Central venous access in adults: General principles

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Literature review current through: **Jul 2024.**
This topic last updated: **Jun 13, 2023.**

INTRODUCTION

Central venous access is a commonly performed procedure to place central venous catheters and facilitate other venous interventions and device insertions, including the following: pulmonary artery catheters, plasmapheresis catheters, hemodialysis catheters, extracorporeal life support cannulas, inferior vena cava filters, and intracardiac pacing wire and defibrillator leads. The central venous access site and techniques by which access is achieved depend upon the indication for placement, patient vascular anatomy, and other patient-related factors.

The general principles of central venous access, including indications, contraindications, and general issues of preparation and placement, will be reviewed here. The role of catheters and devices for monitoring cardiac parameters or administering chemotherapy or parenteral nutrition are discussed in separate topic reviews.

The general principles of ultrasound-guided placement and placement of jugular, subclavian, and femoral catheters; issues specific to these anatomic sites; routine maintenance and care of catheters and port devices; and complications of central venous catheters and related devices are reviewed in more detail elsewhere.

- (See "Basic principles of ultrasound-guided venous access" and "Placement of jugular venous catheters" and "Placement of subclavian venous catheters" and

"Placement of femoral venous catheters".)

- (See "Routine care and maintenance of intravenous devices".)
- (See "Central venous catheters: Overview of complications and prevention in adults".)

CENTRAL VENOUS ACCESS

A central venous access device is defined as a catheter placed into a thoracic central vein (eg, superior vena cava, brachiocephalic vein, subclavian vein, internal jugular vein) or the iliocaval venous system (eg, inferior vena cava, iliac vein, common femoral vein).

Central venous access is obtained at specific anatomic sites by a percutaneous puncture to cannulate the vein, often using ultrasound guidance. (See 'Device and site selection' below.)

A wide range of central venous catheters and devices are available and are classified based on clinical category (ie, acute, subacute, chronic), duration of catheter use (ie, dwell time: short-term, mid-term, long-term) (algorithm 1), type of insertion (ie, central, peripheral), location of insertion (ie, jugular, subclavian, femoral, brachial), number of lumens (ie, single, double, triple), as well as whether the catheter is implanted or not and to what extent (ie, tunneled [ie, hemodialysis], totally implanted [ie, port]) (figure 1). The basic features of the various types of catheters and the way these features influence catheter selection are discussed separately. (See "Central venous access: Device and site selection in adults", section on 'Types of central venous catheters'.)

Several other medical devices also require central venous access for placement (eg, pulmonary artery catheter, extracorporeal life support cannula, inferior vena cava filter, and intracardiac pacing wire and defibrillator leads), often using an introducer sheath for vein access.

Indications — Indications for central venous access include the placement of central venous catheters for the following reasons [1-4]:

- **Inadequate peripheral venous access** – Unable to obtain peripheral access or complex infusion regimen.

- **Peripherally incompatible infusions** – Short- or long-term intermittent or continuous administration of medications such as vasopressors, hyperosmolar solutions, chemotherapy agents, and parenteral nutrition are typically administered into a central vein, as they can cause vein inflammation (phlebitis) when given through a peripheral intravenous catheter.

- **Hemodynamic monitoring** – Central venous access permits measurement of central venous pressure, venous oxyhemoglobin saturation ($ScvO_2$), and cardiac parameters (via pulmonary artery catheter).

- **Extracorporeal therapies** – Large-bore venous access is required to support the high-volume flow required for many extracorporeal therapies, including renal replacement therapy (ie, hemodialysis, hemofiltration), plasmapheresis, and extracorporeal membrane oxygenation.

Central venous access is also needed for other reasons including placement of:

- Vena cava filters (image 1) (see "Placement of vena cava filters and their complications")

- Venous interventional devices such as venous angioplasty balloon/stents or infusion catheters for venous thrombolytic therapy (see "Endovenous intervention for thoracic central venous obstruction" and "Endovenous intervention for iliocaval venous obstruction")

- Pulmonary artery catheters (figure 2) (see "Pulmonary artery catheters: Insertion technique in adults")

- Pacemakers/defibrillators (figure 3) (see "Temporary cardiac pacing" and "Permanent cardiac pacing: Overview of devices and indications" and "Implantable cardioverter-defibrillators: Overview of indications, components, and functions")

Precautions — Conditions that increase the risk of bleeding or increase the risk for mechanical complications may require special attention to reduce the risk of central venous access. These are reviewed briefly below and in the linked topic reviews. (See 'Device and site selection' below and 'Patients with coagulopathy and/or thrombocytopenia' below.)

GENERAL PREPARATION

Nontunneled percutaneous central catheters are usually placed at the bedside, while tunneled catheters, catheters with subcutaneous ports (ie, totally implantable central venous devices), and other devices are generally placed in an interventional suite or operating room using fluoroscopic guidance. The equipment needed for central venous catheterization is given in the table (table 1).

Device and site selection — The most appropriate site and approach for central venous cannulation should be individualized based on the clinical situation. Operator skill, ultrasound availability and precannulation vein anatomy and patency assessment, patient anatomy (eg, recognizable landmarks, patient tolerance for access positioning, known venous occlusion, presence of lymphedema), risks associated with placement (eg, coagulopathy, pulmonary disease), and access needs (eg, patient needs and duration of catheter use) are important considerations [5-9]. (See "Central venous access: Device and site selection in adults", section on 'Access site'.)

The anatomic site chosen for central catheter placement also influences the risk for and type of complications, including catheter-associated infection [10]. Complications associated with catheters may be minimized with experienced clinician insertion of catheters, strict sterile technique, proper catheter positioning, and appropriate routine care and monitoring after placement [11]. (See "Central venous catheters: Overview of complications and prevention in adults".)

Specific veins (jugular, subclavian, femoral) and access approaches have inherent advantages and disadvantages. These issues are reviewed separately.

- Jugular venous catheters. (See "Placement of jugular venous catheters", section on 'Specific approaches'.)
- Subclavian venous catheters. (See "Placement of subclavian venous catheters", section on 'Approaches to the subclavian vein'.)
- Femoral venous catheters. (See "Placement of femoral venous catheters", section on 'Femoral vein cannulation'.)
- Peripherally inserted central catheters are typically placed into a superficial vein

(basilic vein, cephalic vein) in the upper extremity.

Consent, monitoring and anesthesia — Central venous access is an invasive procedure and informed consent should be obtained unless implied consent or emergency demand is recognized. (See "Informed procedural consent".)

All patients should be monitored during central venous access procedures, including continuous cardiac rhythm and pulse oximetry. Supplemental oxygen should be immediately available, and, for some patients, it may be prudent to administer oxygen by nasal cannula prior to covering the patient's head with sterile drapes.

Central venous devices are typically placed using local anesthesia; however, patients at risk for respiratory compromise with supine or Trendelenburg positioning (obstructive pulmonary disease, patient with obesity), which facilitates venous filling (jugular, subclavian), may require anesthesia with a controlled airway to safely place a central venous catheter or device. (See "Considerations for non-operating room anesthesia (NORA)".)

Patients with coagulopathy and/or thrombocytopenia — The risk of bleeding with central venous access is increased in patients with moderate-to-severe coagulopathy and/or thrombocytopenia, although major bleeding is uncommon [12-14]. A 2017 systematic review of central line placement in patients with coagulopathy or thrombocytopenia documented a wide range of bleeding incidence with major bleeding occurring in <1 percent [12]. The correlation between bleeding risk and severity of coagulopathy was weak.

The optimal platelet count, prothrombin time/international normalized ratio, and activated partial thromboplastin time below which central venous catheterization cannot safely be performed is unclear. Thrombocytopenia, especially when coupled with platelet dysfunction, appears to pose a greater risk compared with prolonged clotting times [15,16].

Individuals at increased risk of bleeding who receive central venous access should be closely monitored and managed in an environment with capabilities to respond rapidly with appropriate interventions if bleeding occurs. In general, venous access sites that are easy to monitor for bleeding are preferred. A subclavian approach is often avoided patients with coagulopathy or severe thrombocytopenia, unless an alternative site is not suitable, due to limitations in monitoring and reduced ability to directly compress the venipuncture site. (See "Central venous access: Device and site selection in adults", section on 'Benefits/risk for specific sites'.)

Low platelet count — The risk of bleeding is increased in individuals with platelet counts <50,000/microL, but among these individuals, the correlation between platelet count and bleeding risk is uncertain. Whether to proceed with and the suggested threshold below which prophylactic platelet transfusion should be used varies in available guidelines [17-21]. We suggest an individualized approach to prophylactic platelet transfusion before central venous catheter placement rather than using a specific platelet count for all patients. In general, the patient's overall bleeding risk should be assessed, including platelet count, cause of thrombocytopenia, and other comorbidities. We are more likely to transfuse platelets prior to central venous access if the platelet count is <20,000 to 30,000/microL, especially if there are comorbidities that increase bleeding risk such as coexistent coagulation abnormalities, fever, and kidney or liver disease [22]. The ability to rapidly respond to bleeding with platelet transfusions is also critical. Considerations when ordering platelets are presented separately. (See "Platelet transfusion: Indications, ordering, and associated risks".)

