Routine care and maintenance of intravenous devices

AUTHORS: Amanda J Ullman, RN, PhD, Vineet Chopra, MD, MSc
SECTION EDITORS: Amalia Cochran, MD, FACS, FCCM, Ingemar Davidson, MD, PhD, FACS
DEPUTY EDITORS: Kathryn A Collins, MD, PhD, FACS, Keri K Hall, MD, MS

All topics are updated as new evidence becomes available and our peer review process is complete.

Literature review current through: **Jul 2024.**
This topic last updated: **Mar 05, 2024.**

INTRODUCTION

Management of intravenous devices is complex, occurring in a diverse patient population; each case, incidence, and circumstance must be evaluated on an individual basis and actions guided by circumstances and local expertise. Despite the technical skills required to ensure safe intravenous device insertion, placement represents only a moment, with the subsequent time spent caring and managing these devices representing the largest portion of time in the device "life-cycle."

Each clinical interaction with an intravenous device represents an opportunity to promote performance (eg, patency) or introduce harm (eg, infection, malfunction). Care and management of an intravenous device encompasses several aspects, including site assessment, evaluation of patency, and dressing changes. Care and management procedures span a wide interdisciplinary workforce, with varying expertise and competency.

Routine care and maintenance of intravenous devices are reviewed with an aim to outline strategies to prevent complications. We focus on strategies that are universal and include strategies that help mitigate extraluminal and intraluminal harm. Where appropriate, specific guidance for central compared with peripheral intravenous catheters is provided, as well as a section on guidance for pediatric compared with adult age groups.

Placement of intravenous catheters and devices and device-related complications are reviewed separately. (See "Central venous access in adults: General principles" and "Peripheral venous access in adults" and "Central venous catheters: Overview of complications and prevention in adults".)

GOALS OF CARE

Prevention of intravenous device-related infection and malfunction are the primary goals of good intravenous device care. Adequate care and maintenance of intravenous devices can avert or reduce the burden of complications.

Catheter-related bloodstream infection is one of the main complications of intravenous catheter placement. The incidence varies according to type of device. For central venous catheters, the reported incidence is 0.87 in 1000 [1]. For peripheral intravenous devices, 0.18 percent are affected [2]. Infections during intravenous device dwell are primarily caused by intraluminal or extraluminal routes (figure 1). To prevent infection from these sources, care and maintenance procedures must be targeted across both these domains. (See 'Extraluminal specific strategies' below and 'Intraluminal specific strategies' below.)

Many noninfectious intravenous device-associated harms cause significant morbidity and mortality. Catheter-associated thromboses affects up to 15 percent of central venous catheters and can be caused by suboptimal catheter selection, insertion, or care [3]. Device occlusion can result from infrequent flushing, failure to check for device patency, or motion of the device at the insertion site. With peripheral intravenous devices, problems can present in the form of infiltration or extravasation injury.

KEY TERMS

Antiseptic — An antiseptic is a substance used to reduce the risk of infection by killing or inhibiting the growth of microorganisms in or on living tissue [4]. Chlorhexidine gluconate (CHG) is a cationic biguanide that provides rapid antisepsis because of its broad-spectrum germicidal activity against most bloodstream infection-causing pathogens [5].

Aseptic technique — Aseptic technique is a set of infection prevention actions during

invasive clinical procedures and during routine care and management of indwelling medical devices.

Colonization — Colonization is the presence of microorganisms in or on the body without signs or symptoms of infection or disease. For intravenous devices, colonization can be **extraluminal** or **intraluminal** (figure 1). With **extraluminal** colonization, microorganisms originate from the skin in and around the catheter insertion site [4]. By contrast, **intraluminal** colonization refers to the process in which microorganisms enter via the catheter apparatus itself (eg, catheter hub, intravenous tubing, etc) [4]. This distinction is important, as both the timing and pathogens associated with colonization and infection differ according to these routes.

Catheter-related bloodstream infection — Catheter-related bloodstream infection is a primary (ie, not due to infection at another body site) bloodstream infection associated with an intravenous catheter. Diagnostic criteria include either isolation of the same organism from blood culture as from the tip of the catheter with a quantity greater than 15 colony-forming units [4], or alternatively a positive differential time to positivity (DTP). DTP requires the same organism to be isolated from a peripheral vein and catheter lumen blood culture, with growth detected sooner by two hours in the sample drawn from the catheter (ie, faster incubation).

Peripheral intravenous catheter — A peripheral venous catheter is an intravenous device whose tip is positioned outside of the superior or inferior vena cava [6]. These are placed from a peripheral venous access site. Midline catheters are a special type of peripheral intravenous catheter.

Central venous catheter — A central venous catheter is an intravenous device whose tip lies within the superior vena cava, right atrium, or inferior vena cava [6]. A central venous catheter can be inserted from a central venous access site or from a peripheral vein (ie, peripherally inserted central catheter [PICC]) [7]. Tunneled central venous catheters, totally implanted venous devices (ie, subcutaneous ports), and PICCs are commonly used for the administration of long-term intravenous fluids, antibiotics, or nutrition support. PICCs are flexible catheters that are usually inserted into the veins of the arm.

- **Temporary central venous catheter** – A temporary central venous catheter is one that is placed for shorter durations (eg, days, weeks) and removed after the indication for its use has been met. Common examples of these include nontunneled

central venous catheters that are placed in critical care settings in the internal jugular or subclavian veins.

- **Permanent central venous catheter/device** – A permanent central venous catheter is one that is placed for prolonged durations (weeks, months) and often anchored to, or implanted beneath the skin to ensure durability and to reduce the risk for infection. Examples include tunneled central venous catheters (eg, hemodialysis catheter) and subcutaneous ports.

It is important to note that the distinction between a permanent versus temporary device is at best an artificial one and is most often related to indication and implantation technique. In general, tunneled catheters and port devices are generally considered to be "permanent" devices, while nontunneled catheters are considered "temporary"; however, a nontunneled (uncuffed) central venous catheter can be tunneled to allow it to remain in place for a longer period. Similarly, peripherally inserted central catheters, although not implanted, can dwell for prolonged durations (ie, months for parenteral nutrition administration), and as such as they may be considered permanent devices. Subcutaneous ports are placed typically for much longer durations. While imprecise, these terms are nevertheless often used in clinical care and hence it is important to provide context regarding these aspects. Importantly, the care and management of "temporary" and "permanent catheters" are predominantly the same with only minor differences, which are discussed in the sections below.

