Central venous access: Device and site selection in adults

AUTHOR: Vineet Chopra, MD, MSc
SECTION EDITORS: Amalia Cochran, MD, FACS, FCCM, Ingemar Davidson, MD, PhD, FACS
DEPUTY EDITOR: Kathryn A Collins, MD, PhD, FACS

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INTRODUCTION

Secure and reliable venous access is a cornerstone in the care of hospitalized adult patients, as well as for a variety of outpatient situations. Central venous access (ie, insertion of a vascular catheter such that the tip terminates in a deep vein of the neck, chest, or abdomen) is a key component of this practice.

Patients often need central venous access for indications including ongoing hemodynamic monitoring, difficult venous access, or long-term intravenous therapy (eg, antimicrobial therapy, fluid therapy, chemotherapy). A variety of central venous catheters and devices are available to achieve such access, each with its own risks and benefits. Specific clinical situations that may indicate the need for central venous access are reviewed separately.

- Perioperative fluid/nutrition support (see "Intraoperative fluid management" and "Overview of postoperative fluid therapy in adults" and "Postoperative parenteral nutrition in adults")
- Outpatient chemotherapy (see "Dosing of anticancer agents in adults")
- Outpatient fluid therapy/nutrition support (see "Postoperative parenteral nutrition in adults" and "Nutrition and dietary management for adults with inflammatory bowel

disease" and "Management of short bowel syndrome in adults")

- Critical care/hemodynamic monitoring (see "Evaluation of and initial approach to the adult patient with undifferentiated hypotension and shock", section on 'Hemodynamic support')
- Hemodialysis/renal replacement therapy (see "Central venous catheters for acute and chronic hemodialysis access and their management" and "Continuous kidney replacement therapy in acute kidney injury" and "Approach to the adult patient needing vascular access for chronic hemodialysis")
- Apheresis (see "Therapeutic apheresis (plasma exchange or cytapheresis): Indications and technology")
- Trauma/burn resuscitation (see "Initial management of moderate to severe hemorrhage in the adult trauma patient" and "Overview of the management of the severely burned patient" and "Approach to shock in the adult trauma patient")

The types of central venous catheters and the general approach for selecting the most appropriate device for central venous access is reviewed. An overview of central catheters, and catheter placement, are presented in separate topic reviews. (See "Central venous access in adults: General principles" and "Placement of jugular venous catheters" and "Placement of subclavian venous catheters" and "Placement of femoral venous catheters".)

TYPES OF CENTRAL VENOUS CATHETERS

A variety of central venous access devices are available, each with its own risks and benefits. Central venous access devices are generally classified based on duration of catheter use (ie, dwell time; short-term, mid-term, long-term), catheter tip location (ie, central, peripheral), location of insertion (eg, jugular, brachial), number of lumens (ie, single, double, triple), as well as whether the catheter is implanted or not, and to what extent (eg, tunneled, totally implanted [ie, port]). The basic features of the various types of central venous access catheters are reviewed briefly below. The manner in which these features influence catheter selection is discussed below. (See 'Factors influencing catheter selection' below.)

Some central venous access devices are compatible with radiographic injectors for contrast administration (ie, "power-injectable" devices). These devices are essentially engineered with reinforced walls to absorb the high pressure associated with the timed contrast injection. Almost all available central venous catheters are power-compatible but ensuring this is the case is always prudent.

Nontunneled catheters — Nontunneled centrally inserted central catheters (CICCs) (figure 1) are placed percutaneously with the catheter exiting the skin in the vicinity of the venous cannulation site (jugular, subclavian, femoral). These catheters are most commonly used for temporary venous access. Specialized nontunneled catheters for longer-term infusion may contain a valve mechanism to limit backflow of blood for the purpose of preventing infection, occlusion, and catheter-associated thrombosis. Nontunneled CICCs are available in a variety of lengths (15 to 30 cm) and catheter materials. Most modern central venous catheters are made of polyurethane polymers.

Nontunneled CICCs may be single, double, triple, or quadruple lumen. The different lumens infuse or aspirate fluid through slit-like openings located either on the side (eg, side ports) or the tip (eg, distal end) of the catheter. The distal opening is more reliable for drawing blood because it is less likely to be suctioned against the wall of the vein during aspiration and is situated in the deepest and often the largest portion of the vein. In general, as the number of lumens increases, the overall diameter of the catheter increases, and the diameter of the individual luminal channels generally decreases. Later generation catheters that maintain catheter diameter while providing >1 lumen are available; these catheters retain external size profile by sacrificing individual lumen size. Thus, flow rates and rates of occlusion may be higher in these narrower lumens. Regardless of generation, the use of multilumen catheters reduces the maximum infusion rate of the catheter and increases the rate of catheter thrombosis and bloodstream infection. (See 'Number of lumens needed' below and "Catheter-related upper extremity venous thrombosis in adults", section on 'Catheter-related factors' and "Intravascular catheter-related infection: Epidemiology, pathogenesis, and microbiology", section on 'Catheter factors'.)

Peripherally inserted central catheters (PICCs) are another type of commonly used central venous access device. These devices are popular due to the relative ease and safety of insertion into the peripheral veins of the upper extremity (eg, brachial vein, basilic veins) (figure 2), a lower risk of insertion-related complications, and improved patient

tolerance. Single-, double-, and triple-lumen PICCs that may be valved or nonvalved are available. However, like all central venous catheters, PICCs are not without risks and complications. As with CICCs, the rates of deep vein thrombosis (DVT) and bloodstream infection for PICCs increase with increasing number of lumens and catheter diameter. In addition, PICCs are thought to be more thrombogenic than CICCs due to insertion in veins that have smaller diameters. PICCs should be avoided in patients with chronic kidney disease due to the increased risk of PICC-related DVT or central vein stenosis that complicates future long-term access options for hemodialysis [1,2]. In spite of guidelines recommending against their use in patients with chronic kidney disease, PICC use nevertheless remains a common practice [3-5]. (See "Approach to the adult patient needing vascular access for chronic hemodialysis", section on 'Strategy for lifelong hemodialysis access' and "Peripherally inserted central catheter (PICC)-related venous thrombosis in adults".)

Implanted — Implanted catheters are meant to be semipermanent with removal reserved if complications occur, the device is no longer needed (eg, completion of chemotherapy), or patient comfort. Two types of implanted central venous devices are available: tunneled catheters and totally implantable venous access devices, which are placed entirely under the skin tissue (no skin exit site) (figure 1).

Tunneled catheters — Tunneled central venous catheters traverse a subcutaneous tunnel between the catheterized vein (vein puncture site) and the skin exit site. In reality, any catheter can be tunneled by placing it under the skin in the subcutaneous tissue, typically in the chest. The tunnel, then, refers to the passage of a short length of the catheter from the site of skin entry to that of venous puncture, either with or without a cuff to anchor it in place and limit bacterial entry [6].

The catheter may be round or flat, and catheter sizes can range from 2.7 to 12.5 F (eg, Hickman, Broviac). A cuff (velour, Dacron) is positioned in the subcutaneous tissue adjacent to the exit site to anchor the catheter and create a fibrous barrier to skin pathogens. In general, rates of infection associated with tunneled catheters are lower compared with nontunneled central venous catheters [7]. PICCs may also be tunneled.

Hemodialysis and apheresis catheters (eg, Hickman, Quinton-Mahurkar, MedComp) are specialized large-bore tunneled double-lumen catheters designed for the exchange of large volumes of blood at high flow rates. (See "Central venous catheters for acute and

chronic hemodialysis access and their management" and "Therapeutic apheresis (plasma exchange or cytapheresis): Indications and technology".)

Tunneled, cuffed catheters and implanted ports are generally associated with lower rates of catheter-related blood stream infection compared with non-implanted catheters [8-11]. (See "Intravascular catheter-related infection: Epidemiology, pathogenesis, and microbiology", section on 'Catheter factors' and "Tunneled hemodialysis catheter-related bloodstream infection (CRBSI): Epidemiology, pathogenesis, clinical manifestations, and diagnosis", section on 'Epidemiology and Risk Factors'.)

Totally implantable (ports) — Totally implantable venous access devices have been used widely since their introduction in the 1980s (eg, Port-a-Cath, BardPort, PowerPort, Infuse-a-Port, Mediport) [12-15].

The catheter of these devices passes from the cannulated vein beneath the skin and attaches to a subcutaneous infusion port or reservoir that is placed into a subcutaneous pocket. Ports are most often placed in the upper chest of adult patients, but placement in the upper extremity, abdominal wall, and lower extremity is also possible [16,17]. PICCs can also be attached to a subcutaneous port in the upper extremity (eg, PICC port), but these are novel devices and typically used for shorter durations compared with other implanted ports [18]. PICC ports have become more popular in Europe, where they provide the benefit of being implanted which allows for activities of daily living and avoids the need for chest placement, which may be of particular importance if chest access is not possible (eg, burns) or undesirable (eg, breast cancer) [19,20].

Subcutaneous ports have the advantage of concealment from view and protection from the overlying skin, making this option more cosmetically appealing and compatible with activities such as bathing or swimming. Magnetic resonance compatible devices are available.

Growing evidence suggests that subcutaneous ports are associated with a lower rate of complications and cost in patients with solid malignancies [21-23].

The port or reservoir is accessed through the skin by needle puncture into the port's self-sealing septum. Single- and dual-port devices are available. The main factor limiting infusion rate with these devices is the bore of the access needle (eg, Huber, 19 [0.053" = 1.33 mm diameter] to 22 gauge [0.045" = 1.2 mm diameter]), which is nearly always

smaller than the internal diameter of the catheter attached to the port.

Coated and impregnated catheters — Available antibiotic- or antiseptic-impregnated CICCs and PICCs, as well as heparin-bonded catheters, may decrease complication rates (eg, bacterial colonization, catheter-related infection, catheter thrombosis).

