

Practice Guidelines for Central Venous Access 2020

*An Updated Report by the American Society of Anesthesiologists Task Force on Central Venous Access**

Practice guidelines are systematically developed recommendations that assist the practitioner and patient in making decisions about health care. These recommendations may be adopted, modified, or rejected according to clinical needs and constraints and are not intended to replace local institutional policies. In addition, practice guidelines developed by the American Society of Anesthesiologists (ASA) are not intended as standards or absolute requirements, and their use cannot guarantee any specific outcome. Practice guidelines are subject to revision as warranted by the evolution of medical knowledge, technology, and practice. They provide basic recommendations that are supported by a synthesis and analysis of the current literature, expert and practitioner opinion, open forum commentary, and clinical feasibility data.

This document updates the “Practice Guidelines for Central Venous Access: A Report by the American Society of Anesthesiologists Task Force on Central Venous Access,” adopted by the ASA in 2011 and published in 2012.¹

Methodology

Definition of Central Venous Access

For these guidelines, central venous access is defined as placement of a catheter such that the catheter is inserted into a venous great vessel. The venous great vessels include the superior vena cava, inferior vena cava, brachiocephalic veins, internal jugular veins, subclavian veins, iliac veins, and

common femoral veins.[†] Excluded are catheters that terminate in a systemic artery.

Purposes of the Guidelines

The purposes of these guidelines are to (1) provide guidance regarding placement and management of central venous catheters; (2) reduce infectious, mechanical, thrombotic, and other adverse outcomes associated with central venous catheterization; and (3) improve management of arterial trauma or injury arising from central venous catheterization.

Focus

These guidelines apply to patients undergoing elective central venous access procedures performed by anesthesiologists or healthcare professionals under the direction/supervision of anesthesiologists. The guidelines do not address (1) clinical indications for placement of central venous catheters; (2) emergency placement of central venous catheters; (3) patients with peripherally inserted central catheters; (4) placement and residence of a pulmonary artery catheter; (5) insertion of tunneled central lines (e.g., permacaths, portacaths, Hickman, Quinton); (6) methods of detection or treatment of infectious complications associated with central venous catheterization; (7) removal of central venous catheters[‡]; (8) diagnosis and management of central venous catheter-associated trauma or injury (e.g., pneumothorax or air embolism), with the exception of carotid arterial injury;

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A complete bibliography used to develop this updated Advisory, arranged alphabetically by author, is available as Supplemental Digital Content 1, <http://links.lww.com/ALN/C6>.

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†This description of the venous great vessels is consistent with the venous subset for central lines defined by the National Healthcare Safety Network.

‡Although catheter removal is not addressed by these guidelines (and is not typically performed by anesthesiologists), the risk of venous air embolism upon removal is a serious concern. Suggestions for minimizing such risk are those directed at raising central venous pressure during and immediately after catheter removal and following a defined nursing protocol. These suggestions include, but are not limited to, positioning the patient in the Trendelenburg position, using the Valsalva maneuver, applying direct pressure to the puncture site, using air-occlusive dressings, and monitoring the patient for a reasonable period of time after catheter removal.

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(9) management of periinsertion coagulopathy; and (10) competency assessment for central line insertion.

Application

These guidelines are intended for use by anesthesiologists and individuals under the supervision of an anesthesiologist. They also may serve as a resource for other physicians (*e.g.*, surgeons, radiologists), nurses, or healthcare providers who manage patients with central venous catheters.

Task Force Members

The original guidelines were developed by an ASA appointed task force of 12 members, consisting of anesthesiologists in private and academic practices from various geographic areas of the United States and two methodologists from the ASA Committee on Standards and Practice Parameters. In 2017, the ASA Committee on Standards and Practice Parameters requested that these guidelines be updated. This update is a revision developed by an ASA-appointed task force of seven members, including five anesthesiologists and two methodologists. Conflict-of-interest documentation regarding current or potential financial and other interests pertinent to the practice guideline were disclosed by all task force members and managed.

Process and Evaluation of Evidence

These updated guidelines were developed by means of a five-step process. First, consensus was reached on the criteria for evidence. Second, original published articles from peer-reviewed journals relevant to the perioperative management of central venous catheters were evaluated and added to literature included in the original guidelines. Third, consultants who had expertise or interest in central venous catheterization and who practiced or worked in various settings (*e.g.*, private and academic practice) were asked to participate in opinion surveys addressing the appropriateness, completeness, and feasibility of implementation of the draft recommendations and to review and comment on a draft of the guidelines. Fourth, additional opinions were solicited from random samples of active ASA members. Fifth, all available information was used to build consensus to finalize the guidelines. A summary of recommendations can be found in appendix 1.

Preparation of these updated guidelines followed a rigorous methodological process. Evidence was obtained from two principal sources: scientific evidence and opinion-based evidence. Detailed descriptions of the ASA process and methodology used in these guidelines may be found in other related publications.^{2–5} Appendix 1 contains a footnote indicating where information may be found on the evidence model, literature search process, literature findings, and survey results for these guidelines.

Within the text of these guidelines, literature classifications are reported for each intervention using the following:

Category A level 1, meta-analysis of randomized controlled trials (RCTs); Category A level 2, multiple RCTs; Category A level 3, a single RCT; Category B level 1, nonrandomized studies with group comparisons; Category B level 2, nonrandomized studies with associative findings; Category B level 3, nonrandomized studies with descriptive findings; and Category B level 4, case series or case reports. Statistically significant outcomes ($P < 0.01$) are designated as either beneficial (B) or harmful (H) for the patient; statistically nonsignificant findings are designated as equivocal (E). Survey findings from task force-appointed expert consultants and a random sample of the ASA membership are fully reported in the text of these guidelines. Survey responses for each recommendation are reported using a 5-point scale based on median values from strongly agree to strongly disagree.

Guidelines

Resource Preparation

Resource preparation topics include (1) assessing the physical environment where central venous catheterization is planned to determine the feasibility of using aseptic techniques; (2) availability of a standardized equipment set; (3) use of a checklist or protocol for central venous catheter placement and maintenance; and (4) use of an assistant for central venous catheterization.

Literature Findings. The literature is insufficient to evaluate the effect of the physical environment for aseptic catheter insertion, availability of a standardized equipment set, or the use of an assistant on outcomes associated with central venous catheterization. An observational study reports that implementation of a trauma intensive care unit multidisciplinary checklist is associated with reduced catheter-related infection rates (*Category B2-B evidence*).⁶ Observational studies report that central line-associated or catheter-related bloodstream infection rates are reduced when intensive care unit-wide bundled protocols are implemented^{7–36} (*Category B2-B evidence*); evidence from fewer observational studies is equivocal^{37–55} (*Category B2-E evidence*); other observational studies^{56–71} do not report levels of statistical significance or lacked sufficient data to calculate them. These studies do not permit assessing the effect of any single component of a checklist or bundled protocol on infection rates.

Survey Findings. The consultants and ASA members strongly agree with the recommendation to perform central venous catheterization in an environment that permits use of aseptic techniques and to ensure that a standardized equipment set is available for central venous access. The consultants strongly agree and ASA members agree with the recommendation to use a checklist or protocol for placement and maintenance of central venous catheters. The consultants and ASA members agree with the recommendation to use an assistant during placement of a central venous catheter.

Recommendations for Resource Preparation

- Perform central venous catheterization in an environment that permits use of aseptic techniques
- Ensure that a standardized equipment set is available for central venous access[§]
- Use a checklist or protocol for placement and maintenance of central venous catheters^{||}
- Use an assistant during placement of a central venous catheter[#]

Prevention of Infectious Complications

Interventions intended to prevent infectious complications associated with central venous access include, but are not limited to, (1) intravenous antibiotic prophylaxis; (2) aseptic preparation of practitioner, staff, and patients; (3) selection of antiseptic solution; (4) selection of catheters containing antimicrobial agents; (5) selection of catheter insertion site; (6) catheter fixation method; (7) insertion site dressings; (8) catheter maintenance procedures; and (9) aseptic techniques using an existing central venous catheter for injection or aspiration.

Intravenous Antibiotic Prophylaxis

Literature Findings. The literature is insufficient to evaluate outcomes associated with the routine use of intravenous prophylactic antibiotics.

Survey Findings. The consultants strongly agree and ASA members agree with the recommendation to not routinely administer intravenous antibiotic prophylaxis.

Aseptic Preparation of Practitioner, Staff, and Patients

Literature Findings. An RCT comparing maximal barrier precautions (*i.e.*, mask, cap, gloves, gown, large full-body drape) with a control group (*i.e.*, gloves and small drape) reports equivocal findings for reduced colonization and catheter-related septicemia (*Category A3-E evidence*).⁷² A majority of observational studies reporting or with calculable levels of statistical significance report that “bundles” of aseptic protocols (*e.g.*, combinations of hand washing, sterile full-body drapes, sterile gloves, caps, and masks) reduce the frequency of central line-associated or catheter-related bloodstream infections (*Category B2-B evidence*).^{7–36} These studies do not permit assessing the effect of any single component of a bundled protocol on infection rates.

Survey Findings. The consultants and ASA members strongly agree with the recommendation to use aseptic techniques (*e.g.*, hand washing) and maximal barrier precautions (*e.g.*, sterile gowns, sterile gloves, caps, masks covering both mouth and nose, and full-body patient drapes) in preparation for the placement of central venous catheters.

§Refer to appendix 2 for an example of a list of standardized equipment for adult patients.

||Refer to appendix 3 for an example of a checklist or protocol.

#Refer to appendix 4 for an example of a list of duties performed by an assistant.

Selection of Antiseptic Solution

Literature Findings. One RCT comparing chlorhexidine (2% aqueous solution without alcohol) with povidone-iodine (10% without alcohol) for skin preparation reports equivocal findings for catheter colonization and catheter-related bacteremia (*Category A3-E evidence*).⁷³ An RCT comparing chlorhexidine (2% with 70% isopropyl alcohol) with povidone-iodine (5% with 69% ethanol) with or without scrubbing finds lower rates of catheter colonization for chlorhexidine (*Category A3-B evidence*) and equivocal evidence for decreased catheter-related bloodstream infection (*Category A3-E evidence*).⁷⁴ A third RCT compared two chlorhexidine concentrations (0.5% or 1.0% in 79% ethanol) with povidone-iodine (10% without alcohol), reporting equivocal evidence for colonization (*Category A3-E evidence*) and catheter-related bloodstream infection (*Category A3-E evidence*).⁷⁵ A quasiexperimental study (secondary analysis of an RCT) reports a lower rate of catheter-related bloodstream infection with chlorhexidine (2% with 70% alcohol) than povidone-iodine (5% with 69% alcohol) (*Category B1-B evidence*).⁷⁶ The literature is insufficient to evaluate the safety of antiseptic solutions containing chlorhexidine in neonates, infants and children.**

Comparative studies are insufficient to evaluate the efficacy of chlorhexidine and alcohol compared with chlorhexidine without alcohol for skin preparation during central venous catheterization. An RCT of 5% povidone-iodine with 70% alcohol compared with 10% povidone-iodine alone indicates that catheter tip colonization is reduced with alcohol containing solutions (*Category A3-B evidence*); equivocal findings are reported for catheter-related bloodstream infection and clinical signs of infection (*Category A3-E evidence*).⁷⁷

Survey Findings. The consultants and ASA members strongly agree with the recommendation to use a chlorhexidine-containing solution for skin preparation in adults, infants, and children. For neonates, the consultants and ASA members agree with the recommendation to determine the use of chlorhexidine-containing solutions for skin preparation based on clinical judgment and institutional protocol. If there is a contraindication to chlorhexidine, the consultants strongly agree and ASA members agree with the recommendation that povidone-iodine or alcohol may be used. The consultants and ASA members agree with the recommendation to use skin preparation solutions containing alcohol unless contraindicated.

Catheters Containing Antimicrobial Agents

Literature Findings. Meta-analyses of RCTs comparing antibiotic-coated with uncoated catheters indicates that antibiotic-coated catheters are associated with reduced catheter colonization^{78–85} and catheter-related bloodstream infection (*Category A1-B evidence*).^{80,81,83,85,86} Meta-analyses of RCTs comparing silver or silver-platinum-carbon-impregnated

**See 2017 Food and Drug Administration warning on chlorhexidine allergy.

catheters with uncoated catheters yield equivocal findings for catheter colonization (*Category A1-E evidence*)^{87–97} but a decreased risk of catheter-related bloodstream infection (*Category A1-B evidence*).^{87–94,96–99} Meta-analyses of RCTs indicate that catheters coated with chlorhexidine and silver sulfadiazine reduce catheter colonization compared with uncoated catheters (*Category A1-B evidence*)^{83,95,100–118} but are equivocal for catheter-related bloodstream infection (*Category A1-E evidence*).^{83,100–102,104–110,112–117,119,120} Cases of anaphylactic shock are reported after placement of a catheter coated with chlorhexidine and silver sulfadiazine (*Category B4-H evidence*).^{121–129}

Survey Findings. The consultants and ASA members agree with the recommendation to use catheters coated with antibiotics or a combination of chlorhexidine and silver sulfadiazine based on infectious risk and anticipated duration of catheter use for selected patients. The consultants strongly agree and ASA members agree with the recommendation to not use catheters containing antimicrobial agents as a substitute for additional infection precautions.