UNIVERSAL CARE STRATEGIES

Aseptic no-touch technique — Intravenous device care should always be performed using an aseptic, no-touch technique (ANTT) as a foundational step in preventing complications. ANTT is an aseptic technique theory/practice framework based on the concepts of key-part and key-site protection [4] and is a key step in preventing bacterial transmigration into an intravenous device. ANTT is achieved by integrating standard precautions such as hand hygiene (see 'Hand hygiene' below) and the use of personal protective equipment, with appropriate aseptic field management, no-touch technique, and sterilized supplies.

The five practice terms include [8]:

- **Key-site** – The portal of entry into the patient (ie, intravenous device)
- **Key-part** – The part of the procedure equipment that, if contaminated, is likely to contaminate the patient (eg, syringe tip, male Luer end/spike of administration set, injection needle)
- **General aseptic field** – A decontaminated and disinfected procedure tray or single-use procedure kit/barrier
- **Critical aseptic field** – A sterile drape/barrier
- **Micro critical aseptic field** – A small, protective sterile surface (eg, sterile caps, covers) that protects key-parts individually

Hand hygiene — Hand hygiene is the single most important measure to reduce transmission of microorganisms across intravenous devices [9]. Hand hygiene includes hand-washing with soap and water- and alcohol-based hand disinfectant. The primary challenge associated with hand hygiene is not product technology or efficacy, but clinician compliance of practice [9].

The Five Moments for Hand Hygiene (World Health Organization) highlight the key moments when health care workers should perform hand hygiene, the 2nd, 3rd, and 4th of which are especially relevant in the care and maintenance of intravenous devices [10].

These include:

1. Before touching a patient
2. Before clean/aseptic procedures
3. After body fluid exposure/risk
4. After touching a patient
5. After touching patient surroundings

EXTRALUMINAL SPECIFIC STRATEGIES

The most common source of catheter-related bloodstream infection is by microorganisms from the patient's skin. Human skin naturally has abundant microbiologic flora. Microorganisms gain access to the device insertion wound and migrate along the insertion tract into the fibrin sheath that surrounds the intravenous device. Each of the

following care techniques aims to prevent this translocation.

Skin antisepsis — Skin antisepsis involves mechanical and chemical removal of microorganisms from the skin at the intravenous device insertion site during dressing change procedures. Trials evaluating the effectiveness of chlorhexidine gluconate (CHG) and other skin decontaminants have focused primarily on central venous catheters; however, it is reasonable to expect that the efficacy of any skin decontaminants would be similar for peripheral intravenous devices.

Alcohol-containing CHG (≥0.5 percent) is superior to other skin antiseptic agents (eg, povidone iodine in water or alcohol) at reducing microbial contamination at the intravenous device insertion site and thereby preventing catheter-related bloodstream infection [11].

In the intensive care unit setting, the use of chlorhexidine for routine bathing, rather than soap and water, may also be an effective strategy to decrease the rate of bloodstream infection. Issues related to patient bathing in the intensive care unit and noncritical care units are discussed separately. (See "Nosocomial infections in the intensive care unit: Epidemiology and prevention", section on 'Patient bathing/decolonization' and "Infection prevention: Precautions for preventing transmission of infection", section on 'Other clinical infection control issues'.)

Dressing and securement

Dressings as a shield — Dressing products cover the catheter entry site and provide a protective barrier from contamination from the environment [12,13]. Prior to application of adhesive products to secure dressings, all skin decontaminants must be allowed to dry completely. (See 'Skin antisepsis' above.)

Ideally, intravenous device dressings should be transparent (ie, sterile semipermeable dressing; eg, Tegaderm, Opsite), to allow frequent assessment of the exit site. However, if the insertion site is bleeding or oozing, additional products can be applied beneath, including hemostatic agents and gauze products. In a systematic review that included 22 studies involving 7436 participants comparing various types of dressings, the authors concluded that it was unclear whether there were any differences in the rate of catheter-related bloodstream infection comparing standard polyurethane with gauze [5]. Nevertheless, for practical reasons, we agree with practice guidelines that do not

recommend the use of gauze beyond 24 hours following catheter insertion, or in circumstances in which there is **no** active oozing or bleeding from the catheter [4,14]. Overlying gauze dressings obscure the view of the catheter insertion site and can serve as media for bacterial growth.

To achieve their intended goal, dressings must be kept clean, dry, and intact. Clinical guidelines recommend routine dressing changes (every seven days for polyurethane dressings,) unless contraindicated due to clinical safety (eg, extreme critical illness) [4,14]. More frequent dressings may need to be performed if any visible oozing, wound discharge, or loosened (including peeling) dressing is noted. However, excessively frequent dressing changes can also increase the risk of infection, bacterial colonization, and skin irritation [15]. Thus, in general, routinely changing the dressing more frequently than every seven days is generally not recommended [5].

Medicated dressings to prevent infections — Medication-impregnated dressing products provide a slow release of antiseptic solutions onto the intravenous access site (see 'Key terms' above). There are a variety of antiseptic solutions available; however, the most common are CHG and silver-impregnated dressings. The strongest evidence for medicated dressings relates to CHG dressing for central venous catheters, where evidence suggests immediate and delayed benefits from reduced microbial colonization preventing extraluminal infection. In general, medicated dressings are selected in response to a particular clinical circumstance, such as nontunneled central venous catheters in an intensive care unit setting, or for the management of long-term hemodialysis catheters; however, these dressings may also benefit patients in other circumstances.

All trials evaluating the effectiveness of medicated dressings have been performed in central rather than peripheral intravenous devices. While there is no physiological reason that medication-impregnated dressings would function differently in peripheral intravenous devices, their necessity and value have not been established.

In the systematic review discussed above, the rate of central venous catheter-related bloodstream infection per 1000 patient-days was significantly reduced for central venous catheters managed with chlorhexidine gluconate (CHG)-impregnated dressing products (eg, disk, gel, or throughout dressing) compared with plain polyurethane dressings (relative risk [RR] 0.51, 95% CI 0.33-0.78) [5]. There was moderate-quality evidence that catheter tip colonization was also reduced with CHG dressings compared with plain

polyurethane dressings (RR 0.58, 95% CI 0.47-0.73). It was unclear if there was any difference in rates of skin irritation or damage when CHG dressings were used compared with plain polyurethane dressings (moderate-quality evidence; RR 11.17, 95% CI 0.84-149.48).

There are little data to support the use of silver-impregnated dressings outside of the hemodialysis population. In patients who are dialyzing with tunneled hemodialysis catheters, the use of a silver-impregnated dressing may be more effective for prevention of infection compared with CHG dressings [16]. However, some have described development of bacterial resistance with silver-impregnated dressings [17]. Thus, evidence to support optimal recommendations for use of these dressings is limited at this time. (See "Central venous catheters for acute and chronic hemodialysis access and their management", section on 'Dressings'.)

