Practice Guidelines for Central Venous Access

A 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.

- What other guideline statements are available on this topic?
  - Several major organizations have produced practice guidelines on central venous access[128–132]
- Why was this Guideline developed?
  - The ASA has created this new Practice Guideline to provide updated recommendations on some issues and new recommendations on issues that have not been previously addressed by other guidelines. This was based on a rigorous evaluation of recent scientific literature as well as findings from surveys of expert consultants and randomly selected ASA members
- How does this statement differ from existing guidelines?
  - The ASA Guidelines differ in areas such as insertion site selection (*e.g.*, upper body site) guidance for catheter placement (*e.g.*, use of real-time ultrasound) and verification of venous location of the catheter
- Why does this statement differ from existing guidelines?
  - The ASA Guidelines differ from existing guidelines because it addresses the use of bundled techniques, use of an assistant during catheter placement, and management of arterial injury

Methodology

A. 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.

B. 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.

C. Focus

These Guidelines apply to patients undergoing elective central venous access procedures performed by anesthesiologists or health care 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,

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Address correspondence to the American Society of Anesthesiologists: 520 North Northwest Highway, Park Ridge, Illinois 60068-2573. These Practice Guidelines, as well as all ASA Practice Parameters, may be obtained at no cost through the Journal Web site, www.anesthesiology.org.

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

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Hickman®, Quinton®, (6) methods of detection or treatment of infectious complications associated with central venous catheterization, or (7) diagnosis and management of central venous catheter-associated trauma or injury (*e.g.*, pneumothorax or air embolism), with the exception of carotid arterial injury.

D. Application

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

E. Task Force Members and Consultants

The ASA appointed a Task Force of 12 members, including anesthesiologists in both private and academic practice from various geographic areas of the United States and two consulting methodologists from the ASA Committee on Standards and Practice Parameters.

The Task Force developed the Guidelines by means of a seven-step process. First, they reached consensus on the criteria for evidence. Second, original published research studies from peer-reviewed journals relevant to central venous access were reviewed and evaluated. Third, expert consultants were asked to (1) participate in opinion surveys on the effectiveness of various central venous access recommendations and (2) review and comment on a draft of the Guidelines. Fourth, opinions about the Guideline recommendations were solicited from a sample of active members of the ASA. Opinions on selected topics related to pediatric patients were solicited from a sample of active members of the Society for Pediatric Anesthesia (SPA). Fifth, the Task Force held open forums at three major national meetings† to solicit input on its draft recommendations. Sixth, the consultants were surveyed to assess their opinions on the feasibility of implementing the Guidelines. Seventh, all available information was used to build consensus within the Task Force to finalize the Guidelines. A summary of recommendations may be found in appendix 1.

F. Availability and Strength of Evidence

Preparation of these Guidelines followed a rigorous methodologic process. Evidence was obtained from two principal sources: scientific evidence and opinion-based evidence.

† 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.

‡ 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.

Scientific Evidence

Study findings from published scientific literature were aggregated and are reported in summary form by evidence category, as described in the following paragraphs. All literature (*e.g.*, randomized controlled trials, observational studies, case reports) relevant to each topic was considered when evaluating the findings. However, for reporting purposes in this document, only the highest level of evidence (*i.e.*, level 1, 2, or 3 within category A, B, or C, as identified in the following paragraphs) is included in the summary.

Category A: Supportive Literature

Randomized controlled trials report statistically significant ($P < 0.01$) differences between clinical interventions for a specified clinical outcome.

Level 1: The literature contains multiple randomized controlled trials, and aggregated findings are supported by meta-analysis.‡

Level 2: The literature contains multiple randomized controlled trials, but the number of studies is insufficient to conduct a viable meta-analysis for the purpose of these Guidelines.

Level 3: The literature contains a single randomized controlled trial.

Category B: Suggestive Literature

Information from observational studies permits inference of beneficial or harmful relationships among clinical interventions and clinical outcomes.

Level 1: The literature contains observational comparisons (*e.g.*, cohort, case-control research designs) of clinical interventions or conditions and indicates statistically significant differences between clinical interventions for a specified clinical outcome.

Level 2: The literature contains noncomparative observational studies with associative (*e.g.*, relative risk, correlation) or descriptive statistics.

Level 3: The literature contains case reports.

Category C: Equivocal Literature

The literature cannot determine whether there are beneficial or harmful relationships among clinical interventions and clinical outcomes.

Level 1: Meta-analysis did not find significant differences ($P > 0.01$) among groups or conditions.

Level 2: The number of studies is insufficient to conduct meta-analysis, and (1) randomized controlled trials have not found significant differences among groups or conditions or (2) randomized controlled trials report inconsistent findings.

Level 3: Observational studies report inconsistent findings or do not permit inference of beneficial or harmful relationships.

Category D: Insufficient Evidence from Literature

The lack of scientific evidence in the literature is described by the following terms:

Inadequate: The available literature cannot be used to assess relationships among clinical interventions and clinical outcomes. The literature either does not meet the criteria for content as defined in the "Focus" of the Guidelines or does not permit a clear interpretation of findings due to methodologic concerns (*e.g.*, confounding in study design or implementation).

Silent: No identified studies address the specified relationships among interventions and outcomes.

Opinion-based Evidence

All opinion-based evidence relevant to each topic (*e.g.*, survey data, open-forum testimony, Internet-based comments, letters, editorials) is considered in the development of these Guidelines. However, only the findings obtained from formal surveys are reported.

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 ASA members, and a survey addressing selected pediatric issues was distributed to SPA members.

Category A: Expert Opinion

Survey responses from Task Force-appointed expert consultants are reported in summary form in the text, with a complete listing of consultant survey responses reported in appendix 5.

Category B: Membership Opinion

Survey responses from active ASA and SPA members are reported in summary form in the text, with a complete listing of ASA and SPA member survey responses reported in appendix 5.

Survey responses are 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).

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).

Category C: Informal Opinion

Open-forum testimony, Internet-based comments, letters, and editorials are all informally evaluated and discussed during the development of Guideline recommendations. When warranted, the Task Force may add educational information or cautionary notes based on this information.

Guidelines

I. Resource Preparation

Resource preparation includes (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 an assistant for central venous catheterization, and (4) use of a checklist or protocol for central venous catheter placement and maintenance.

The literature is insufficient to specifically 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 (*Category D evidence*). An observational study reports that the implementation of a trauma intensive care unit multidisciplinary checklist is associated with reduced catheter-related infection rates (*Category B2 evidence*).[1] Observational studies report reduced catheter-related bloodstream infection rates when intensive care unit-wide bundled protocols are implemented (*Category B2 evidence*).[2–7] These studies do not permit the assessment of the effect of any single component of a checklist or bundled protocol on outcome. The Task Force notes that the use of checklists in other specialties or professions has been effective in reducing the error rate for a complex series of activities.[8,9]

The consultants and ASA members strongly agree that central venous catheterization should be performed in a location that permits the use of aseptic techniques. The consultants and ASA members strongly agree that a standardized equipment set should be available for central venous access. The consultants and ASA members agree that a trained assistant should be used during the placement of a central venous catheter. The ASA members agree and the consultants strongly agree that a checklist or protocol should be used for the placement and maintenance of central venous catheters.