Selection of Catheter Insertion Site

Literature Findings. RCTs comparing subclavian and femoral insertion sites report higher rates of catheter colonization at the femoral site (*Category A2-H evidence*); findings for catheter-related sepsis or catheter-related bloodstream infection are equivocal (*Category A2-E evidence*).^{130,131} An RCT finds a higher rate of catheter colonization for internal jugular compared with subclavian insertion (*Category A3-H evidence*) and for femoral compared with internal jugular insertion (*Category A3-H evidence*); evidence is equivocal for catheter-related bloodstream infection for either comparison (*Category A3-E evidence*).¹³¹ A nonrandomized comparative study of burn patients reports that catheter colonization and catheter-related bloodstream infection occur more frequently with an insertion site closer to the burn location (*Category B1-H evidence*).¹³²

Survey Findings. The consultants and ASA members strongly agree with the recommendations to (1) determine catheter insertion site selection based on clinical need; (2) select an insertion site that is not contaminated or potentially contaminated (*e.g.*, burned or infected skin, inguinal area, adjacent to tracheostomy, or open surgical wound); and (3) select an upper body insertion site when possible to minimize the risk of infection in adults.

Catheter Fixation

Literature Findings. The literature is insufficient to evaluate whether catheter fixation with sutures, staples, or tape is associated with a higher risk for catheter-related infections.

Survey Findings. The consultants strongly agree and ASA members agree with the recommendation to determine the use of sutures, staples, or tape for catheter fixation on a local or institutional basis. The consultants and ASA members both strongly agree with the recommendation to minimize the number of needle punctures of the skin.

Insertion Site Dressings

Literature Findings. The literature is insufficient to evaluate the efficacy of transparent bioocclusive dressings to reduce the risk of infection. Pooled estimates from RCTs are consistent with lower rates of catheter colonization with chlorhexidine sponge dressings compared with standard polyurethane (*Category A1-B evidence*)^{90,133–138} but equivocal for catheter-related bloodstream infection (*Category A1-E evidence*).^{90,133–140} An RCT reports a higher frequency of severe localized contact dermatitis in neonates with chlorhexidine-impregnated dressings compared with povidone-iodine-impregnated dressings (*Category A3-H evidence*)¹³³; findings concerning dermatitis from RCTs in adults are equivocal (*Category A2-E evidence*).^{90,134,136,137,141}

Survey Findings. The consultants and ASA members both strongly agree with the recommendations to use transparent bioocclusive dressings to protect the site of central venous catheter insertion from infection. The consultants and ASA members both agree with the recommendation that dressings containing chlorhexidine may be used in adults, infants, and children unless contraindicated. For neonates, the consultants and ASA members agree with the recommendation to determine the use of transparent or sponge dressings containing chlorhexidine based on clinical judgment and institutional protocol. If a chlorhexidine-containing dressing is used, the consultants and ASA members both strongly agree with the recommendation to observe the site daily for signs of irritation, allergy or, necrosis.

Catheter Maintenance

Catheter maintenance consists of (1) determining the optimal duration of catheterization, (2) conducting catheter site inspections, (3) periodically changing catheters, and (4) changing catheters using a guidewire instead of selecting a new insertion site.

Literature Findings. Nonrandomized comparative studies indicate that longer catheterization is associated with higher catheter colonization rates, infection, and sepsis (*Category B1-H evidence*).^{21,142–145} The literature is insufficient to evaluate whether time intervals between catheter site inspections are associated with the risk for catheter-related infection. RCTs report equivocal findings for catheter tip colonization when catheters are changed at 3-day *versus* 7-day intervals (*Category A2-E evidence*).^{146,147} RCTs report equivocal findings for catheter tip colonization when guidewires are used to change catheters compared with new insertion sites (*Category A2-E evidence*).^{148–150}

Survey Findings. The consultants and ASA members strongly agree with the following recommendations: (1) determine the duration of catheterization based on clinical need; (2) assess the clinical need for keeping the catheter in place on a daily basis; (3) remove catheters promptly when no longer deemed clinically necessary; (4) inspect the catheter insertion site daily for signs of infection; (5) change or

remove the catheter when catheter insertion site infection is suspected; and (6) when a catheter-related infection is suspected, replace the catheter using a new insertion site rather than changing the catheter over a guidewire.

Aseptic Techniques Using an Existing Central Venous Catheter for Injection or Aspiration

Aseptic techniques using an existing central venous catheter for injection or aspiration consist of (1) wiping the port with an appropriate antiseptic, (2) capping stopcocks or access ports, and (3) use of needleless catheter connectors or access ports.

Literature Findings. The literature is insufficient to evaluate whether cleaning ports or capping stopcocks when using an existing central venous catheter for injection or aspiration decreases the risk of catheter-related infections. RCTs comparing needleless connectors with standard caps indicate lower rates of microbial contamination of stopcock entry ports with needleless connectors (*Category A2-B evidence*),^{151–153} but findings for catheter-related bloodstream infection are equivocal (*Category A2-E evidence*).^{151,154}

Survey Findings. The consultants and ASA members strongly agree with the recommendations to wipe catheter access ports with an appropriate antiseptic (*e.g.*, alcohol) before each access when using an existing central venous catheter for injection or aspiration and to cap central venous catheter stopcocks or access ports when not in use. The consultants and ASA members agree that needleless catheter access ports may be used on a case-by-case basis

Recommendations for Prevention of Infectious Complications

Intravenous Antibiotic Prophylaxis

- Do not routinely administer intravenous antibiotic prophylaxis

Aseptic Preparation

- In preparation for the placement of central venous catheters, use aseptic techniques (*e.g.*, hand washing) and maximal barrier precautions (*e.g.*, sterile gowns, sterile gloves, caps, masks covering both mouth and nose, full-body patient drapes, and eye protection)

Selection of Antiseptic Solution

- Use a chlorhexidine-containing solution for skin preparation in adults, infants, and children
 - For neonates, determine the use of chlorhexidine-containing solutions for skin preparation based on clinical judgment and institutional protocol
- If there is a contraindication to chlorhexidine, povidone-iodine or alcohol may be used
- Unless contraindicated, use skin preparation solutions containing alcohol

Catheters Containing Antimicrobial Agents

- For selected patients, use catheters coated with antibiotics, a combination of chlorhexidine and silver sulfadiazine, or silver-platinum-carbon-impregnated catheters based on risk of infection and anticipated duration of catheter use
 - Do not use catheters containing antimicrobial agents as a substitute for additional infection precautions

Selection of Catheter Insertion Site

- Determine catheter insertion site selection based on clinical need
- Select an insertion site that is not contaminated or potentially contaminated (*e.g.*, burned or infected skin, inguinal area, adjacent to tracheostomy or open surgical wound)
- In adults, select an upper body insertion site when possible to minimize the risk of infection

Catheter Fixation

- Determine the use of sutures, staples, or tape for catheter fixation on a local or institutional basis
- Minimize the number of needle punctures of the skin

Insertion Site Dressings

- Use transparent bioocclusive dressings to protect the site of central venous catheter insertion from infection
- Unless contraindicated, dressings containing chlorhexidine may be used in adults, infants, and children
- For neonates, determine the use of transparent or sponge dressings containing chlorhexidine based on clinical judgment and institutional protocol
- If a chlorhexidine-containing dressing is used, observe the site daily for signs of irritation, allergy, or necrosis

Catheter Maintenance

- Determine the duration of catheterization based on clinical need
- Assess the clinical need for keeping the catheter in place on a daily basis
- Remove catheters promptly when no longer deemed clinically necessary
- Inspect the catheter insertion site daily for signs of infection
- Change or remove the catheter when catheter insertion site infection is suspected
- When a catheter-related infection is suspected, a new insertion site may be used for catheter replacement rather than changing the catheter over a guidewire

Aseptic Techniques Using an Existing Central Venous Catheter for Injection or Aspiration

- Clean catheter access ports with an appropriate antiseptic (*e.g.*, alcohol) before each access when using an existing central venous catheter for injection or aspiration

- Cap central venous catheter stopcocks or access ports when not in use
- Needleless catheter access ports may be used on a case-by-case basis

Prevention of Mechanical Trauma or Injury

Interventions intended to prevent mechanical trauma or injury associated with central venous access include but are not limited to (1) selection of catheter insertion site; (2) positioning the patient for needle insertion and catheter placement; (3) needle insertion, wire placement, and catheter placement; (4) guidance for needle, guidewire, and catheter placement, and (5) verification of needle, wire, and catheter placement.

Selection of Catheter Insertion Site

Literature Findings. RCTs comparing subclavian and femoral insertion sites report that the femoral site has a higher risk of thrombotic complications in adult patients (*Category A2-H evidence*)^{130,131}; one RCT¹³¹ concludes that thrombosis risk is higher with internal jugular than subclavian catheters (*Category A3-H evidence*), whereas for femoral *versus* internal jugular catheters, findings are equivocal (*Category A3-E evidence*). RCTs report equivocal findings for successful venipuncture when the internal jugular site is compared with the subclavian site (*Category A2-E evidence*).^{131,155,156} Equivocal findings are also reported for the femoral *versus* subclavian site (*Category A2-E evidence*),^{130,131} and the femoral *versus* internal jugular site (*Category A3-E evidence*).¹³¹ RCTs examining mechanical complications (primarily arterial injury, hematoma, and pneumothorax) report equivocal findings for the femoral *versus* subclavian site (*Category A2-E evidence*)^{130,131} as well as the internal jugular *versus* subclavian or femoral sites (*Category A3-E evidence*).¹³¹

Survey Findings. The consultants and ASA members strongly agree with the recommendation to determine catheter insertion site selection based on clinical need and practitioner judgment, experience, and skill. The consultants agree and ASA members strongly agree with the recommendations to select an upper body insertion site to minimize the risk of thrombotic complications relative to the femoral site.

Positioning the Patient for Needle Insertion and Catheter Placement

Literature Findings. Although observational studies report that Trendelenburg positioning (*i.e.*, head down from supine) increases the right internal jugular vein diameter or cross-sectional area in adult volunteers (*Category B2-B evidence*),^{157–161} findings are equivocal for studies enrolling adult patients (*Category B2-E evidence*).^{158,162–164} Observational studies comparing the Trendelenburg position and supine position in pediatric patients report increased right internal jugular vein diameter or cross-sectional area (*Category B2-B evidence*),^{165–167} and one observational study of newborns reported similar findings (*Category B2-B evidence*).¹⁶⁸ The

literature is insufficient to evaluate whether Trendelenburg positioning improves insertion success rates or decreases the risk of mechanical complications.

Survey Findings. The consultants and ASA members strongly agree with the recommendation to perform central venous access in the neck or chest with the patient in the Trendelenburg position when clinically appropriate and feasible.

Needle Insertion, Wire Placement, and Catheter Placement

Needle insertion, wire placement, and catheter placement includes (1) selection of catheter size and type; (2) use of a wire-through-thin-wall needle technique (*i.e.*, Seldinger technique) *versus* a catheter-over-the-needle-then-wire-through-the-catheter technique (*i.e.*, modified Seldinger technique); (3) limiting the number of insertion attempts; and (4) introducing two catheters in the same central vein.