Device securement — Intravenous devices are foreign objects, and securement products are necessary to stabilize the external portion of the device to the surrounding skin. By doing so, securement devices ensure stability of the device either in a central or peripheral position. Securement products also aim to prevent "micromotion" of the intravenous device within the vessel lumen preventing vessel irritation and endothelial damage, which can promote thrombosis, and within the wound preventing wound irritation and local site infection [13].

All devices should have at least one element of securement applied. This should be selected based on type of device and insertion location (eg, insertion near a joint such as the antecubital fossa), line weight (ie, additional administration set parts), and skin integrity and strength (ie, the ability for the underlying skin to support the securement device) (table 1).

While suturing central venous catheters is often necessary, suturing peripheral intravenous devices is typically not appropriate. It introduces considerable risk to the patient (eg, infection, pain) and clinician (eg, needlestick injury), with minimal benefit that can be better achieved by alternative securement products. Tissue adhesive products are effective at promoting peripheral intravenous device security [18,19].

Preventing skin irritation and injury — The repeated application and removal of adhesives and decontaminant products can cause medical adhesive-related skin injuries, such as irritant or allergic contact dermatitis, skin tears, blistering, and pressure injuries

[20]. These injuries can increase the risk of local infection [21]. (See "Common allergens in allergic contact dermatitis", section on 'Adhesives' and "Common allergens in allergic contact dermatitis", section on 'Acrylates'.)

Prevention of significant irritation and injury can be achieved with regular site assessment, early identification (including documentation of skin health progression within records), and high-quality management procedures [21]. Skin barrier films can be used to protect the skin from adhesive products; however, their efficacy to prevent intravenous device wound irritation and injury is not established compared with not using barrier films.

INTRALUMINAL SPECIFIC STRATEGIES

Microorganisms can migrate from the external environment intraluminally into the bloodstream from colonized intravenous line hubs, connectors, syringes, and administration sets. With each interaction with intravenous devices, hand hygiene, aseptic no-touch technique (ANTT) principles, and high-quality procedures need to be used consistently to prevent this translocation.

Hubs, needleless connectors, and line access — Needleless connectors are used to connect syringes and administration sets to the intravenous device.

These connectors vary between positive, neutral, and negative pressure for fluid displacement within the line, which causes varying degrees of fluid motion within the catheter.

The manufacturer's instructions for flushing, clamping, and disconnection sequences should be adhered to. If unavailable, in general, for each type of connector [4]:

- Negative displacement devices – Flush, clamp, disconnect
- Positive displacement devices – Flush, disconnect, clamp
- Neutral devices – No specific sequence required

A systematic review (observational studies, no meta-analysis) reported that the rate of central line-associated bloodstream infections was lower with positive displacement devices compared with negative displacement or neutral devices (one study), but lower with negative displacement devices compared with three-way stopcocks (three studies).

There was variation, however, among the different positive, negative, and neutral displacement device designs (four studies) [22]. Some needleless devices (eg, positive displacement) have been temporally associated with increased rates of catheter-related bloodstream infection that have not been clearly associated with lack of compliance with recommended catheter care [23,24].

The needleless connector should be accessed using standard ANTT (see 'Aseptic no-touch technique' above). Prior to accessing, the connection surface and sides of the needleless connectors must be decontaminated to prevent intraluminal contamination and transmission of infection through the connector. This can be achieved via an active (ie, decontamination cap containing chlorhexidine gluconate [CHG] or alcohol) or passive (scrub for 5 to 15 seconds) approach. Decontaminants are normally an alcohol-based CHG or a 70% isopropyl alcohol, with unclear superiority between the approach and product [25]. Decontaminant products should be allowed to dry prior to needleless connector access.

Administration sets — Administration sets should be kept intact as much as possible. Administration set changes are performed using standard ANTT at a frequency based on factors such as solution type. (See 'Aseptic no-touch technique' above.)

There is moderate-quality evidence (systematic review, randomized trials, and observational studies) that continuous administration sets used to administer solutions other than lipid, blood, or blood products, and other special uses, should be changed no more frequently than every 96 hours, but at least every seven days [4].

A systematic review of predominantly studies that compared replacement greater than or equal to every 96 hours versus every 72 hours with studies that compared replacement greater than or equal to every 48 hours versus every 24 hours reported no differences in catheter-related or infusate-related bacteremia or fungemia, or colonization rates with more frequent administration set replacement overall [26]. In a meta-analysis of five studies, less frequent administration set replacement reduced the rate of all-cause bloodstream infection (relative risk [RR] 0.73, 95% CI 0.54-0.98). However, some evidence suggested increased mortality within the neonatal population with less frequent administration set replacement (RR 1.84, 95% CI 1.00-3.36). A later large trial involving 2944 adults and children reported an incidence of catheter-related bloodstream infection was similar for seven-day (1463 patients) or four-day (1481 patients) administration set

replacement for central venous catheters (absolute risk difference 0.32 percent, 95% CI -0.73 to 1.37) [27].

Administration sets used for other infusates vary based on infusate characteristics being conducive to the growth of microorganisms, but evidence quality is poor. Examples include [4]:

- Parenteral nutrition (with and without lipids) – Change at least every 24 hours and when the container is changed
- Lipids – Change at least every 12 hours and when the container is changed
- Propofol – Change at least every 6 to 12 hours and when the container is changed

Flushing and locking — A variety of strategies can be used to promote intravenous device patency, including pulsatile flushing using normal saline, locking with normal saline, or heparin.

Flushing — Intravenous devices should be flushed with normal saline after placement and before and after medication administration to create turbulent flow (use a push-pause or start-stop-start techniques), thereby promoting patency and reducing intraluminal catheter colonization. The minimum volume should be equal to twice the internal volume of the catheter system, using a 10 mL syringe (or lower injection pressure barrel) [4]. The volume of a catheter lumen is generally less than 1 mL, and for a needleless connector, 0.1 mL; therefore, 2 to 3 mL (minimum) of normal saline should be sufficient.

Locking — Locking is used mostly for central venous catheters and aims to prevent reflux of blood during periods of disuse. Normal saline or heparinized saline can be used as routine lock solutions, with a variety of heparin doses used depending upon the device type, length, and the perceived risk of occlusion [28,29]. Data are inadequate to support the choice (eg, heparin versus normal saline) or frequency of routine locking [28,29].

Evidence is limited to support the routine prophylactic use of other lock solutions. These include fibrinolytic agents, ethanol, antibiotics (eg, vancomycin), antibiotic-heparin mixes, and taurolidine. Their use is recommended only when clinically indicated for populations with an established high risk for catheter-related complications and sequelae. These agents are used as secondary prophylaxis in patients who depend on their catheters for life-saving therapies (eg, hemodialysis in end-stage kidney disease, parenteral nutrition

for those who depend on external nourishment), patients with a diagnosis of a central line-associated bloodstream infection, or patients with other complications (eg, medication precipitate, catheter thrombosis).