Recommendations for Resource Preparation. Central venous catheterization should be performed in an environment that permits use of aseptic techniques. A standardized equipment set should be available for central venous access.‖ A checklist or protocol should be used for placement and maintenance of central venous catheters.# An assistant should be used during placement of a central venous catheter.**

§ 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.

‖ 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.

II. 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 techniques (*i.e.*, practitioner aseptic preparation and patient skin preparation), (3) selection of coated or impregnated catheters, (4) selection of catheter insertion site, (5) catheter fixation method, (6) insertion site dressings, (7) catheter maintenance procedures, and (8) aseptic techniques using an existing central venous catheter for injection or aspiration.

Intravenous Antibiotic Prophylaxis. Randomized controlled trials indicate that catheter-related infections and sepsis are reduced when prophylactic intravenous antibiotics are administered to high-risk immunosuppressed cancer patients or neonates. (*Category A2 evidence*).[10,11] The literature is insufficient to evaluate outcomes associated with the routine use of intravenous antibiotics (*Category D evidence*).

The consultants and ASA members agree that intravenous antibiotic prophylaxis may be administered on a case-by-case basis for immunocompromised patients or high-risk neonates. The consultants and ASA members agree that intravenous antibiotic prophylaxis should not be administered routinely.

Recommendations for Intravenous Antibiotic Prophylaxis. For immunocompromised patients and high-risk neonates, administer intravenous antibiotic prophylaxis on a case-by-case basis. Intravenous antibiotic prophylaxis should not be administered routinely.

Aseptic Preparation and Selection of Antiseptic Solution

Aseptic preparation of practitioner, staff, and patients: A randomized controlled trial comparing maximal barrier precautions (*i.e.*, mask, cap, gloves, gown, large full-body drape) with a control group (*i.e.*, gloves and small drape) reported equivocal findings for reduced colonization ($P = 0.03$) and catheter-related septicemia ($P = 0.06$) (*Category C2 evidence*).[12] The literature is insufficient to evaluate the efficacy of specific aseptic activities (*e.g.*, hand washing) or barrier precautions (*e.g.*, sterile full-body drapes, sterile gown, gloves, mask, cap) (*Category D evidence*). Observational studies report hand washing, sterile full-body drapes, sterile gloves, caps, and masks as elements of care "bundles" that result in reduced catheter-related bloodstream infections (*Category B2 evidence*).[2–7] However, the degree to which each particular element contributed to improved outcomes could not be determined.

Most consultants and ASA members indicated that the following aseptic techniques should be used in preparation for the placement of central venous catheters: hand washing (100% and 96%); sterile full-body drapes (87.3% and 73.8%); sterile gowns (100% and 87.8%), gloves (100% and 100%), caps (100% and 94.7%), and masks covering both the mouth and nose (100% and 98.1%).

Selection of Antiseptic Solution

Chlorhexidine solutions: A randomized controlled trial comparing chlorhexidine (2% aqueous solution without alcohol) with 10% povidone iodine (without alcohol) for skin preparation reports equivocal findings regarding catheter colonization ($P = 0.013$) and catheter-related bacteremia ($P = 0.28$) (*Category C2 evidence*).[13] The literature is insufficient to evaluate chlorhexidine with alcohol compared with povidone-iodine with alcohol (*Category D evidence*). The literature is insufficient to evaluate the safety of antiseptic solutions containing chlorhexidine in neonates, infants and children (*Category D evidence*).

Solutions containing alcohol: Comparative studies are insufficient to evaluate the efficacy of chlorhexidine with alcohol in comparison with chlorhexidine without alcohol for skin preparation during central venous catheterization (*Category D evidence*). A randomized controlled trial of povidone-iodine with alcohol indicates that catheter tip colonization is reduced when compared with povidone-iodine alone (*Category A3 evidence*); equivocal findings are reported for catheter-related infection ($P = 0.04$) and clinical signs of infection ($P = 0.09$) (*Category C2 evidence*).[14]

The consultants and ASA members strongly agree that chlorhexidine with alcohol should be used for skin preparation. SPA members are equivocal regarding whether chlorhexidine-containing solutions should be used for skin preparation in neonates (younger than 44 gestational weeks); they agree with the use of chlorhexidine in infants (younger than 2 yr) and strongly agree with its use in children (2–16 yr).

Recommendations for Aseptic Preparation and Selection of Antiseptic Solution

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

Catheters Containing Antimicrobial Agents. Meta-analysis of randomized controlled trials[15–19] comparing antibiotic-coated with uncoated catheters indicates that antibiotic-coated catheters reduce catheter colonization (*Category A1 evidence*). Meta-analysis of randomized controlled trials[20–24]

comparing silver-impregnated catheters with uncoated catheters report equivocal findings for catheter-related bloodstream infection (*Category C1 evidence*); randomized controlled trials were equivocal regarding catheter colonization ($P = 0.16–0.82$) (*Category C2 evidence*).[20–22,24] Meta-analyses of randomized controlled trials[25–36] demonstrate that catheters coated with chlorhexidine and silver sulfadiazine reduce catheter colonization (*Category A1 evidence*); equivocal findings are reported for catheter-related bloodstream infection (*i.e.*, catheter colonization and corresponding positive blood culture) (*Category C1 evidence*).[25–27,29–35,37,38] Cases of anaphylactic shock are reported after placement of a catheter coated with chlorhexidine and silver sulfadiazine (*Category B3 evidence*).[39–41]

Consultants and ASA members agree that catheters coated with antibiotics or a combination of chlorhexidine and silver sulfadiazine may be used in selected patients based on infectious risk, cost, and anticipated duration of catheter use.

Recommendations for Use of Catheters Containing Antimicrobial Agents. Catheters coated with antibiotics or a combination of chlorhexidine and silver sulfadiazine should be used for selected patients based on infectious risk, cost, and anticipated duration of catheter use. The Task Force notes that catheters containing antimicrobial agents are not a substitute for additional infection precautions.

Selection of Catheter Insertion Site. A randomized controlled trial comparing the subclavian and femoral insertion sites report higher levels of catheter colonization with the femoral site (*Category A3 evidence*); equivocal findings are reported for catheter-related sepsis ($P = 0.07$) (*Category C2 evidence*).[42] A randomized controlled trial comparing the internal jugular insertion site with the femoral site reports no difference in catheter colonization ($P = 0.79$) or catheter related bloodstream infections ($P = 0.42$) (*Category C2 evidence*).[43] Prospective nonrandomized comparative studies are equivocal (*i.e.*, inconsistent) regarding catheter-related colonization[44–46] and catheter related bloodstream infection[46–48] when the internal jugular site is compared with the subclavian site (*Category C3 evidence*). A nonrandomized comparative study of burn patients reports that catheter colonization and bacteremia occur more frequently the closer the catheter insertion site is to the burn wound (*Category B1 evidence*).[49]

Most consultants indicate that the subclavian insertion site is preferred to minimize catheter-related risk of infection. Most ASA members indicate that the internal jugular insertion site is preferred to minimize catheter-related risk of infection. The consultants and ASA members agree that femoral catheterization should be avoided when possible to minimize the risk of infection. The consultants and ASA members strongly agree that an insertion site should be selected that is not contaminated or potentially contaminated.