Antimicrobial-impregnated catheters — Commonly available coated catheters in use today include chlorhexidine-silver sulfadiazine (CHSS)-coated catheters and minocycline-rifampin (MR)-coated catheters. In spite of an apparent benefit for antimicrobial-impregnated catheters, the efficacy and role of these devices in clinical care remains uncertain [24-33]. While some meta-analyses suggest benefits [34], most have inherent methodologic flaws including variable definitions of outcomes, failure to determine clinically important end points, and failure to consider key confounding variables and stratify results when pooling data [25,31]. Later studies including randomized trials suggest that the benefits of such coatings are unclear, at best [35,36].Antimicrobial-impregnated catheters also have potential limitations, such as a risk for anaphylaxis and emergence of resistant organisms [37].

While many centers in the United States use antimicrobial catheters routinely, in general, guidelines favor their use if rates of catheter-related infections have not fallen to acceptable levels (which may include zero infections) in spite of implementation of other basic infection prevention measures [38,39]. Some favor reserving use of an antimicrobial or antiseptic-bonded catheter for circumstances in which the rate of catheter-related blood stream infection is higher than national surveillance data rates (eg, ≥1.6 per 1000 catheter-days), or in units where patients are at higher risk of developing blood stream infection (eg, trauma/burn units) in spite of adherence to maximal antisepsis [37].

CHSS-impregnated catheters were first introduced in the 1990s. The first-generation CHSS devices were coated on the external surface only; thus, intraluminal colonization and infections were not protected. Second-generation CHSS devices have featured higher concentrations of chlorhexidine and silver-sulfadiazine and include coating on both the internal and external aspects of the device. First-generation CHSS devices were associated with significant reductions in catheter-related bacteremia [25,31]. In a meta-analysis of first-generation CHSS devices that included more than 2600 catheters, catheter colonization was significantly decreased for impregnated catheters (summary odds ratio 0.44, 95% CI 0.36-0.54) [25]. A later meta-analysis found similar results for first-generation

devices [31]. In a large trial of 780 patients that compared second-generation CHSS catheters with uncoated catheters in an intensive care unit setting, the antiseptic-coated catheter significantly decreased bacterial colonization, but there was a nonsignificant reduction in the rate of blood stream infections [40]. Because of the small number of events, no conclusion could be made regarding the effect of the coated catheter on blood stream infection. Another trial in patients with hematological malignancies similarly failed to show significant reduction in catheter-related blood stream infection but did show reduction in colonization [41].

Reductions in catheter-related infection have also been observed with minocycline-rifampin-bonded catheters [30,42,43]. In a trial of 736 catheter insertions comparing minocycline-rifampin-impregnated catheters with CHSS catheters, patients who received an MR-impregnated catheter had a lower rate of blood stream infection compared with CHSS catheters (0.3 versus 3.4 percent) [30]. No adverse effect related to the MR-impregnated catheters or change in antimicrobial resistance was noted. The better outcome observed with the MR-impregnated catheter may have been related, in part, to differences in CHSS catheter generation (ie, first-generation CHSS catheters rather than second-generation catheters coated on both the internal and external surface).

The incidence of infection may be reduced with catheters that have a silver-impregnated collagen cuff [44,45]. In one trial of 234 catheters, those with catheters that had a silver-impregnated collagen cuff catheters were significantly less likely to be colonized at removal compared with cuffless catheters (9 versus 29 percent) or to be associated with bacteremia (1.0 versus 3.7 percent) [44]. However, later studies have not confirmed a benefit [46-48]. A metaanalysis suggested that benefit, if any, may be conferred within specific use context (eg, critically ill patients) rather than across all patients and settings [32]. The 2022 central line-associated bloodstream infections (CLABSI) guidelines recommend use of these types of coated catheters in hospital units or patient populations where rates of infection remain high despite compliance with essential CLABSI prevention practices [39].

Heparin bonding — A number of central venous catheters are manufactured with heparin-bonded components [49-51]. The use of heparin-bonded catheters may have a role in the prevention of catheter-related thrombosis.

While several studies suggest that heparin bonding may diminish the frequency of

catheter-related infection, at present, their role for preventing catheter-related bacteremia or blood stream infection is limited. As an example, in a small trial that randomly assigned 55 adults to heparin-coated or standard CVCs, bacteremia or fungemia occurred significantly more frequently in the standard catheter group among the 32 patients who completed the trial (5 of 19 versus 0 of 13 with heparin catheters) [49]. In addition, when the catheters were removed, microbial colonization was more common in the standard catheter group (14 of 19 versus 4 of 13).

Novel catheter materials and designs — Novel catheter materials emerging on the market promise various safety outcomes, yet high-quality evidence is lacking.

In one small pilot trial, outcomes were improved for peripherally inserted central catheters (PICCs) made from the hydrophobic compound Endexo compared with available polyurethane PICCs [52]. The trial also found that Endexo catheters were associated with fewer catheter failure events including lower rates of thrombosis and occlusion.

Other novel catheter materials include devices coated with bioactive materials such as Ceragenins (synthetic mimetics of antimicrobial peptides [53,54]), hydrogel catheters coated with a bacteriophage suspension [55], and catheters coated with Disperin B (a hexosaminidase enzyme that dissolves biofilm [56]). However, none of these devices have been tested in vivo. Later studies examining novel compounds, such as poly-2-methoxyethylacrylate (PMEA), have similarly suggested in vitro benefit [57].

External-energy activated catheters that include light and acoustic energy (eg, light or sound is applied along the catheter to enhance antimicrobial activity) have also been studied, but remain experimental [58,59].

Finally, changes to catheter design including "stealth surfaces" that repel or prevent attachment to microbes are in development. Such surfaces include fluoropolymer and biomimetic coatings as well as changes to the surface geometry of catheter that inhibit colonization by unfavorable topologies and surface contours. These catheters remain in development at this time but may represent non-drug-eluting strategies to protect patients from infections in the future.

ACCESS SITE

Centrally inserted central venous catheters are primarily placed via the internal jugular vein, subclavian vein, or femoral vein. Alternative insertion sites include the external jugular vein, cephalic vein, and proximal great saphenous vein. The latter superficial veins can be cannulated percutaneously or by using a cutdown technique with catheters advanced such that the tip resides in the deep vessels of the neck, chest, or abdomen. Peripherally inserted central venous catheters are typically inserted via the basilic, cephalic, or brachial veins.

Selection of the most appropriate site for central venous cannulation is based upon the expertise and skill of the operator, patient anatomy (eg, known venous occlusion, presence of lymphedema), risks associated with placement (eg, coagulopathy, pulmonary disease), access needs (eg, patient needs and duration of catheter use) and device type (eg, tunneled catheter, implanted port) [60-65]. Although it is tempting to use a preferred common site and approach, knowledge of access techniques at multiple anatomic sites is important to meet patient needs while ensuring patient safety [66]. Higher success rates and lower rates of mechanical complications are clearly related to operator experience and comfort with the use of ultrasound to guide placement [67-70].

The needle insertion site should be chosen in an area that is not contaminated or will not potentially become contaminated (eg, burned or infected skin, adjacent to tracheostomy or open surgical wound) [71]. Access sites with altered local anatomy (eg, prior clavicle fracture), multiple scars from prior access, and the presence of another central venous catheter or device (such as a pacemaker or internal defibrillator) are associated with higher rates of access failure, malposition, dysrhythmia, and other complications and should be avoided if alternative sites are available [72-74]. If a patient has significant unilateral lung disease, the hemithorax ipsilateral to the disease should be cannulated, for internal jugular and subclavian access, to minimize respiratory decompensation in the event of a procedure-related pneumothorax.

Benefits/risk for specific sites — Specific anatomic sites and access approaches have inherent advantages and disadvantages (table 1).

Jugular — The jugular veins (external, internal) are reliable access sites for temporary and permanent (eg, tunneled central catheters and subcutaneous ports) venous devices to support hemodynamic monitoring, fluid and medication administration, and parenteral nutrition. Jugular venous access can also be used for the placement of inferior vena cava

filters and other venous devices.

Internal jugular venous access (especially right-sided) is associated with a low rate of catheter malposition [75] and is commonly used in situations that require reliable tip positioning for immediate use, such as drug administration or transvenous pacing. Similarly, the direct route from the right internal jugular vein to the superior vena cava facilitates hemodialysis access and pulmonary artery catheter placement. (See "Pulmonary artery catheters: Insertion technique in adults" and "Central venous catheters for acute and chronic hemodialysis access and their management", section on 'Access site'.)

The internal jugular vein can be accessed via a central, posterior, or anterior approach. Specific techniques for placement of jugular venous catheters at these sites are discussed elsewhere. (See "Placement of jugular venous catheters".)

Relative contraindications to jugular venous access, in general, include coagulopathy, prior access, the presence of another device at the site, and altered local anatomy. At the jugular site, local anatomy may be altered due to prior clavicle fracture, median sternotomy, neck surgery, or neck irradiation. Following neck surgery (eg, carotid endarterectomy), the internal jugular vein generally maintains its patency, course, and anatomic relationships, but scar tissue may impede access [76]. Internal jugular access in patients with coagulopathy places the patient at risk for neck hematoma, which can be life-threatening due to airway compromise if inadvertent carotid artery puncture occurs [77,78]. However, when arterial puncture is recognized, direct pressure can be applied to the neck to control bleeding, which is not the case for inadvertent subclavian artery puncture. Similarly, internal jugular vein access may be contraindicated in patients with unstable neck injuries in which extension or movement of the cervical spine needed for line positioning may be risky.

Subclavian — The subclavian veins are reliable access sites for temporary and permanent (eg, tunneled central catheters and subcutaneous ports) venous cannulation to support hemodynamic monitoring, fluid and medication administration, and parenteral nutrition. Given the shorter and more direct path to the right atrium, the left subclavian access site is particularly well suited for cardiac access, including placement of pulmonary artery catheters, temporary transvenous pacer leads, and implantable pacers and defibrillators. Subclavian venous access may also be preferred for subcutaneous port

placement due to the short distance between the subclavian vein and chest wall, making the catheter less prone to kinking.