Literature Findings. Case reports describe severe injury (*e.g.*, hemorrhage, hematoma, pseudoaneurysm, arteriovenous fistula, arterial dissection, neurologic injury including stroke, and severe or lethal airway obstruction) when unintentional arterial cannulation occurs with large-bore catheters (*Category B4-H evidence*).^{169–178}

An RCT comparing a thin-wall needle technique *versus* a catheter-over-the-needle for right internal jugular vein insertion in adults reports equivocal findings for first-attempt success rates and frequency of complications (*Category A3-E evidence*)¹⁷⁹; for right-sided subclavian insertion in adults an RCT reports first-attempt success more likely and fewer complications with a thin-wall needle technique (*Category A3-B evidence*).¹⁸⁰ One RCT reports equivocal findings for first-attempt success rates and frequency of complications when comparing a thin-wall needle with catheter-over-the-needle technique for internal jugular vein insertion (preferentially right) in neonates (*Category A3-E evidence*).¹⁸¹ Observational studies report a greater frequency of complications occurring with increasing number of insertion attempts (*Category B3-H evidence*).^{182–184} One nonrandomized comparative study reports a higher frequency of dysrhythmia when two central venous catheters are placed in the same vein (right internal jugular) compared with placement of one catheter in the vein (*Category B1-H evidence*); differences in carotid artery punctures or hematomas were not noted (*Category B1-E evidence*).¹⁸⁵

Survey Findings. The consultants and ASA members strongly agree with the recommendation to select catheter size (*i.e.*, outside diameter) and type based on the clinical situation and skill/experience of the operator. The consultants and ASA members agree with the recommendations to (1) select the smallest size catheter appropriate for the clinical situation; (2) select a thin-wall needle (*i.e.*, Seldinger) technique *versus* a catheter-over-the-needle (*i.e.*, modified Seldinger) technique for the subclavian approach; (3) select a thin-wall needle or catheter-over-the-needle technique for the jugular or femoral approach based on the clinical situation

and the skill/experience of the operator; and (4) base the decision to use a thin-wall needle technique or a catheter-over-the-needle technique at least in part on the method used to confirm that the wire resides in the vein before a dilator or large-bore catheter is threaded. The consultants agree and ASA members strongly agree that the number of insertion attempts should be based on clinical judgment and that the decision to place two catheters in a single vein should be made on a case-by-case basis.

Guidance for Needle, Wire, and Catheter Placement

Guidance for needle, wire, and catheter placement includes (1) real-time or dynamic ultrasound for vessel localization and guiding the needle to its intended venous location and (2) static ultrasound imaging for the purpose of prepuncture vessel localization.

Literature Findings. Meta-analyses of RCTs comparing real-time ultrasound-guided venipuncture of the internal jugular with an anatomical landmark approach report higher first insertion attempt success rates,^{186–197} higher overall success rates,^{186,187,189–192,194–204} lower rates of arterial puncture,^{186–188,190–201,203,205} and fewer insertion attempts (*Category A1-B evidence*).^{188,190,191,194–197,199,200,203–205} RCTs also indicate reduced access time or times to cannulation with ultrasound compared with a landmark approach (*Category A2-B evidence*).^{188,191,194–196,199,200,202–205}

For the subclavian vein, RCTs report fewer insertion attempts with real-time ultrasound-guided venipuncture (*Category A2-B evidence*),^{206,207} and higher overall success rates (*Category A2-B evidence*).^{206–208} When compared with a landmark approach, findings are equivocal for arterial puncture^{207,208} and hematoma (*Category A2-E evidence*).^{207,208} For the femoral vein, an RCT reports a higher first-attempt success rate and fewer needle passes with real-time ultrasound-guided venipuncture compared with the landmark approach in pediatric patients (*Category A3-B evidence*).²⁰⁹

Meta-analyses of RCTs comparing static ultrasound with a landmark approach yields equivocal evidence for improved overall success for internal jugular insertion (*Category A1-E evidence*),^{190,202,210–212} overall success irrespective of insertion site (*Category A1-E evidence*),^{182,190,202,210–212} or impact on arterial puncture rates (*Category A1-E evidence*).^{190,202,210–212} RCTs comparing static ultrasound with a landmark approach for locating the internal jugular vein report a higher first insertion attempt success rate with static ultrasound (*Category A3-B evidence*).^{190,212} The literature is equivocal regarding overall success for subclavian vein access (*Category A3-E evidence*)¹⁸² or femoral vein access when comparing static ultrasound to the landmark approach (*Category A3-E evidence*).²⁰²

Survey Findings. The consultants and ASA members strongly agree with the recommendation to use real-time ultrasound guidance for vessel localization and venipuncture when the internal jugular vein is selected for cannulation. The consultants and ASA members agree that when

feasible, real-time ultrasound may be used when the subclavian or femoral vein is selected. The consultants strongly agree and ASA members agree with the recommendation to use static ultrasound imaging before prepping and draping for prepuncture identification of anatomy to determine vessel localization and patency when the internal jugular vein is selected for cannulation. The consultants and ASA members agree that static ultrasound may also be used when the subclavian or femoral vein is selected.

Verification of Needle, Wire, and Catheter Placement

Verification of needle, wire, and catheter placement includes (1) confirming that the catheter or thin-wall needle resides in the vein, (2) confirming venous residence of the wire, and (3) confirming residence of the catheter in the venous system and final catheter tip position.^{††}

Literature Findings. A retrospective observational study reports that manometry can detect arterial punctures not identified by blood flow and color (*Category B3-B evidence*).²¹³ The literature is insufficient to address ultrasound, pressure-waveform analysis, blood gas analysis, blood color, or the absence of pulsatile flow as effective methods of confirming catheter or thin-wall needle venous access.

Two observational studies indicate that ultrasound can confirm venous placement of the wire before dilation or final catheterization (*Category B3-B evidence*).^{214,215} Observational studies also demonstrate that transthoracic ultrasound can confirm residence of the guidewire in the venous system (*Category B3-B evidence*).^{216–219} One observational study indicates that transesophageal echocardiography can be used to identify guidewire position (*Category B3-B evidence*),²²⁰ and case reports document similar findings (*Category B4-B evidence*).^{221,222}

Observational studies indicate that transthoracic ultrasound can confirm correct catheter tip position (*Category B2-B evidence*).^{216,217,223–240,††§§} Observational studies also indicate that fluoroscopy^{241,242} and chest radiography^{243,244} can identify the position of the catheter (*Category B2-B evidence*). RCTs comparing continuous electrocardiographic guidance for catheter placement with no electrocardiography indicate that continuous electrocardiography is more effective in identifying proper catheter tip placement (*Category A2-B evidence*).^{245–247} Case reports document unrecognized retained guidewires resulting in complications including embolization and fragmentation,²⁴⁸ infection,²⁴⁹ arrhythmia,²⁵⁰ cardiac perforation,²⁴⁸ stroke,²⁵¹ and migration through soft-tissue (*Category B-4H evidence*).²⁵²

††Verification methods for needle, wire, or catheter placement may include any one or more of the following: ultrasound, manometry, pressure-waveform analysis, venous blood gas, fluoroscopy, continuous electrocardiography, transesophageal echocardiography, and chest radiography.

†††Studies also report high specificities of transthoracic ultrasound for excluding the presence of a pneumothorax.^{216,218,219,227–229,232,233,236,238,240}

§§Chest radiography was used as a reference standard for these studies.

Survey Findings. The consultants and ASA members strongly agree with the recommendation to confirm venous access after insertion of a catheter that went over the needle or a thin-wall needle and with the recommendation to not rely on blood color or absence of pulsatile flow for confirming that the catheter or thin-wall needle resides in the vein. The consultants strongly agree and ASA members agree with the recommendation to confirm venous residence of the wire after the wire is threaded when using the thin-wall needle technique. The consultants are equivocal and ASA members agree that when using the catheter-over-the-

needle technique, confirmation that the wire resides in the vein may not be needed (1) if the catheter enters the vein easily and manometry or pressure-waveform measurement provides unambiguous confirmation of venous location of the catheter and (2) if the wire passes through the catheter and enters the vein without difficulty. The consultants and ASA members strongly agree with the recommendation to confirm venous residence of the wire after the wire is threaded if there is any uncertainty that the catheter or wire resides in the vein, and insertion of a dilator or large-bore catheter may then proceed. The consultants and ASA

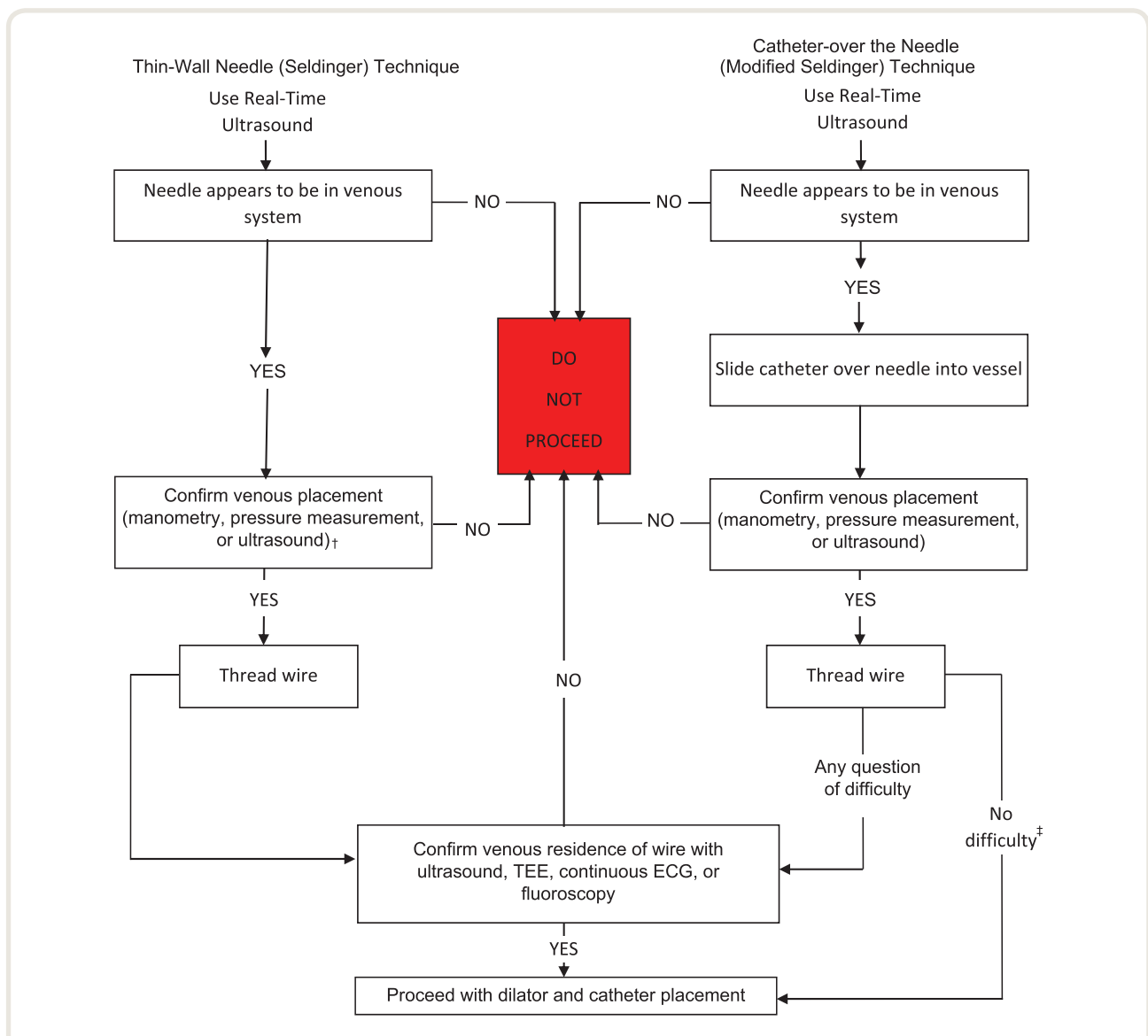


Fig. 1. Algorithm for central venous insertion and verification. This algorithm compares the thin-wall needle (*i.e.*, Seldinger) technique versus the catheter-over-the needle (*i.e.*, modified Seldinger) technique in critical safety steps to prevent unintentional arterial placement of a dilator or large-bore catheter. The variation between the two techniques reflects mitigation steps for the risk that the thin-wall needle in the Seldinger technique could move out of the vein and into the wall of an artery between the manometry step and the threading of the wire step. ECG, electrocardiography; TEE, transesophageal echocardiography. †For neonates, infants, and children, confirmation of venous placement may take place after the wire is threaded. ‡Consider confirming venous residence of the wire.

members strongly agree with the following recommendations: (1) after final catheterization and before use, confirm residence of the catheter in the venous system as soon as clinically appropriate; (2) confirm the final position of the catheter tip as soon as clinically appropriate; (3) for central venous catheters placed in the operating room, perform a chest radiograph no later than the early postoperative period to confirm the position of the catheter tip; (4) verify that the wire has not been retained in the vascular system at the end of the procedure by confirming the presence of the removed wire in the procedural field; and (5) if the complete guidewire is not found in the procedural field, order chest radiography to determine whether the guidewire has been retained in the patient's vascular system.