Recommendations for Selection of Catheter Insertion Site. Catheter insertion site selection should be based on clinical need. An insertion site should be selected that is not contaminated or potentially contaminated (*e.g.*, burned or infected skin, inguinal area, adjacent to tracheostomy or open surgical wound). In adults, selection of an upper body insertion site should be considered to minimize the risk of infection.

Catheter Fixation. The literature is insufficient to evaluate whether catheter fixation with sutures, staples or tape is associated with a higher risk for catheter-related infections (*Category D evidence*).

Most consultants and ASA members indicate that use of sutures is the preferred catheter fixation technique to minimize catheter-related infection.

Recommendations for Catheter Fixation. The use of sutures, staples, or tape for catheter fixation should be determined on a local or institutional basis.

Insertion Site Dressings. The literature is insufficient to evaluate the efficacy of transparent bio-occlusive dressings to reduce the risk of infection (*Category D evidence*). Randomized controlled trials are equivocal ($P = 0.04–0.96$) regarding catheter tip colonization[50,51] and inconsistent ($P = 0.004–0.96$) regarding catheter-related bloodstream infection[50,52] when chlorhexidine sponge dressings are compared with standard polyurethane dressings (*Category C2 evidence*). A randomized controlled trial is also equivocal regarding catheter tip colonization for silver-impregnated transparent dressings compared with standard dressings ($P > 0.05$) (*Category C2 evidence*).[53] A randomized controlled trial reports a greater frequency of severe localized contact dermatitis when neonates receive chlorhexidine-impregnated dressings compared with povidone-iodine impregnated dressings (*Category A3 evidence*).[54]

The ASA members agree and the consultants strongly agree that transparent bio-occlusive dressings should be used to protect the site of central venous catheter insertion from infection. The consultants and ASA members agree that dressings containing chlorhexidine may be used to reduce the risk of catheter-related infection. SPA members are equivocal regarding whether dressings containing chlorhexidine may be used for skin preparation in neonates (younger than 44 gestational weeks); they agree that the use of dressings containing chlorhexidine may be used in infants (younger than 2 yr) and children (2–16 yr).

Recommendations for Insertion Site Dressings. Transparent bio-occlusive dressings should be used 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, the use of transparent or sponge dressings containing chlorhexidine should be based on clinical judgment and institutional protocol.

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.

Nonrandomized comparative studies indicate that longer catheterizations are associated with higher rates of catheter colonization, infection, and sepsis (*Category B2 evidence*).[45,55] The literature is insufficient to evaluate whether specified time intervals between catheter site inspections are associated with a higher risk for catheter-related infection (*Category D evidence*). Randomized controlled trials report equivocal findings ($P = 0.54–0.63$) regarding differences in catheter tip colonizations when catheters are changed at 3- *versus* 7-day intervals (*Category C2 evidence*).[56,57] Meta-analysis of randomized controlled trials[58–62] report equivocal findings for catheter tip colonization when guidewires are used to change catheters compared with the use of new insertion sites (*Category C1 evidence*).

The ASA members agree and the consultants strongly agree that the duration of catheterization should be based on clinical need. The consultants and ASA members strongly agree that (1) the clinical need for keeping the catheter in place should be assessed daily; (2) catheters should be promptly removed when deemed no longer clinically necessary; (3) the catheter site should be inspected daily for signs of infection and changed when infection is suspected; and (4) when catheter infection is suspected, replacing the catheter using a new insertion site is preferable to changing the catheter over a guidewire.

Recommendations for Catheter Maintenance. The duration of catheterization should be based on clinical need. The clinical need for keeping the catheter in place should be assessed daily. Catheters should be removed promptly when no longer deemed clinically necessary. The catheter insertion site should be inspected daily for signs of infection, and the catheter should be changed or removed when catheter insertion site infection is suspected. When a catheter related infection is suspected, replacing the catheter using a new insertion site is preferable to 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.

The literature is insufficient to evaluate whether wiping ports or capping stopcocks when using an existing central venous catheter for injection or aspiration is associated with a reduced risk for catheter-related infections (*Category D evidence*). Randomized controlled trials comparing needleless connectors with standard caps indicate decreased levels of microbial contamination of stopcock entry ports with needleless connectors (*Category A2 evidence*);[63,64] no differences in catheter-related bloodstream infection are reported ($P = 0.3–0.9$) (*Category C2 evidence*).[65,66]

The consultants and ASA members strongly agree that catheter access ports should be wiped with an appropriate antiseptic before each access. The consultants and ASA members agree that needleless ports may be used on a case-by-case basis. The consultants and ASA members strongly agree that central venous catheter stopcocks should be capped when not in use.

Recommendations for Aseptic Techniques Using an Existing Central Line. Catheter access ports should be wiped with an appropriate antiseptic before each access when using an existing central venous catheter for injection or aspiration. Central venous catheter stopcocks or access ports should be capped when not in use. Needleless catheter access ports may be used on a case-by-case basis.

III. 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 and catheter placement, and (4) monitoring for needle, guidewire, and catheter placement.

1. Selection of Catheter Insertion Site. A randomized controlled trial comparing the subclavian and femoral insertion sites reports that the femoral site had a higher frequency of thrombotic complications in adult patients (*Category A3 evidence*).[42] A randomized controlled trial comparing the internal jugular insertion site with the femoral site reports equivocal findings for arterial puncture ($P = 0.35$), deep venous thrombosis ($P = 0.62$) or hematoma formation ($P = 0.47$) (*Category C2 evidence*).[43] A randomized controlled trial comparing the internal jugular insertion site with the subclavian site reports equivocal findings for successful venipuncture ($P = 0.03$) (*Category C2 evidence*).[67] Nonrandomized comparative studies report equivocal findings for arterial puncture, pneumothorax, hematoma, hemothorax, or arrhythmia when the internal jugular insertion site is compared with the subclavian insertion site (*Category C3 evidence*).[68–70]

Most consultants and ASA members indicate that the internal jugular insertion site is preferred to minimize catheter cannulation-related risk of injury or trauma. Most consultants and ASA members also indicate that the internal jugular insertion site is preferred to minimize catheter-related risk of thromboembolic injury or trauma.

Recommendations for Catheter Insertion Site Selection. Catheter insertion site selection should be based on clinical need and practitioner judgment, experience, and

skill. In adults, selection of an upper body insertion site should be considered to minimize the risk of thrombotic complications.

2. Positioning the Patient for Needle Insertion and Catheter Placement. Nonrandomized studies comparing the Trendelenburg (*i.e.*, head down) position with the normal supine position indicates that the right internal jugular vein increases in diameter and cross-sectional area to a greater extent when adult patients are placed in the Trendelenburg position (*Category B2 evidence*).[71–76] One nonrandomized study comparing the Trendelenburg position with the normal supine position in pediatric patients reports an increase in right internal jugular vein diameter only for patients older than 6 yr (*Category B2 evidence*).[77]

The consultants and ASA members strongly agree that, when clinically appropriate and feasible, central vascular access in the neck or chest should be performed with the patient in the Trendelenburg position.

Recommendations for Positioning the Patient for Needle Insertion and Catheter Placement

When clinically appropriate and feasible, central venous access in the neck or chest should be performed with the patient in the Trendelenburg position.

3. 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.