The subclavian vein can be accessed via a supraclavicular, infraclavicular, or axillary approach. Specific techniques for placement of subclavian venous catheters at these sites are discussed elsewhere. (See "Placement of subclavian venous catheters".)

Relative contraindications to subclavian venous catheterization include coagulopathy, limited clinician experience, and altered local anatomy [75,79-82]. Subclavian access should be avoided, if possible, at sites with altered local anatomy (eg, previous clavicle fracture), prior access, or the presence of an indwelling pacemaker or internal defibrillator because these are associated with a higher risk of failure, complication, and malposition [72,73]. In patients with significant unilateral lung disease, cannulation of the vessel ipsilateral to the compromised lung is preferred to avoid respiratory decompensation that is more likely to occur in the event of a procedure-related pneumothorax. Right subclavian anatomy carries the theoretical advantage of lower pneumothorax risk due to the lower pleural apex and absence of the thoracic duct. However, this access site is associated with higher rates of catheter malposition and vessel trauma [83]. However, for implanted port access, one trial did not find a significant difference in the rate of thrombotic or occlusion events for right-sided versus left-sided access [84].

The subclavian site should be avoided for large-bore hemodialysis catheters due to the risk of venous stenosis that limits outflow for future arteriovenous hemodialysis access [62,85]. The subclavian access site is also not appropriate for the short, relatively stiff catheters used for acute hemodialysis or apheresis. These catheters do not have the flexibility needed to negotiate the curve from the brachiocephalic vein into the superior vena cava. Perforation of the central veins can occur.

Although significant bleeding is uncommon in the era of ultrasound-guided access, the subclavian approach is generally avoided in patients with significant coagulopathy, including therapeutic anticoagulation, if an alternative access site is available. Bleeding from the subclavian vein or inadvertent subclavian artery puncture may go unrecognized and cannot be treated with direct pressure due to the deep location of the vessel beneath the clavicle.

Femoral — The femoral veins are commonly viewed as an alternative access site for central venous access due to a higher incidence of catheter-related deep vein thrombosis

compared with jugular or subclavian access, and a perceived higher risk for infection (table 1). With contemporary skin preparation and proper routine catheter maintenance, infection rates appear to be comparable to other sites [86-88].

Compared with subclavian and jugular access sites, the femoral veins may be preferred in the face of coagulopathy due to the ability to provide direct pressure at this access site. The femoral veins are also frequently preferred when other access sites are exhausted or there is increased risk for complications such as with emergency access or in the uncooperative patient [89]. The femoral veins are generally easier to access and provide dependable access for less experienced operators or when there is concern for arterial injury at upper extremity sites because of altered local anatomy. Caution is needed when this approach is used in pulseless patients because chest compressions can produce femoral venous pulsations that may be misinterpreted as arterial. Catheter misplacement at the femoral site occurs in up to 30 percent of cardiac arrest resuscitations [90,91].

Femoral venous access is also used for the delivery of most inferior vena cava filters and for lower extremity venous intervention. (See "Placement of vena cava filters and their complications".)

Site comparisons

Anatomic location — The anatomic site chosen for central catheter placement influences the risk for and type of complications, including catheter-related infection, which is generally more common at the femoral site [69,86,92-94] and, probably to a lesser degree, internal jugular site [93,95], compared with subclavian access [94]. Ongoing studies examining the association between site of insertion and outcomes continue to suggest this trend [96,97].

We recommend following the United States Centers for Disease Control and Prevention (CDC) guidelines and generally avoid the femoral site unless there are outstanding issues with cannulation of alternative sites. Access site comparisons for hemodialysis access are reviewed separately. (See "Central venous catheters for acute and chronic hemodialysis access and their management", section on 'Access site'.)

The risk associated with catheters may also be minimized with experienced clinician insertion of catheters, use of ultrasound guidance rather than blind insertion, strict sterile technique, and trained nursing staff catheter care [88]. Care should be taken to preserve

sterile insertion when ultrasound is used as violations of sterility may happen if the probe or other equipment is not appropriately managed [98].

Subclavian versus internal jugular access — Systematic reviews show minor variations in complications between the subclavian and internal jugular access sites [86,99-101]. Subclavian access appears to be associated with a lower risk for infection but a higher rate of insertion failure. The rate of overall mechanical complications appears similar.

A 2012 meta-analysis that analyzed short-term catheters in critically ill patients suggested that nontunneled subclavian access is associated with lower risk of catheter-related infection compared with alternative sites [100]. A later multicenter trial also found a lower composite risk of bloodstream infection and symptomatic deep vein thrombosis for subclavian compared with jugular vein catheterization for nontunneled catheters [94]. A later meta-analysis, which included this trial, two other trials, and six observational studies, showed the rates of surgical site infection were similar between these two torso sites [101]. For implantable port access for cancer therapy, a trial comparing the internal jugular with subclavian site also found no significant difference in infection rates [102].

In an important randomized multicenter trial [94], subclavian access was associated with a higher rate of insertion failure and had a higher rate of pneumothorax (1.5 versus 0.5 percent), but no overall difference in major mechanical complications between the sites (2.1 versus 1.4 percent; hazard ratio [HR] 0.5, 95% CI 0.3-1.1). Although not mandated at all trial sites, nearly two-thirds of jugular access procedures were performed with ultrasound, and while the trend showed reduction in mechanical complications, the results were not statistically significant.

For patients who are cachectic or have respiratory compromise, a jugular approach may be preferred to avoid pneumothorax. The subclavian site may be preferentially avoided in patients with severe coagulopathy unless alternative sites are suboptimal. Although arterial puncture may occur more frequently with the jugular approach, recognition of bleeding and its control are easier at this site. (See "Central venous access in adults: General principles", section on 'Patients with coagulopathy and/or thrombocytopenia'.)

Femoral access versus other sites — We generally favor nonfemoral access points due to ease of care and ability to permit ambulation; in the absence of clinical factors such as emergency situations, respiratory distress, uncooperative patient, and absence of another alternative site; and when the operator is sufficiently experienced with nonfemoral central

venous access [71].

Warnings to avoid femoral cannulation have focused on higher risks of thrombotic and infectious complications compared with torso access sites [69,93,103]. Proponents have suggested that staphylococci, pathogens frequently associated with serious catheter infections, are more common in moist (eg, femoral) insertion sites [104]. In a large trial, the composite outcome of bloodstream infection and symptomatic deep vein thrombosis was significantly greater for the femoral compared with the subclavian site (HR 3.5, 95% CI 1.5-7.8), but similar to the internal jugular site [94]. Femoral access was associated with the fewest mechanical complications. Even short-term use does not completely eliminate the risk of deep vein thrombosis, which can occur within one day of cannulation [105,106]. Contemporary trials examining femoral access sites have shown decreasing rates of infection that are comparable with other sites [94,107]. A systematic review reported similar rates of catheter-related bloodstream infection when comparing femoral, subclavian, and jugular sites [63].

In a secondary analysis of data from two large multicenter studies that included 2128 patients (2527 catheters and 19,481 catheter-days), the incidence of catheter-related bloodstream infection was similar for internal jugular versus femoral sites (1.0 versus 1.1, respectively, per 1000 catheter-days), as was the incidence of major catheter-related infection (1.8 versus 1.4, respectively, per 1000 catheter-days) and colonization (11.6 versus 12.9, respectively, per 1000 catheter-days) [107]. However, the risk of catheter-tip colonization was higher for femoral catheters in females when catheters were left in place more than four days and when chlorhexidine-impregnated dressings were not used.

The lower rates for femoral catheter-associated infection in these reviews parallels an overall reduction in catheter-related bloodstream infection, which is a testament to the impact of improved adherence to aseptic technique and proper catheter and site management. Higher body mass index was a factor associated with nontunneled catheter-related infection at the femoral site in one trial [87].

Peripheral versus central vein insertion — Peripherally inserted central catheters (PICCs) have gained popularity for ease of insertion and lower procedural risk (eg, hemo- or pneumothorax). In the United States, PICCs are commonly placed by specialized vascular access teams to provide temporary access (expected infusion >14 days) [108], including as a transition device to continue intravenous antibiotic administration following

hospitalization.

As with central venous catheter placement, contemporary PICC placement is performed with ultrasound guidance using a micro-introducer kit. Once the vein is accessed, a catheter is placed over a guidewire and positioned in the central veins. The initial catheter length is based on estimates using anatomic landmarks. Catheter position is confirmed radiographically or via intracavitary electrocardiograph techniques. One retrospective study reported that PICCs positioned via intracavitary electrocardiograph technique were associated with a lower risk of deep vein thrombosis compared with those confirmed radiographically [109] or using fluoroscopic techniques.

Although PICCs may avoid many of the risks associated with CVCs, such as injury to the vessels of the neck or chest and pneumothorax, they are not without long-term risks. The perception of decreased risk of catheter-associated bloodstream infection and thrombosis with PICCs compared with CVCs is not supported in the literature, especially among hospitalized patients or those diagnosed with malignancy [110-114]. PICCs are associated with higher rate of catheter-related deep vein thrombosis compared with CVCs. This issue is discussed in detail separately. (See "Peripherally inserted central catheter (PICC)-related venous thrombosis in adults".)