Recommendations for Prevention of Mechanical Trauma or Injury

Catheter Insertion Site Selection

- Determine catheter insertion site selection based on clinical need and practitioner judgment, experience, and skill
- Select an upper body insertion site when possible to minimize the risk of thrombotic complications relative to the femoral site

Positioning the Patient for Needle Insertion and Catheter Placement

- Perform central venous access in the neck or chest with the patient in the Trendelenburg position when clinically appropriate and feasible

Needle Insertion, Wire Placement, and Catheter Placement

- Select catheter size (*i.e.*, outside diameter) and type based on the clinical situation and skill/experience of the operator
- Select the smallest size catheter appropriate for the clinical situation
- For the subclavian approach select a thin-wall needle (*i.e.*, Seldinger) technique *versus* a catheter-over-the-needle (*i.e.*, modified Seldinger) technique
- For the jugular or femoral approach, select a thin-wall needle or catheter-over-the-needle technique based on the clinical situation and the skill/experience of the operator
- For accessing the vein before threading a dilator or large-bore catheter, base the decision to use a thin-wall needle technique or a catheter-over-the-needle technique at least in part on the method used to confirm that the wire resides in the vein (fig. 1)^{###}
- The number of insertion attempts should be based on clinical judgment
- The decision to place two catheters in a single vein should be made on a case-by-case basis

###The catheter over-the-needle technique may provide more stable venous access if manometry is used for venous confirmation.

Guidance of Needle, Wire, and Catheter Placement

- Use real-time ultrasound guidance for vessel localization and venipuncture when the internal jugular vein is selected for cannulation (see fig. 1)^{##}
 - When feasible, real-time ultrasound may be used when the subclavian or femoral vein is selected
- Use static ultrasound imaging before prepping and draping for prepuncture identification of anatomy to determine vessel localization and patency when the internal jugular vein is selected for cannulation
 - Static ultrasound may also be used when the subclavian or femoral vein is selected

Verification of Needle, Wire, and Catheter Placement

- After insertion of a catheter that went over the needle or a thin-wall needle, confirm venous access^{***}
 - Do not rely on blood color or absence of pulsatile flow for confirming that the catheter or thin-wall needle resides in the vein
- When using the thin-wall needle technique, confirm venous residence of the wire after the wire is threaded
 - When using the catheter-over-the-needle technique, confirmation that the wire resides in the vein may not be needed (1) when the catheter enters the vein easily and manometry or pressure-waveform measurement provides unambiguous confirmation of venous location of the catheter and (2) when the wire passes through the catheter and enters the vein without difficulty
 - If there is any uncertainty that the catheter or wire resides in the vein, confirm venous residence of the wire after the wire is threaded; insertion of a dilator or large-bore catheter may then proceed^{††}
- After final catheterization and before use, confirm residence of the catheter in the venous system as soon as clinically appropriate^{§§§}

##This approach may not be feasible in emergency circumstances or in the presence of other clinical constraints.

***For neonates, infants, and children, confirmation of venous placement may take place after the wire is threaded.

††Methods for confirming that the catheter or thin-wall needle resides in the vein include, but are not limited to, ultrasound, manometry, or pressure-waveform analysis measurement.

†††Methods for confirming that the wire resides in the vein include, but are not limited to, ultrasound (identification of the wire in the vein) or transesophageal echocardiography (identification of the wire in the superior vena cava or right atrium), continuous electrocardiography (identification of narrow-complex ectopy), or fluoroscopy.

§§§Methods for confirming that the catheter is still in the venous system after catheterization and before use include manometry, pressure-waveform measurement, or contrast-enhanced ultrasound.

- Confirm the final position of the catheter tip as soon as clinically appropriate^{||||}
 - For central venous catheters placed in the operating room, perform a chest radiograph no later than the early postoperative period to confirm the position of the catheter tip
- Verify that the wire has not been retained in the vascular system at the end of the procedure by confirming the presence of the removed wire in the procedural field
 - If the complete guidewire is not found in the procedural field, order chest radiography to determine whether the guidewire has been retained in the patient's vascular system

Management of Arterial Trauma or Injury Arising from Central Venous Catheterization

Literature Findings. Case reports of adult patients with arterial puncture by a large-bore catheter/vessel dilator during attempted central venous catheterization indicate severe complications (e.g., cerebral infarction, arteriovenous fistula, hemothorax) after immediate catheter removal (*Category B4-H evidence*)^{172,176,253}; complications are uncommonly reported for adult patients whose catheters were left in place before surgical consultation and repair (*Category B4-E evidence*).^{172,176,254}

Survey Findings. The consultants and ASA members strongly agree that when unintended cannulation of an arterial vessel with a dilator or large-bore catheter occurs, leave the dilator or catheter in place and immediately consult a general surgeon, a vascular surgeon, or an interventional radiologist regarding surgical or nonsurgical catheter removal for adults. The consultants and ASA members strongly agree that for neonates, infants, and children, determine on a case-by-case basis whether to leave the catheter in place and obtain consultation or to remove the catheter nonsurgically. The consultants strongly agree and ASA members agree with the recommendation that after the injury has been evaluated and a treatment plan has been executed, confer with the surgeon regarding relative risks and benefits of proceeding with the elective surgery *versus* deferring surgery to allow for a period of patient observation.

Recommendations for Management of Arterial Trauma or Injury Arising from Central Venous Access

- When unintended cannulation of an arterial vessel with a dilator or large-bore catheter occurs, leave the dilator or catheter in place and immediately consult a general surgeon, a vascular surgeon, or an interventional radiologist regarding surgical or nonsurgical catheter removal for adults

|||||Methods for confirming the position of the catheter tip include chest radiography, fluoroscopy, or point-of-care transthoracic echocardiography or continuous electrocardiography.

- For neonates, infants, and children, determine on a case-by-case basis whether to leave the catheter in place and obtain consultation or to remove the catheter nonsurgically
- After the injury has been evaluated and a treatment plan has been executed, confer with the surgeon regarding relative risks and benefits of proceeding with the elective surgery *versus* deferring surgery to allow for a period of patient observation

Appendix 1. Summary of Recommendations^{###}

Resource Preparation

- Perform central venous catheterization in an environment that permits use of aseptic techniques
- Ensure that a standardized equipment set is available for central venous access
- Use a checklist or protocol for placement and maintenance of central venous catheters
- Use an assistant during placement of a central venous catheter

Prevention of Infectious Complications

Intravenous Antibiotic Prophylaxis

- Do not routinely administer intravenous antibiotic prophylaxis

Aseptic Preparation

- In preparation for the placement of central venous catheters, use aseptic techniques (e.g., hand washing) and maximal barrier precautions (e.g., sterile gowns, sterile gloves, caps, masks covering both mouth and nose, full-body patient drapes, and eye protection)

Selection of Antiseptic Solution

- Use a chlorhexidine-containing solution for skin preparation in adults, infants, and children
 - For neonates, determine the use of chlorhexidine-containing solutions for skin preparation based on clinical judgment and institutional protocol
- If there is a contraindication to chlorhexidine, povidone-iodine or alcohol may be used
- Unless contraindicated, use skin preparation solutions containing alcohol

Catheters Containing Antimicrobial Agents

- For selected patients, use catheters coated with antibiotics, a combination of chlorhexidine and silver sulfadiazine, or silver-platinum-carbon-impregnated catheters based on risk of infection and anticipated duration of catheter use
 - Do not use catheters containing antimicrobial agents as a substitute for additional infection precautions

###Refer to appendix 5 for a summary of methods and analysis.

Selection of Catheter Insertion Site

- Determine catheter insertion site selection based on clinical need
- Select an insertion site that is not contaminated or potentially contaminated (*e.g.*, burned or infected skin, inguinal area, adjacent to tracheostomy or open surgical wound)
- In adults, select an upper body insertion site when possible to minimize the risk of infection

Catheter Fixation

- Determine the use of sutures, staples, or tape for catheter fixation on a local or institutional basis
- Minimize the number of needle punctures of the skin

Insertion Site Dressings

- Use transparent bioocclusive dressings to protect the site of central venous catheter insertion from infection
- Unless contraindicated, dressings containing chlorhexidine may be used in adults, infants, and children
- For neonates, determine the use of transparent or sponge dressings containing chlorhexidine based on clinical judgment and institutional protocol
- If a chlorhexidine-containing dressing is used, observe the site daily for signs of irritation, allergy or necrosis

Catheter Maintenance

- Determine the duration of catheterization based on clinical need
- Assess the clinical need for keeping the catheter in place on a daily basis
- Remove catheters promptly when no longer deemed clinically necessary
- Inspect the catheter insertion site daily for signs of infection
- Change or remove the catheter when catheter insertion site infection is suspected
- When a catheter-related infection is suspected, a new insertion site may be used for catheter replacement rather than changing the catheter over a guidewire

Aseptic Techniques Using an Existing Central Venous Catheter for Injection or Aspiration

- Clean catheter access ports with an appropriate antiseptic (*e.g.*, alcohol) before each access when using an existing central venous catheter for injection or aspiration
- Cap central venous catheter stopcocks or access ports when not in use
- Needleless catheter access ports may be used on a case-by-case basis

Prevention of Mechanical Trauma or Injury

Catheter Insertion Site Selection

- Determine catheter insertion site selection based on clinical need and practitioner judgment, experience, and skill
- Select an upper body insertion site when possible to minimize the risk of thrombotic complications relative to the femoral site

Positioning the Patient for Needle Insertion and Catheter Placement

- Perform central venous access in the neck or chest with the patient in the Trendelenburg position when clinically appropriate and feasible

Needle Insertion, Wire Placement, and Catheter Placement

- Select catheter size (*i.e.*, outside diameter) and type based on the clinical situation and skill/experience of the operator
- Select the smallest size catheter appropriate for the clinical situation
- For the subclavian approach select a thin-wall needle (*i.e.*, Seldinger) technique *versus* a catheter-over-the-needle (*i.e.*, modified Seldinger) technique
- For the jugular or femoral approach, select a thin-wall needle or catheter-over-the-needle technique based on the clinical situation and the skill/experience of the operator
- For accessing the vein before threading a dilator or large-bore catheter, base the decision to use a thin-wall needle technique or a catheter-over-the-needle technique at least in part on the method used to confirm that the wire resides in the vein (fig. 1)^{****}
- The number of insertion attempts should be based on clinical judgment
- The decision to place two catheters in a single vein should be made on a case-by-case basis

Guidance of Needle, Wire, and Catheter Placement

- Use real-time ultrasound guidance for vessel localization and venipuncture when the internal jugular vein is selected for cannulation (see fig. 1)^{†††}
 - When feasible, real-time ultrasound may be used when the subclavian or femoral vein is selected
- Use static ultrasound imaging before prepping and draping for prepuncture identification of anatomy to determine vessel localization and patency when the internal jugular vein is selected for cannulation
 - Static ultrasound may also be used when the subclavian or femoral vein is selected

****The catheter over-the-needle technique may provide more stable venous access if manometry is used for venous confirmation.

†††This approach may not be feasible in emergency circumstances or in the presence of other clinical constraints.

††††For neonates, infants, and children, confirmation of venous placement may take place after the wire is threaded.

Verification of Needle, Wire, and Catheter Placement

- After insertion of a catheter that went over the needle or a thin-wall needle, confirm venous access^{§§§§}
 - Do not rely on blood color or absence of pulsatile flow for confirming that the catheter or thin-wall needle resides in the vein
- When using the thin-wall needle technique, confirm venous residence of the wire after the wire is threaded
 - When using the catheter-over-the-needle technique, confirmation that the wire resides in the vein may not be needed (1) when the catheter enters the vein easily and manometry or pressure-waveform measurement provides unambiguous confirmation of venous location of the catheter and (2) when the wire passes through the catheter and enters the vein without difficulty
 - If there is any uncertainty that the catheter or wire resides in the vein, confirm venous residence of the wire after the wire is threaded; insertion of a dilator or large-bore catheter may then proceed^{||||}
- After final catheterization and before use, confirm residence of the catheter in the venous system as soon as clinically appropriate^{####}
- Confirm the final position of the catheter tip as soon as clinically appropriate^{****}
 - For central venous catheters placed in the operating room, perform a chest radiograph no later than the early postoperative period to confirm the position of the catheter tip
- Verify that the wire has not been retained in the vascular system at the end of the procedure by confirming the presence of the removed wire in the procedural field
 - If the complete guidewire is not found in the procedural field, order chest radiography to determine whether the guidewire has been retained in the patient's vascular system

§§§§Methods for confirming that the catheter or thin-wall needle resides in the vein include, but are not limited to, ultrasound, manometry, or pressure-waveform analysis measurement.

|||||Methods for confirming that the wire resides in the vein include, but are not limited to, ultrasound (identification of the wire in the vein) or transesophageal echocardiography (identification of the wire in the superior vena cava or right atrium), continuous electrocardiography (identification of narrow-complex ectopy), or fluoroscopy.

####Methods for confirming that the catheter is still in the venous system after catheterization and before use include manometry or pressure-waveform measurement.

****Methods for confirming the position of the catheter tip include chest radiography, fluoroscopy, or point-of-care transthoracic echocardiography or continuous electrocardiography.

