness Criteria®. Literature search process. Reston (VA): American College of Radiology; 2015 Feb. 1 p. Available from the ACR Web site .

ACR Appropriateness Criteria®. Evidence table development. Reston (VA): American College of Radiology; 2015 Nov. 5 p. Available from the ACR Web site .

ACR Appropriateness Criteria®. Topic development process. Reston (VA): American College of Radiology; 2015 Nov. 2 p. Available from the ACR Web site .

ACR Appropriateness Criteria®. Rating round information. Reston (VA): American College of Radiology; 2017 Sep. 5 p. Available from the ACR Web site .

ACR Appropriateness Criteria® radiologic management of central venous access. Evidence table. Reston (VA): American College of Radiology; 2017. 64 p. Available from the ACR Web site .

ACR Appropriateness Criteria® radiologic management of central venous access. Literature search. Reston (VA): American College of Radiology; 2017. 2 p. Available from the ACR Web site .

## Patient Resources

None available

## NGC Status

This NGC summary was completed by ECRI Institute on March 15, 2018. The guideline developer agreed to not review the content.

This NEATS assessment was completed by ECRI Institute on February 14, 2018. The information was verified by the guideline developer on March 15, 2018.

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