Our approach is supported by a noninferiority trial that randomly assigned patients with a platelet count of 10,000 to 50,000/microL to receive prophylactic platelet transfusion (one unit) or no platelet transfusion before central venous catheter placement [23]. Three hundred seventy-three central lines were placed in 338 patients. Catheters of any diameter (nontunneled or tunneled) were placed into the internal jugular vein, subclavian vein, or femoral vein according to local practice all using ultrasound guidance by an experienced practitioner. Catheter-related bleeding of grade 2 to 4 was significantly lower in the transfusion compared with no transfusion group (4.8 versus 11.9 percent; relative risk [RR] 2.45, 90% CI 1.27-4.70). Catheter-related major bleeding (grade 3 or 4) requiring intervention or transfusion was also lower in the transfusion group but was not statistically significant (2.1 versus 4.9 percent; RR 2.43, 95% CI 0.75-7.93). Most patients in the no-transfusion group who had a platelet count of 10,000 to 30,000/microL received platelet transfusion within 24 hours after central venous catheter placement. In subgroup analysis comparing the no-transfusion and transfusion groups, situations recognized as higher risk for catheter-related bleeding included nontunneled catheter insertion (10.6 versus 3.5 percent; RR 3.01, 95% CI 1.20–7.55), subclavian venous access (18.1 versus 3.2 percent; RR 6.19, 95% CI 1.39–27.64), and being in a hematology ward (RR 2.99, (16.5

versus 5.4 percent; 95% CI 1.19–7.54). The highest bleeding risk occurred in hematology patients with a platelet count of 10,000 to 20,000/microL.

Prolonged clotting times — The threshold and interventions for prolonged clotting times depend on the reason for prolongation. Blood products such as plasma should **not** be routinely used to "correct" an abnormal clotting time, as this exposes the patient to transfusion-associated risks for unclear benefit, especially if a more specific intervention is available [12,22,24]. (See "Clinical use of plasma components", section on 'Settings in which plasma is not appropriate'.)

- **Anticoagulants** – Specific reversal agents should be used if needed; in some cases, the risks or burdens of reversal may outweigh the benefits and/or it may be preferable to wait for the anticoagulant effect to wear off. (See "Perioperative management of patients receiving anticoagulants".)

- **Bleeding disorders** – Generally, a specific clotting factor or other hemostatic agent is used. (See "Acute treatment of bleeding and surgery in hemophilia A and B" and "von Willebrand disease (VWD): Treatment of minor bleeding, use of DDAVP, and routine preventive care".)

- **Liver disease** – (See "Hemostatic abnormalities in patients with liver disease", section on 'Non-surgical invasive procedures'.)

Aseptic technique — To reduce infectious complications, central venous access procedures, including emergency procedures, should be performed in a location that permits the use of aseptic technique.

- **Barrier precautions** – This includes sterile drapes large enough to cover the entire patient, sterile cover for ultrasound probe, surgical antiseptic hand wash, long-sleeved sterile gown, surgical mask, gloves, and head covering [2,25-29]. Other measures to prevent access site infection should also be used (eg, hair clipping rather than shaving, skin antisepsis). (See "Overview of control measures for prevention of surgical site infection in adults", section on 'Infection control'.)

- **Skin antisepsis** – Preinsertion application of antiseptic solution for skin disinfection at the catheter insertion site reduces catheter colonization and aims to reduce risk of infection. Chlorhexidine gluconate (CHG)-based solutions (>0.5% chlorhexidine preparation with alcohol) are superior to both aqueous and alcohol-based povidone-iodine (PI) solutions [30-36]. In a large trial (2547 catheters), the incidence of catheter-related infection was lower for CHG-alcohol compared with PI (0.28 versus 1.77 per 1000 catheter-days; hazard ratio 0.15, 95% CI 0.05-0.41). If there is a contraindication to CHG, PI, an iodophor, or 70% alcohol can be used as alternatives [37]. CHG antiseptic is typically applied via swab stick and should be applied at the access site and surrounding skin for 30 to 60 seconds. The solution should be allowed to air dry completely prior to draping the patient [32,34].

- **No role for systemic antimicrobial prophylaxis** – Antimicrobial prophylaxis prior to percutaneous central venous catheter placement is not standard practice. A meta-analysis comparing antibiotics versus no antibiotics for totally implanted venous access devices also showed and overall low rate of infection (1.25 percent) which was similar in both treatment groups [38].

USE OF ULTRASOUND AND EFFICACY AT SPECIFIC SITES

Use of ultrasound — We recommend ultrasound-guided venous access, performed by an experienced provider, whenever possible [39]. (See 'Use of ultrasound and efficacy at specific sites' above.)

Precannulation vein assessment — Before cannulation, routine bedside ultrasound by the provider placing the access aims to evaluate the vein location, size, and patency and aids in selecting the most appropriate site of access. It is particularly useful in patients who have a history of prior instrumentation or deep vein thrombosis in the region of the proposed access site [40]. (See "Basic principles of ultrasound-guided venous access", section on 'Global use of ultrasound' and "Catheter-related upper extremity venous thrombosis in adults", section on 'Duplex ultrasonography'.)

Preprocedure ultrasound also identifies anatomic variations, which is particularly useful for reducing trauma associated with line placement.

Real-time ultrasound guidance — We recommend using of real-time ultrasound guidance during central venous cannulation at any site when it is available and practical to use. Ultrasound guidance reduces the number of access attempts and time to cannulation. Ultrasound guidance also reduces bleeding complications related to multiple punctures and inadvertent arterial punctures. However, even with optimal techniques, bleeding can still occur in those at risk. In a trial evaluating individuals with thrombocytopenia, while all central lines were placed using ultrasound guidance, serious catheter-related bleeding still occurred in 13 of 373 patients (3.5 percent) [23]. (See 'Patients with coagulopathy and/or thrombocytopenia' above.)

The principles of ultrasound and techniques to identify venous structures for venous access are discussed in detail elsewhere. (See "Basic principles of ultrasound-guided venous access".)

When ultrasound is not available, landmark techniques are used to guide access. (See "Placement of jugular venous catheters" and "Placement of subclavian venous catheters" and "Placement of femoral venous catheters".)

Detection of complications — Proper use of ultrasound aims to reduce major complications. Ultrasound also assists with early detection of arterial and venous guidewire malposition and identification of procedure-related pneumothorax [41,42]. An important caveat to studies of ultrasound for this purpose is that accuracy of diagnosis was dependent upon ultrasound operator skill. (See 'Confirming catheter tip position' below and "Bedside pleural ultrasonography: Equipment, technique, and the identification of pleural effusion and pneumothorax".)

Specific sites

Supraclavicular venous access

Internal jugular — Much of the experience in the literature regards the use of ultrasound for internal jugular cannulation [43-45]:

- A systematic review evaluated the overall effectiveness of ultrasound-guided jugular venous catheter placement in 35 trials with 5108 participants [43]. Compared with landmark techniques, ultrasound guidance increased the rate of successful catheter placement by from 91.7 to 97.6 percent (25 trials, relative risk [RR] 1.12, 95% CI 1.08-1.17) and successful first attempt by from 50.1 to 82.2 percent (18 trials; RR 1.57, 95% CI 1.36-1.82) and reduced the time needed for successful cannulation. The total incidence of complications (including arterial puncture) was reduced from 13.5 to 3.4 percent (14 trials RR 0.29, 95% CI 0.17-0.52), and the incidence of inadvertent arterial puncture was reduced from 9.4 to 2.0 percent (RR 0.28, 95% CI 0.18-0.44).

- In an earlier meta-analysis, seven trials including 608 adults undergoing internal jugular cannulation were included [46]. The rate of successful placement was significantly higher for dynamic ultrasound-guided compared with landmark-based techniques (99 versus 78 percent). Failure on the first attempt was significantly reduced from 57 to 33 percent in adults. On average, there were significantly fewer total numbers of attempts in adults (1.5 mean fewer needle passes, respectively). Complications, predominantly arterial puncture, were reduced from 16 to 5 percent.

Other advanced supraclavicular vein options — Ultrasound can guide supraclavicular access to other thoracic veins. The external jugular vein can also be accessed by ultrasound where it is deep, running parallel, posterior, and superior to the subclavian vein. A supraclavicular approach to the subclavian vein has also been described, though it is associated with a higher risk of pleural puncture.

Infraclavicular venous access — When central veins are accessed from an infraclavicular approach, clinical studies have been less consistent in defining the benefit of ultrasound guidance [47,48]. Still, evidence suggests that ultrasound guidance improves the success rate, decreases the risk of puncture-related complications, and decreases the length of time for the procedure compared with "blind" landmark techniques [46,47,49-56].

In a meta-analysis of three trials, direct (ie, dynamic) ultrasound significantly reduced the risk of inadvertent arterial puncture from 5.8 to 0.8 percent (relative risk [RR] 0.21, 95% CI 0.06-0.82) and hematoma formation from 6.6 to 1.2 percent (RR 0.26, 95% CI 0.09-0.76), but not other complications [47,50,52,54]. , There were no significant differences in number of attempts until success, first-time success rates, or time taken to insert the catheter. In a separate meta-analysis of five trials, dynamic ultrasound also significantly reduced inadvertent arterial puncture and hematoma formation, also other chest complications including hemo/pneumothorax, hemo/pneumomediastinum, thrombosis/embolism (1.3 versus 9.7 percent) [49].