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 there is unintentional arterial cannulation with large bore catheters (*Category B3 evidence*).[78–88] The literature is insufficient to evaluate whether the risk of injury or trauma is associated with the use of a thin-wall needle technique *versus* a catheter-over-the needle technique (*Category D evidence*). The literature is insufficient to evaluate whether the risk of injury or trauma is related to the number of insertion attempts (*Category D evidence*). 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 B2 evidence*); no differences in carotid artery puncture ($P = 0.65$) or hematoma ($P = 0.48$) were noted (*Category C3 evidence*).[89]

The consultants agree and the ASA members strongly agree that the selection of catheter type (*i.e.*, gauge, length, number of lumens) and composition (*e.g.*, polyurethane, Teflon) should be based on the clinical situation, and the skill and experience of the operator. The consultants and ASA members agree that the selection of a modified Seldinger technique *versus* a Seldinger technique should be based on the clinical situation and the skill and experience of the operator. The consultants and ASA members agree that the number of insertion attempts should be based on clinical judgment. The ASA members agree and the consultants strongly agree that the decision to place two central catheters in a single vein should be made on a case-by-case basis.

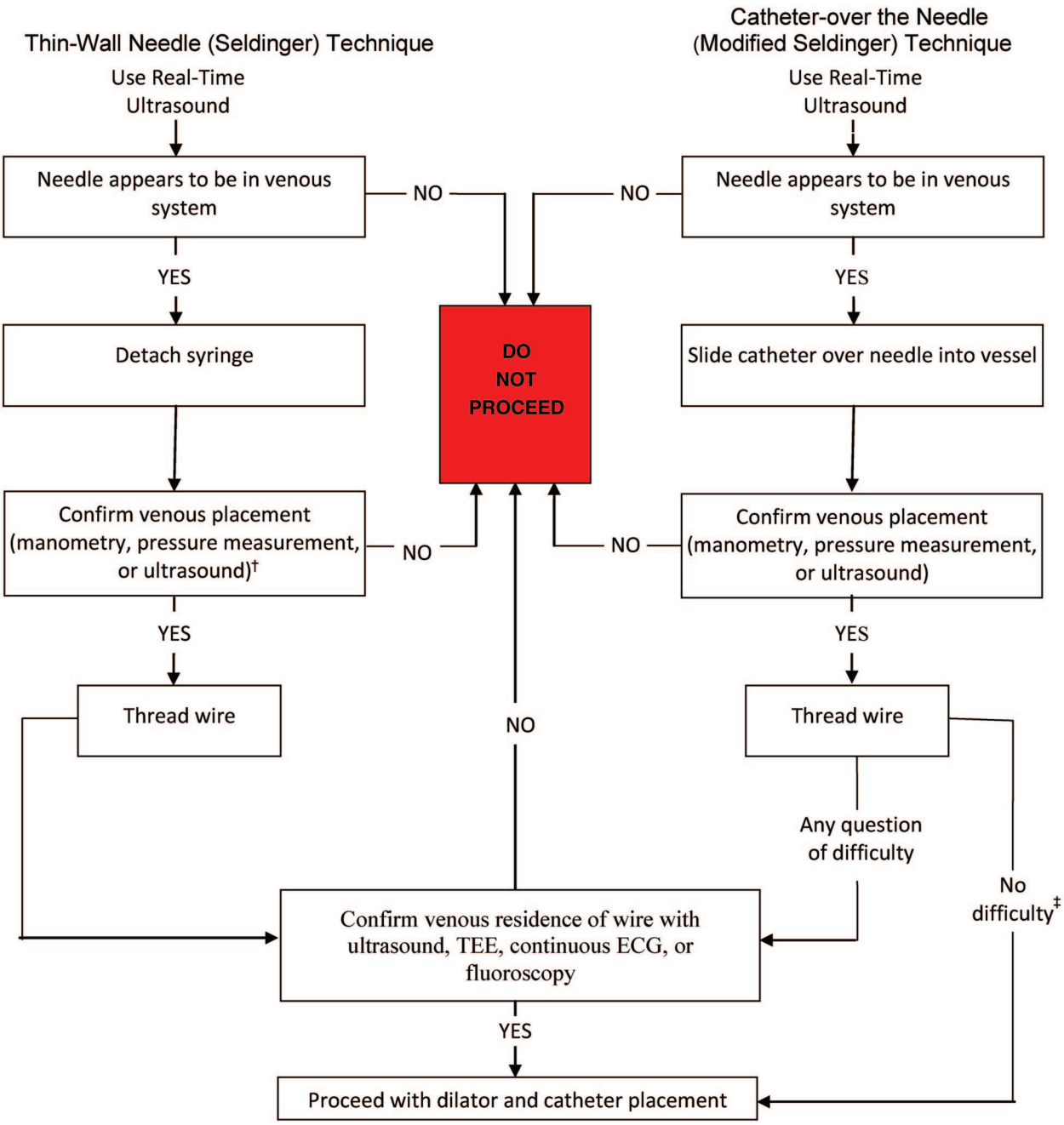
Recommendations for Needle Insertion, Wire Placement, and Catheter Placement. Selection of catheter size (*i.e.*, outside diameter) and type should be based on the clinical situation and skill/experience of the operator. Selection of the smallest size catheter appropriate for the clinical situation should be considered. Selection of a thin-wall needle (*i.e.*, Seldinger) technique *versus* a catheter-over-the-needle (*i.e.*, modified Seldinger) technique should be based on the clinical situation and the skill/experience of the operator. The decision to use a thin-wall needle technique or a catheter-over-the-needle technique should be based 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 (fig. 1). The Task Force notes that the catheter-over-the-needle technique may provide more stable venous access if manometry is used for venous confirmation. 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.

4. Guidance and Verification of Needle, Wire, and Catheter Placement. Guidance for needle, wire, and catheter placement includes ultrasound imaging for the purpose of prepuncture vessel localization (*i.e.*, static ultrasound) and ultrasound for vessel localization and guiding the needle to its intended venous location (*i.e.*, real time or dynamic ultrasound). Verification of needle, wire, or catheter location includes any one or more of the following methods: (1) ultrasound, (2) manometry, (3) pressure waveform analysis, (4) venous blood gas, (5) fluoroscopy, (6) continuous electrocardiography, (7) transesophageal echocardiography, and (8) chest radiography.

Guidance

Static Ultrasound. Randomized controlled trials comparing static ultrasound with the anatomic landmark approach for locating the internal jugular vein report a higher first insertion attempt success rate for static ultrasound (*Category A3 evidence*);[90] findings are equivocal regarding overall successful cannulation rates ($P = 0.025–0.57$) (*Category C2 evidence*).[90–92] In addition, the literature is equivocal regarding subclavian vein access ($P = 0.84$) (*Category C2 evidence*) [93] and insufficient for femoral vein access (*Category D evidence*).

The consultants and ASA members agree that static ultrasound imaging should be used in elective situations for prepuncture identification of anatomy and vessel localization



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

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 largebore 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.

when the internal jugular vein is selected for cannulation; they are equivocal regarding whether static ultrasound imaging should be used when the subclavian vein is selected. The consultants agree and the ASA members are equivocal regarding the use of static ultrasound imaging when the femoral vein is selected.