Special populations

Emergency central access — Achieving rapid intravenous access is essential in the care of critically ill patients, including those undergoing cardiopulmonary resuscitation (CPR). Volume resuscitation does not generally require central access if sufficient peripheral intravenous (IV) access can be obtained (eg, 14- or 16- gauge IV catheters). Peripheral IV access is preferred due to the higher flow rates that can be achieved through these short, large-bore catheters. However, peripheral access may be challenging in patients with hypovolemic or distributive shock. Placement of an intraosseous device offers a quick, easy, and reliable way of gaining access to larger vascular spaces with minimal risk to patients and providers [115]. Intraosseous access may be obtained quickly at a number of anatomical sites, including the humeral head, the tibia, or even the manubrium [116]. However, some studies suggest that return of spontaneous circulation may vary in prehospital cardiac arrest patients when intraosseous devices rather than peripheral IV devices are used [117].

Under circumstances when large-bore peripheral access is inadequate or unobtainable

(typically emergency situations, such as for trauma resuscitation), nontunneled large-bore central access (eg, introducer sheath) is recommended. The large diameter permits rapid infusion of fluid or blood. (See 'Nontunneled catheters' above and "Central venous access: acute and emergency access in adults" and "Initial management of moderate to severe hemorrhage in the adult trauma patient" and "Approach to shock in the adult trauma patient".)

Femoral venous access is less likely to disrupt CPR, whereas subclavian or internal jugular insertion may interfere with chest compressions or intubation efforts. In a small, randomized study of patients receiving CPR, real-time ultrasound-guided femoral catheterization was faster and more likely to be successful than other approaches [118]. (See "Placement of femoral venous catheters".)

Internal jugular access (especially right-sided) carries the lowest rate of catheter malposition and may be the optimal central venous access site in emergency situations when correct positioning is needed for immediate use, such as for drug administration or transvenous pacing (table 1) [63,99]. The supraclavicular approach is another option [119]. Instillation of medications via the subclavian or internal jugular veins allows rapid delivery to the heart [90,120]. Placement of peripherally inserted central catheters (PICCs), which requires more time and have smaller lumens limiting flow, is not appropriate in the context of emergency central vein access. (See "Placement of jugular venous catheters" and "Placement of subclavian venous catheters".)

Chronic kidney disease — Peripherally inserted central catheter lines are **not** recommended in patients with advanced chronic kidney disease (ie, Stage IIIb or greater; estimated glomerular filtration rate <45 ml/min]) due to the incidence of PICC-related deep vein thrombosis (DVT) and peripheral or central venous stenosis, which complicates future hemodialysis access [108,121-123]. When questions regarding the suitability of PICC use in patients with chronic kidney disease emerge, discussion with the patient's nephrologist to estimate the risk of progression to renal replacement therapy and patient wishes regarding potential future dialysis access should occur prior to consideration of PICC insertion. (See "Peripherally inserted central catheter (PICC)-related venous thrombosis in adults".)

Subclavian venous access is also preferably avoided in patients with chronic kidney disease due to risk of complications (deep vein thrombosis, venous stenosis) that can

affect future hemodialysis arteriovenous access needs [63]. (See "Central venous catheters for acute and chronic hemodialysis access and their management".)

Patients who require prone positioning — Obtaining venous access in patients who require prone positioning is technically challenging and can present significant safety concerns. Given these issues, the most critical aspect to define is whether central venous access is necessary. If so, the clinician should first consider whether it is possible to position the patient supine to perform the access procedure.

The least challenging and most feasible central venous catheter to place in prone patients is a PICC in an upper extremity vein. If it is not possible to use a PICC or to position the patient supine to perform access, then a central venous catheter can be placed with the patient in the prone position but must be inserted using ultrasound guidance in all cases [124]. The use of prone positioning in patients with coronavirus disease 2019 (COVID-19) may make the PICC an optimal venous catheter in these settings [125].

When a patient is placed prone, the shoulder is internally rotated such that the basilic vein can be easily accessed and evaluated by ultrasound [126], thus making insertion of the PICC relatively more straightforward compared with accessing a neck vein. While more technically challenging, internal jugular central venous access can also be obtained in prone patients. The patient's neck should be assessed using an in-plane ultrasound to identify the internal jugular vein, which is the preferred site of central vein cannulation in the prone patient [127]. While evaluating the internal jugular vein by ultrasound, care must be taken to identify carotid vessels that lie in close proximity and may overlay a segment of the internal jugular vein when a patient is prone [128]. To reduce the number of access sites needed in patients who require dialysis, triple lumen nontunneled hemodialysis catheters can be used. (See "Central venous catheters for acute and chronic hemodialysis access and their management", section on 'Nontunneled hemodialysis catheters'.)

If central venous access is not necessary, then peripheral venous access is recommended as the vascular access approach of choice in prone patients. Peripheral veins of the arm, hand, and lower extremities (with or without use of ultrasound) can be targeted for placement of peripheral access. Although uncommon, unique approaches to access in prone patients, such as use of the popliteal vessels for venous cannulation and continuous renal replacement therapy, have also been described [129].

FACTORS INFLUENCING CATHETER SELECTION

As noted in the above sections, a wide range of central venous catheters and devices are available. Catheter selection depends primarily upon the indication and anticipated duration of the access, but many factors influence the choice, including desired number of lumens, taking into account the catheter diameter in relation to the vein diameter, nature of the infusate, possible benefits of catheter impregnations or coating, as well as other patient considerations and provider-related issues.

Also, while most central venous access devices are made of polyurethane compatible with radiographic pressure injectors, this property should be confirmed before placing a catheter into a patient who is likely to require such imaging.

Duration of venous access — The suitability, safety, and utility of central catheters varies based on the intended duration of treatment (dwell time), with the design of the catheter or device (eg, nontunneled, tunneled, implanted) tending to support a shorter or longer duration of use. (See 'Types of central venous catheters' above.)

From a practical and clinical perspective, central venous catheters and devices can be classified into three overlapping categories (short-term, mid-term, long-term) based upon the anticipated duration of catheter use.

As examples, a patient who requires access for only a short period of time (days) need not be exposed to the discomfort or risks associated with tunneled devices [108], whereas patients requiring long-term access (weeks, permanent) benefit from devices that are associated with lower rates of catheter infection and those that are compatible with longer dwell. A patient who requires parenteral nutrition for several months would not be well served with a nontunneled centrally inserted central catheter (CICC) for which the risk of infection increases with number of lumens, insertion site, and dwell time [94]. Rather, placement of a peripherally inserted central catheter (PICC), port, or a tunneled CICC would be more appropriate in this context [130].

Short-term — Short-term devices are in place for a few days to no more than one to two weeks. Nontunneled CICCs are mostly used for temporary access to the central circulation and are commonly placed into the internal jugular, subclavian, or femoral veins. (See 'Emergency central access' above.)

Other examples of short-term access include PICCs, which are usually placed into peripheral veins of the upper extremity, and, although not strictly a central venous access device, intraosseous devices placed during medical emergencies also fit this duration of use and may be considered in this category.

Owing to their unique route of insertion, PICCs avoid many of the risks associated with insertion of CICCs, such as injury to the vessels of the neck or chest and pneumothorax; however, PICCs are not without their own risks [131,132]. In a systematic review and meta-analysis, PICCs were associated with a higher risk of thrombosis compared with CICCs (odds ratio 2.55, 95% CI 1.54-4.23) [133]. Rates of bloodstream infection with PICCs parallel those of CICCs, especially in those who are critically ill or those with malignancy [111]. Thus, PICCs should not be used as a strategy to reduce bloodstream infection [134].

Nontunneled CICCs avoiding the subclavian site are used for short-term access when acute hemodialysis (specialty catheter) is indicated, or for nonhemodialysis indications (small-bore nontunneled catheter) [135]. PICCs are **not** recommended for short-term access in patients with low glomerular filtration rates (<45 mL/minute or stage IIIb kidney disease or higher), as they have been reported to be a major reason for subsequent hemodialysis arteriovenous access failure [136]. Catheters appropriate for acute hemodialysis access are discussed separately. (See 'Chronic kidney disease' above and "Central venous catheters for acute and chronic hemodialysis access and their management".)

Mid-term — Mid-term venous access devices may dwell from one to two weeks to several months. The most common devices in this category include PICCs and tunneled CICCs. Any catheter (including PICCs) can be tunneled by placing it under the skin in the subcutaneous tissue [6].

Tunneling is advantageous because it limits bacterial entry from the catheter exit site into the bloodstream. It also allows for the catheter to be situated where care can be more easily performed and preservation of the integrity of the wound be maintained. For all of these reasons, tunneling is often used when medium- to long-term access is desired [137].

Tunneled hemodialysis catheters may be necessary for hemodialysis while awaiting maturation of an arteriovenous fistula. For patients with chronic kidney disease requiring mid-term central access (not related to hemodialysis), small-bore, tunneled central catheters avoiding the subclavian veins are preferred [135]. For the reasons discussed,

PICCs are **not** appropriate for mid-term nonhemodialysis central access in patients with chronic kidney disease. Catheters appropriate for chronic hemodialysis access are discussed separately. (See "Central venous catheters for acute and chronic hemodialysis access and their management" and 'Peripheral versus central vein insertion' above.)

Long-term — Tunneled catheters and totally implanted ports fall into this category and can remain in place for months to years. Innovations in port design and placement have made them potentially better options for long-term care compared with other devices [138,139].

Implanted ports differ from tunneled catheters in that they are placed entirely under the skin tissue (no skin exit site) and are best suited for intermittent treatments, where the risk of infection and complications is lower compared with devices such as PICCs [16,140]. Subcutaneous ports are commonly used to administer chemotherapy agents because of their low rates of extravasation and infection [141]. Like catheters, port devices are available in single or multiple lumens to facilitate simultaneous infusion of incompatible medications. Ports may also be considered appropriate for patients with chronic conditions where recurrent hospitalization or infusions may be necessary (eg, sickle cell anemia, short-gut syndrome with intermittent parenteral nutritional or fluid requirements).