The potential advantages of an ultrasound-guided infraclavicular access to the axillary vein in terms of skin access site make this approach one of the most useful sites in critically ill patients, particularly for patients with a tracheostomy [55,57-60]. An ultrasound-guided infraclavicular approach to the cephalic vein has also been used [61].

The advantages of this approach are avoidance of accidental injury to the axillary artery or to the pleura. Such an approach is possible only when the cephalic vein has a caliber appropriate to the diameter of the catheter to be inserted.

Femoral veins — The common femoral vein (CFV) can be accessed in the groin [47]. Studies of "femoral vein" access typically refer to the CFV, though successful ultrasound cannulation of the femoral vein at mid-thigh has also been described [62,63]. (See "Basic principles of ultrasound-guided venous access", section on 'Ultrasound views' and "Basic principles of ultrasound-guided venous access", section on '"In-plane" versus "out-of-plane" venipuncture'.)

- For femoral vein access, the pooled success rate on the first attempt from three trials was significantly higher for ultrasound compared with landmark techniques (84.1 versus 46.1 percent, RR 1.73, 95% CI 1.34-2.22), and the overall success rate was increased (89.3 versus 78.9 percent, RR 1.11, 95% CI 1.00-1.23) [47]. There were no significant differences in the rate of inadvertent arterial puncture or other complications.

- In a meta-analysis of four trials involving 4065 subjects [64-67], ultrasound-guided femoral vein cannulation for electrophysiologic procedure reduced major vascular complications (1.0 versus 2.0 percent, RR 0.40, 95% CI 0.28-0.91) as well as minor vascular complications (0.42 versus 1.2 percent, RR 0.34, 95% CI 0.15-0.78) [68].

Basilic and brachial veins — Considering the special features of peripherally inserted central catheters (PICCs), ultrasound is required for choosing the best site (ie, preprocedural scan) and for "tip navigation" (ie, control of the proper direction of the catheter into the brachiocephalic vein using supraclavicular ultrasound). Ultrasound guidance helps avoid puncture-related complications (eg, avoiding the brachial artery and median nerve) [69,70]. Ultrasound guidance has had a dramatic impact on the overall clinical performance of PICCs. When PICCs were first introduced, they were typically inserted by puncture and cannulation of the visible/palpable veins of the antecubital fossa, a practice now abandoned. Simply by moving the access site from the superficial veins of the antecubital area to the deeper veins in the middle third of the upper arm, ultrasound guidance has been associated with a 95 to 99 percent rate of successful cannulation and a substantial decrease in early and late complications.

GENERAL ASPECTS OF PLACEMENT

Venous access for the placement of central venous devices follows a series of standard steps that adhere to common safety principles. This step-wise approach is outlined in the table for acute and emergency venous access (eg, nontunneled catheters, venous sheaths) (table 2); placement of other central venous devices follows a similar approach.

The Seldinger guidewire method is the preferred approach [71]. This method gains access to a central vein via an introducer needle through which a matched guidewire is threaded to maintain venous access after needle withdrawal. The catheter is advanced into position over the intravascular guidewire, which is subsequently removed from the catheter.

Specific details of central venous catheter placement at various anatomic locations (jugular, subclavian, femoral) and other devices are presented separately. (See "Placement of jugular venous catheters" and "Placement of subclavian venous catheters" and "Placement of femoral venous catheters".)

Acute or emergency access — Acute or emergency central venous access includes the placement of nontunneled central venous catheters, which may be needed for a variety of reasons (eg, fluid therapy, hemodialysis, plasmapheresis). Details of acute or emergency central venous access are provided separately (table 2). (See "Central venous access: acute and emergency access in adults".)

In the acute setting, a venous sheath can be used for large volume intravenous infusion or for the placement of pulmonary artery catheters. (See 'Venous sheath' below and "Pulmonary artery catheters: Insertion technique in adults".)

Other venous devices — The basic principles for placing other central venous devices starts with the general steps outlined in the table for acute or emergency central venous access (table 2). Other aspects of placement are described below for each device.

Venous sheath — A venous (introducer) sheath is a combined tissue dilator and sheath assembly that is sized according to the intended device. Venous sheaths are commonly used to introduce a variety of venous devices including some tunneled catheters (which may use a peel-away sheath), pulmonary artery catheters, pacing leads, inferior vena cava filters, intravascular ultrasound, and venous interventional devices, including venous angioplasty balloons and stents.

The venous sheath is typically placed using the Seldinger guidewire technique. After the guidewire is in place, the tissue dilator and sheath are advanced over the guidewire together. The tissue dilator and guidewire are then removed, leaving the sheath in place, through which other venous devices can be inserted. The attached side port is then aspirated and irrigated to check function, and the sheath is secured to the skin at its exit site.

Tunneled catheters — Venous access for tunneled catheters is obtained in a manner like nontunneled catheters. The exit site of the catheter on the skin is chosen, which determines the length of catheter that will be needed for proper catheter tip positioning. For some tunneled catheters, the excess length of catheter provided is trimmed before the catheter is tunneled; for others, it can be trimmed afterward. Other types of catheters come in fixed lengths (eg, dialysis catheters), and the position of the exit site is chosen to accommodate the predetermined length of the catheter. For subclavian and jugular tunneled catheters, the exit site on the chest wall should be located below the mid-clavicle in a position that does not interfere with clothing or upper extremity mobility.

Percutaneous access is performed as outlined in the table (table 2). Once the guidewire is in position, the skin at the guidewire exit site is incised to accommodate at least the diameter of the catheter. Following administration of local anesthesia to the catheter exit site and planned subcutaneous tunnel, an incision is made at the planned catheter exit site. A tunneling device is usually included in the catheter kit and is attached to the distal catheter lumen orifice (ie, catheter tip lumen hole rather than a more proximal port). The catheter is advanced subcutaneously from the catheter exit site to the guidewire exit site (antegrade), and the tunneler is removed. Some catheters will need to be tunneled retrograde. Care is taken to ensure that the tunnel provides a gentle curve in the catheter from the catheter exit site to the guidewire site. Acute angulation may lead to poor flow rates and catheter malfunction. After dilating the vein, the tissue dilator/sheath combination is placed over the wire using fluoroscopic guidance. The tissue dilator is removed, and the catheter is advanced through the sheath and the sheath peeled away. The position of the tip of the catheter is checked and adjusted, as needed. The cuff of the tunneled catheter is ideally located 2 cm from the skin exit site of the catheter. The catheter is sutured to the skin to prevent malposition until the cuff is incorporated in the subcutaneous tissue.

Subcutaneous ports — Percutaneous venous access is obtained as outlined in the table (table 2). Once the guidewire is in place, local anesthetic is administered into the skin and subcutaneous tissue in the region of the planned pocket. An incision is made through the skin and, using electrocautery, the pocket is created to accommodate the device by undermining the subcutaneous tissue to the level of the fascia. Prior to placing the port, its function should be checked by inserting a needle and irrigating with saline, which should flow freely through the port hub. The device is placed into the pocket, and the size of the pocket and orientation of the device is adjusted as needed.

Once the pocket is completed, the catheter is tunneled from the pocket to the guidewire exit site, if needed (eg, jugular venous access). Care is taken to avoid catheter angulation, which will lead to mechanical dysfunction. After dilating the vein, the tissue dilator/sheath combination is placed over the wire. The tissue dilator is removed, the catheter is placed through the sheath, and the sheath is peeled away. The catheter is positioned and adjusted as needed. The excess catheter is trimmed and attached to the hub of the port device, which is placed into the pocket and sutured into place. Placing sutures at three points of fixation into fascial tissue is important to prevent port rotation, which can transpose the access hub away from the skin surface, making access difficult. The subcutaneous tissues and skin are sutured closed. Prior to dressing the wound, the port should be accessed through the skin, and the port aspirated and irrigated to confirm its proper functioning. Ports are typically loaded with heparinized saline according to the manufacturer's recommendation if they are not accessed for immediate use.

Confirming catheter tip position — Catheter tip positioning can be confirmed with one or more of the following methods: chest radiography, fluoroscopy, ultrasound, transesophageal echocardiography (typically intraoperative), and intracavitary electrocardiography (IC-ECG) [42,72-80]. Chest radiography and fluoroscopy are the most used methods in the United States.

Radiography — In nonemergency situations, a postprocedure chest radiograph is recommended to confirm catheter course and tip position prior to use of jugular and subclavian catheters. Femoral catheters do not require radiologic confirmation of position. The need for routine radiography confirmation of apparently uncomplicated right internal jugular catheter placement has been questioned [74,76,77].

Ultrasound and echocardiography — Alternative imaging modalities to radiography to localize intraprocedure guidewire position and ultimate catheter tip position include ultrasound and transesophageal echocardiography, which are particularly useful in critical care settings and in the operating room. Real-time transthoracic ultrasound can also be used to assess for proper positioning of the guidewire tip prior to catheter insertion and pneumothorax [41,81-83]. A meta-analysis that pooled 20 studies showed sensitivity of 88 percent and specificity of 99 percent for ultrasound detection of pneumothorax, compared with 52 and 100 percent for chest radiography [82,84]. (See "Clinical presentation and diagnosis of pneumothorax", section on 'Pleural ultrasonography'.)