Real-time Ultrasound. Meta-analysis of randomized controlled trials[94–104] indicates that, compared with the anatomic landmark approach, real-time ultrasound guided venipuncture of the internal jugular vein has a higher first insertion attempt success rate, reduced access time, higher overall successful cannulation rate, and decreased

rates of arterial puncture (*Category A1 evidence*). Randomized controlled trials report fewer number of insertion attempts with real-time ultrasound guided venipuncture of the internal jugular vein (*Category A2 evidence*).[97,99,103,104]

For the subclavian vein, randomized controlled trials report fewer insertion attempts with real-time ultrasound guided venipuncture (*Category A2 evidence*),[105,106] and one randomized clinical trial indicates a higher success rate and reduced access time, with fewer arterial punctures and hematomas compared with the anatomic landmark approach (*Category A3 evidence*).[106]

For the femoral vein, a randomized controlled trial reports a higher first-attempt success rate and fewer needle passes with real-time ultrasound guided venipuncture compared with the anatomic landmark approach in pediatric patients (*Category A3 evidence*).[107]

The consultants agree and the ASA members are equivocal that, when available, real time ultrasound should be used for guidance during venous access when either the internal jugular or femoral veins are selected for cannulation. The consultants and ASA members are equivocal regarding the use of real time ultrasound when the subclavian vein is selected.

Verification

Confirming that the Catheter or Thin-wall Needle Resides in the Vein. A retrospective observational study reports that manometry can detect arterial punctures not identified by blood flow and color (*Category B2 evidence*).[108] 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 (*Category D evidence*).

Confirming Venous Residence of the Wire. An observational study indicates that ultrasound can be used to confirm venous placement of the wire before dilation or final catheterization (*Category B2 evidence*).[109] Case reports indicate that transesophageal echocardiography was used to identify guidewire position (*Category B3 evidence*).[110–112] The literature is insufficient to evaluate the efficacy of continuous electrocardiography in confirming venous residence of the wire (*Category D evidence*), although narrow complex electrocardiographic ectopy is recognized by the Task Force as an indicator of venous location of the wire. The literature is insufficient to address fluoroscopy as an effective method to confirm venous residence of the wire (*Category D evidence*); the Task Force believes that fluoroscopy may be used.

Confirming Residence of the Catheter in the Venous System. Studies with observational findings indicate that fluoroscopy[113,115] and chest radiography[115–125] are useful in identifying the position of the catheter tip (*Category B2 evidence*). Randomized controlled trials indicate that continuous electrocardiography is effective in identifying proper catheter tip placement compared with not using electrocardiography (*Category A2 evidence*).[115,126,127]

The consultants and ASA members strongly agree that before insertion of a dilator or large- bore catheter over a wire, venous access should be confirmed for the catheter or thin-wall needle that accesses the vein. The Task Force believes that blood color or absence of pulsatile flow should not be relied upon to confirm venous access. The consultants agree and ASA members are equivocal that venous access should be confirmed for the wire that subsequently resides in the vein after traveling through a catheter or thin-wall needle before insertion of a dilator or large-bore catheter over a wire. The consultants and ASA members agree that, when feasible, both the location of the catheter or thin-wall needle and wire should be confirmed.

The consultants and ASA members agree that a chest radiograph should be performed to confirm the location of the catheter tip as soon after catheterization as clinically appropriate. They also agree that, for central venous catheters placed in the operating room, a confirmatory chest radiograph may be performed in the early postoperative period. The ASA members agree and the consultants strongly agree that, if a chest radiograph is deferred to the postoperative period, pressure waveform analysis, blood gas analysis, ultrasound, or fluoroscopy should be used to confirm venous positioning of the catheter before use.

Recommendations for Guidance and Verification of Needle, Wire, and Catheter Placement

The following steps are recommended for prevention of mechanical trauma during needle, wire, and catheter placement in elective situations:

- 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 be used when the subclavian or femoral vein is selected.
- Use real time ultrasound guidance for vessel localization and venipuncture when the internal jugular vein is selected for cannulation (see fig. 1). Real-time ultrasound may be used when the subclavian or femoral vein is selected. The Task Force recognizes that this approach may not be feasible in emergency circumstances or in the presence of other clinical constraints.
- After insertion of a catheter that went over the needle or a thin-wall needle, confirm venous access.†† Methods for confirming that the catheter or thin-wall needle resides in the vein include, but are not limited to, ultrasound, manometry, pressure-waveform analysis, or venous blood gas measurement. Blood color or absence of pulsatile flow

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

should not be relied upon 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. 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.
- After final catheterization and before use, confirm residence of the catheter in the venous system as soon as clinically appropriate. Methods for confirming that the catheter is still in the venous system after catheterization and before use include manometry or pressure waveform measurement.
- Confirm the final position of the catheter tip as soon as clinically appropriate. Methods for confirming the position of the catheter tip include chest radiography, fluoroscopy, or continuous electrocardiography. For central venous catheters placed in the operating room, perform the chest radiograph no later than the early postoperative period to confirm the position of the catheter tip.

IV. Management of Arterial Trauma or Injury Arising from Central Venous Catheterization

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; no such complications were reported for adult patients whose catheters were left in place before surgical consultation and repair (*Category B3 evidence*).[80,86]

The consultants and ASA members agree that, when unintended cannulation of an arterial vessel with a large-bore catheter occurs, the catheter should be left in place and a general surgeon or vascular surgeon should be consulted. When unintended cannulation of an arterial vessel with a large-bore catheter occurs, the SPA members indicate that the catheter should be left in place and a general surgeon, vascular surgeon, or interventional radiologist should be immediately consulted before deciding on whether to remove the catheter, either surgically or nonsurgically, as follows: 54.9% (for neonates), 43.8% (for infants), and 30.0% (for children). SPA members indicating that the catheter may be nonsurgically removed without consultation is as follows: 45.1% (for neonates), 56.2% (for infants), and 70.0% (for children). The Task Force agrees that the anesthesiologist and surgeon should confer regarding the relative risks and benefits of proceeding with elective surgery after an arterial vessel has sustained unintended injury by a dilator or large-bore catheter.

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, the dilator or catheter should be left in place and a general surgeon, a vascular surgeon, or an interventional radiologist should be immediately consulted regarding surgical or nonsurgical catheter removal for adults. For neonates, infants, and children the decision to leave the catheter in place and obtain consultation or to remove the catheter nonsurgically should be based on practitioner judgment and experience. After the injury has been evaluated and a treatment plan has been executed, the anesthesiologist and surgeon should confer 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

- Central venous catheterization should be performed in an environment that permits use of aseptic techniques.
- A standardized equipment set should be available for central venous access.
- A checklist or protocol should be used for placement and maintenance of central venous catheters.
- An assistant should be used during placement of a central venous catheter.

Prevention of Infectious Complications

- For immunocompromised patients and high-risk neonates, administer intravenous antibiotic prophylaxis on a case-by-case basis.
  - Intravenous antibiotic prophylaxis should not be administered routinely.
- 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).
- A chlorhexidine-containing solution should be used for skin preparation in adults, infants, and children.
  - For neonates, the use of a chlorhexidine-containing solution for skin preparation should be based on clinical judgment and institutional protocol.

- If there is a contraindication to chlorhexidine, povidone-iodine or alcohol may be used as alternatives.
- Unless contraindicated, skin preparation solutions should contain alcohol.