Management of Arterial Trauma or Injury Arising from Central Venous Catheterization

- When unintended cannulation of an arterial vessel with a dilator or large-bore catheter occurs, leave the dilator or catheter in place and immediately consult a general surgeon, a vascular surgeon, or an interventional radiologist regarding surgical or nonsurgical catheter removal for adults
- For neonates, infants, and children, determine on a case-by-case basis whether to leave the catheter in place and obtain consultation or to remove the catheter nonsurgically
- After the injury has been evaluated and a treatment plan has been executed, confer with the surgeon regarding relative risks and benefits of proceeding with the elective surgery *versus* deferring surgery to allow for a period of patient observation

Appendix 2. Example of a Standardized Equipment Cart for Central Venous Catheterization for Adult Patients

Item Description	Quantity
First drawer	
Bottles of alcohol-based hand cleanser	2
Transparent bioocclusive dressings with catheter stabilizer devices	2
Transducer kit: NaCl 0.9% 500-ml bag; single line transducer, pressure bag	1
Needle holder, Webster disposable 5 inch	1
Scissors, 4-1/2 inch sterile	1
Vascular access tray (chloraprep, sponges, labels)	1
Disposable pen with sterile labels	4
Sterile tubing, arterial line pressure-rated (for manometry)	2
Intravenous connector with needleless valve	4
Second drawer	
Ultrasound probe cover, sterile 3 × 96	2
Applicator, chloraprep 10.5 ml	3
Surgical hair clipper blade	3
Solution, NaCl bacteriostatic 30 ml	2
Third drawer	
Surgical hats	6
Goggles	2
Mask, surgical fluid shield	2
Gloves, sterile sizes 6.0–8.0 (2 each size)	10
Packs, sterile gowns	2
Fourth drawer	
Drape, total body (with femoral window)	1
Sheet, central line total body (no window)	1
Fifth drawer	
Dressing, sterile sponge packages	4
Catheter kit, central venous pressure single lumen 14 gauge	1
Catheter kits, central venous pressure two lumens 16 cm 7 French	2
Sixth drawer	
Triple lumen central venous catheter sets, 7 French antimicrobial-impregnated	2
Introducer catheter sets, 9 French with side port	2

Appendix 3. Example of a Central Venous Catheterization Checklist

Central Line Insertion Standard Work & Safety (Bundle) Checklist for OR and CCU

Date: _____ Start Time: _____ End Time: _____

Procedure Operator: _____ Person Completing Form: _____

Catheter Type: Central Venous PA/Swan-Ganz™

French Size of catheter: _____ Catheter lot number: _____

Number of Lumens: 1 2 3 4

Insertion Site: Jugular Upper Arm Subclavian Femoral

Side of Body: Left Right Bilateral

Clinical Setting: Elective Emergent

BEFORE	1. Consent form complete and in chart Exception: Emergent procedure	<input type="checkbox"/>
	2. Patient's Allergy Assessed (especially to Lidocaine or Heparin)	<input type="checkbox"/>
	3. Patient's Latex Allergy Assessed (modify supplies)	<input type="checkbox"/>
	4. Hand Hygiene: <ul style="list-style-type: none"> Operator and assistant cleanse hands (ASK, if not witnessed) 	<input type="checkbox"/>
	5. Optimal Catheter Site Selection: <ul style="list-style-type: none"> In adults, consider upper body site Check / explain why femoral site used: _____ <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <input type="checkbox"/> <i>Anatomy – distorted, prior surgery/radiation. Scar</i> <input type="checkbox"/> <i>Coagulopathy</i> <input type="checkbox"/> <i>Emergency / CPR</i> </div> <div style="width: 45%;"> <input type="checkbox"/> <i>Chest wall infection or burn</i> <input type="checkbox"/> <i>COPD severe/ lung disease</i> <input type="checkbox"/> <i>Pediatric</i> </div> </div>	<input type="checkbox"/> <input type="checkbox"/> OR Exception(s) checked to left
	6. Pre-procedure Ultrasound Check of internal jugular location and patency if IJ	<input type="checkbox"/>
	7. Skin Prep Performed (Skin Antisepsis): <ul style="list-style-type: none"> Chloraprep 10.5 ml applicator used <u>Dry technique (normal, unbroken skin): 30 second scrub + 30 second dry time</u> <u>Wet technique (abnormal or broken skin): 2 minute scrub + 1 minute dry time</u> 	<input type="checkbox"/> <input type="checkbox"/> DRY <input type="checkbox"/> WET
	8. MAXIMUM Sterile Barriers: <ul style="list-style-type: none"> Operator wearing hat, mask, sterile gloves, and sterile gown Others in room wearing hats and masks, (except patient) Patient's body covered by sterile drape 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
	9. Procedural "Time out" Performed: <ul style="list-style-type: none"> Patient ID X 2 Procedure to be performed has been announced Insertion site marked Patient positioned correctly for procedure (Supine or Trendelenburg) Assembled equipment/ supplies including venous confirmation method verified Labels on all medication & syringes are verified 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
	10. Ultrasound Guidance Used for Elective Internal Jugular insertions (sterile probe cover in place)	<input type="checkbox"/> Used for IJ <input type="checkbox"/> Not used (Other site used)
	11. Confirmation of Venous Placement of Access Needle or Catheter: (do not rely on blood color or presence/absence of pulsatile flow for confirming that the catheter or thin-wall needle resides in the vein)	<input type="checkbox"/> Manometry <input type="checkbox"/> Ultrasound <input type="checkbox"/> Transducer

Appendix 3. Continued

DURING	12. Confirmation of Venous Placement of the Wire: <ul style="list-style-type: none"> • Access catheter easily in vein & confirmed (catheter-over needle technique) • Access <i>via</i> thin-wall needle (confirmation of wire recommended) <ul style="list-style-type: none"> • or ambiguous catheter or wire placement when using catheter-over-the-needle technique 	<input type="checkbox"/> Not Needed <input type="checkbox"/> Ultrasound <input type="checkbox"/> TEE <input type="checkbox"/> Fluoroscopy <input type="checkbox"/> ECG
	13. Confirmation of Final Catheter in Venous System Prior to Use:	<input type="checkbox"/> Manometry <input type="checkbox"/> Transducer <input type="checkbox"/> Contrast-enhanced ultrasound
	14. Final Steps: <ul style="list-style-type: none"> • Verify guidewire not retained • Type and Dosage (ml / units) of Flush: _____ • Catheter caps placed on lumens • Final catheter tip position confirmation: <ul style="list-style-type: none"> Fluoroscopy Continuous ECG Transthoracic ultrasound Chest radiograph ordered • Catheter Secured / Sutured in place 	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
	15. Transparent Bio-occlusive dressing applied	<input type="checkbox"/>
	16. Sterile Technique Maintained when applying dressing	<input type="checkbox"/>
	17. Dressing Dated	<input type="checkbox"/>
	18. After tip location confirmed, "Approved for use" Written on Dressing	<input type="checkbox"/>
	19. Central line (maintenance) Order Placed	<input type="checkbox"/>
	19. Central line (maintenance) Order Placed	<input type="checkbox"/>
AFTER		

Comments:**Tip location:**

COPD, chronic obstructive pulmonary disease; CPR, cardiopulmonary resuscitation; ECG, electrocardiography; IJ, internal jugular; PA, pulmonary artery; TEE, transesophageal echocardiography.

Appendix 4. Example Duties Performed by an Assistant for Central Venous Catheterization

Reads prompts on checklist to ensure that no safety step is forgotten or missed
 Completes checklist as task is completed
 Verbally alerts anesthesiologist if a potential error or mistake is about to be made
 Gathers equipment/supplies or brings standardized supply cart
 Brings the ultrasound machine, positions it, turns it on, makes adjustments as needed
 Provides moderate sedation (if registered nurse) if needed
 Participates in "time-out" before procedure
 Washes hands and wears mask, cap, and nonsterile gloves (scrubs or cover gown required if in the sterile envelope)
 Attends to patient requests if patient awake during procedure
 Assists with patient positioning
 Assists with draping
 Assists with sterile field setup; drops sterile items into field as needed
 Assists with sterile ultrasound sleeve application to ultrasound probe
 Assists with attachment of intravenous lines or pressure lines if needed
 Assists with application of a sterile bandage at the end of the procedure
 Assists with clean-up of patient, equipment, and supply cart; returns items to their proper location

Appendix 5: Methods and Analyses

For these updated guidelines, a systematic search and review of peer-reviewed published literature was conducted, with scientific findings summarized and reported below and in the document. Assessment of conceptual issues, practicality, and feasibility of the guideline recommendations was also evaluated, with opinion data collected from surveys and other sources. Both the systematic literature review and the opinion data are based on evidence linkages or statements regarding potential relationships between interventions and outcomes associated with central venous access. The evidence model below guided the search, providing inclusion and exclusion information regarding patients, procedures, practice settings, providers, clinical interventions, and outcomes. After review of all evidentiary information, the task force placed each recommendation into one of three categories: (1) provide the intervention or treatment, (2) the intervention or treatment may be provided to the patient based on circumstances of the case and the practitioner's clinical judgment, or (3) do not provide the intervention or treatment. The policy of the American Society of Anesthesiologists (ASA) Committee on Standards and

Practice Parameters is to update practice guidelines every 5 yr. The ASA Committee on Standards and Practice Parameters reviews all practice guidelines at the ASA annual meeting and determines update and revision timelines.

Evidence Model

Patients

- Inclusion criteria:
 - Adults
 - Children
 - Infants
 - Neonates
- Exclusion criteria:
 - None

Procedures

- Inclusion criteria:
 - Elective central venous access procedures
- Exclusion criteria:
 - Emergency central venous access procedures

Practice Settings

- Inclusion criteria:
 - Any setting where elective central venous access procedures are performed
- Exclusion criteria:
 - All other settings

Providers

- Inclusion criteria:
 - Anesthesia care providers
- Anesthesiologists
- Providers working under the direction of anesthesiologists
- Exclusion criteria:
 - Individuals who do not perform central venous catheterization

Interventions

- Inclusion criteria:
 - Resource preparation
 - Selection of a sterile environment (*e.g.*, operating room) for elective central venous catheterization
 - Availability of a standardized equipment set (*e.g.*, kit/cart/set of tools) for central venous catheterization
 - Use of a trained assistant for central venous catheterization

- Use of a checklist for central venous catheter placement and maintenance
- Prevention of infectious complications
 - Intravenous antibiotic prophylaxis
 - Aseptic techniques:
 - Aseptic preparation
 - Washing hands immediately before placement
 - Sterile full-body drapes
 - Sterile gown, gloves, mask, cap for the operators
 - Shaving hair *versus* clipping hair *versus* no hair removal
 - Remove rings, watches
 - Skin preparation solution
 - Chlorhexidine *versus* povidone-iodine
 - Skin preparation with *versus* without alcohol
 - Selection of catheter type
 - Antibiotic-coated catheters *versus* no coating
 - Silver-impregnated catheters *versus* no coating
 - Heparin-coated catheters *versus* no coating
 - Antibiotic-coated or silver-impregnated catheter cuffs
 - Selection of catheter insertion site
 - External jugular
 - Internal jugular
 - Subclavian
 - Femoral
 - Selecting an insertion site that is not contaminated or potentially contaminated (*e.g.*, burned or infected skin, a site adjacent to a tracheostomy site)
 - Catheter fixation
 - Suture *versus* staple
 - Suture *versus* tape
 - Staple *versus* tape
 - Sterile dressing type
 - Clear plastic
 - Chlorhexidine
 - Gauze and tape
 - Dermabond
 - Biopatch
 - Antibiotic ointment
 - Catheter maintenance:
 - Long-term *versus* short-term catheterization
 - Frequency of assessing the necessity of retaining access
 - Frequency of insertion site inspection for signs of infection
 - Time intervals for changing catheters
 - At specified time intervals *versus* no specified time intervals
 - One specified time interval *versus* another time interval
 - Changing a catheter site