Intracavitary electrocardiography — IC-ECG is another technique that relies on detection of intracardiac P wave patterns obtained during catheter positioning. The rationale for this approach is that the sinoatrial node is located at the junction of the right atrium and superior vena cava (cavoatrial junction). Thus, mapping the catheter tip to the sinoatrial node internally identifies the biologically correct catheter tip position. Following catheter insertion, an electromagnetic guidewire is threaded through an introducer needle and connected to an electrocardiograph monitor lead. On the IC-ECG tracing:

- A normally shaped P wave identifies the mid-to-upper superior vena cava.
- The widest P wave indicates the central catheter tip is at the superior vena cava-right atrium junction.
- A biphasic P wave identifies the location of the right atrium.
- Superimposition of the intracavitary ECG with a surface ECG at the point of maximal P wave deflection indicates appropriate positioning of the catheter tip.

Several reviews in hemodialysis populations have confirmed the utility of this technique [85-88]. In the largest review of over 1000 cases, the technique was successfully applied in 98 percent. The presence of preexisting cardiac arrhythmias that affect P wave generation and propagation (eg, atrial flutter and fibrillation) constitutes a main technique limitation, and in these cases, IC-ECG may not be helpful [88]. A meta-analysis and large registry review have found improved tip positioning for IC-ECG compared with plain radiography for placement of peripherally inserted central catheters [89,90].

Optimal catheter tip positioning — The optimal positioning of the catheter tip depends on the specific access site. In general, catheters function well with the tip situated in any major vein. However, suboptimal tip position may be related to delayed complications. As an example, catheter tip position within the subclavian vein is associated with thrombosis. If a catheter is malpositioned within the venous system, it may be used under emergency circumstances but should be repositioned when feasible. By contrast, inadvertent placement of a catheter into the arterial system mandates immediate attention [91]. (See "Vascular complications of central venous access and their management in adults".)

Common access sites, catheter tip positioning, and management of malpositioned catheters are reviewed separately.

- (See "Placement of jugular venous catheters", section on 'Confirmation of jugular catheter position'.)
- (See "Placement of subclavian venous catheters", section on 'Confirmation of subclavian catheter position'.)
- (See "Placement of femoral venous catheters", section on 'Confirmation of femoral catheter position'.)

SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Venous access".)

INFORMATION FOR PATIENTS

UpToDate offers two types of patient education materials, "The Basics" and "Beyond the Basics." The Basics patient education pieces are written in plain language, at the 5^{th} to 6^{th} grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are written at the 10^{th} to 12^{th} grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or email these topics to your patients. (You can also locate patient education articles on a variety of subjects by searching on "patient info" and the keyword(s) of interest.)

- Basics topic (see "Patient education: Central line infections (The Basics)")

SUMMARY AND RECOMMENDATIONS

- **Indications for central venous access** – Common indications for central venous access include inadequate intravenous access, medication and fluid administration, hemodynamic monitoring, and extracorporeal therapy (eg, hemodialysis, plasmapheresis). Central venous access is also used to facilitate insertion of venous devices, including pulmonary artery catheters, pacemakers/defibrillators, inferior vena cava filters, and to perform venous intervention. (See 'Indications' above.)

- **Catheter type and site selection** – Central venous catheters can be inserted through the jugular, subclavian, or femoral veins, or peripherally inserted via upper arm peripheral veins. The type of catheter used is based on the clinical scenario of the individual patient, anticipated duration of use, and provider preference. The optimal site is determined by patient anatomy, clinical circumstances, and operator experience. (See 'Device and site selection' above and "Central venous access: Device and site selection in adults", section on 'Access site'.)

- **Use of ultrasound**

  - **Precannulation ultrasound** – Prior to the placement of central venous catheters, precannulation ultrasound is performed by the proceduralist inserting the access to evaluate venous anatomy and patency and aid in selecting the most appropriate site of access. (See 'Use of ultrasound' above.)

  - **Intraprocedure ultrasound** – For all adults undergoing central venous access (any site), we recommend ultrasound guidance during venous cannulation (**Grade 1B**). The use of ultrasound reduces the risk of complications and shortens the time to successful cannulation. Ultrasound guidance is particularly useful in high-risk patients, such as those with thrombocytopenia or coagulopathy. Important steps during real-time ultrasound guidance include needle guidance for target vessel puncture, guidewire position confirmation at the entry site, and guidewire tip recognition to reduce catheter malposition. If ultrasound is not available or not practical to use (eg, emergency access), landmark techniques are used to guide central venous access. (See 'Use of ultrasound' above.)

- **Post-cannulation ultrasound** – Intra- or postprocedure ultrasound can assist with early confirmation of guidewire and catheter tip position and identify procedure-related pneumothorax. (See 'Ultrasound and echocardiography' above.)

- **Patients with increased bleeding risk** – Individuals with thrombocytopenia and/or prolonged clotting times should have careful site selection avoiding the subclavian vein approach (when possible), receive interventions as appropriate to reduce bleeding risk, and receive close monitoring. We are more likely to transfuse platelets for platelet count <20,000 to 30,000/microL, but other comorbidities are factored into the decision to transfuse platelets, and clinical judgment is required. Coagulation abnormalities should be addressed based on the underlying cause (eg, specific reversal agent for anticoagulants or delay until anticoagulant effect is resolved); routine transfusion of plasma should be avoided. (See 'Patients with coagulopathy and/or thrombocytopenia' above.)

- **Aseptic technique** – To reduce infectious complications, all central venous access procedures, including emergency procedures, should be performed using aseptic technique, which includes full barrier precautions and skin antisepsis. We suggest using a chlorhexidine gluconate (CHG)-based solution (>0.5% chlorhexidine preparation with alcohol), rather than a povidone iodine solution (**Grade 2B**). If a CHG-based solution is not available, alternative agents can be used (eg, povidone iodine, an iodophor, or 70% alcohol). Systemic antimicrobial prophylaxis prior to percutaneous central venous catheter placement is not necessary. (See 'Aseptic technique' above.)

- **General access techniques** – Central venous catheterization is performed through a series of well-defined steps as outlined in the table (table 2). Central venous access for venous sheaths and other venous devices is performed in a similar manner. (See 'General aspects of placement' above.)

- **Confirming catheter tip positioning** – Catheter tip positioning can be confirmed with one or more of the following methods: chest radiography, fluoroscopy, ultrasound, transesophageal echocardiography (typically intraoperative), and intracavitary electrocardiography (IC-ECG). To detect catheter malposition and pneumothorax, chest radiography is typically used, but periprocedural ultrasound or IC-ECG are alternative techniques. (See 'Confirming catheter tip position' above.)

- Chest radiography is often used to confirm jugular and subclavian catheter placement prior to use in nonemergency situations. (See "Placement of subclavian venous catheters", section on 'Confirmation of subclavian catheter position'.)

- Femoral catheters do not require radiologic confirmation of position. (See "Placement of femoral venous catheters", section on 'Confirmation of femoral catheter position'.)

- The need for chest radiography in all patients undergoing jugular venous access procedures is controversial. (See "Placement of jugular venous catheters", section on 'Confirmation of jugular catheter position'.)

REFERENCES

1. Infusion Nursing Standards of Practice 2016. J Infus Nurs. https://www.ins1.org/Default.aspx?TabID=251&productId=113266 (Accessed on December 02, 2017).
2. American Society of Anesthesiologists Task Force on Central Venous Access, Rupp SM, Apfelbaum JL, et al. Practice guidelines for central venous access: a report by the American Society of Anesthesiologists Task Force on Central Venous Access. Anesthesiology 2012; 116:539.
3. Freel AC, Shiloach M, Weigelt JA, et al. American College of Surgeons Guidelines Program: a process for using existing guidelines to generate best practice recommendations for central venous access. J Am Coll Surg 2008; 207:676.
4. Bodenham Chair A, Babu S, Bennett J, et al. Association of Anaesthetists of Great Britain and Ireland: Safe vascular access 2016. Anaesthesia 2016; 71:573.
5. Plumhans C, Mahnken AH, Ocklenburg C, et al. Jugular versus subclavian totally

implantable access ports: catheter position, complications and intrainterventional pain perception. Eur J Radiol 2011; 79:338.