- If there is a contraindication to chlorhexidine, povidone-iodine or alcohol may be used. Unless contraindicated, skin preparation solutions should contain alcohol.
- Catheters coated with antibiotics or a combination of chlorhexidine and silver sulfadiazine should be used for selected patients based on infectious risk, cost, and anticipated duration of catheter use.
  - Catheters containing antimicrobial agents are not a substitute for additional infection precautions.
- Catheter insertion site selection should be based on clinical need.
  - An insertion site should be selected that is not contaminated or potentially contaminated (*e.g.*, burned or infected skin, inguinal area, adjacent to tracheostomy or open surgical wound).
  - In adults, selection of an upper body insertion site should be considered to minimize the risk of infection.
- The use of sutures, staples, or tape for catheter fixation should be determined on a local or institutional basis.
- Transparent bio-occlusive dressings should be used 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, the use of transparent or sponge dressings containing chlorhexidine should be based on clinical judgment and institutional protocol.
- The duration of catheterization should be based on clinical need.
  - The clinical need for keeping the catheter in place should be assessed daily.
  - Catheters should be removed promptly when no longer deemed clinically necessary.
- The catheter insertion site should be inspected daily for signs of infection.
  - The catheter should be changed or removed when catheter insertion site infection is suspected.
- When a catheter-related infection is suspected, replacing the catheter using a new insertion site is preferable to changing the catheter over a guidewire.
- Catheter access ports should be wiped with an appropriate antiseptic before each access when using an existing central venous catheter for injection or aspiration.
- Central venous catheter stopcocks or access ports should be capped 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 should be based on clinical need and practitioner judgment, experience, and skill.
  - In adults, selection of an upper body insertion site should be considered to minimize the risk of thrombotic complications.
- When clinically appropriate and feasible, central venous access in the neck or chest should be performed with the patient in the Trendelenburg position.
- Selection of catheter size (*i.e.*, outside diameter) and type should be based on the clinical situation and skill/experience of the operator.
  - Selection of the smallest size catheter appropriate for the clinical situation should be considered.
- Selection of a thin-wall needle (a wire-through-thin-wall-needle, or Seldinger) technique *versus* a catheter-over-the-needle (a catheter-over-the-needle-then-wire-through-the-catheter, or Modified Seldinger) technique should be based on the clinical situation and the skill/experience of the operator.
  - The decision to use a thin-wall needle technique or a catheter-over-the-needle technique should be based 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 catheter-over-the-needle technique may provide more stable venous access if manometry is used for venous confirmation.
- 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.
- Use static ultrasound imaging in elective situations 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 be used when the subclavian or femoral vein is selected.
- Use real-time ultrasound guidance for vessel localization and venipuncture when the internal jugular vein is selected for cannulation.
  - Real-time ultrasound may be used when the subclavian or femoral vein is selected.
  - Real-time ultrasound may not be feasible in emergency circumstances or in the presence of other clinical constraints.
- After insertion of a catheter that went over the needle or a thin-wall needle, confirm venous access.††
  - Methods for confirming that the catheter or thin-wall needle resides in the vein include, but are not limited to: ultrasound, manometry, pressure-waveform analysis, or venous blood gas measurement.
  - Blood color or absence of pulsatile flow should not be relied upon 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 con-

firmation 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.
  - Methods for confirming that the wire resides in the vein include, but are not limited to surface 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.
- After final catheterization and before use, confirm residence of the catheter in the venous system as soon as clinically appropriate.
  - Methods for confirming that the catheter is still in the venous system after catheterization and before use include waveform manometry or pressure measurement.
- Confirm the final position of the catheter tip as soon as clinically appropriate.
  - Methods for confirming the position of the catheter tip include chest radiography, fluoroscopy, or continuous electrocardiography.
- For central venous catheters placed in the operating room, perform the chest radiograph no later than the early postoperative period to confirm the position of the catheter tip.

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, the dilator or catheter should be left in place and a general surgeon, a vascular surgeon, or an interventional radiologist should be immediately consulted regarding surgical or nonsurgical catheter removal for adults.
  - For neonates, infants, and children, the decision to leave the catheter in place and obtain consultation or to remove the catheter nonsurgically should be based on practitioner judgment and experience.
- After the injury has been evaluated and a treatment plan has been executed, the anesthesiologist and surgeon should confer regarding relative risks and benefits of proceeding with the elective surgery *versus* deferring surgery 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 Alcohol-based Hand Cleanser	2
Transparent bio-occlusive 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 inchSterile	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	
Cap, Nurses Bouffant	3
Surgeon hats	6
Goggles	2
Mask, surgical fluidshield	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 lumen14 gauge	1
Catheter kits, central venous pressure two lumens 16 cm 7 French	2
Sixth Drawer	
Triple Lumen Centravel Venous Catheter Sets, 7 French Antimicrobial Impregnated	2
Introducer catheter sets, 9 French with sideport	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	☐
	2. Patient's Allergy Assessed (especially to Lidocaine or Heparin)	☐
	3. Patient's Latex Allergy Assessed (modify supplies)	☐
	4. Hand Hygiene: ☐ Operator and Assistant cleanse hands (ASK, if not witnessed)	☐
	5. Optimal Catheter Site Selection: ☐ In adults, Consider Upper Body Site ☐ Check / explain why femoral site used: _____ ☐ Anatomy – distorted, prior surgery/rad. Scar ☐ Chest wall infection or burn ☐ Coagulopathy ☐ COPD severe/ lung disease ☐ Emergency / CPR ☐ Pediatric	☐ ☐ **OR** Exception(s) checked to left
	6. Pre-procedure Ultrasound Check of internal jugular location and patency if IJ	☐
	7. Skin Prep Performed (Skin Antisepsis): ☐ **Chloraprep** 10.5 ml applicator used ☐ **Dry technique (normal, unbroken skin):** 30 second scrub + 30 second dry time ☐ **Wet technique (abnormal or broken skin):** 2 minute scrub + 1 minute dry time	☐ ☐ DRY ☐ WET
	8. MAXIMUM Sterile Barriers: ☐ **Operator wearing hat, mask, sterile gloves, and sterile gown** ☐ **Others** in room, (except patient) **wearing mask** ☐ **Patient's body covered by sterile drape**	☐ ☐ ☐
	9. Procedural "Time out" performed: ☐ 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	☐ ☐ ☐ ☐ ☐ ☐

(*continued*)

Appendix 3. Continued

DURING	**10. Ultrasound Guidance Used for Elective Internal Jugular insertions (sterile probe cover in place)**	☐ Used for IJ ☐ 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 pulsatility)	☐ Manometry ☐ Ultrasound ☐ Transducer ☐ Blood Gas
	12. Confirmation of Venous Placement of the Wire: ☐ Access catheter easily in vein & confirmed (catheter-over needle technique)	☐ Not Needed
	☐ Access *via* thin-wall needle (confirmation of wire recommended) ☐ *or* ambiguous catheter or wire placement when using catheter-over-the-needle technique	☐ Ultrasound ☐ TEE ☐ Fluoroscopy ☐ ECG
	13. Confirmation of Final Catheter in Venous System Prior to Use:	☐ Manometry ☐ Transducer
	14. Final steps: ☐ **Verify guidewire not retained** ☐ **Type and Dosage** (ml / units) **of Flush: _____** ☐ **Catheter Caps Placed on Lumens** ☐ Tip position confirmation: **Fluoroscopy** **Chest radiograph ordered** ☐ **Catheter Secured / Sutured in place**	☐ ☐ ☐ ☐ ☐ ☐