- Changing over a wire *versus* a new catheter at a new site
 - Injecting or aspirating using an existing central venous catheter
 - Aseptic techniques (*e.g.*, wiping port with alcohol)
 - Not using stopcocks
 - Prevention of mechanical trauma or injury:
 - Selection of catheter insertion site
 - External jugular
 - Internal jugular
 - Subclavian
 - Femoral
 - Patient preparation for needle insertion and catheter placement
 - Awake *versus* anesthetized patient during insertion
 - Positive pressure (*i.e.*, mechanical) *versus* spontaneous ventilation during insertion
 - Patient position: Trendelenburg *versus* supine
 - Prepuncture identification of anatomy
 - Surface landmark inspection to identify target vein
 - Needle insertion and catheter placement
 - Catheter selection
 - Selection of catheter diameter
 - Selection of catheter composition (*e.g.*, polyvinyl chloride, polyethylene, Teflon)
 - Selection of catheter type (all types will be compared with each other)
 - Single lumen
 - Double lumen
 - Triple lumen
 - Cordis (side arm introducer sheath)
 - Use of a finder (seeker) needle *versus* no seeker needle (*e.g.*, a wider-gauge access needle)
 - Use of a thin-wall needle *versus* a cannula over a needle before insertion of a wire for the Seldinger technique
 - Placement of two lines in the same vein
 - Limiting number of insertion attempts
 - Use of a vessel dilator
 - Monitoring for needle, wire, and catheter placement
 - Ultrasound (including audio-guided Doppler ultrasound)
 - Prepuncture identification of insertion site *versus* no ultrasound
 - Guidance during needle puncture and placement *versus* no ultrasound
 - Confirmation of venous insertion of needle
 - Confirmation of venous placement of wire
 - Confirmation of catheter tip location
- Identification of free aspiration of dark (PO₂) nonpulsatile blood
 - Confirmation of venous placement of catheter
- Venous blood gas
 - Confirmation of venous placement of catheter
- Manometry *versus* direct pressure measurement (*via* pressure transducer)
 - Confirmation of venous placement of catheter
- Continuous EKG
 - Confirmation of wire placement
 - Confirmation of catheter tip location
- Fluoroscopy
 - Confirmation of venous placement of wire
 - Confirmation of catheter tip location
- X-rays
 - Confirmation of catheter tip location
 - Timing of x-ray immediately after placement *versus* postop
- Real-time transthoracic echocardiography
- Management of trauma or injury arising from central venous catheterization:
 - Management of arterial cannulation, arterial injury, or cerebral embolization
 - Pulling out a catheter from the carotid artery *versus* the subclavian artery
 - Immediate removal *versus* retaining catheter until a vascular surgery consult is obtained
 - Management of catheter or wire shearing or loss
 - Interventional radiology consultation
 - Management of hemo/pneumothorax; retroperitoneal bleeding after femoral catheterization
 - Volume replacement
 - Chest tube
 - Serial hematocrit measurement
 - Management of tamponade
 - Fluid resuscitation
 - Pericardiocentesis
 - Surgical consultation
 - Management of wire knot, wire, or catheter that will not come out
 - Interventional radiology consultation
 - Management of tracheal injury
 - Thoracic surgery consultation
 - ENT consultation
 - Management of air embolism
 - Aspiration
 - Vasoactive medication

- Volume therapy
 - Hyperbaric therapy
 - Management of phrenic nerve injury
 - Neurology consultation
 - Management of neck hematoma
 - Airway protection
 - Management of thromboembolism during removal
 - Anticoagulation
 - Vascular surgery consultation
 - Neurosurgery surgery consultation
 - Exclusion criteria:
 - Arterial (pulmonary artery) catheters
 - Floatation and residence (*i.e.*, maintenance) issues of a pulmonary artery catheter
 - Central venous catheters *versus* other methods of assessing volume status or presence of tamponade/pericarditis (*e.g.*, pulse pressure variability and echo)
 - Clinical indications for placement of central venous catheters
 - Detection and treatment of infectious complications
 - Dialysis catheters
 - Education, training, and certification of providers
 - Monitoring central line pressure waveforms and pressures
 - Nursing care
 - Pacing catheters
 - Peripheral IV insertion and care
 - Peripherally inserted percutaneous intravenous central catheter (PICC line) placement for long-term use (*e.g.*, chemotherapy regimens, antibiotic therapy, total parenteral nutrition, chronic vasoactive agent administration, *etc.*)
 - Tunneled catheters (*e.g.*, Hickman, Quinton, permacaths, portacaths)
 - Infections
 - Lacerations of great vessels
 - Catheter colonization
 - Mortality
 - Number of attempts at central line placement
 - Patient satisfaction
 - Pneumothorax
 - Procedural efficiency
 - Sepsis
 - Stroke
 - Successful, nontraumatic procedure
 - Time required for placement of central venous catheters
 - Venous and arterial air embolism
 - Wire, needle, catheter injury
- Exclusion criteria:
 - Infections or other complications not associated with central venous catheterization
 - Mechanical injury or trauma not associated with central venous catheterization

Evidence Collection

Outcomes

- Inclusion criteria:
 - Arterial cannulation/injury/cerebral embolization/hemorrhage
 - Catheter or wire shearing or loss
 - Hemo/pneumothorax; peritoneal hemorrhage
 - Tamponade
 - Wire, knot, inability to remove the catheter
 - Tracheal injury
 - Air embolism
 - Phrenic nerve injury
 - Bloodstream infections
 - Exsanguination
 - Failed insertion attempts
 - Heart puncture (tamponade)
 - Hemothorax
 - Hospital costs
 - Hospital, intensive care unit length of stay
- Literature inclusion criteria:
 - Randomized controlled trials (RCTs)
 - Prospective nonrandomized comparative studies (*e.g.*, quasiexperimental, cohort)
 - Retrospective comparative studies (*e.g.*, case-control)
 - Observational studies (*e.g.*, correlational or descriptive statistics)
 - Case reports, case series
- Literature exclusion criteria (except to obtain new citations):
 - Editorials
 - Literature reviews
 - Meta-analyses conducted by others
 - Unpublished studies
 - Studies in non-peer-reviewed journals
 - Newspaper articles
- Survey evidence:
 - Expert consultant survey
 - ASA membership survey
 - Other participating organization surveys
 - Reliability survey
 - Feasibility survey

State of the Literature. For the systematic review, potentially relevant clinical studies were identified *via* electronic and manual searches. Bibliographic database searches included PubMed and EMBASE. The searches covered an 8.3-yr period from January 1, 2011, through April 30, 2019. Citation searching (backward and forward) of relevant meta-analyses and other systematic reviews was also performed; pre-2011 studies relevant to meta-analyses or use of ultrasound were

eligible for inclusion. No search for gray literature was conducted. Publications identified by task force members were also considered. Accepted studies from the previous guidelines were also rereviewed, covering the period of January 1, 1971, through June 31, 2011. Only studies containing original findings from peer-reviewed journals were acceptable. Editorials, letters, and other articles without data were excluded. A literature search strategy and PRISMA* flow diagram are available as Supplemental Digital Content 2 (<http://links.lww.com/ALN/C7>). In total, 4,491 unique new citations were identified, with 1,013 full articles assessed for eligibility. After review, 729 were excluded, with 284 new studies meeting inclusion criteria. These studies were combined with 258 pre-2011 articles from the previous guidelines, resulting in a total of 542 articles accepted as evidence for these guidelines. In this document, 249 are referenced, with a complete bibliography of articles used to develop these guidelines, organized by section, available as Supplemental Digital Content 3 (<http://links.lww.com/ALN/C8>).

Each pertinent outcome reported in a study was classified by evidence category and level and designated as beneficial, harmful, or equivocal. Findings were then summarized for each evidence linkage and reported in the text of the updated Guideline, with summary evidence tables available as Supplemental Digital Content 4 (<http://links.lww.com/ALN/C9>).

Evidence categories refer specifically to the strength and quality of the research design of the studies. Category A evidence represents results obtained from RCTs, and category B evidence represents observational results obtained from nonrandomized study designs or RCTs without pertinent comparison groups. When available, category A evidence is given precedence over category B evidence for any particular outcome. These evidence categories are further divided into evidence levels. Evidence levels refer specifically to the strength and quality of the summarized study findings (*i.e.*, statistical findings, type of data, and the number of studies reporting/replicating the findings). In this document, only the highest level of evidence is included in the summary report for each intervention—outcome pair, including a directional designation of benefit, harm, or equivocality.

Category A: RCTs report comparative findings between clinical interventions for specified outcomes. Statistically significant ($P < 0.01$) outcomes are designated as either beneficial (B) or harmful (H) for the patient; statistically nonsignificant findings are designated as equivocal (E).

Level 1: The literature contains a sufficient number of RCTs to conduct meta-analysis,^{††††} and meta-analytic findings from these aggregated studies are reported as evidence.

Level 2: The literature contains multiple RCTs, but the number of RCTs is not sufficient to conduct a viable meta-analysis for the purpose of these Guidelines. Findings from these RCTs are reported separately as evidence.

Level 3: The literature contains a single RCT, and findings from this study are reported as evidence.

Category B: Observational studies or RCTs without pertinent comparison groups may permit inference of beneficial or harmful relationships among clinical interventions and clinical outcomes. Inferred findings are given a directional designation of beneficial (B), harmful (H), or equivocal (E). For studies that report statistical findings, the threshold for significance is $P < 0.01$.

Level 1: The literature contains nonrandomized comparisons (*e.g.*, quasiexperimental, cohort [prospective or retrospective], or case-control research designs) with comparative statistics between clinical interventions for a specified clinical outcome.

Level 2: The literature contains noncomparative observational studies with associative statistics (*e.g.*, correlation, sensitivity, and specificity).

Level 3: The literature contains noncomparative observational studies with descriptive statistics (*e.g.*, frequencies, percentages).

Level 4: The literature contains case reports.

Insufficient Literature. The lack of sufficient scientific evidence in the literature may occur when the evidence is either unavailable (*i.e.*, no pertinent studies found) or inadequate. Inadequate literature cannot be used to assess relationships among clinical interventions and outcomes because a clear interpretation of findings is not obtained due to methodological concerns (*e.g.*, confounding of study design or implementation) or the study does not meet the criteria for content as defined in the “Focus” of the guidelines.

The literature relating to seven evidence linkages contained enough studies with well defined experimental designs and statistical information to conduct formal meta-analyses (table 1). These seven evidence linkages are: (1) antimicrobial catheters, (2) silver impregnated catheters, (3) chlorhexidine and silver-sulfadiazine catheters, (4) dressings containing chlorhexidine, and (5) ultrasound guidance for venipuncture. For meta-analyses of antimicrobial, silver, or silver-sulfadiazine catheters studies reported actual event rates and odds ratios were pooled. Because not all studies of dressings reported event rates, relative risks or hazard ratios (recognizing they approximate relative risks) were pooled. Ultrasound guidance outcomes were pooled using risk or mean differences (continuous outcomes) for clinical relevance. Fixed-effects models were fitted using Mantel-Haenszel or inverse variance weighting as appropriate. Random-effects models were fitted with inverse variance weighting using the DerSimonian and Laird estimate of between-study variance. Small study effects

††††All meta-analyses are conducted by the ASA methodology group. Meta-analyses from other sources are reviewed but not included as evidence in this document. A minimum of five independent RCTs (*i.e.*, sufficient for fitting a random-effects model²⁵⁹) is required for meta-analysis.

(including potential publication bias) were explored by examining forest and funnel plots, regression tests, trim-and-fill results, and limit meta-analysis. Sensitivity to effect measure was also examined. Heterogeneity was quantified with I^2 and prediction intervals estimated (see table 1). Analyses were conducted in R version 3.5.3²⁵⁶ using the Meta²⁵⁷ and Metasens²⁵⁸ packages. A significance level of $P < 0.01$ was applied for analyses.

Although interobserver agreement among task force members and two methodologists was not assessed for this update, the original guidelines reported agreement levels using a κ statistic for two-rater agreement pairs as follows: (1) research design, $\kappa = 0.70$ to 1.00 ; (2) type of analysis, $\kappa = 0.60$ to 0.84 ; (3) evidence linkage assignment, $\kappa = 0.91$ to 1.00 ; and (4) literature inclusion for database, $\kappa = 0.28$ to 1.00 . Three-rater κ values between two methodologists and task force reviewers were: (1) research design, $\kappa = 0.70$; (2) type of analysis, $\kappa = 0.68$; (3) linkage assignment, $\kappa = 0.79$; and (4) literature database inclusion, $\kappa = 0.65$. These values represented moderate to high levels of agreement.

Consensus-based Evidence

Validation of the concepts addressed by these guidelines and subsequent recommendations proposed was obtained by consensus from multiple sources, including: (1) survey opinion from consultants^{####} who were selected based on their knowledge or expertise in central venous access (2) survey opinions from a randomly selected sample of active members of the ASA; (3) testimony from attendees of publicly held open forums for the original guidelines at a national anesthesia meeting^{#####}; and (4) internet commentary. All opinion-based evidence relevant to each topic was considered in the development of these guidelines. However, only findings obtained from formal surveys are reported in the document. Opinion surveys were developed by the task force to address each clinical intervention identified in the document. Identical surveys were distributed to expert consultants and a random sample of members of the participating organizations.