Compared with ports, tunneled catheters have some disadvantages. Because they exit the skin, activities such as taking a shower or swimming are not possible. Tunneled catheters also are associated with higher infection rates likely emanating from the externalized portion of the catheter [142]. The disadvantages of ports are the need to puncture the port through the skin to access the device and the small caliber of the catheter and, thus, limited infusion rate; thus, ports may be less appropriate for patients who require frequent dosing or continuous infusion of larger fluid volumes such as with parenteral nutrition.

Placement of these long-term devices is more invasive compared with PICCs or nontunneled CICCs, often requiring intravenous contrast and anesthesia with or without sedation for placement in an interventional radiology or surgical suite, particularly if complications are expected [143,144].

Placement of a PICC or a tunneled central venous catheter is appropriate for the patient who will be discharged with a prescription for parenteral nutrition or fluid therapy for a

prolonged duration (eg, months, indefinitely) [94]. (See "Postoperative parenteral nutrition in adults" and "Nutrition and dietary management for adults with inflammatory bowel disease" and "Management of short bowel syndrome in adults".)

Permanent hemodialysis access using a tunneled hemodialysis catheter is avoided whenever possible in favor of hemodialysis arteriovenous access or peritoneal dialysis. For patients with chronic kidney disease in whom central venous access (not related to hemodialysis) is deemed appropriate, using a small-bore CICC avoiding the subclavian veins is preferred (algorithm 1) [135]. For the reasons discussed, PICCs are **not** appropriate for long-term nonhemodialysis central access in patients with chronic kidney disease. Catheters appropriate for chronic hemodialysis access are discussed separately. (See "Central venous catheters for acute and chronic hemodialysis access and their management".)

Selected patients who need long-term access may benefit from antibiotic-coated catheters based upon infectious risk, cost, and anticipated duration of the catheter. As an example, for specific populations (eg, burns) or certain clinical settings (intensive care units with high rates of infection despite adherence to best practice), the use of a chlorhexidine- or minocycline-rifampin-coated catheter might also help reduce the risk of central line-associated bloodstream infection [40,145,146]. (See 'Types of central venous catheters' above and "Routine care and maintenance of intravenous devices", section on 'Medicated dressings to prevent infections'.)

Nature of infusate — Consideration of the type of infusion is important when selecting a device.

Certain infusates are characterized as vesicants or irritants based on pH and osmolarity (that is, they cause extensive necrosis or intimal damage if exposed to tissue or the intima of blood vessels, respectively) (table 2). When long-term vesicant or irritant infusions are indicated (eg, parenteral nutrition or chemotherapy), a central venous device whose tip terminates in a region of greater blood flow to achieve greater hemodilution should be considered. Summary statements from the Infusion Nursing Society, oncological societies, and related fields provide guidance and recommendations for managing these agents [147-149]. (See 'Recommendations of others' below.)

With respect to blood transfusions, one large observational study found a higher risk of thrombosis among patients transfused through PICCs compared with other devices [150].

In patients who may need frequent transfusions such as those on myelosuppressive therapy or hematological conditions (eg, sickle cell anemia), a more permanent device that is less likely to be associated with thrombosis (eg, port) should be considered.

Number of lumens needed — The number of catheter lumens is an important predictor of infectious and noninfectious (eg, occlusion and thrombosis) complications for both CICCs and PICCs. Selecting catheters with the least number of lumens clinically necessary is important to avoid complications [151-155]. Similarly, catheter gauge and catheter-to-vein ratio are important determinants of fluid flow rates and catheter-related venous thrombosis [156]; selecting an appropriately sized catheter is also important for preventing complications [151,157,158].

A single-lumen, large-bore introducer sheath facilitates rapid administration of large volumes of fluid during emergencies, when needed (eg, poor peripheral venous access). For less urgent fluid resuscitation, a nontunneled central line is preferred over PICCs, which take longer to insert and may not provide adequate flow rates due to their small caliber and longer catheter length.

Multi-lumen catheters may be necessary because of the need to administer multiple pharmaceutical agents that are noncompatible. In general, though, the smallest-diameter catheter (fewer lumens) appropriate for the clinical situation should be used to reduce the risk of venous thrombosis [71]. Separating infusions over time and working with pharmacists may help reduce the need for multi-lumen devices, reducing cost and complications [159]. Reminders using electronic health systems and specialist review to reduce the number of lumens have shown promise in improving catheter use and patient outcomes [160].

General patient considerations — Considering patient factors in selection of a device is important. As an example, patient handedness or presence of prior chest surgery (eg, mastectomy) influences both choice of arm for PICC placement and, possibly, risk of complications [161,162]. Similarly, resources available for home care (ie, caregiver to provide dressing changes) and the patient's lifestyle (eg, desire to swim or play sports) should influence the decision between placement of a PICC versus a port [163,164].

Some patients are uncomfortable with the presence of a catheter in plain view, preferring a port or a PICC instead [165]. Subcutaneous ports allow more activities of daily living, are hidden (and thus are not an external reminder of the patient's illness), and are often

preferred when intermittent infusion therapy (eg, chemotherapy) is needed.

Another issue pertains to the need for and frequency of blood draws, though this is a complex issue. We would generally advise to use the catheter for blood draws using all sterile and aseptic precautions if there are no other options or when patient comfort is paramount. However, there are exceptions, and there no definitive rules for drawing blood from catheters. Each situation should be individually determined. As an example, if peripheral sites are available and the patient is neutropenic, the peripheral site should be used rather than accessing a port each time for a blood draw. On the other hand, the ability to avoid needle-sticks through using the catheter in place aids overall routine inpatient care and improves patient satisfaction, so it is important to consider in those at the end of life.

In general, most outpatients who need blood draws often have the port accessed for the blood draw because it is happening in the setting of some other clinical care (eg, chemotherapy infusion). However, the benefit of ready access needs to be weighed against the risk for infection or thrombosis. For adults, it is generally advisable not to use a port for only blood draws, but there is no consensus on this issue. If a port is already accessed and being used for infusion purposes, performing therapeutic phlebotomy through the port using all antiseptic precautions is acceptable. The Michigan Appropriateness Guide for Intravenous Catheters (MAGIC) provides some guidance. (See 'Michigan Appropriateness Guide for Intravenous Catheters (MAGIC)' below.)

Patients who have experienced prior central venous access complications (eg, thrombosis, infection, or occlusion) are known to be at heightened risk of similar events when devices are placed again [151,157,166-168]. Thus, in selecting a central venous access device, careful review of the patient's past medical history, social support, preferences, and lifestyle is necessary, especially for mid- to long-term catheters. Tunneled hemodialysis catheters may be necessary for hemodialysis while awaiting maturation of an arteriovenous fistula. For patients with chronic kidney disease requiring mid-term central access (not related to hemodialysis), small-bore, tunneled central catheters avoiding the subclavian veins are preferred.

Specific patient populations

Patients with malignancy — Central venous access devices are vital for patients with malignancy for the administration of chemotherapy, blood products, intravenous fluid

therapy, antibiotics, and sometimes for nutritional support. Reduction in the need for repeated venipuncture for blood sampling also improves quality of life. Choosing the safest central venous access device is essential given that patients with malignancy are at especially increased risk for device-related complications (eg, infection, thrombosis). Few of the available guidelines have addressed central venous access selection [108,169,170]. Based on randomized trials and observational studies demonstrating lower complication rates and other benefits, we suggest placement of an implantable, subcutaneous port device, rather than a tunneled catheter (eg, Hickman) or PICC. Because port placement requires an interventional or surgical procedure, immediate availability may be limited. PICC placement (fewest number of lumens) is a reasonable option when port placement is not immediately feasible (or contraindicated) and can serve as a short-term bridge to port placement especially if long-term, intermittent, or cyclical therapy is planned.

A growing number of randomized trials and observational studies provide comparisons primarily between implanted ports and PICCs and ports and tunneled catheters, all supporting the use of port devices [133,140,142,171-175]. The Cancer And Vascular Access (CAVA) trial randomly assigned 1061 patients with solid or hematologic malignancy receiving systemic anticancer therapy to placement of an implanted port, a tunneled catheter, or a PICC [142]. Complication rates were significantly lower for ports compared with PICCs (32 versus 47 percent, OR 0.52 95% CI 0.33-0.83) and compared with Hickman catheters (29 versus 43 percent, odds ratio [OR] 0.54, 95% CI 0.37-0.77). Complication rates for Hickman catheters and PICCs were similar; however, the sample size for this comparison was not adequately powered. The difference in complications between ports and Hickman catheters was driven mainly driven by the difference in bloodstream infection (14 versus 25 percent, respectively). Ports had significantly lower rates of both mechanical and thrombotic complications compared with PICCs; the risk of venous thrombosis was about five times higher for PICCs (11 versus 2 percent, respectively).

In an earlier trial that compared ports with PICCs in 70 patients receiving chemotherapy for non-hematological malignancies, port devices were associated with significantly fewer complications (hazard ratio [HR] 0.25, 95% CI 0.09-0.86) [140]. The rate of major complications was 6 percent for ports with 20 percent for PICCs (0.047 versus 0.193 major complications/100 catheter-days). Thrombosis, the most common complication, occurred in none of the port patients but 25 percent of the PICC patients. Quality-of-life and cost estimates did not differ significantly between the two groups. Similarly, a trial comparing ports with tunneled catheters also supported the use of port devices [171]. A systematic

review analyzed data from 15 cohort studies (ports versus PICCs) [175]. PICC use was associated with higher rates of complications, including occlusion, infection, malposition, catheter-related thrombosis, extravasation, phlebitis, and accidental removal. The lifespan of ports was longer compared with PICCs, and the costs of ports over the entire time horizon were lower.

Hemodialysis patients — Nontunneled and tunneled specialty hemodialysis catheters (placed into the jugular or femoral veins) may be necessary for acute hemodialysis or while awaiting maturation of an arteriovenous fistula [176,177]. (See "Central venous catheters for acute and chronic hemodialysis access and their management".)