- Issues related to use of lock solutions for prevention of hemodialysis catheter complications are discussed in detail separately. (See "Central venous catheters for acute and chronic hemodialysis access and their management", section on 'Access, flushing, and catheter locking'.)

- Use of antibiotic lock techniques for treatment of catheter-related infection is discussed in detail separately. (See "Lock therapy for treatment and prevention of intravascular non-hemodialysis catheter-related infection".)

Blood sampling — Ideally, blood sampling is obtained from an independent venipuncture site; however, poor peripheral access is often the reason for placement of central venous catheters. (See "Central venous access in adults: General principles", section on 'Indications'.)

If a peripheral device is being selected specifically for blood sampling, careful selection of device location will assist with flow; however, not all intravenous devices can facilitate blood drawing.

Three common techniques when blood sampling from intravenous devices include the following:

- **Discard** – The discard method is most common and involves the aspiration and then disposal of clearance blood (a volume that depends on the line volume) prior to blood sampling. The potential fluid losses with this method are of particular concern in the pediatric population. (See 'Pediatric considerations' below.)

- **Reinfusion** – The reinfusion method involves aspiration of clearance blood, sampling, and then reinfusion of clearance blood, followed by flushing of the catheter. This technique potentially increases the risk of microbial colonization and thrombosis within the clearance volume.

- **Push-pull** – The push-pull method involves the multiple rapid infusion and aspiration of first saline and then blood through into the syringe, theoretically clearing the line of infusion fluid prior to sampling. This minimizes potential contamination,

thrombosis formation, and fluid loss but increases the risk of inaccurate laboratory results due to dilution and hemolysis.

DAILY EVALUATION FOR REMOVAL

Maintenance of the intravenous catheter is justified if it is mandatory, functional, in the correct position, and not infected. However, the best way to prevent an intravenous device-associated infection or other complications is to not have a device. Given the association of increasing dwell time and risk for complications, the second best way is to remove intravenous devices when no longer needed and when they no longer function properly.

Devices should be assessed by the treating team for necessity at least daily, with an active decision to either continue dwell or remove the intravenous device. Devices should also be assessed for performance and complications, including early signs of infection, occlusion, and infiltration [30]. Catheters that are malfunctioning may need to be replaced.

Practical examples of assessment tools to promote daily evaluation and early removal include I-DECIDED [30] and PIVC SUCCESS [31].

Complications related to removal (eg, bleeding, air embolism) are reviewed separately. (See "Vascular complications of central venous access and their management in adults" and "Air embolism".)

Catheter dwell time and replacement — The dwell time is an important risk factor for complications. The risk of infection increases with longer duration of use; however, vigilant clinical evaluation and assessment of the catheter site are recommended instead of scheduled changes of the catheter [32]. The maximum intended dwell time does help inform the selection of the type of central venous catheter. (See "Central venous access: Device and site selection in adults", section on 'Duration of venous access'.)

If adherence to aseptic technique was not assured when an intravenous device was placed (such as in the setting of emergency catheter placement), the device should be replaced as soon as possible (and no longer than 48 hours after insertion) [33].

Peripheral intravenous catheters — Clinical trial data suggest that routine replacement of catheters does not decrease the risk of infection [34,35]. Removing peripheral

intravenous catheters as clinically indicated is reasonable and is consistent with the Centers for Disease Control (CDC) guidelines [14].

A number of early observational studies reported an increased rate of phlebitis over time with peripheral intravenous catheters [36-38]. In one prospective study of 1054 peripheral intravenous catheters, the incidence of phlebitis exceeded 50 percent by day 4. While the data from these studies might suggest that routine placement would be useful, data from later randomized trials do not support this approach. In one large trial of 3379 patients who were randomly assigned to routine catheter replacement every three days or replacement only when clinically indicated, the rate of phlebitis (tenderness, erythema, swelling, discharge, or a palpable cord at the insertion site) was similar between the two groups (7 percent in both) [35]. Less than 25 percent of devices remained in place for more than four days. Similarly, a later meta-analysis that included 7323 patients noted no difference in catheter-related bloodstream infection (seven trials including the large trial above), phlebitis (six trials), catheter blockage (seven trials), or local infection (4 trials) comparing patients who underwent peripheral intravenous catheter replacement when clinically indicated versus routinely [34]. The incidence of infiltration was lower for catheters that were routinely changed (21 versus 24 percent, risk ratio 1.16, 95% CI 1.06-1.26). When irritating infusions are used, vigilance is important to prevent extravasation injury. (See "Extravasation injury from cytotoxic and other noncytotoxic vesicants in adults".)

Central venous catheters — The risk of infection and other complications increases with longer duration of use for central venous catheters, but depends on the type of device (eg, tunneled versus nontunneled, totally implanted venous devices (ie, ports), peripherally inserted central catheters [PICCs]) [39-42]. In general, we recommend against routine replacement. When replacement is necessary, using a new site for access reduces the risk of bloodstream infection compared with guidewire exchange techniques.

Permanent catheters — Totally implanted venous devices (ie, ports) are designed for long-term administration of intravenous therapies. PICCs are designed to remain in place for weeks to months. These mid-term to long-term catheters are generally only removed for complications (eg, thrombosis, malposition, infection) or when they are no longer required.

Temporary catheters — For nontunneled central venous catheters, a defined period to

routinely change the catheter has not been conclusively established. Available trial data suggest similar rates of catheter-related bloodstream infection for clinically indicated compared with routine catheter replacement [43-45]. The rate of mechanical complications is increased when catheters are routinely changed, and use of multiple central venous access sites may limit available sites in the future. As such, routine replacement of these catheters is not recommended. Vigilant clinical evaluation and assessment of the catheter site should be performed at least every day. Indications for device removal replacement include malfunction or suspicion of catheter-related infection, particularly if associated with hemodynamic instability [33].

Guidewire techniques should generally not be used to exchange central venous catheters since this approach increases the risk of bloodstream infection [33,44]. The lack of efficacy of routine replacement and catheter exchange at the same site was best demonstrated in a randomized trial in intensive care units in which 160 adults were assigned to one of four methods of central venous catheter or pulmonary artery catheter change: replacement every three days, either by insertion at a new site (group 1) or by exchange over a guidewire (group 2); or replacement when clinically indicated either by insertion at a new site (group 3) or by exchange over a guidewire (group 4) [44]. The following findings were noted:

- The incidence of catheter-related bloodstream infection did not favor scheduled replacement (3, 6, 2, and 3 per 1000 catheter-days for groups 1 through 4, respectively). Five of the eight catheter-related bloodstream infections occurred in patients in whom the catheter was changed every three days. Six of the infections occurred within 72 hours of initial catheter insertion or replacement.