Survey responses were recorded using a 5-point scale and summarized based on median values.^{#####}

Strongly agree: Median score of 5 (at least 50% of the responses are 5)

Agree: Median score of 4 (at least 50% of the responses are 4 or 4 and 5)

Consultants were drawn from the following specialties where central venous access is a concern: anesthesiology (97% of respondents) and critical care (3% of respondents).

Society for Pediatric Anesthesia Winter Meeting, April 17, 2010, San Antonio, Texas; Society of Cardiovascular Anesthesia 32nd Annual Meeting, April 25, 2010, New Orleans, Louisiana; and International Anesthesia Research Society Annual Meeting, May 22, 2011, Vancouver, British Columbia, Canada.

When an equal number of categorically distinct responses are obtained, the median value is determined by calculating the arithmetic mean of the two middle values. Ties are calculated by a predetermined formula.

Equivocal: Median score of 3 (at least 50% of the responses are 3, or no other response category or combination of similar categories contain at least 50% of the responses)

Disagree: Median score of 2 (at least 50% of responses are 2 or 1 and 2)

Strongly disagree: Median score of 1 (at least 50% of responses are 1)

The rate of return for the survey addressing guideline recommendations was 37% ($n = 40$ of 109) for consultants. For membership respondents, the survey rate of return was 8% ($n = 393$ of $5,000$) members. The results of the surveys are reported in tables 2 and 3 and are summarized in the text of the guidelines.^{#####}

An additional survey was sent to the consultants accompanied by a draft of the guidelines asking them to indicate which, if any, of the recommendations would change their clinical practices if the guidelines were instituted. The rate of return was 17.4% ($n = 19$ of 109). The percentage of responding consultants expecting *no change* associated with each linkage were as follows: (1) resource preparation (environment with aseptic techniques, standardized equipment set) = 89.5%; (2) use of a trained assistant = 100%; (3) use of a checklist or protocol for placement and maintenance = 89.5%; (4) aseptic preparation (hand washing, sterile full-body drapes, etc.) = 100%; (5) selection of antiseptic solution for skin preparation = 100%; (6) catheters with antibiotic or antiseptic coatings/impregnation = 68.5%; (7) catheter insertion site selection (for prevention of infectious complications) = 100%; (8) catheter fixation methods (sutures, staples, tape) = 100%; (9) insertion site dressings = 100%; (10) catheter maintenance (insertion site inspection, changing catheters) = 100%; (11) aseptic techniques using an existing central line for injection or aspiration = 100%; (12) selection of catheter insertion site (for prevention of mechanical trauma) = 100%; (13) positioning the patient for needle insertion and catheter placement = 100%; (14) needle insertion, wire placement, and catheter placement (catheter size, type) = 100%; (15) guiding needle, wire, and catheter placement (ultrasound) = 100%; (16) verifying needle, wire, and catheter placement = 100%; (17) confirmation of final catheter tip location = 89.5%; and (18) management of trauma or injury arising from central venous catheterization = 100%.

Of the respondents, 82% indicated that the guidelines would have no effect on the amount of time spent on a typical case, and 17.6% indicated that there would be an increase of the amount of time spent on a typical case with the implementation of these guidelines. No respondents indicated that new equipment, supplies, or training would not be needed to implement the guidelines, and 88.9% indicated that implementation of the guidelines would not require changes in practice that would affect costs.

To view a bar chart with the above findings, refer to Supplemental Digital Content 5 (<http://links.lww.com/ALN/C10>).

Table 1. Meta-analysis Summary

Evidence Linkages*	Studies†	Patients	Effect				Heterogeneity	
			Fixed	P	Random	P	I ²	P [‡]
Impregnated versus uncoated catheters								
Colonization								
Odds Ratio (99% CI) [§]								
Antibiotic ^{78–85}	8	1,262	0.27 (0.18 to 0.40)	< 0.001	0.27 (0.15 to 0.46)	< 0.001	29%	0.20
Chlorhexidine silver sulfadiazine ^{83,95,100–118}	21	4,819	0.50 (0.41 to 0.61)	< 0.001	0.49 (0.37 to 0.65)	< 0.001	46%	0.013
Silver or silver-platinum-carbon ^{87–97}	11	3,091	0.98 (0.79 to 1.23)	0.85	0.98 (0.79 to 1.23)	0.85	0%	0.48
Catheter-related bloodstream infection								
Antibiotic ^{72,80,83,85,86}	5	1,921	0.29 (0.12 to 0.74)	< 0.001	0.33 (0.13 to 0.85)	0.003	0%	0.68
Chlorhexidine silver sulfadiazine ^{83,100–102,104–110,112–117,119,120}	19	4,931	0.69 (0.48 to 1.00)	0.01	0.69 (0.44 to 1.08)	0.032	18%	0.23
Silver or silver-platinum-carbon ^{87–94,96–99}	12	3,276	0.59 (0.38 to 0.92)	0.002	0.59 (0.37 to 0.94)	0.003	0%	0.66
Chlorhexidine versus conventional dressing								
Relative Risk (99% CI)								
Colonization ^{90–133}	7	4,786	0.47 (0.38 to 0.59)	< 0.001	0.53 (0.35 to 0.81)	< 0.001	57%	0.031
Bloodstream infection ^{90,133–140}	9	6,000	0.61 (0.39 to 0.95)	0.005	0.62 (0.35 to 1.09)	0.03	26%	0.21
Real-time ultrasound versus landmark (internal jugular)								
Risk Difference (99% CI)								
Overall success ^{186,187,189–192,194–204}	17	3,488	8.6% (6.6% to 10.5%)	< 0.001	10.0% (4.8% to 15.1%) ^{††}	< 0.001	85%	0.001
First attempt success ^{186–197}	12	2,096	30.7% (25.9% to 35.5%)	< 0.001	30.1% (18.5% to 41.6%)	< 0.001	80%	< 0.001
Arterial puncture ^{186–188,190–201,203,205}	17	3,678	–0.7.0% (0.89% to –0.5%)	< 0.001	–6.9% (–9.9% to –3.9%)	< 0.001	49%	0.012
Mean Difference (99% CI)								
Mean attempts ^{188,190,191,194–197,199,200,203–205}	12	3,123	–0.85 (–0.94 to –0.77)	< 0.001	0.70 (0.47 to 1.02)	< 0.001	29%	< 0.001
Static ultrasound versus landmark								
Risk Difference (99% CI)								
Internal jugular/subclavian/femoral								
Overall success ^{182,190,202,210–212}	6	1,439	3.1% (–1.3% to 7.6%)	0.067	5.3% (–1.8% to 12.5%)	0.053	54%	0.054
Arterial puncture ^{190,202,210–212}	5	618	–2.4% (–7.8% to 2.9%)	0.24	–2.5% (–11.0% to 6.1%)	0.46	56%	0.057
Internal jugular								
Overall success ^{190,202,210–212}	5	592	7.4% (0.7% to 14.1%)	0.005	7.7% (–2.0% to 17.3%)	0.041	51%	0.085

*Evidence linkage with references for included studies. †Number of studies included in the meta-analysis. ‡Statistical significance values for heterogeneity of effect size; a *P* value of <0.01 indicates that the studies are significantly heterogeneous. §Continuity correction of 0.5 for zero cell frequencies. ||Small study effects (potential for publication bias).

Table 2. Expert Consultant Survey Results

Recommendations	N	Strongly Agree, Agree, Equivocal, Disagree, Strongly Disagree, %				
		Strongly Agree, %	Agree, %	Equivocal, %	Disagree, %	Strongly Disagree, %
Resource preparation						
1. Perform central venous catheterization in an environment that permits use of aseptic techniques	40	95*	5	0	0	0
2. Ensure that a standardized equipment set is available for central venous access	39	77*	18	5	0	0
3. Use a checklist or protocol for placement and maintenance of central venous catheters	38	60*	26	8	5	0
4. Use an assistant during placement of a central venous catheter	40	42	28*	23	8	0
Prevention of infections complications						
Intravenous antibiotic prophylaxis						
5. For immunocompromised patients and high-risk neonates, administer intravenous antibiotic prophylaxis on a case-by-case basis	40	12	30	40*	18	0
6. Do not routinely administer intravenous antibiotic prophylaxis	40	55*	38	8	0	0
Aseptic preparation						
7. In preparation for the placement of central venous catheters, use aseptic techniques (e.g., hand washing) and maximal barrier precautions (e.g., sterile gowns, sterile gloves, caps, masks covering both mouth and nose, and full-body patient drapes)	39	74*	21	3	3	0
Selection of antiseptic solution						
8. Use a chlorhexidine-containing solution for skin preparation in adults, infants, and children	39	85*	15	0	0	0
9. For neonates, determine the use of chlorhexidine-containing solutions for skin preparation based on clinical judgment and institutional protocol	38	42	40*	18	0	0
10. If there is a contraindication to chlorhexidine, povidone-iodine or alcohol may be used	39	59*	36	5	0	0
11. Unless contraindicated, use skin preparation solutions containing alcohol	39	28	39*	23	10	0
Catheters containing antimicrobial agents						
12. For selected patients, use catheters coated with antibiotics or a combination of chlorhexidine and silver sulfadiazine based on infectious risk, cost, and anticipated duration of catheter use	38	29	40*	24	8	0
13. Do not use catheters containing antimicrobial agents as a substitute for additional infection precautions	38	63*	18	16	3	0

(Continued)

Table 2. (Continued)

Recommendations	N	Strongly	Agree,	Equivocal,	Disagree,	Strongly
		Agree,	%	%	%	Disagree,
		%	%	%	%	%
14. Determine catheter insertion site selection based on clinical need	38	71*	29	0	0	0
15. Select an insertion site that is not contaminated or potentially contaminated (e.g., burned or infected skin, inguinal area, adjacent to tracheostomy or open surgical wound)	38	82*	16	3	0	0
16. To minimize the risk of infection in adults, select an upper body insertion site when possible	38	76*	21	3	0	0
Catheter fixation						
17. Determine the use of sutures, staples, or tape for catheter fixation on a local or institutional basis	38	47*	32	8	13	0
18. Minimize the number of needle punctures of the skin	38	61*	32	8	0	0
Insertion site dressings						
19. Use transparent bioocclusive dressings to protect the site of central venous catheter insertion from infection	38	71*	29	0	0	0
20. Unless contraindicated, dressings containing chlorhexidine may be used in adults, infants, and children	38	45	37*	18	0	0
21. For neonates, determine the use of transparent or sponge dressings containing chlorhexidine based on clinical judgment and institutional protocol	38	37	47*	13	3	0
22. If a chlorhexidine-containing dressing is used, observe the site daily for signs of irritation, allergy, or necrosis	38	66*	26	8	0	0
Catheter maintenance						
23. Determine the duration of catheterization based on clinical need	38	79*	21	0	0	0
24. Assess the clinical need for keeping the catheter in place on a daily basis	38	87*	13	0	0	0
25. Remove catheters promptly when no longer deemed clinically necessary	38	90*	11	0	0	0
26. Inspect the catheter insertion site daily for signs of infection	38	92*	8	0	0	0
27. Change or remove the catheter when catheter insertion site infection is suspected	38	66*	32	0	3	0
28. When a catheter-related infection is suspected, replace the catheter using a new insertion site rather than changing the catheter over a guidewire	38	61*	34	3	3	0
Aseptic techniques using an existing central venous catheter for injection or aspiration						
29. Wipe catheter access ports with an appropriate antiseptic (e.g., alcohol) before each access when using an existing central venous catheter for injection or aspiration	38	90*	8	3	0	0
30. Cap central venous catheter stopcocks or access ports when not in use	38	79*	18	3	0	0
31. Needleless catheter access ports may be used on a case-by-case basis	38	24	53*	13	11	0
Prevention of mechanical trauma or injury						
Catheter insertion site selection						
32. Determine catheter insertion site selection based on clinical need and practitioner judgment, experience, and skill	38	68*	26	3	3	0
33. Selection of an upper body insertion site may minimize the risk of thrombotic complications relative to the femoral site	38	21	47*	26	5	0
Positioning the patient for needle insertion and catheter placement						
34. When clinically appropriate and feasible, perform central venous access in the neck or chest with the patient in the Trendelenburg position	38	53*	34	11	3	0
Needle insertion, wire placement, and catheter placement						
35. Select catheter size (i.e., outside diameter) and type based on the clinical situation and skill/experience of the operator	38	63*	32	5	0	0
36. Select the smallest size catheter appropriate for the clinical situation	38	40	42*	18	0	0
37. For the subclavian approach select a thin-wall needle (i.e., Seldinger) technique versus a catheter-over-the-needle (i.e., modified Seldinger) technique	38	32	50*	18	0	0
38. For the jugular or femoral approach, select a thin-wall needle or catheter-over-the-needle technique based on the clinical situation and the skill/experience of the operator	38	32	42*	18	8	0
39. Base the decision to use a thin-wall needle technique or a catheter-over-the-needle technique at least in part on the method used to confirm that the wire resides in the vein before a dilator or large-bore catheter is threaded	38	34	50*	11	5	0
40. The number of insertion attempts should be based on clinical judgment; the decision to place two catheters in a single vein should be made on a case-by-case basis	38	42	47*	8	3	0
Guidance of needle, wire, and catheter placement						
41. Use static ultrasound imaging before prepping and draping for prepuncture identification of anatomy to determine vessel localization and patency when the internal jugular vein is selected for cannulation	36	56*	19	22	3	0
42. Static ultrasound may also be used when the subclavian or femoral vein is selected	36	39	47*	11	3	0
43. Use real-time ultrasound guidance for vessel localization and venipuncture when the internal jugular vein is selected for cannulation	36	67*	31	0	3	0
44. When feasible, real-time ultrasound may be used when the subclavian or femoral vein is selected	36	44	50*	3	3	0
Verification of needle, wire, and catheter placement						