AFTER	**15. Transparent Bio-occlusive dressing applied**	☐
	16. Sterile Technique Maintained when applying dressing	☐
	17. Dressing Dated	☐
	18. Confirm Final Location of Catheter Tip	☐ CXR ☐ Fluoroscopy ☐ Continuous ECG
	19. After tip location confirmed, "Approved for use" Written on Dressing	☐
	20. Central line (maintenance) Order Placed	☐

Comments:
Tip location:

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

State of the Literature

For these Guidelines, a literature review was used in combination with opinions obtained from expert consultants and other sources (*e.g.*, ASA members, SPA members, open forums, Internet postings). Both the literature review and opinion data were based on evidence linkages, or statements regarding potential relationships between clinical interventions and outcomes. The interventions listed below were examined to assess their effect on a variety of outcomes related to central venous catheterization.

Resource Preparation
- Selection of a Sterile Environment
- Availability of a standardized equipment set
- Use of a checklist or protocol for placement and maintenance
- Use of an assistant for placement

Prevention of Infectious Complications
- Intravenous antibiotic prophylaxis
- Aseptic techniques
  - Aseptic preparation
    - Hand washing, sterile full-body drapes, sterile gown, gloves, mask, cap
  - Skin preparation
    - Chlorhexidine *versus* povidone-iodine
  - Aseptic preparation with *versus* without alcohol
- Selection of catheter coatings or impregnation
  - Antibiotic-coated catheters *versus* no coating
  - Silver-impregnated catheters *versus* no coating
  - Chlorhexidine combined with silver sulfadiazine catheter coating *versus* no coating
- Selection of catheter insertion site
  - Internal jugular
  - Subclavian
  - Femoral
  - Selecting a potentially uncontaminated insertion site
- Catheter fixation
  - Suture, staple, or tape
- Insertion site dressings
  - Clear plastic, chlorhexidine, gauze and tape, cyanoacrylate, antimicrobial dressings, patch, antibiotic ointment
- Catheter maintenance
  - Long-term *versus* short-term catheterization
  - Frequency of insertion site inspection for signs of infection
- Changing catheters
  - Specified time intervals
  - Specified time interval *versus* no specified time interval (*i.e.*, as needed)
  - One specified time interval *versus* another specified time interval
  - Changing a catheter over a wire *versus* a new site
- Aseptic techniques using an existing central line for injection or aspiration
  - Wiping ports with alcohol
  - Capping stopcocks
  - Needleless connectors or access ports

Prevention of Mechanical Trauma or Injury
- Selection of catheter insertion site
  - Internal jugular
  - Subclavian
  - Femoral
- Trendelenburg *versus* supine position
- Needle insertion and catheter placement
  - Selection of catheter type (*e.g.*, double lumen, triple lumen, Cordis)
  - Selection of a large-bore catheter
  - Placement of two catheters in the same vein
  - Use of a Seldinger technique *versus* a modified Seldinger technique
  - Limiting number of insertion attempts
- Guidance of needle, wire and catheter placement
  - Static ultrasound *versus* no ultrasound (*i.e.*, anatomic landmarks)
  - Real-time ultrasound guidance *versus* no ultrasound
- Verification of placement
  - Manometry *versus* direct pressure measurement (*via* pressure transducer)
  - Continuous electrocardiogram
  - Fluoroscopy
  - Venous blood gas
  - Transesophageal echocardiography
  - Chest radiography

Management of Trauma or Injury Arising from Central Venous Catheterization
- Not removing *versus* removing central venous catheter on evidence of arterial puncture.

For the literature review, potentially relevant clinical studies were identified *via* electronic and manual searches of the literature. The electronic and manual searches covered a 44-yr period from 1968 through 2011. More than 2,000 citations were initially identified, yielding a total of 671 nonoverlapping articles that addressed topics related to the evidence linkages. After review of the articles, 383 studies did not provide direct evidence, and were subsequently eliminated. A total of 288 articles contained direct linkage-related evidence. A complete bibliography used to develop these Guidelines, organized by section, is available as Supplemental Digital Content 2, http://links.lww.com/ALN/A784.

Initially, each pertinent outcome reported in a study was classified as supporting an evidence linkage, refuting a linkage, or equivocal. The results were then summarized to obtain a directional assessment for each evidence linkage before conducting formal meta-analyses. Literature pertaining to five evidence linkages contained enough studies with well-defined experimental designs and statistical information sufficient for meta-analyses (table 1). These linkages were (1) antimicrobial catheters, (2) silver sulfadiazine catheter coatings, (3) chlorhexidine and silver sulfadiazine catheter coatings, (4) changing a catheter over a wire *versus* a new site, and (5) ultrasound guidance for venipuncture.

General variance-based effect-size estimates or combined probability tests were obtained for continuous outcome measures, and Mantel-Haenszel odds-ratios were obtained for dichotomous outcome measures. Two combined probability tests were employed as follows: (1) the Fisher combined test, producing chi-square values based on logarithmic transformations of the reported *P* values from the independent studies, and (2) the Stouffer combined test, providing weighted representation of the studies by weighting each of the standard normal deviates by the size of the sample. An odds-ratio procedure based on the Mantel-Haenszel method for combining study results using 2 × 2 tables was used with outcome frequency information. An acceptable significance level was set at $P < 0.01$ (one-tailed). Tests for heterogeneity of the independent studies were conducted to assure consistency among the study results. DerSimonian-Laird random-effects odds ratios were obtained when significant heterogeneity was found ($P < 0.01$). To control for potential publishing bias, a "fail-safe n " value was calculated. No search for unpublished studies was conducted, and no reliability tests for locating research results were done. To be accepted as significant findings, Mantel-Haenszel odds ratios must agree with combined test results whenever both types of data are assessed. In the absence of Mantel-Haenszel odds-ratios, findings from both the Fisher and weighted Stouffer combined tests must agree with each other to be acceptable as significant.

Interobserver agreement among Task Force members and two methodologists was established by interrater reliability testing. Agreement levels using a kappa (κ) statistic for two-rater agreement pairs were as follows: (1) type of study design, $\kappa = 0.70–1.00$l; (2) type of analysis, $\kappa = 0.60–0.84$; (3) evidence linkage assignment, $\kappa = 0.91–1.00$; and (4) literature inclusion for database, $\kappa = 0.65–1.00$. Three-rater chance-corrected agreement values were (1) study design, Sav = 0.80, Var (Sav) = 0.006; (2) type of analysis, Sav = 0.70, Var (Sav) = 0.016; (3) linkage assignment, Sav = 0.94, Var (Sav) = 0.002; (4) literature database inclusion, Sav = 0.65, Var (Sav) = 0.034. These values represent moderate to high levels of agreement.