6. Timsit JF. Central venous access in intensive care unit patients: is the subclavian vein the royal route? Intensive Care Med 2002; 28:1006.
7. Marik PE, Flemmer M, Harrison W. The risk of catheter-related bloodstream infection with femoral venous catheters as compared to subclavian and internal jugular venous catheters: a systematic review of the literature and meta-analysis. Crit Care Med 2012; 40:2479.
8. Biffi R, Pozzi S, Bonomo G, et al. Cost effectiveness of different central venous approaches for port placement and use in adult oncology patients: evidence from a randomized three-arm trial. Ann Surg Oncol 2014; 21:3725.
9. O'Grady NP, Alexander M, Burns LA, et al. Guidelines for the prevention of intravascular catheter-related infections. Am J Infect Control 2011; 39:S1.
10. Parienti JJ, Mongardon N, Mégarbane B, et al. Intravascular Complications of Central Venous Catheterization by Insertion Site. N Engl J Med 2015; 373:1220.
11. Deshpande KS, Hatem C, Ulrich HL, et al. The incidence of infectious complications of central venous catheters at the subclavian, internal jugular, and femoral sites in an intensive care unit population. Crit Care Med 2005; 33:13.
12. van de Weerdt EK, Biemond BJ, Baake B, et al. Central venous catheter placement in coagulopathic patients: risk factors and incidence of bleeding complications. Transfusion 2017; 57:2512.
13. Duffy SM, Coyle TE. Platelet transfusions and bleeding complications associated with plasma exchange catheter placement in patients with presumed thrombotic thrombocytopenic purpura. J Clin Apher 2013; 28:356.
14. Cavanna L, Citterio C, Nunzio Camilla D, et al. Central venous catheterization in cancer patients with severe thrombocytopenia: Ultrasound-guide improves safety avoiding prophylactic platelet transfusion. Mol Clin Oncol 2020; 12:435.
15. Vinson DR, Ballard DW, Hance LG, et al. Bleeding complications of central venous catheterization in septic patients with abnormal hemostasis. Am J Emerg Med 2014; 32:737.
16. Frykholm P, Pikwer A, Hammarskjöld F, et al. Clinical guidelines on central venous catheterisation. Swedish Society of Anaesthesiology and Intensive Care Medicine.

Acta Anaesthesiol Scand 2014; 58:508.

17. American Society of Anesthesiologists Task Force on Perioperative Blood Management. Practice guidelines for perioperative blood management: an updated report by the American Society of Anesthesiologists Task Force on Perioperative Blood Management*. Anesthesiology 2015; 122:241.
18. Kaufman RM, Djulbegovic B, Gernsheimer T, et al. Platelet transfusion: a clinical practice guideline from the AABB. Ann Intern Med 2015; 162:205.
19. Estcourt LJ, Birchall J, Allard S, et al. Guidelines for the use of platelet transfusions. Br J Haematol 2017; 176:365.
20. Patel IJ, Rahim S, Davidson JC, et al. Society of Interventional Radiology Consensus Guidelines for the Periprocedural Management of Thrombotic and Bleeding Risk in Patients Undergoing Percutaneous Image-Guided Interventions-Part II: Recommendations: Endorsed by the Canadian Association for Interventional Radiology and the Cardiovascular and Interventional Radiological Society of Europe. J Vasc Interv Radiol 2019; 30:1168.
21. Vlaar AP, Oczkowski S, de Bruin S, et al. Transfusion strategies in non-bleeding critically ill adults: a clinical practice guideline from the European Society of Intensive Care Medicine. Intensive Care Med 2020; 46:673.
22. Hall DP, Lone NI, Watson DM, et al. Factors associated with prophylactic plasma transfusion before vascular catheterization in non-bleeding critically ill adults with prolonged prothrombin time: a case-control study. Br J Anaesth 2012; 109:919.
23. van Baarle FLF, van de Weerdt EK, van der Velden WJFM, et al. Platelet Transfusion before CVC Placement in Patients with Thrombocytopenia. N Engl J Med 2023; 388:1956.
24. Weigand K, Encke J, Meyer FJ, et al. Low levels of prothrombin time (INR) and platelets do not increase the risk of significant bleeding when placing central venous catheters. Med Klin (Munich) 2009; 104:331.
25. O'Grady NP, Gerberding JL, Weinstein RA, Masur H. Patient safety and the science of prevention: the time for implementing the Guidelines for the prevention of intravascular catheter-related infections is now. Crit Care Med 2003; 31:291.
26. Mermel LA, McCormick RD, Springman SR, Maki DG. The pathogenesis and epidemiology of catheter-related infection with pulmonary artery Swan-Ganz

catheters: a prospective study utilizing molecular subtyping. Am J Med 1991; 91:197S.

27. Mermel LA. Prevention of intravascular catheter-related infections. Ann Intern Med 2000; 132:391.
28. Raad II, Hohn DC, Gilbreath BJ, et al. Prevention of central venous catheter-related infections by using maximal sterile barrier precautions during insertion. Infect Control Hosp Epidemiol 1994; 15:231.
29. Geffers C, Meyer E. No reason to conclude that maximal sterile barrier precautions do not reduce catheter-related blood stream infections. Ann Surg 2011; 253:212.
30. Lai NM, Lai NA, O'Riordan E, et al. Skin antisepsis for reducing central venous catheter-related infections. Cochrane Database Syst Rev 2016; 7:CD010140.
31. Guenezan J, Drugeon B, O'Neill R, et al. Skin antisepsis with chlorhexidine-alcohol versus povidone iodine-alcohol, combined or not with use of a bundle of new devices, for prevention of short-term peripheral venous catheter-related infectious complications and catheter failure: an open-label, single-centre, randomised, four-parallel group, two-by-two factorial trial: CLEAN 3 protocol study. BMJ Open 2019; 9:e028549.
32. Mimoz O, Lucet JC, Kerforne T, et al. Skin antisepsis with chlorhexidine-alcohol versus povidone iodine-alcohol, with and without skin scrubbing, for prevention of intravascular-catheter-related infection (CLEAN): an open-label, multicentre, randomised, controlled, two-by-two factorial trial. Lancet 2015; 386:2069.
33. Yamamoto N, Kimura H, Misao H, et al. Efficacy of 1.0% chlorhexidine-gluconate ethanol compared with 10% povidone-iodine for long-term central venous catheter care in hematology departments: a prospective study. Am J Infect Control 2014; 42:574.
34. Chaiyakunapruk N, Veenstra DL, Lipsky BA, Saint S. Chlorhexidine compared with povidone-iodine solution for vascular catheter-site care: a meta-analysis. Ann Intern Med 2002; 136:792.
35. Mimoz O, Villeminey S, Ragot S, et al. Chlorhexidine-based antiseptic solution vs alcohol-based povidone-iodine for central venous catheter care. Arch Intern Med 2007; 167:2066.
36. Yasuda H, Sanui M, Abe T, et al. Comparison of the efficacy of three topical antiseptic solutions for the prevention of catheter colonization: a multicenter randomized

controlled study. Crit Care 2017; 21:320.

37. Mimoz O, Pieroni L, Lawrence C, et al. Prospective, randomized trial of two antiseptic solutions for prevention of central venous or arterial catheter colonization and infection in intensive care unit patients. Crit Care Med 1996; 24:1818.
38. Johnson E, Babb J, Sridhar D. Routine Antibiotic Prophylaxis for Totally Implantable Venous Access Device Placement: Meta-Analysis of 2,154 Patients. J Vasc Interv Radiol 2016; 27:339.
39. Tercan F, Ozkan U, Oguzkurt L. US-guided placement of central vein catheters in patients with disorders of hemostasis. Eur J Radiol 2008; 65:253.
40. Gornik HL, Gerhard-Herman MD, Misra S, et al. ACCF/ACR/AIUM/ASE/IAC/SCAI/SCVS/SIR/SVM/SVS/SVU 2013 appropriate use criteria for peripheral vascular ultrasound and physiological testing part II: testing for venous disease and evaluation of hemodialysis access: a report of the american college of cardiology foundation appropriate use criteria task force. J Am Coll Cardiol 2013; 62:649.
41. Bedel J, Vallée F, Mari A, et al. Guidewire localization by transthoracic echocardiography during central venous catheter insertion: a periprocedural method to evaluate catheter placement. Intensive Care Med 2013; 39:1932.
42. Gillman LM, Blaivas M, Lord J, et al. Ultrasound confirmation of guidewire position may eliminate accidental arterial dilatation during central venous cannulation. Scand J Trauma Resusc Emerg Med 2010; 18:39.
43. Brass P, Hellmich M, Kolodziej L, et al. Ultrasound guidance versus anatomical landmarks for internal jugular vein catheterization. Cochrane Database Syst Rev 2015; 1:CD006962.
44. Griswold-Theodorson S, Hannan H, Handly N, et al. Improving patient safety with ultrasonography guidance during internal jugular central venous catheter placement by novice practitioners. Simul Healthc 2009; 4:212.
45. Chittoodan S, Breen D, O'Donnell BD, Iohom G. Long versus short axis ultrasound guided approach for internal jugular vein cannulation: a prospective randomised controlled trial. Med Ultrason 2011; 13:21.
46. Hind D, Calvert N, McWilliams R, et al. Ultrasonic locating devices for central venous cannulation: meta-analysis. BMJ 2003; 327:361.