Based on observational studies demonstrating high rates of new central vein lesions and thrombotic events after PICC placement [2,136,178,179], PICCs are **not** recommended in patients with a low estimated glomerular filtration rate (eGFR <45 mL/minute per 1.73 m^2, stage IIIb or higher kidney disease) to avoid complications that may interfere with future hemodialysis arteriovenous access placement [180]. Unfortunately, despite guidelines, a high number of PICCs continue to be placed in patients with chronic kidney disease. In a review of over 20,000 patients in whom PICCs were placed, 23.1 percent had an eGFR below this threshold, and 3.4 percent were on dialysis [3]. Among intensive care unit (ICU) patients, the eGFR was below the recommended threshold in 30.9 percent of patients. About 25 percent of the PICCs were placed for short-term access (<5 days), a duration for which other venous access devices are considered more appropriate. Moreover, more than 90 percent of PICCs were multilumen, a catheter characteristic known to be associated with thrombotic catheter complications. In this study, complications occurred in twice as many as patients with multilumen PICCs compared with single-lumen PICCs (for patients with eGFR <45 mL/minute per 1.73 m^2: 22.7 versus 12.5 percent in ICUs and 19.3 versus 10.3 percent in wards). A multimethod study examined barriers to implementing appropriateness guidelines to reduce PICC overuse including in patients with chronic kidney disease [181]. (See 'Number of lumens needed' above and "Central vein obstruction associated with upper extremity hemodialysis access", section on 'Mechanisms of obstruction'.)

Provider-related issues — Patients are better served by venous access placed by an adequately experienced operator or a specialized vascular access teams rather than by providers who are not trained or comfortable with all the options (eg, prone positioning) [182,183]. In an era of modern vascular access, ultrasound training and guidance when

placing central venous catheters improves safety [184]. Simulation-based training, with a focus on the use of ultrasound, is the best way to master central venous catheter insertion [185,186]. (See "Central venous access in adults: General principles" and "Basic principles of ultrasound-guided venous access".)

When resources to insert central venous access devices are limited, device selection is likewise limited, and the best device for the situation may not be used. When a dedicated vascular access team is available, they should be included in both making device choices and placing the most appropriate central venous access [187].

The presence of specialized vascular access teams (often composed of nurses) to guide decisions for all types of device placement, including peripheral intravenous catheters, midlines, PICCs, and CICCs, is associated with greater adherence to infection prevention measures [185,188,189]. As an example, the majority of PICCs are placed by such access teams who receive external certification and employ state-of-the-art technology when placing these devices [185,190-193]. Furthermore, multidisciplinary PICC placement teams are more cost effective than physician-led approaches [190,194,195]. Importantly, nurse-led PICC providers credentialed by external agencies report greater implementation of evidence-based practices than those who are not credentialed [191,192]. Thus, institutional support for such teams and their use are important in device selection and patient safety.

DECISION TREES AND ALGORITHMS

Proper venous access selection means selecting the appropriate device for a particular patient tailored to the specific clinical situation (algorithm 1). This can (and will) change, and thus, frequent reappraisal of access is likewise important. Factors influencing the choice of central venous access include the indication for central line insertion, anticipated duration of use, usage (number of drugs to infuse, blood drawing), nature of the infusate, as well as patient considerations and provider issues [196]. (See 'Factors influencing catheter selection' above.)

A conceptual model suggests that a science and methodology exists for the selection of a central venous catheter [131], and algorithms have been introduced to facilitate this type of decision-making. In addition, some hospitals have developed their own protocols to inform central venous access placement based on local practice and consensus

agreements. One published algorithm begins with considering the context of care; that is, whether acute/emergent access is required [197]. In the case of emergency access, nontunneled centrally inserted central catheters (CICCs) or intraosseous devices are recommended as first-line devices. In the nonemergency setting, the duration of treatment is the next decision point. If a period of use of more than seven days is likely, a PICC is recommended in patients without chronic kidney disease. For patients with chronic kidney disease, a tunneled CICC avoiding the subclavian site is recommended.

Michigan Appropriateness Guide for Intravenous Catheters (MAGIC) — The Michigan Appropriateness Guide for Intravenous Catheters (MAGIC) introduces an algorithmic, evidence-based approach to selecting central venous access devices [108]. Based on the RAND/UCLA Appropriateness Method and systematic review of the literature, MAGIC offers a methodology to determine whether central venous access is appropriate (algorithm 1), and when appropriate, whether a CICC (nontunneled catheter or implanted device [tunneled catheter, port]) or peripherally inserted central catheter (PICC) is clinically appropriate based on risk versus benefit of the device, without regard to cost. Because MAGIC covers multiple devices, provides easy-to-adapt clinical recommendations, and focuses on key factors associated with device outcomes, the criteria have resonated with a number of clinical providers, including infusion nurses [198], critical care physicians [199], and hospitalist physicians [200]. Furthermore, studies performed in real-world hospital settings have validated MAGIC by demonstrating a reduction in inappropriate use of PICCs, and a trend toward a reduction in overall complications, as well as improved overall device selection [201].

Although focused on determining whether use of a PICC is appropriate versus not, MAGIC incorporates peripheral venous access device decisions related to whether central venous access is truly the optimal choice in a given setting. In this way, MAGIC helps avoid unnecessary placement of devices such as PICCs when peripheral alternatives might be more appropriate and safer for patients. MAGIC recommendations use three criteria that determine whether central venous access is appropriate in the first place, including the indication for device use, duration of proposed treatment, and nature of the infusate (central versus peripherally compatible). If an infusate is peripherally compatible or the duration of treatment is <15 days, MAGIC recommendations suggest the use of peripheral intravenous devices such as peripheral intravenous catheters or midline catheters and using ultrasound to guide placement. Importantly, these intravenous devices should not be used to avoid central line-associated bloodstream infections (CLABSI) penalties by not

placing a central venous catheter. Rather, their use should be guided based on the patient's venous anatomy, the type of infusate (eg, not an irritant or vesicant), and the proposed duration of use.

MAGIC also incorporates risk reduction strategies when selecting a central venous access device. As an example, in critically ill patients and patients with cancer, the risk of thrombosis with PICCs is higher compared with nontunneled CICCs; a calculator incorporating clinical variables can help determine which device may be safest to use (calculator 1). Thus, MAGIC recommendations indicate a preference for nontunneled CICCs over PICCs in this setting. On the other hand, for patients who need three or more months of treatment, the MAGIC algorithm recommends implanted ports, tunneled catheters, or PICCs depending upon patient and device factors that influence the risk of adverse events.

A cohort study that included 38,592 PICCs placed at 40 hospital examined outcomes of PICCs based on whether they were placed appropriately or not according to MAGIC. When catheters were placed for appropriate indications, complication rates were significantly lower compared with those placed inappropriately (odds ratio [OR] for all complications 0.29, 95% CI 0.25-0.34). Significantly reduced rates of occlusion (OR 0.25, 95% CI 0.21-0.29), central line-associated bloodstream infection (OR 0.61, 95% CI 0.46-0.81) and venous thromboembolism (OR 0.40, 95% CI 0.33-0.47, all p <0.01) were also observed [202].

Recommendations of others — Several guidelines provide some information regarding selection of central venous catheters, including CICCs and PICCs, but none in themselves provide a comprehensive approach.

- The 2011 Centers for Disease Control (CDC) guidelines for the prevention of intravascular catheter-related infections provide broad recommendations regarding when to use central venous access [65]. In particular, the CDC recommends weighing the risk of infectious complications against the risk of mechanical complications when considering placement of a central venous access device. Recommendations regarding avoidance of specific sites (eg, femoral vein) as well as choosing the internal jugular over the subclavian vein in patients with chronic kidney disease are also provided. (See 'Benefits/risk for specific sites' above.)

  With respect to use of PICCs, these guidelines recommend considering a PICC (if

central access is indicated) or a midline catheter over a peripheral device when the proposed duration of treatment is six or more days. However, specific indications as to when to use a mid- or long-term catheter, or how to select between a CICC (tunneled, port) and PICC, are not provided.

- The 2016 Infusion Nursing Standards emphasize an evidence-based list of indications for central access [203]. Commonly accepted indications for placement of a central venous access device include clinical instability, need for hemodynamic monitoring, complex infusion regimens, episodic chemotherapy for more than three months, and long-term intermittent infusion therapy (eg, antibiotic treatment). These Standards recommend considering a tunneled catheter for patients who are anticipated to require intermittent or continuous long-term infusion therapy (such as parenteral nutrition or chemotherapy). While the level of detail in choosing a device is greater than the CDC guidelines, the Standards do not go so far as providing a framework to choose between the various devices.

- The American Society of Anesthesiology (ASA) practice guidelines for central venous access focus on short-term nontunneled CICCs only [71]. The guidelines emphasize selecting an insertion site based on clinical need; avoiding contaminated insertion sites; using ultrasound over blind anatomic insertion; and focusing on ensuring venous location of the catheter, guidewire, and needle.

- The European Society for Medical Oncology (ESMO) guidelines for central venous access in adult cancer patients include CICCs and PICCs [170]. Although guidance on how best to select a device in these populations is not provided, the guidelines emphasize treatment and prevention of infection and thrombotic complications, including possibly avoiding PICCs in patients at higher risk of thrombosis.

- The 2019 American Society for Parenteral and Enteral Nutrition (ASPEN) guidelines provide guidance for central venous access for the infusion of home parenteral nutrition in adults [149]. A weak recommendation was given for the use of PICCs in patients requiring home parenteral nutrition for less than 30 days short term, while tunneled CICCs are preferred for those in whom longer term infusion is indicated. The use of single-lumen catheters rather than multiple-lumen catheters was recommended for parenteral feeding [130].

- The Society for Healthcare Epidemiology (SHEA)/Infectious Diseases Society of

America (IDSA) published updated recommendations in 2022 aimed at reducing CLABSI [39]. The guidelines updated prior recommendations and feature essential practices that should be performed before, during, and after catheter insertion. Recommendations before insertion now include the use of an evidence-based list of indications for central venous catheter use to minimize unnecessary placement [39].