(Continued)

Table 2. (Continued)

Recommendations	N	Strongly	Agree,	Equivocal,	Disagree,	Strongly
		Agree,	%	%	%	Disagree,
45. After insertion of a catheter that went over the needle or a thin-wall needle, confirm venous access	35	83*	14	0	3	0
46. Do not rely on blood color or absence of pulsatile flow for confirming that the catheter or thin-wall needle resides in the vein	35	57*	26	14	3	0
47. When using the thin-wall needle technique, confirm venous residence of the wire after the wire is threaded	35	57*	37	6	0	0
48. When using the catheter-over-the-needle technique, confirmation that the wire resides in the vein may not be needed (1) when the catheter enters the vein easily and manometry or pressure-wave-form measurement provides unambiguous confirmation of venous location of the catheter and (2) when the wire passes through the catheter and enters the vein without difficulty	35	9	40	20*	14	17
49. If there is any uncertainty that the catheter or wire resides in the vein, confirm venous residence of the wire after the wire is threaded; insertion of a dilator or large-bore catheter may then proceed	34	47	44*	3	0	6
50. After final catheterization and before use, confirm residence of the catheter in the venous system as soon as clinically appropriate	35	63*	34	3	0	0
51. Confirm the final position of the catheter tip as soon as clinically appropriate	35	60*	31	6	3	0
52. For central venous catheters placed in the operating room, perform a chest radiograph no later than the early postoperative period to confirm the position of the catheter tip	35	60*	26	14	0	0
53. Verify that the wire has not been retained in the vascular system at the end of the procedure by confirming the presence of the removed wire in the procedural field	35	74*	20	6	0	0
54. If the complete guidewire is not found in the procedural field, order chest radiography to determine whether the guidewire has been retained in the patient's vascular system	35	77*	23	0	0	0
Management of arterial trauma or injury arising from central venous catheterization						
55. When unintended cannulation of an arterial vessel with a dilator or large-bore catheter occurs, leave the dilator or catheter in place and immediately consult a general surgeon, a vascular surgeon, or an interventional radiologist regarding surgical or nonsurgical catheter removal for adults	35	57*	31	11	0	0
56. For neonates, infants, and children, determine on a case-by-case basis whether to leave the catheter in place and obtain consultation or to remove the catheter nonsurgically	34	21	47*	27	6	0
57. After the injury has been evaluated and a treatment plan has been executed, confer with the surgeon regarding relative risks and benefits of proceeding with the elective surgery <i>versus</i> deferring surgery to allow for a period of patient observation	35	66*	31	3	0	0

N = number of members who responded to each item.

*Median.

Table 3. American Society of Anesthesiologists Member Survey Results

Recommendations	N	Strongly	Agree,	Equivocal,	Disagree,	Strongly
		Agree,	%	%	%	Disagree,
Resource preparation						
1. Perform central venous catheterization in an environment that permits use of aseptic techniques	393	88*	11	1	0	0
2. Ensure that a standardized equipment set is available for central venous access	390	80*	16	3	1	0
3. Use a checklist or protocol for placement and maintenance of central venous catheters	387	50	28*	19	3	1
4. Use an assistant during placement of a central venous catheter	391	26	28*	30	13	3
Prevention of infections complications						
Intravenous antibiotic prophylaxis						
5. For immunocompromised patients and high-risk neonates, administer intravenous antibiotic prophylaxis on a case-by-case basis	381	13	28	39*	15	4
6. Do not routinely administer intravenous antibiotic prophylaxis	382	43	35*	15	5	2
Aseptic preparation						
7. In preparation for the placement of central venous catheters, use aseptic techniques (e.g., hand washing) and maximal barrier precautions (e.g., sterile gowns, sterile gloves, caps, masks covering both mouth and nose, and full-body patient drapes)	379	81*	15	2	2	0

(Continued)

Table 3. (Continued)

Recommendations	N	Strongly Agree, %	Agree, %	Equivocal, %	Disagree, %	Strongly Disagree, %
8. Use a chlorhexidine-containing solution for skin preparation in adults, infants, and children	369	79*	17	4	1	0
9. For neonates, determine the use of chlorhexidine-containing solutions for skin preparation based on clinical judgment and institutional protocol	362	22	37*	38	2	1
10. If there is a contraindication to chlorhexidine, povidone-iodine or alcohol may be used	366	48	46*	5	1	0
11. Unless contraindicated, use skin preparation solutions containing alcohol Catheters containing antimicrobial agents	368	36	35*	25	5	1
12. For selected patients, use catheters coated with antibiotics or a combination of chlorhexidine and silver sulfadiazine based on infectious risk, cost, and anticipated duration of catheter use	357	32	37*	24	7	0
13. Do not use catheters containing antimicrobial agents as a substitute for additional infection precautions Selection of catheter insertion site	358	45	25*	20	8	3
14. Determine catheter insertion site selection based on clinical need	348	55*	40	4	1	0
15. Select an insertion site that is not contaminated or potentially contaminated (<i>e.g.</i> , burned or infected skin, inguinal area, adjacent to tracheostomy or open surgical wound)	349	72*	26	2	0	0
16. To minimize the risk of infection in adults, select an upper body insertion site when possible Catheter fixation	349	71*	26	3	0	0
17. Determine the use of sutures, staples, or tape for catheter fixation on a local or institutional basis	344	29	44*	14	11	2
18. Minimize the number of needle punctures of the skin Insertion site dressings	345	52*	38	9	1	0
19. Use transparent bioocclusive dressings to protect the site of central venous catheter insertion from infection	338	70*	27	2	0	0
20. Unless contraindicated, dressings containing chlorhexidine may be used in adults, infants, and children	337	38	37*	22	2	0
21. For neonates, determine the use of transparent or sponge dressings containing chlorhexidine based on clinical judgment and institutional protocol	330	22	34*	43	1	0
22. If a chlorhexidine-containing dressing is used, observe the site daily for signs of irritation, allergy, or necrosis Catheter maintenance	337	59*	34	7	1	0
23. Determine the duration of catheterization based on clinical need	328	61*	35	2	1	0
24. Assess the clinical need for keeping the catheter in place on a daily basis	327	75*	22	2	1	0
25. Remove catheters promptly when no longer deemed clinically necessary	326	82*	17	2	0	0
26. Inspect the catheter insertion site daily for signs of infection	324	84*	14	2	0	0
27. Change or remove the catheter when catheter insertion site infection is suspected	328	82*	15	2	0	0
28. When a catheter-related infection is suspected, replace the catheter using a new insertion site rather than changing the catheter over a guidewire Aseptic techniques using an existing central venous catheter for injection or aspiration	328	70*	24	5	1	0
29. Wipe catheter access ports with an appropriate antiseptic (<i>e.g.</i> , alcohol) before each access when using an existing central venous catheter for injection or aspiration	317	78*	19	3	1	0
30. Cap central venous catheter stopcocks or access ports when not in use	316	79*	17	4	0	0
31. Needleless catheter access ports may be used on a case-by-case basis Prevention of mechanical trauma or injury Catheter insertion site selection	318	43	39*	15	2	1
32. Determine catheter insertion site selection based on clinical need and practitioner judgment, experience, and skill	314	76*	23	1	0	0
33. Selection of an upper body insertion site may minimize the risk of thrombotic complications relative to the femoral site Positioning the patient for needle insertion and catheter placement	314	50*	39	10	1	0
34. When clinically appropriate and feasible, perform central venous access in the neck or chest with the patient in the Trendelenburg position Needle insertion, wire placement, and catheter placement	308	65*	32	3	1	0
35. Select catheter size (<i>i.e.</i> , outside diameter) and type based on the clinical situation and skill/experience of the operator	301	63*	32	4	2	0
36. Select the smallest size catheter appropriate for the clinical situation	301	37	38*	19	6	0

(Continued)

Table 3. (Continued)

Recommendations	N	Strongly Agree, %	Agree, %	Equivocal, %	Disagree, %	Strongly Disagree, %
38. For the jugular or femoral approach, select a thin-wall needle or catheter-over-the-needle technique based on the clinical situation and the skill/experience of the operator	298	39	36*	20	3	3
39. Base the decision to use a thin-wall needle technique or a catheter-over-the-needle technique least in part on the method used to confirm that the wire resides in the vein before a dilator or large-bore catheter is threaded	300	40	33*	23	3	1
40. The number of insertion attempts should be based on clinical judgment; the decision to place two catheters in a single vein should be made on a case-by-case basis Guidance of needle, wire, and catheter placement	301	54*	36	7	2	0
41. Use static ultrasound imaging before prepping and draping for prepuncture identification of anatomy to determine vessel localization and patency when the internal jugular vein is selected for cannulation	295	34	31*	21	10	4
42. Static ultrasound may also be used when the subclavian or femoral vein is selected	294	28	43*	23	4	2
43. Use real-time ultrasound guidance for vessel localization and venipuncture when the internal jugular vein is selected for cannulation	293	59*	18	18	2	3
44. When feasible, real-time ultrasound may be used when the subclavian or femoral vein is selected Verification of needle, wire, and catheter placement	294	45	34*	18	2	1
45. After insertion of a catheter that went over the needle or a thin-wall needle, confirm venous access	283	75*	20	4	1	0
46. Do not rely on blood color or absence of pulsatile flow for confirming that the catheter or thin-wall needle resides in the vein	285	55*	29	11	6	0
47. When using the thin-wall needle technique, confirm venous residence of the wire after the wire is threaded	281	49	29*	17	4	0
48. When using the catheter-over-the-needle technique, confirmation that the wire resides in the vein may not be needed (1) when the catheter enters the vein easily and manometry or pressure-waveform measurement provides unambiguous confirmation of venous location of the catheter and (2) when the wire passes through the catheter and enters the vein without difficulty	283	22	38*	25	11	4
49. If there is any uncertainty that the catheter or wire resides in the vein, confirm venous residence of the wire after the wire is threaded; insertion of a dilator or large-bore catheter may then proceed	285	45	41*	8	5	1
50. After final catheterization and before use, confirm residence of the catheter in the venous system as soon as clinically appropriate	284	56*	36	6	1	1
51. Confirm the final position of the catheter tip as soon as clinically appropriate	283	59*	38	2	1	0
52. For central venous catheters placed in the operating room, perform a chest radiograph no later than the early postoperative period to confirm the position of the catheter tip	281	61*	34	4	1	0
53. Verify that the wire has not been retained in the vascular system at the end of the procedure by confirming the presence of the removed wire in the procedural field	284	68*	25	4	3	0
54. If the complete guidewire is not found in the procedural field, order chest radiography to determine whether the guidewire has been retained in the patient's vascular system Management of arterial trauma or injury arising from central venous catheterization	284	75*	22	2	1	0
55. When unintended cannulation of an arterial vessel with a dilator or large-bore catheter occurs, leave the dilator or catheter in place and immediately consult a general surgeon, a vascular surgeon, or an interventional radiologist regarding surgical or nonsurgical catheter removal for adults	279	56*	27	9	7	1
56. For neonates, infants, and children, determine on a case-by-case basis whether to leave the catheter in place and obtain consultation or to remove the catheter nonsurgically	276	26	32*	33	6	3
57. After the injury has been evaluated and a treatment plan has been executed, confer with the surgeon regarding relative risks and benefits of proceeding with the elective surgery <i>versus</i> deferring surgery to allow for a period of patient observation	278	50	45*	4	2	0

N = number of members who responded to each item.

*Median.

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Competing Interests

The authors declare no competing interests.

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Address correspondence to the American Society of Anesthesiologists: 1061 American Lane, Schaumburg, Illinois 60173. jeffa@dacc.uchicago.edu. These updated Practice Advisories, and all ASA Practice Parameters, may be obtained at no cost through the Journal Web site, www.anesthesiology.org.

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