47. Brass P, Hellmich M, Kolodziej L, et al. Ultrasound guidance versus anatomical landmarks for subclavian or femoral vein catheterization. Cochrane Database Syst Rev 2015; 1:CD011447.
48. Griswold-Theodorson S, Farabaugh E, Handly N, et al. Subclavian central venous catheters and ultrasound guidance: policy vs practice. J Vasc Access 2013; 14:104.
49. Lalu MM, Fayad A, Ahmed O, et al. Ultrasound-Guided Subclavian Vein Catheterization: A Systematic Review and Meta-Analysis. Crit Care Med 2015; 43:1498.
50. Gualtieri E, Deppe SA, Sipperly ME, Thompson DR. Subclavian venous catheterization: greater success rate for less experienced operators using ultrasound guidance. Crit Care Med 1995; 23:692.
51. Mansfield PF, Hohn DC, Fornage BD, et al. Complications and failures of subclavian-vein catheterization. N Engl J Med 1994; 331:1735.
52. Palepu GB, Deven J, Subrahmanyam M, Mohan S. Impact of ultrasonography on central venous catheter insertion in intensive care. Indian J Radiol Imaging 2009; 19:191.
53. Abboud PA, Kendall JL. Ultrasound guidance for vascular access. Emerg Med Clin North Am 2004; 22:749.
54. Fragou M, Gravvanis A, Dimitriou V, et al. Real-time ultrasound-guided subclavian vein cannulation versus the landmark method in critical care patients: a prospective randomized study. Crit Care Med 2011; 39:1607.
55. O'Leary R, Ahmed SM, McLure H, et al. Ultrasound-guided infraclavicular axillary vein cannulation: a useful alternative to the internal jugular vein. Br J Anaesth 2012; 109:762.
56. Oh AY, Jeon YT, Choi EJ, et al. The influence of the direction of J-tip on the placement of a subclavian catheter: real time ultrasound-guided cannulation versus landmark method, a randomized controlled trial. BMC Anesthesiol 2014; 14:11.
57. Sharma A, Bodenham AR, Mallick A. Ultrasound-guided infraclavicular axillary vein cannulation for central venous access. Br J Anaesth 2004; 93:188.
58. Tamura A, Sone M, Ehara S, et al. Is ultrasound-guided central venous port placement effective to avoid pinch-off syndrome? J Vasc Access 2014; 15:311.
59. Pittiruti M, Biasucci DG, La Greca A, et al. How to make the axillary vein larger? Effect of 90° abduction of the arm to facilitate ultrasound-guided axillary vein puncture. J

Crit Care 2016; 33:38.

60. Bodenham A, Lamperti M. Ultrasound guided infraclavicular axillary vein cannulation, coming of age. Br J Anaesth 2016; 116:325.
61. LeDonne J. Percutaneous cephalic vein cannulation (in the Deltopectoral Groove), with ultrasound guidance. J Am Coll Surg 2005; 200:810.
62. Wan Y, Chu Y, Qiu Y, et al. The feasibility and safety of PICCs accessed via the superficial femoral vein in patients with superior vena cava syndrome. J Vasc Access 2018; 19:34.
63. Xu B, Zhang J, Tang S, et al. Comparison of two types of catheters through femoral vein catheterization in patients with lung cancer undergoing chemotherapy: A retrospective study. J Vasc Access 2018; 19:651.
64. Errahmouni A, Bun SS, Latcu DG, Saoudi N. Ultrasound-guided venous puncture in electrophysiological procedures: a safe method, rapidly learned. Pacing Clin Electrophysiol 2014; 37:1023.
65. Rodríguez Muñoz D, Franco Díez E, Moreno J, et al. Wireless Ultrasound Guidance for Femoral Venous Cannulation in Electrophysiology: Impact on Safety, Efficacy, and Procedural Delay. Pacing Clin Electrophysiol 2015; 38:1058.
66. Tanaka-Esposito CC, Chung MK, Abraham JM, et al. Real-time ultrasound guidance reduces total and major vascular complications in patients undergoing pulmonary vein antral isolation on therapeutic warfarin. J Interv Card Electrophysiol 2013; 37:163.
67. Wynn GJ, Haq I, Hung J, et al. Improving safety in catheter ablation for atrial fibrillation: a prospective study of the use of ultrasound to guide vascular access. J Cardiovasc Electrophysiol 2014; 25:680.
68. Sobolev M, Shiloh AL, Di Biase L, Slovut DP. Ultrasound-guided cannulation of the femoral vein in electrophysiological procedures: a systematic review and meta-analysis. Europace 2017; 19:850.
69. Sofocleous CT, Schur I, Cooper SG, et al. Sonographically guided placement of peripherally inserted central venous catheters: review of 355 procedures. AJR Am J Roentgenol 1998; 170:1613.
70. Pittiruti M, Hamilton H, Biffi R, et al. ESPEN Guidelines on Parenteral Nutrition: central venous catheters (access, care, diagnosis and therapy of complications). Clin Nutr

2009; 28:365.

71. SELDINGER SI. Catheter replacement of the needle in percutaneous arteriography; a new technique. Acta radiol 1953; 39:368.
72. Gu X, Paulsen W, Tisnado J, et al. Malposition of a central venous catheter in the right main pulmonary artery detected by transesophageal echocardiography. J Am Soc Echocardiogr 2009; 22:1420.e5.
73. Sawchuk C, Fayad A. Confirmation of internal jugular guide wire position utilizing transesophageal echocardiography. Can J Anaesth 2001; 48:688.
74. Lucey B, Varghese JC, Haslam P, Lee MJ. Routine chest radiographs after central line insertion: mandatory postprocedural evaluation or unnecessary waste of resources? Cardiovasc Intervent Radiol 1999; 22:381.
75. Gebhard RE, Szmuk P, Pivalizza EG, et al. The accuracy of electrocardiogram-controlled central line placement. Anesth Analg 2007; 104:65.
76. Abood GJ, Davis KA, Esposito TJ, et al. Comparison of routine chest radiograph versus clinician judgment to determine adequate central line placement in critically ill patients. J Trauma 2007; 63:50.
77. Lessnau KD. Is chest radiography necessary after uncomplicated insertion of a triple-lumen catheter in the right internal jugular vein, using the anterior approach? Chest 2005; 127:220.
78. Wirsing M, Schummer C, Neumann R, et al. Is traditional reading of the bedside chest radiograph appropriate to detect intraatrial central venous catheter position? Chest 2008; 134:527.
79. Francis KR, Picard DL, Fajardo MA, Pizzi WF. Avoiding complications and decreasing costs of central venous catheter placement utilizing electrocardiographic guidance. Surg Gynecol Obstet 1992; 175:208.
80. Calabria M, Zamboli P, D'Amelio A, et al. [Use of ECG-EC in the positioning of central venous catheters]. G Ital Nefrol 2012; 29:49.
81. Dalton BG, Gonzalez KW, Keirsy MC, et al. Chest radiograph after fluoroscopic guided line placement: No longer necessary. J Pediatr Surg 2016; 51:1490.
82. Ding W, Shen Y, Yang J, et al. Diagnosis of pneumothorax by radiography and ultrasonography: a meta-analysis. Chest 2011; 140:859.
83. Ablordeppey EA, Drewry AM, Beyer AB, et al. Diagnostic Accuracy of Central Venous

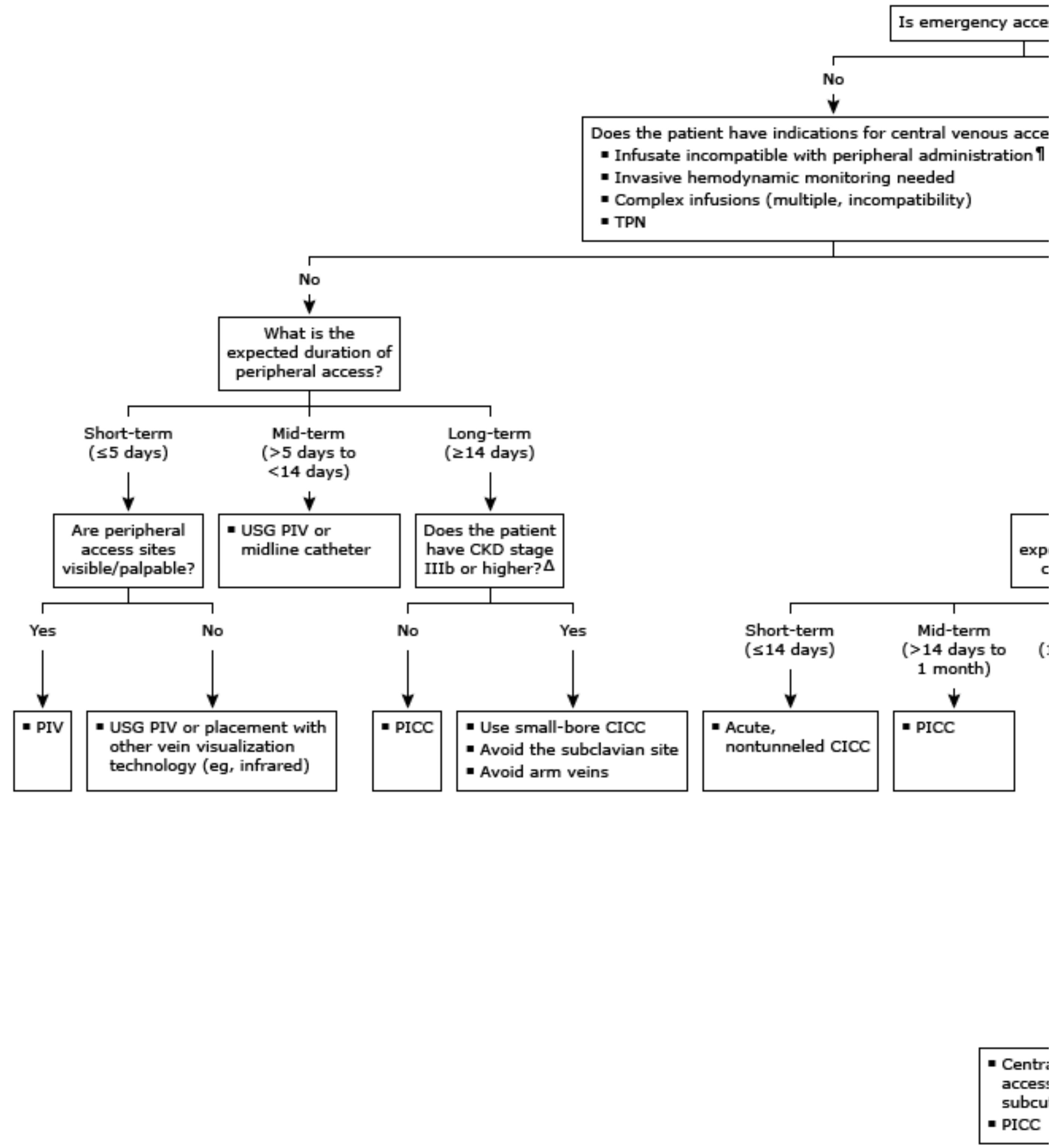
Catheter Confirmation by Bedside Ultrasound Versus Chest Radiography in Critically Ill Patients: A Systematic Review and Meta-Analysis. Crit Care Med 2017; 45:715.