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" and "Society guideline links: Nutrition support (parenteral and enteral nutrition) in adults".)

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 5th to 6th 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 10th to 12th 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

- **General principles** – Secure and reliable central venous access is a cornerstone in the care of hospitalized patients (eg, critical monitoring, drug infusion), as well as for a variety of outpatient situations (eg, parenteral nutrition, fluid therapy). (See

'Introduction' above and "Central venous access in adults: General principles", section on 'Indications'.)

- **Types of catheters** – Central venous access devices are generally classified based upon duration of catheter use (ie, acute, chronic), type of insertion (ie, central, peripheral), location of insertion (eg, jugular, brachial), number of lumens (ie, single, double, triple), as well as whether the catheter is implanted or not, and to what extent (eg, tunneled, totally implanted [port]). (See 'Types of central venous catheters' above.)

- **Number of lumens** – As the number of lumens increases, the overall diameter of the catheter increases, and the diameter of the individual luminal channels generally decreases. Catheter gauge and catheter-to-vein ratio are important determinants of fluid flow rates and catheter-related venous thrombosis. The number of catheter lumens is an important predictor of infectious and thrombotic complications for both centrally inserted central catheters (CICCs) and peripherally inserted central catheters (PICCs). Selecting catheters with the least number of lumens clinically necessary is important to avoid complications. (See 'Number of lumens needed' above.)

- **Device and site selection** – Proper venous access selection means selecting the appropriate device for a particular patient tailored to the specific clinical situation such that benefits outweigh risks. For a given patient, this may change over time, and thus, frequent reappraisal of access is likewise important. Central venous catheters can be inserted through the jugular, subclavian, or femoral veins, or via upper arm peripheral veins. (See "Central venous access in adults: General principles", section on 'Device and site selection'.)

  - Factors influencing the choice of central venous access include the anticipated duration of use, usage (number of drugs to infuse, blood drawing), nature of the infusate, and also patient considerations (eg, catheter care) and provider-related issues. The best way to prevent a central venous catheter-related complication is to only use this type of device when appropriate. (See 'Factors influencing catheter selection' above.)

  - For patients in whom the intended infusate(s) is/are peripherally compatible (ie, not a vesicant or irritant) or the duration of treatment will be <14 days, peripheral

access (eg, peripheral intravenous catheter, ultrasound-guided extended dwell catheter, midline catheter) is more appropriate than central venous access.

- When central venous access is indicated, we use the following approach (algorithm 1) (see 'Introduction' above and 'Factors influencing catheter selection' above and 'Decision trees and algorithms' above):
  - For short-term access (<14 days): Nontunneled CICCs or PICC (no chronic kidney disease).
  - For mid-term access (≥14 days to 3 months): Tunneled CICCs or PICCs (no chronic kidney disease).
  - For long-term access (≥3 months): Implanted CICCs (tunneled catheter, port). These are semipermanent with removal reserved if complications occur, or once the device is no longer needed.

- **Special populations**
  - **Emergency access** – For emergency access: Large-bore peripheral access, nontunneled single-lumen central access (eg, introducer sheath), intraosseous device.
  - **Patients with chronic kidney disease** – For patients with chronic kidney disease (glomerular filtration rates <45 mL/minute; stage IIIb kidney disease or higher) requiring central venous access (not related to hemodialysis), PICCs should **not** be used. A small-bore, tunneled CICC avoiding the subclavian veins is preferred. This helps avoid complications (deep vein thrombosis, venous stenosis) that can interfere with future hemodialysis arteriovenous access placement. (See 'General patient considerations' above.)
  - **Patients with malignancy** – For patients with malignancy requiring long-term access, we suggest placement of an implanted port device rather than a tunneled catheter or PICC (**Grade 2B**). Complication rates associated with implanted ports are lower compared with other types of access, quality of life may be improved, and costs are lower over the life of the port even considering higher upfront costs due to implantation of the device. However, port placement requires an interventional or surgical procedure, the availability of which may be limited. For

those in whom port placement is not immediately feasible (or is contraindicated), PICC placement (fewest number of lumens) is a reasonable option as a short-term strategy to bridge to port placement, especially if long-term, intermittent, or cyclical cancer therapy is planned.

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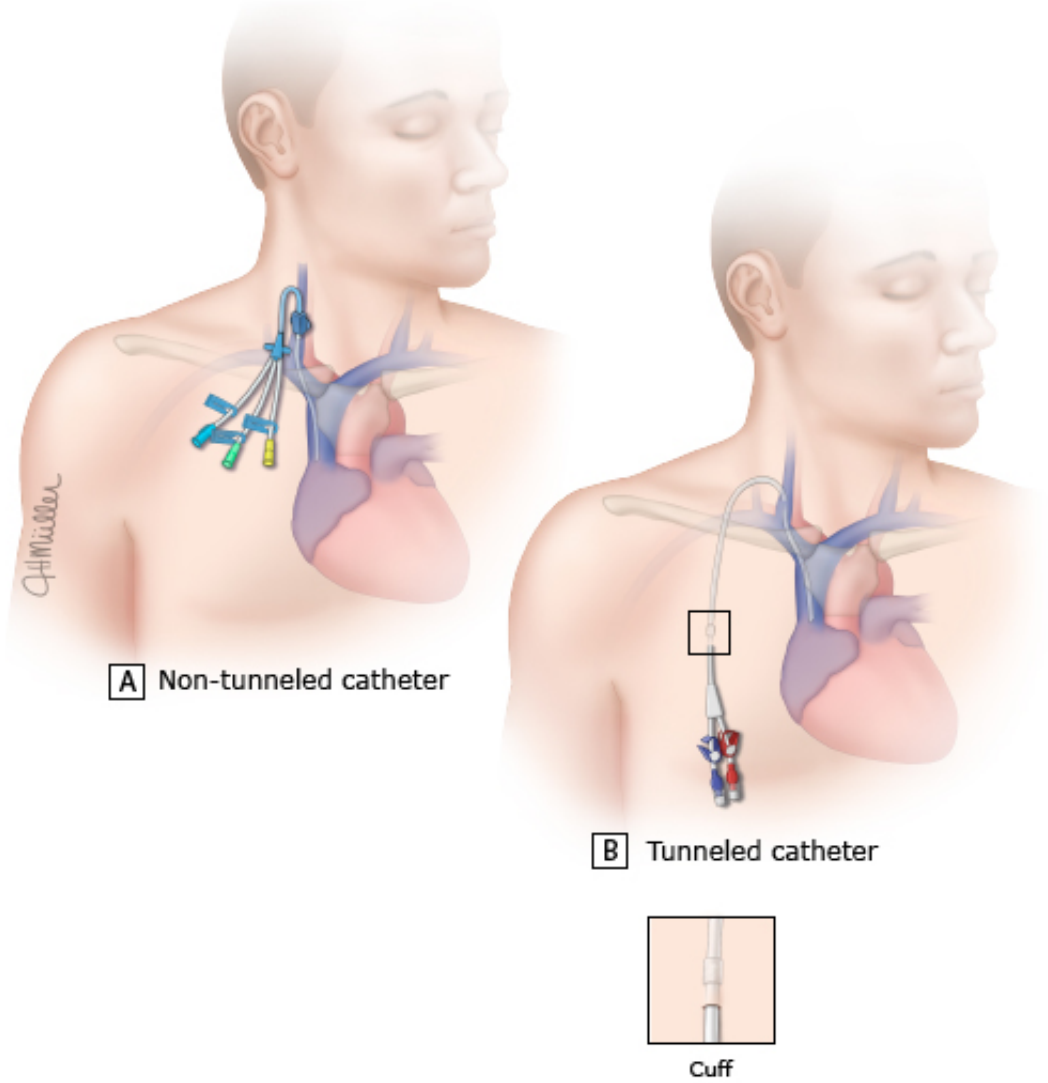
Topic 115957 Version 24.0

GRAPHICS

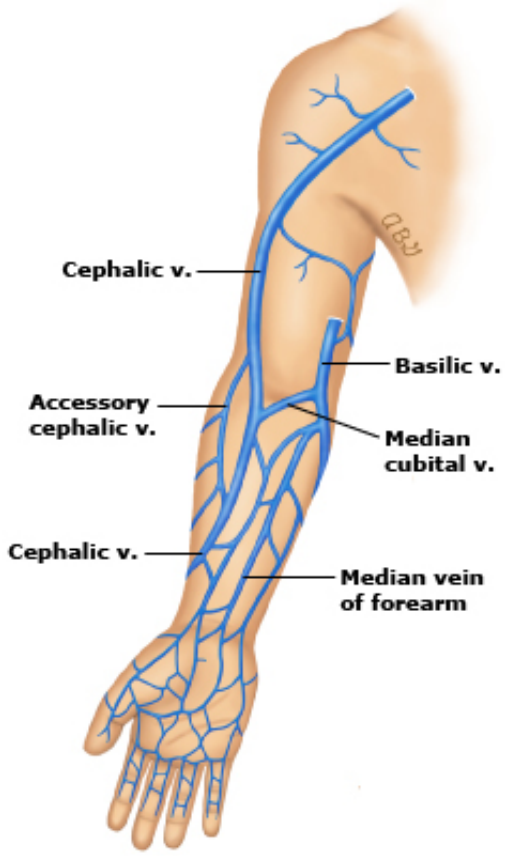
Non-tunneled versus tunneled central venous catheter



The figures illustrate the difference between non-tunneled (A) and tunneled (B) central venous catheters. Tunneled central venous catheters are used long-term and typically include a cuff (see inset) located just cephalad to the skin exit site. The cuff facilitates tissue ingrowth over a two- to three-week period, which anchors the catheter and minimizes bacterial migration from the exit site.