- Exchanging catheters over a guidewire after the first three days of catheterization significantly increased the incidence of bloodstream infection (6 versus 0 percent). Replacement of catheters at new sites was associated with a higher risk of mechanical complications comprising 11 of 14 of the mechanical complications.

Catheter teams and use of checklist — Data from several studies suggest that catheters placed under emergency conditions are associated with higher rates of infection [46]. In contrast, catheters placed by health care workers skilled in intravenous catheter placement have lower rates of infection. This has been demonstrated with insertion of central venous catheters [47-51] and for peripheral intravenous catheters [52,53].

The largest study involved 103 intensive care units in Michigan and over 375,000 catheter-days [47]. The intervention consisted of five recommended evidence-based practices including handwashing, barrier precautions during central line insertion, chlorhexidine for skin disinfection, avoidance of the femoral site for access, and removal of catheters when no longer needed [33]. Following implementation, the mean rate of catheter-related bloodstream infections per 1000 catheter-days decreased from 7.7 at baseline to 1.4 at 16 to 18 months. The rate of infection fell continuously during this period (incidence-rate ratio 0.62 in the first three months and 0.34 at 16 to 18 months). The use of antibiotic-impregnated catheters was not reported.

In settings with relatively low rates of catheter-related bloodstream infection (approximately 1/1000 central line-days) and a highly reliable insertion process including checklist completion, a dedicated insertion team may not further reduce infections, since many of these may be more related to maintenance than insertion practices [54]. For peripheral intravenous catheters, the importance of a specialized team was illustrated in a controlled trial in a university hospital in which patients were randomly assigned to insertion by a house officer and maintenance by the ward nursing staff or insertion and maintenance by an intravenous therapy team [52]. The team approach was associated with a significantly lower frequency of signs or symptoms of inflammation (7.9 versus 21.7 percent with the house staff-nursing approach), no episodes of bacteremia versus three (2.2 percent), and a higher number of catheters placed per patient (2.1 versus 1.6).

Even in the absence of a specialized catheter team, the rate of catheter-related infections can be reduced by a comprehensive prevention strategy (eg, guidelines for insertion and routine care of the catheter, hand disinfection before and after any care of the line) that includes slide shows, practical demonstrations, and in-service training [55,56].

PEDIATRIC CONSIDERATIONS

- **Skin sensitivity** — Neonatal and pediatric skin is fundamentally different than adult skin. The US Food and Drug Administration and other guidelines recommend caution when using chlorhexidine gluconate (CHG) for patients under two months of age due to concerns of CHG absorption and skin irritation [14,57].

  Contact dermatitis has also been reported when alcohol-based solutions are used in neonates and infants. For neonates and young infants and children with impaired

skin integrity, povidone iodine, water-based solutions, or other decontaminants may be considered.

The risk-to-benefit ratio of using CHG and alcohol needs to be taken into consideration. This consideration also extends to the use of medicated dressings used to treat infection (eg, CHG). (See 'Skin antisepsis' above and 'Dressing and securement' above.)

- **Intravascular volume sensitivity** — The additional fluid administered during flushing is an issue of concern for pediatric patients who may be fluid restricted because of their age or underlying medical conditions. With small-gauge intravenous devices (eg, 1.9 Fr peripherally inserted central catheters), a low-volume continuous infusion of a crystalloid solution may be used to promote patency by preventing thrombus formation [58].

  On the other hand, fluid loss can be due to blood sampling. The discard method can result in significant fluid loss and preventable anemia during times of frequent blood sampling (eg, sepsis). Clinical trials in pediatric populations have demonstrated statistically but not clinically different results using the push-pull method [59,60]. (See 'Blood sampling' above.)

- **Compliance** — Infants and small children are rarely compliant in their dressing and securement application and may intentionally attempt to remove the device. Additional security and coverage (eg, splints when intravenous devices are inserted in areas of flexion) are often necessary.

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 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

- **Intravenous devices** – A variety of devices are used to access the venous system for the administration of fluid, medications, and nutrition support. Devices may be placed into the peripheral or central veins in diverse patient populations with varying needs. (See 'Introduction' above and 'Goals of care' above.)

- **Routine care and maintenance** – Each clinical interaction with an intravenous device represents an opportunity to promote performance (eg, patency) or introduce harm (eg, infection, malfunction). For routine care and maintenance, the following procedures are required to reduce the risk of catheter-related complications. These include using the following:

  - **ANTT techniques** – Intravenous device care should always be performed using an aseptic, no-touch technique (ANTT) as a foundational step in preventing complications. ANTT is achieved by integrating standard precautions such as hand hygiene and use of personal protective equipment, with appropriate aseptic field management, no-touch technique, and sterilized supplies. (See 'Universal care strategies' above.)

  - **Hand hygiene** – Hand-washing with an antiseptic-containing soap or alcohol-base gel or foam is the single most important measure to reduce transmission of microorganisms across intravenous devices. The use of gloves does not obviate

the need for hand hygiene. Hand-washing should be performed before touching the patient, before clean/aseptic procedures, after body fluid exposure/risk, after touching a patient, and after touching patient surroundings. (See 'Hand hygiene' above.)

- **Skin antisepsis** – The most common source of catheter-related bloodstream infection is colonization by microorganisms from the patient's skin. Disinfecting the skin at the intravenous device insertion site prior to catheter insertion and with each dressing changes using a chlorhexidine-alcohol solution removes microorganisms mechanically and chemically. (See 'Skin antisepsis' above.)

- **Catheter-specific strategies** – Specific intraluminal and extraluminal strategies can help reduce the risk for catheter complications. These include:

  - Accessing needleless connectors using ANTT. Adhere to the manufacturer's instructions for flushing, clamping, and disconnection sequences.

  - Flushing intravenous devices with normal saline with a minimum volume equal to twice the internal volume of the catheter system using a 10 mL syringe before and after medication administration. Flushing promotes patency and reduces intraluminal catheter colonization.

  - Locking the catheter using a solution appropriate for the type of catheter and clinical situation. Normal saline and heparinized saline are commonly used as routine lock solutions. Other locking solutions are used only when clinically indicated and generally as secondary prophylaxis in patients who depend on their catheters for life-saving therapies (eg, hemodialysis, nutrition support).