84. Chui J, Saeed R, Jakobowski L, et al. Is Routine Chest X-Ray After Ultrasound-Guided Central Venous Catheter Insertion Choosing Wisely?: A Population-Based Retrospective Study of 6,875 Patients. Chest 2018; 154:148.
85. Avolio L, Rinaldi A, Serafini G, Martucciello G. Endocavitary electrocardiography during central vein catheter positioning in a newborn with persistent left superior vena cava. J Vasc Access 2009; 10:212.
86. Cavatorta F, Zollo A, Galli S, Dionisio P. Central venous catheter placement in hemodialysis: evaluation of electrocardiography using a guide-wire. J Vasc Access 2001; 2:45.
87. Parigi GB, Verga G. Accurate placement of central venous catheters in pediatric patients using endocavitary electrocardiography: reassessment of a personal technique. J Pediatr Surg 1997; 32:1226.
88. Dionisio P, Cavatorta F, Zollo A, et al. The placement of central venous catheters in hemodialysis: role of the endocavitary electrocardiographic trace. Case reports and literature review. J Vasc Access 2001; 2:80.
89. Kleidon TM, Horowitz J, Rickard CM, et al. Peripherally Inserted Central Catheter Thrombosis After Placement via Electrocardiography vs Traditional Methods. Am J Med 2021; 134:e79.
90. Liu G, Hou W, Zhou C, et al. Meta-analysis of intracavitary electrocardiogram guidance for peripherally inserted central catheter placement. J Vasc Access 2019; 20:577.
91. Guilbert MC, Elkouri S, Bracco D, et al. Arterial trauma during central venous catheter insertion: Case series, review and proposed algorithm. J Vasc Surg 2008; 48:918.

Topic 8194 Version 47.0

GRAPHICS

Approach to venous access catheter selection in adults



This algorithm is intended for use in conjunction with additional UpToDate content on central venous access.

TPN: total parenteral nutrition; PIV: peripheral intravenous; CICC: centrally inserted central catheter; CKD: chronic kidney disease; USG: ultrasound-guided; PICC: peripherally inserted central catheter.

* For example, shock, cardiopulmonary arrest.

¶ Vesicants, infusate pH <5 or >9, infusate osmolarity ≥600 mOsm.

Δ Estimated glomerular filtration rate ≤45 mL/minute.

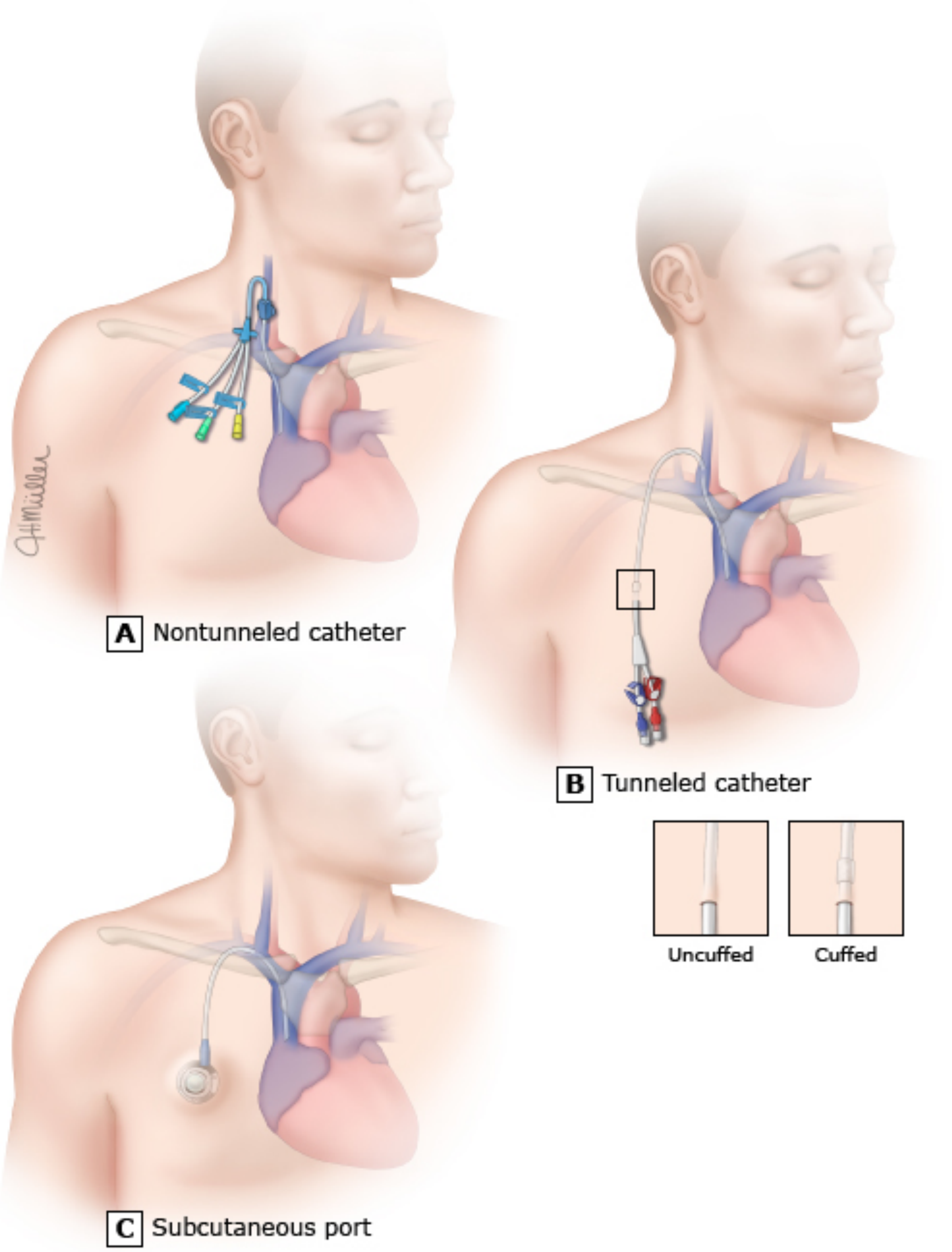
◇ Chemotherapy, nonchemotherapy vesicants.

Adapted from:

1. *Chopra V, Flanders SA, Saint S, et al. The Michigan Appropriateness Guide for Intravenous Catheters (MAGIC): Results from a multispecialty panel using the RAND/UCLA appropriateness method. Ann Int Med 2015; 153:S1.*
2. *Simonov BS, Pittiruti M, Rickard CM, et al. Navigating venous access: A guide for hospitalists. J Hosp Med 2018; 10:471.*

Graphic 117705 Version 3.0

Types of central venous access



Long-term tunneled central venous catheters typically include a cuff (B) located just above (cephalad) to the skin exit site. The cuff facilitates tissue ingrowth over a 2- to 3-week period to anchor the catheter and minimize bacterial migration from the exit site.