Graphic 129706 Version 1.0

Anterior view superficial veins of the upper extremity



- The cephalic vein originates at the radial aspect of the wrist traversing the radial border of the forearm. It receives tributaries from both the ventral and dorsal surfaces. At the antecubital fossa, it provides a tributary to the median cubital vein. In the upper arm, it travels in the groove between the pectoralis major and deltoid muscles. It pierces the coracoclavicular fascia and, crossing the axillary artery, ends in the axillary vein just below the clavicle. Sometimes it communicates with the external jugular vein by a branch that ascends anterior to the clavicle.
- The basilic vein originates in the ulnar aspect of the wrist traversing the ulnar side of the forearm to the antecubital fossa where it is joined by the median cubital vein. It ascends in the groove between the biceps brachii and pronator teres, crosses the brachial artery at the elbow, and continues cephalad along the medial border of the biceps brachii. It perforates the deep fascia of the upper arm and joins the brachial vein.

Graphic 55596 Version 8.0

Advantages and disadvantages of central vein approaches

Approach	Advantages	Disadvantages
External jugular	▪ Superficial vessel that is often visible ▪ Coagulopathy not prohibitive ▪ Minimal risk of pneumothorax (especially with US guidance) ▪ Head-of-table access ▪ Prominent in older adult patients ▪ Rapid venous access	▪ Not ideal for prolonged venous access ▪ Poor landmarks in patients with obesity ▪ High rate of malposition ▪ Catheter may be difficult to thread
Internal jugular	▪ Minimal risk of pneumothorax (especially with US guidance) ▪ Head-of-table access ▪ Procedure-related bleeding amenable to direct pressure ▪ Lower failure rate with novice operator ▪ Excellent target using US guidance	▪ Not ideal for prolonged access ▪ Risk of carotid artery puncture ▪ Uncomfortable ▪ Dressings and catheter difficult to maintain ▪ Thoracic duct injury possible on left ▪ Poor landmarks in patients with obesity/edematous patients ▪ Potential access and maintenance issues with concomitant tracheostomy ▪ Vein prone to collapse with hypovolemia ▪ Difficult access during emergencies when airway control being established
Subclavian	▪ Easier to maintain dressings ▪ More comfortable for patient ▪ Better landmarks in patients with obesity ▪ Accessible when airway control is being established ▪ Associated with lower incidence of catheter-related infection*[1]	▪ Increased risk of pneumothorax ▪ Procedure-related bleeding less amenable to direct pressure ▪ Decreased success rate with inexperience ▪ Longer path from skin to vessel ▪ Catheter malposition more common (especially right SCV) ▪ Interference with chest

		compressions ▪ Risk for stenosis/occlusion, which impacts future hemodialysis arteriovenous access
Femoral	▪ Rapid access with high success rate ▪ Does not interfere with CPR ▪ Does not interfere with intubation ▪ No risk of pneumothorax ▪ Trendelenburg position not necessary during insertion	▪ Delayed circulation of drugs during CPR ▪ Prevents patient mobilization ▪ Difficult to keep site sterile ▪ Difficult for PA catheter insertion ▪ Increased risk of iliofemoral thrombosis

US: ultrasound; SCV: subclavian vein; CPR: cardiopulmonary resuscitation; PA: pulmonary artery.

* From Parienti, infection rates: subclavian 0.5%; jugular 1.4%; femoral 1.2%.

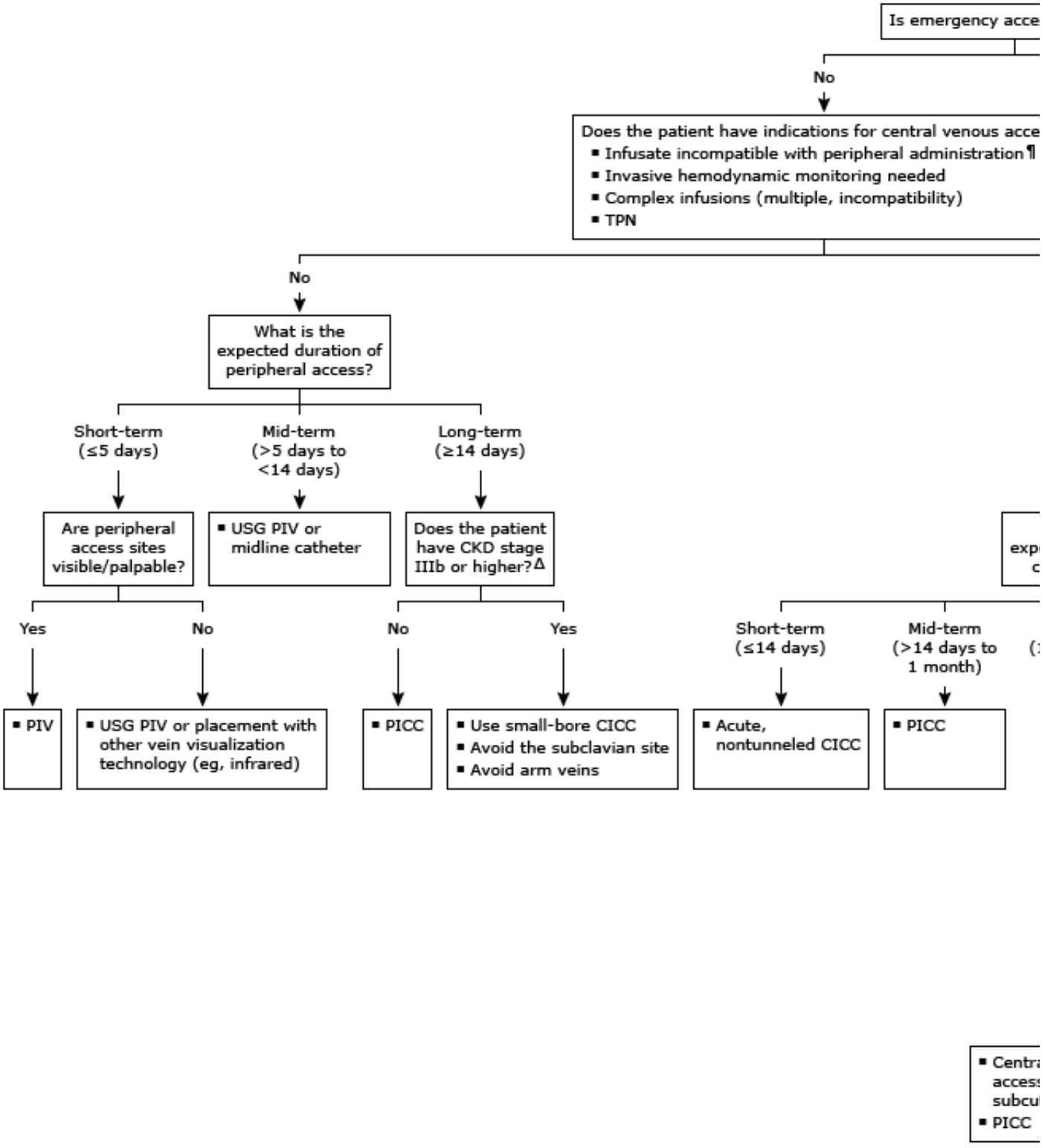
Adapted from: Factor P, Sznajder JI. Vascular cannulation. In: Principles of Critical Care, Hall JB, Schmidt GA, Wood LDH (Eds), McGraw-Hill, New York, 1992.

Reference:

1. *Parienti JJ, Mongardon N, Mégarbane B, et al. Intravascular Complications of Central Venous Catheterization by Insertion Site. 3SITES Study Group. N Engl J Med 2015; 373:1220.*

Graphic 71716 Version 11.0

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

Antineoplastic drugs that act as vesicants or irritants

Vesicants
Amsacrine
Dactinomycin
Daunorubicin
Doxorubicin
Epirubicin
Idarubicin
Lurbinectedin
Mechlorethamine
Mitomycin
Trabectedin
Vinblastine
Vincristine and liposomal vincristine
Vindesine
Vinorelbine
Irritants
Ado-trastuzumab emtansine*
Bendamustine¶
Bleomycin
Bortezomib
Busulfan
Carboplatin
Carmustine
Cisplatin$^{\Delta}$
Cladribine
Cyclophosphamide
Cytarabine
Dacarbazine$^{\Delta}$

Docetaxel
Enfortumab vedotin
Etoposide
Fluorouracil/floxuridine
Gemcitabine
Ifosfamide
Irinotecan¶
Ixabepilone
Liposomal daunorubicin¶
Liposomal doxorubicin¶
Melphalan¶
Mitoxantrone¶
Oxaliplatin¶
Paclitaxel¶
Paclitaxel, nanoparticle albumin bound (nabpaclitaxel)
Streptozocin
Teniposide
Topotecan

* A single case of skin necrosis after ado-trastuzumab emtansine extravasation has been reported.[1]

¶ Irritants that may cause soft tissue injury when extravasated.

Δ May have vesicant properties depending on the concentration of volume of drug extravasated. As an example, extravasation of a large volume (>20 mL) of concentrated cisplatin (>0.5 mg/mL) may produce tissue necrosis.

Reference:

1. *Shafaee MN, Salahudeen AA, Valero V. Skin Necrosis After Ado-Trastuzumab Emtansine Extravasation. J Oncol Pract 2017; 13:555.*

Graphic 67517 Version 27.0

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Vineet Chopra, MD, MSc No relevant financial relationship(s) with ineligible companies to disclose. **Amalia Cochran, MD, FACS, FCCM** Other Financial Interest: JAMA Surgery [Web and social media editor]. All of the relevant financial relationships listed have been mitigated. **Ingemar Davidson, MD, PhD, FACS** No relevant financial relationship(s) with ineligible companies to disclose. **Kathryn A Collins, MD, PhD, FACS** No relevant financial relationship(s) with ineligible companies to disclose.

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