- **Dressing changes** – Dressings cover the catheter entry site and provide a barrier from contamination and must be kept clean, dry, and intact. Transparent dressings are ideal for frequent assessment of the catheter exit site. Other types of dressings may be needed depending on the clinical situation. The frequency of dressing changes depends on the material selected (eg, polyurethane dressings are changed every seven days). Medicated dressings may help prevent catheter-related infection but are generally only selected only in response to a particular clinical circumstance (eg, nontunneled central venous catheters in an intensive care unit setting, long-term hemodialysis catheters). (See 'Dressing and

securement' above.)

- **Device securement** – Device securement is necessary to stabilize the device to prevent damage to the vessel that can lead to thrombosis or irritation to the surrounding tissues and infection. Select a securement appropriate to the device and insertion location (table 1); all devices should have at least one element of securement. (See 'Dressing and securement' above.)

- **Removal and replacement** – Intravenous devices are removed as soon as they are no longer clinically needed, or for complications. Observers trained to recognize catheter complications must examine the catheter site at least once each day. The risk of infection increases with the duration of catheterization for most device types. (See 'Catheter dwell time and replacement' above.)

  - For catheters placed in a setting in which adherence to aseptic technique cannot be assured (eg, emergency catheter placement), the catheter should be replaced as soon as possible (and within 48 hours after insertion).

  - For peripheral intravenous devices, we suggest against routine replacement at a designated interval (**Grade 2B**). Catheters should be removed when clinically indicated.

  - For temporary central venous catheters, we recommend against routine replacement at a designated interval (**Grade 1B**). Furthermore, when replacement is needed, we recommend replacement at a new site, rather than using guidewire exchange techniques (**Grade 1B**). This approach reduces the risk of bloodstream infection.

  - Long-term (permanent) central venous catheters are designed to remain in place for prolonged durations (weeks, months) and are generally only removed for complications (eg, thrombosis, malposition, infection) or when they are no longer required.

REFERENCES

1. Patel PR, Weiner-Lastinger LM, Dudeck MA, et al. Impact of COVID-19 pandemic on central-line-associated bloodstream infections during the early months of 2020, National Healthcare Safety Network. Infect Control Hosp Epidemiol 2022; 43:790.
2. Mermel LA. Short-term Peripheral Venous Catheter-Related Bloodstream Infections: A Systematic Review. Clin Infect Dis 2017; 65:1757.
3. Chopra V, Anand S, Hickner A, et al. Risk of venous thromboembolism associated with peripherally inserted central catheters: a systematic review and meta-analysis. Lancet 2013; 382:311.
4. Gorski LA, Hadaway L, Hagle ME, et al. Infusion Therapy Standards of Practice, 8th Edition. J Infus Nurs 2021; 44:S1.
5. Ullman AJ, Cooke ML, Mitchell M, et al. Dressings and securement devices for central venous catheters (CVC). Cochrane Database Syst Rev 2015; :CD010367.
6. Ullman AJ, Chopra V, Brown E, et al. Developing Appropriateness Criteria for Pediatric Vascular Access. Pediatrics 2020; 145:S233.
7. Smith RN, Nolan JP. Central venous catheters. BMJ 2013; 347:f6570.
8. Rowley S, Clare S, Macqueen S, Molyneux R. ANTT v2: An updated practice framework for aseptic technique. Br J Nurs 2010; 19:S5.
9. Gould DJ, Moralejo D, Drey N, et al. Interventions to improve hand hygiene compliance in patient care. Cochrane Database Syst Rev 2017; 9:CD005186.
10. Your 5 moments for hand hygiene. World Health Organization. Available at: https://cdn.who.int/media/docs/default-source/integrated-health-services-(ihs)/infection-prevention-and-control/your-5-moments-for-hand-hygiene-poster.pdf?sfvrsn=83e2fb0e_16 (Accessed on May 17, 2022).
11. 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.
12. Shapey IM, Foster MA, Whitehouse T, et al. Central venous catheter-related bloodstream infections: improving post-insertion catheter care. J Hosp Infect 2009; 71:117.
13. Ullman AJ, Cooke M, Rickard C. Examining the role of securement and dressing products to prevent central venous access device failure: a narrative review. J Assoc Vasc Access 2015; 20:99.
14. O'Grady NP, Alexander M, Burns LA, et al. Guidelines for the prevention of

intravascular catheter-related infections. Clin Infect Dis 2011; 52:e162.

15. Timsit JF, Bouadma L, Ruckly S, et al. Dressing disruption is a major risk factor for catheter-related infections. Crit Care Med 2012; 40:1707.
16. Karlnoski R, Abboud EC, Thompson P, et al. Reduction in Central Line-Associated Bloodstream Infections Correlated With the Introduction of a Novel Silver-Plated Dressing for Central Venous Catheters and Maintained for 6 Years. J Intensive Care Med 2019; 34:544.
17. Tambe SM, Sampath L, Modak SM. In vitro evaluation of the risk of developing bacterial resistance to antiseptics and antibiotics used in medical devices. J Antimicrob Chemother 2001; 47:589.
18. Kleidon TM, Rickard CM, Gibson V, et al. Smile - Secure my intravenous line effectively: A pilot randomised controlled trial of peripheral intravenous catheter securement in paediatrics. J Tissue Viability 2020; 29:82.
19. Bugden S, Shean K, Scott M, et al. Skin Glue Reduces the Failure Rate of Emergency Department-Inserted Peripheral Intravenous Catheters: A Randomized Controlled Trial. Ann Emerg Med 2016; 68:196.
20. McNichol L, Lund C, Rosen T, Gray M. Medical adhesives and patient safety: state of the science: consensus statements for the assessment, prevention, and treatment of adhesive-related skin injuries. Orthop Nurs 2013; 32:267.
21. Broadhurst D, Moureau N, Ullman AJ, World Congress of Vascular Access (WoCoVA) Skin Impairment Management Advisory Panel. Management of Central Venous Access Device-Associated Skin Impairment: An Evidence-Based Algorithm. J Wound Ostomy Continence Nurs 2017; 44:211.
22. Rosenthal VD. Clinical impact of needle-free connector design: A systematic review of literature. J Vasc Access 2020; 21:847.
23. Rupp ME, Sholtz LA, Jourdan DR, et al. Outbreak of bloodstream infection temporally associated with the use of an intravascular needleless valve. Clin Infect Dis 2007; 44:1408.
24. Maragakis LL, Bradley KL, Song X, et al. Increased catheter-related bloodstream infection rates after the introduction of a new mechanical valve intravenous access port. Infect Control Hosp Epidemiol 2006; 27:67.
25. Flynn JM, Larsen EN, Keogh S, et al. Methods for microbial needleless connector

decontamination: A systematic review and meta-analysis. Am J Infect Control 2019; 47:956.