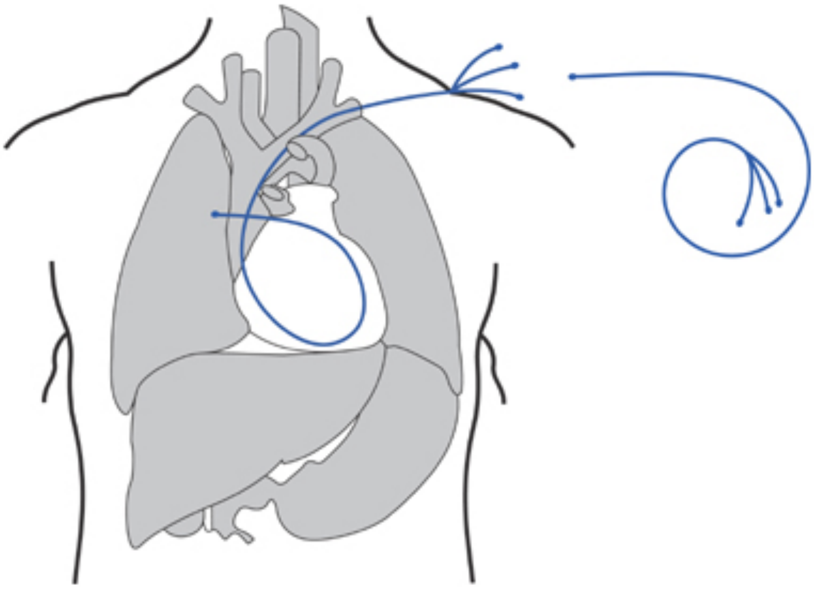
Graphic 95494 Version 7.0

IVC filter prior to left iliac angioplasty

Inferior vena cava (IVC) venogram demonstrating patency and proper placement of retrievable IVC filter placed in a patient with May-Thurner syndrome prior to angioplasty and stenting.

Graphic 111783 Version 2.0

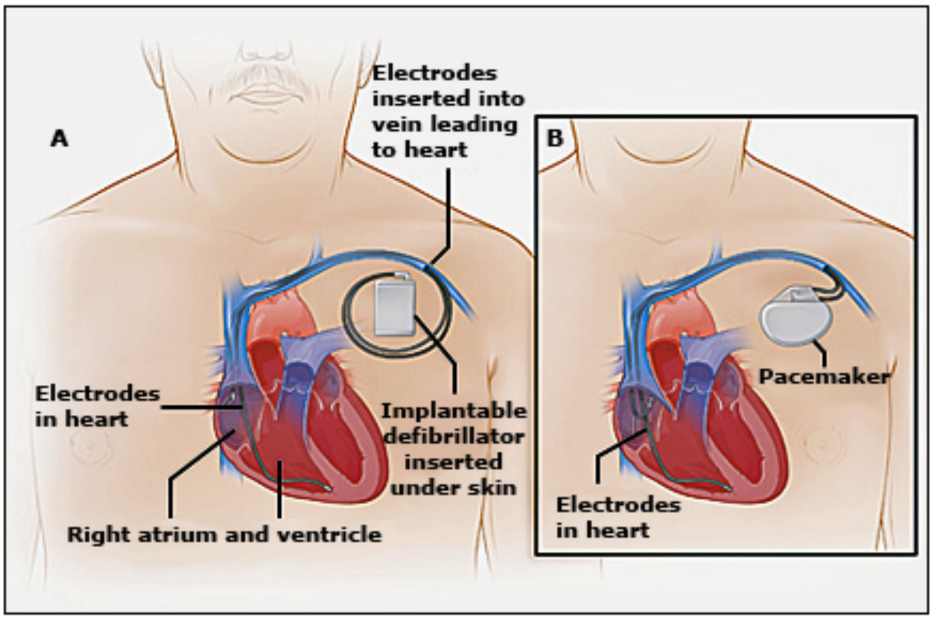
Pulmonary artery catheter insertion



This schematic diagram shows the proper orientation of the pulmonary artery catheter when inserted through the left subclavian vein. The curvature of the catheter is oriented so that it will facilitate passage of the catheter through the cardiac chambers and into the pulmonary artery.

Graphic 54333 Version 2.0

ICDs and pacemakers compared



Implantable cardioverter defibrillators (ICDs) work differently than pacemakers do. Both devices are implanted under the skin and have wires called "electrodes" leading to the heart. Both devices send electrical signals to the heart to keep it beating normally. But ICDs can give a much more powerful jolt to the heart if it starts to beat in a dangerous way. Pacemakers cannot do that.

http://www.nhlbi.nih.gov/health/dci/Diseases/icd/icd_whatis.html.

Graphic 67053 Version 8.0

Equipment for central venous cannulation

2% chlorhexidine skin preparation solution
Sterile gown, gloves, face shield, and cap
Sterile gauze pads: 4" x 4"
Sterile drapes
1% lidocaine; 5 cc
25 Ga. needle with 3 cc lock-tip syringe
Seeker needle: 3.5 cm 22 Ga. needle with 5 cc slip-tip syringe
Introducer needle: 6 cm 18 Ga. large-bore needle with 5 cc slip-tip syringe
J-tip guidewire
Transduction catheter: 6 cm 18 Ga. catheter
Transduction tubing
Tissue dilator
Sterile catheter flush solution
Sheath
Catheter or other device (eg, port, pulmonary catheter)
Sterile sleeve for the catheter
2-0 silk sutures
Sterile dressing

Equipment needed for central venous cannulation, in order of use during procedure. For certain procedures (eg, pulmonary artery catheter placement), additional supplies (drapes, gowns) or additional catheter sets (introducer, sheath, pulmonary catheter, other venous device) may be needed.

Graphic 54646 Version 5.0

Technical guide for acute/emergency central venous access

Temporary single and multilumen central venous catheters are important acute and emergency access devices that establish dependable venous access for monitoring, invasive procedures, pharmacologic therapy, fluid and blood resuscitation, and blood exchange therapies in acute and critical illness.
Preparation
- Obtain procedural consent as appropriate.   - Obtain the equipment and devices needed for catheter placement.   - Select access site appropriate to the clinical situation.   - Prepare and position the patient, with attention to ensuring patient monitoring and support as needed for the situation.   - Identify pertinent surface landmarks with special attention to access to the intended puncture site.   - Confirm the location and patency of the target vein and relationship to surface landmarks with ultrasound, as available.   - Pause for a procedural time-out to verify the procedure, site, and technique with team members.   - Use sterile technique to prepare the skin and drape the patient.
Needle access to the target vein
- Flush the catheter lumens with sterile saline. Arrange and position central venous access supplies to expedite the procedure.   - Re-identify pertinent anatomic landmarks, even if ultrasound will be used. Reconfirm the vein target with ultrasound.   - Infiltrate the skin with local anesthetic (eg, 1 to 2% lidocaine or an alternative agent) at the intended insertion site.   - Use real-time ultrasound imaging to cannulate the vein using a standard introducer needle, micropuncture needle, or angiocatheter.   - Using landmark and ultrasound guidance of the needle trajectory, insert and advance the needle while applying continuous negative pressure on the syringe plunger.   - Monitor needle insertion depth, even during ultrasound guidance, to avoid deep tissue penetration, which risks procedure complication.   - Aspiration of free-flowing venous-colored blood confirms vein cannulation[*].
Advance guidewire
Gently remove the syringe from the needle hub while confirming low-pressure venous-colored blood return. Cover the needle hub with a finger between manipulations to avoid air

entrainment.
- Insert the guidewire through the access needle or angiocatheter. The guidewire should advance with minimal resistance. Maintain awareness of guidewire depth during insertion.
- Advance the guidewire just beyond the anticipated catheter depth, which is approximately 20 cm for adults and is often marked by two hash marks on the guidewire.
- Avoid intracardiac advancement that may trigger arrhythmias.
- Confirm intravenous guidewire placement via ultrasound, if available.
- Remove the needle or angiocatheter while controlling the guidewire.

Place catheter

- Use a #11 scalpel blade to make a single stab skin incision at the puncture site and along the guidewire path.
- Advance the tissue dilator over the guidewire to the approximate depth of the vein but not deeper, then remove the tissue dilator while maintaining guidewire position.
- Load the venous catheter onto the guidewire while maintaining control of the guidewire at the skin entry site.
- Back the guidewire out of the vein through the catheter until it emerges from the distal access port. This allows continuous manual contact with the guidewire to avoid inadvertent catheter insertion without guidewire removal, which is the common mistake leading to a retained guidewire.
- Stabilize the distal guidewire as it exits the distal access port while advancing the catheter over the guidewire into the vein.
- With the catheter in place, remove the guidewire, taking care to stabilize the catheter to maintain intravascular placement.
- Place the removed guidewire in a visible location on the sterile field as a confirmation step for guidewire removal. This also maintains guidewire sterility in case the guidewire is again needed to troubleshoot catheter malposition.
- Aspirate blood from each access hub and flush with sterile saline to ensure a functioning catheter.
- Secure catheter and place sterile dressing.

Confirm catheter position

- In emergency situations, the central venous access may be used immediately*.
- Obtain chest radiography to confirm catheter tip position for jugular and subclavian approaches. Femoral catheters do not require radiologic confirmation*.

Catheter and site care and maintenance

- If adherence to sterile technique during placement cannot be assured, the catheter should be replaced as soon as possible (and within 48 hours after insertion).
- Replace dressings whenever soiled. Otherwise, routinely change polyurethane dressings every

7 days.

- Routine catheter replacement is not necessary. When replacement is needed based on clinical examination, replace at a new site, rather than using guidewire exchange.

* If needed, blood from the access site can be sent as an arterial blood gas or connected to an arterial line setup to assess the waveform or pressure.

Graphic 139634 Version 3.0

Contributor Disclosures

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