26. Ullman AJ, Cooke ML, Gillies D, et al. Optimal timing for intravascular administration set replacement. Cochrane Database Syst Rev 2013; 2013:CD003588.
27. Rickard CM, Marsh NM, Larsen EN, et al. Effect of infusion set replacement intervals on catheter-related bloodstream infections (RSVP): a randomised, controlled, equivalence (central venous access device)-non-inferiority (peripheral arterial catheter) trial. Lancet 2021; 397:1447.
28. Bradford NK, Edwards RM, Chan RJ. Normal saline (0.9% sodium chloride) versus heparin intermittent flushing for the prevention of occlusion in long-term central venous catheters in infants and children. Cochrane Database Syst Rev 2020; 4:CD010996.
29. López-Briz E, Ruiz Garcia V, Cabello JB, et al. Heparin versus 0.9% sodium chloride locking for prevention of occlusion in central venous catheters in adults. Cochrane Database Syst Rev 2018; 7:CD008462.
30. Ray-Barruel G, Cooke M, Chopra V, et al. The I-DECIDED clinical decision-making tool for peripheral intravenous catheter assessment and safe removal: a clinimetric evaluation. BMJ Open 2020; 10:e035239.
31. Kleidon TM, Cattanach P, Mihala G, Ullman AJ. Implementation of a paediatric peripheral intravenous catheter care bundle: A quality improvement initiative. J Paediatr Child Health 2019; 55:1214.
32. Mermel LA. Prevention of intravascular catheter-related infections. Ann Intern Med 2000; 132:391.
33. O'Grady NP, Alexander M, Dellinger EP, et al. Guidelines for the prevention of intravascular catheter-related infections. Centers for Disease Control and Prevention. MMWR Recomm Rep 2002; 51:1.
34. Webster J, Osborne S, Rickard CM, Marsh N. Clinically-indicated replacement versus routine replacement of peripheral venous catheters. Cochrane Database Syst Rev 2019; 1:CD007798.
35. Rickard CM, Webster J, Wallis MC, et al. Routine versus clinically indicated replacement of peripheral intravenous catheters: a randomised controlled equivalence trial. Lancet 2012; 380:1066.

36. Lai KK. Safety of prolonging peripheral cannula and i.v. tubing use from 72 hours to 96 hours. Am J Infect Control 1998; 26:66.
37. Collin J, Collin C, Constable FL, Johnston ID. Infusion thrombophlebitis and infection with various cannulas. Lancet 1975; 2:150.
38. Band JD, Maki DG. Steel needles used for intravenous therapy. Morbidity in patients with hematologic malignancy. Arch Intern Med 1980; 140:31.
39. 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.
40. Maki DG, Stolz SS, Wheeler S, Mermel LA. A prospective, randomized trial of gauze and two polyurethane dressings for site care of pulmonary artery catheters: implications for catheter management. Crit Care Med 1994; 22:1729.
41. Raad I, Umphrey J, Khan A, et al. The duration of placement as a predictor of peripheral and pulmonary arterial catheter infections. J Hosp Infect 1993; 23:17.
42. Gil RT, Kruse JA, Thill-Baharozian MC, Carlson RW. Triple- vs single-lumen central venous catheters. A prospective study in a critically ill population. Arch Intern Med 1989; 149:1139.
43. Panse J, Tölle D, Fiegle E, et al. Scheduled removal of central venous catheters (CVC) to prevent CVC-related bloodstream infections in patients with hematological disease or autologous stem cell transplantation: a registry-based randomized simulation-study. Ann Hematol 2022; 101:2317.
44. Cobb DK, High KP, Sawyer RG, et al. A controlled trial of scheduled replacement of central venous and pulmonary-artery catheters. N Engl J Med 1992; 327:1062.
45. Eyer S, Brummitt C, Crossley K, et al. Catheter-related sepsis: prospective, randomized study of three methods of long-term catheter maintenance. Crit Care Med 1990; 18:1073.
46. Larson E, Hargiss C. A decentralized approach to maintenance of intravenous therapy. Am J Infect Control 1984; 12:177.
47. Pronovost P, Needham D, Berenholtz S, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. N Engl J Med 2006; 355:2725.
48. Centers for Disease Control and Prevention (CDC). Reduction in central line-associated bloodstream infections among patients in intensive care units--

Pennsylvania, April 2001-March 2005. MMWR Morb Mortal Wkly Rep 2005; 54:1013.

49. Warren DK, Zack JE, Cox MJ, et al. An educational intervention to prevent catheter-associated bloodstream infections in a nonteaching, community medical center. Crit Care Med 2003; 31:1959.
50. Lobo RD, Levin AS, Gomes LM, et al. Impact of an educational program and policy changes on decreasing catheter-associated bloodstream infections in a medical intensive care unit in Brazil. Am J Infect Control 2005; 33:83.
51. Berenholtz SM, Pronovost PJ, Lipsett PA, et al. Eliminating catheter-related bloodstream infections in the intensive care unit. Crit Care Med 2004; 32:2014.
52. Soifer NE, Borzak S, Edlin BR, Weinstein RA. Prevention of peripheral venous catheter complications with an intravenous therapy team: a randomized controlled trial. Arch Intern Med 1998; 158:473.
53. Tomford JW, Hershey CO, McLaren CE, et al. Intravenous therapy team and peripheral venous catheter-associated complications. A prospective controlled study. Arch Intern Med 1984; 144:1191.
54. Styslinger E, Nguyen H, Hess O, et al. Central line-associated bloodstream infections and completion of the central line insertion checklist: A descriptive analysis comparing a dedicated procedure team to other providers. Am J Infect Control 2019; 47:1400.
55. Eggimann P, Harbarth S, Constantin MN, et al. Impact of a prevention strategy targeted at vascular-access care on incidence of infections acquired in intensive care. Lancet 2000; 355:1864.
56. Blot K, Bergs J, Vogelaers D, et al. Prevention of central line-associated bloodstream infections through quality improvement interventions: a systematic review and meta-analysis. Clin Infect Dis 2014; 59:96.
57. U.S. Food & Drug Administration. Clinical review: ReadyPrep CHG (2% Chlorhexidine g luconate). Available at: https://www.accessdata.fda.gov/drugsatfda_docs/nda/2018/207964Orig1s000MedR.pdf (Accessed on May 19, 2022).
58. Doellman D, Buckner JK, Hudson Garrett J Jr, et al. Best practice guidelines in the care and maintenance of pediatric central venous catheters, 2, Association for Vascular Ac cess, Herriman, UT 2015.
59. Adlard K. Examining the push-pull method of blood sampling from central venous

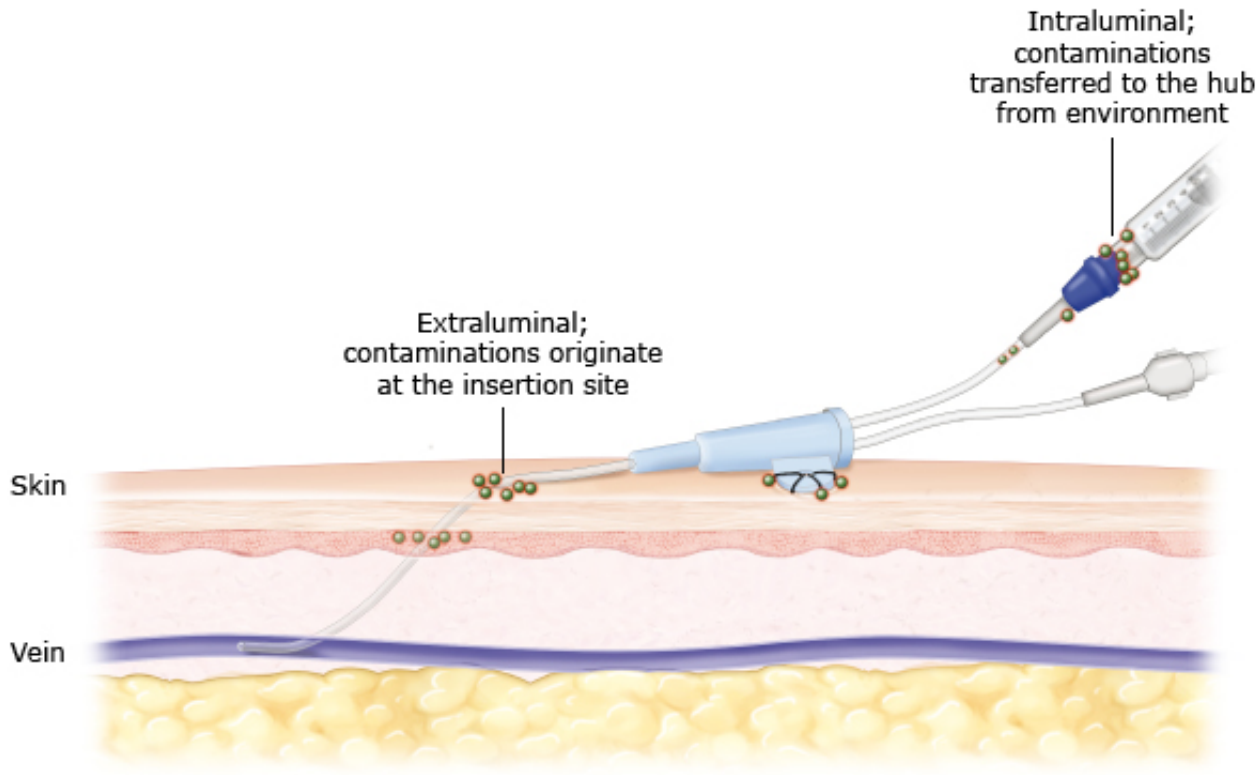
access devices. J Pediatr Oncol Nurs 2008; 25:200.

60. Barton SJ, Chase T, Latham B, Rayens MK. Comparing two methods to obtain blood specimens from pediatric central venous catheters. J Pediatr Oncol Nurs 2004; 21:320.

Topic 15671 Version 6.0

GRAPHICS

Diagram of intraluminal versus extraluminal colonization sources



Modified from: Molitor MJ. BSI: Addressing clinical challenges with catheter maintenance. 3M Health Care Academy lecture, March 15, 2018.

Graphic 138640 Version 1.0

Securement options for central venous catheters

Securement options	Description	Benefits or concerns
Sutures	Synthetic or silk sutures have traditionally been used to attach the CVC to the patient's subcutaneous tissue	Device dislodgement if suture is pulled out and possible increased risk of CRBSI[1]
Adhesive securement devices	Adhesive footplate and clasp or Velcro-based attachments to the external IV device provide sutureless securement	Enhanced security without increased risk of needle puncture
Integrated securement devices	New-generation dressings that incorporate a securement function, such as engineered adhesives and padded borders	Unimpaired view of the insertion site
Tissue adhesive	Medical-grade cyanoacrylate glue used at the insertion site to promote hemostasis	Potentially improve device security[2,3]; have not been demonstrated to reduce CRBSI or device dislodgement for CVCs[4]; may cause skin irritation
Subcutaneous anchor securement systems	Flexible posts (usually nitinol based) placed beneath the skin to secure CVCs at the insertion point; the product stays in place for the entire CVC dwell	Useful to reduce the time needed to complete dressing changes, especially when the peri-skin is irritated or injured[5]; requires training for insertion and removal

CVC: central venous catheter; CRBSI: catheter-related bloodstream infection; IV: intravenous.

References:

1. *Yamamoto A, Solomon J, Soulen M, et al. Sutureless securement device reduces complications of peripherally inserted central venous catheters. J Vasc Interv Radiol 2002; 13:77.*
2. *Kleidon TM, Ullman AJ, Gibson V, et al. A pilot randomized controlled trial of novel dressing and securement techniques in 101 pediatric patients. J Vasc Interv Radiol 2017; 28:1548.*
3. *Rickard CM, Marsh N, Webster J, et al. Dressings and securements for the prevention of peripheral intravenous catheter failure in adults (SAVE): A pragmatic, randomised controlled, superiority trial. Lancet 2018; 392:419.*
4. *Rickard CM, Edwards M, Spooner AJ, et al. A 4-arm randomized controlled pilot trial of innovative solutions for jugular central venous access device securement in 221 cardiac surgical patients. J Crit Care 2016; 36:35.*
5. *Goossens GA, Grumiaux N, Janssens C, et al. SecurAstaP trial: Securement with SecurAcath versus StatLock for peripherally inserted central catheters, a randomised open trial. BMJ Open 2018; 8:e016058.*

Graphic 138642 Version 1.0

Contributor Disclosures

Amanda J Ullman, RN, PhD Grant/Research/Clinical Trial Support: 3M Medical [Intravenous catheter dressings]; BioLife [Catheter hemostatic agent]. All of the relevant financial relationships listed have been mitigated. **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. **Keri K Hall, MD, MS** No relevant financial relationship(s) with ineligible companies to disclose.

Contributor disclosures are reviewed for conflicts of interest by the editorial group. When found, these are addressed by vetting through a multi-level review process, and through requirements for references to be provided to support the content. Appropriately referenced content is required of all authors and must conform to UpToDate standards of evidence.

Conflict of interest policy

→