Consensus-based Evidence

Consensus was obtained 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 solicited from active members of the ASA and SPA, (3) testimony from attendees of publicly-held open forums at two national anesthesia meetings, (4) Internet commentary, and (5) task force opinion and interpretation. The survey rate of return was 41.0% (n = 55 of 134) for the consultants (table 2), 530 surveys were received from active ASA members (table 3), and 251 surveys were received from active SPA members (table 4).

An additional survey was sent to the expert consultants asking them to indicate which, if any, of the evidence linkages would change their clinical practices if the Guidelines were instituted. The rate of return was 16% (n = 22 of 134). The percentage of responding consultants expecting no change associated with each linkage were as follows: (1) availability of a standardized equipment set = 91.8%, (2) use of a trained assistant = 83.7%, (3) use of a checklist or protocol for placement and maintenance = 75.5%, (4) use of bundles that include a checklist or protocol = 87.8%, (5) intravenous antibiotic prophylaxis = 93.9%, (6) aseptic preparation (*e.g.*, hand washing, caps, masks) = 98.0%, (8) skin preparation = 98.0%, (9) selection of catheters with antibiotic or antiseptic coatings/impregnation = 89.8%, (10) selection of catheter insertion site for prevention of infection = 100%, (11) catheter fixation methods = 89.8%, (12) insertion site dressings = 100%, (13) catheter maintenance = 100%, (14) aseptic techniques using an existing central line for injection or aspiration = 95.9%, (15) selection of catheter insertion site for prevention of mechanical trauma or injury = 100%, (16) Trendelenburg *versus* supine patient positioning for neck or chest venous access = 100%, (17) needle insertion and catheter placement = 100%, (18) guidance of needle, wire, and catheter placement = 89.8%, (19) verification of needle puncture and placement = 98.0%, (20) management of trauma or injury = 100%.

Fifty-seven percent of the respondents indicated that the Guidelines would have no effect on the amount of time spent on a typical case, and 43% indicated that there would be an increase of the amount of time spent on a typical case with the implementation of these Guidelines. Seventy-four percent indicated that new equipment, supplies, or training would not be needed to implement the Guidelines, and 78% indicated that implementation of the Guidelines would not require changes in practice that would affect costs.

Combined Sources of Evidence

Evidence for these Guidelines was formally collected from multiple sources, including randomized controlled trials, observational literature, surveys of expert consultants, and randomly selected samples of ASA and SPA members. This information is summarized in table 5, with a brief description of each corresponding recommendation.

Table 1. Meta-analysis Summary

Evidence Linkages	N	Fisher Chi-square	*P* Value	Weighted Stouffer Zc	*P* Value	Effect Size	Odds Ratio	Confidence Interval	Heterogeneity *P* Values	Heterogeneity Effect Size
Antibiotic-coated catheters *vs*. no coating										
Catheter colonization	5						0.35	0.23–0.55		ns
Silver sulfadiazine catheter coating *vs*. no coating										
Catheter-related bloodstream infection	5						0.70	0.45–1.10		ns
Chlorhexidine + silver sulfadiazine catheter coating *vs*. no coating										
Catheter colonization	12						0.43	0.34–0.54		ns
Catheter-related bloodstream infection	12						0.70	0.47–1.03		ns
Changing a catheter over a wire *vs*. a new site										
Catheter colonization	5						1.18	0.66–2.09		ns
Real-time ultrasound guidance *vs*. no ultrasound*										
Successful insertion/ cannulation	11						7.15†	1.33–18.27		0.005
First attempt success	5						3.24	1.93–5.45		ns
Time to insertion	6	70.67	0.001	−7.15	0.001	−0.23			ns	ns
Arterial puncture	10						0.24	0.15–0.38		ns

* Findings represent studies addressing internal jugular access. † Random-effects odds ratio.
ns = $P > 0.01$.

Table 2. Consultant Survey Responses*

	N	Percent Responding to Each Item: Strongly Agree	Agree	Equivocal	Disagree	Strongly Disagree
I. Resource preparation						
1. Central venous catheterization should be performed in a location that permits the use of aseptic techniques	54	92.6*	7.4	0.0	0.0	0.0
2. A standardized equipment set should be available for central venous access	55	78.2*	16.4	5.4	0.0	0.0
3. A trained assistant should be present during placement of a central venous catheter	54	33.3	29.6*	16.7	18.4	1.9
4. A checklist or protocol should be used for the placement and maintenance of central venous catheters	54	59.3*	20.4	9.3	9.3	1.8
II. Prevention of infectious complications						
5. Intravenous antibiotic prophylaxis should not be administered routinely	55	43.6	32.7*	12.7	7.3	3.6
6. For immunocompromised patients and high-risk neonates, intravenous antibiotic prophylaxis may be administered on a case-by-case basis	55	23.6	36.4*	27.3	10.9	1.8
7. The practitioner should use the following aseptic techniques in preparation for the placement of central venous catheters (check all that apply)	55	Percentage				
Hand washing		100.0				
Sterile full-body drapes		87.3				
Sterile gowns		100.0				
Gloves		100.0				
Caps		100.0				
Masks covering both mouth and nose		100.0				

(*continued*)

Table 2. Continued

		Percent Responding to Each Item				
	N	Strongly Agree	Agree	Equivocal	Disagree	Strongly Disagree
8. Chlorhexidine with alcohol should be used for skin preparation	55	72.7*	27.3	0.0	0.0	0.0
9. Catheters coated with antibiotics or a combination of chlorhexidine and silver sulfadiazine may be used in selected patients based on infectious risk, cost, and anticipated duration of catheter use	55	38.2	45.5*	16.3	0.0	0.0
10. Please indicate your preferred central venous catheter insertion site to minimize catheter-related risk of infection (check one)	55	Percentage				
Internal jugular		41.8				
Subclavian		52.7				
Femoral		0.0				
No preference		5.5				
11. Femoral catheterization should be avoided when possible to minimize the risk of infection	54	37.0	53.7*	3.7	3.7	1.9
12. An insertion site should be selected that is not contaminated or potentially contaminated (*e.g.*, burned or infected skin, inguinal area, adjacent to tracheostomy or open surgical wound)	53	71.7*	24.5	7.8	0.0	0.0
13. Please indicate your preferred catheter fixation technique to minimize catheter-related risk of infection (check one)	54	Percentage				
Sutures		70.4				
Staples		3.7				
Tape		5.5				
No preference		20.4				
14. Transparent bio-occlusive dressings should be used to protect the site of central venous catheter insertion from infection	55	52.7*	41.8	3.6	1.8	0.0
15. Dressings containing chlorhexidine may be used to reduce the risk of catheter-related infection	55	20.0	34.6*	45.4	0.0	0.0
16. The duration of catheterization should be based on clinical need	55	61.8*	30.9	0.0	7.3	0.0
17. The clinical need for keeping a catheter in place should be assessed daily	53	90.6*	9.4	0.0	0.0	0.0
18. Catheters should be promptly removed when deemed no longer clinically necessary	54	88.9*	11.1	0.0	0.0	0.0
19. The catheter site should be inspected daily for signs of infection	54	88.9*	11.1	0.0	0.0	0.0
20. The catheter should be changed or removed when infection is suspected	55	74.6*	20.0	3.6	1.8	0.0
21. When catheter-related infection is suspected, replacing the catheter using a new insertion site is preferable to changing the catheter over a guidewire	55	70.9*	27.3	1.8	0.0	0.0
22. Catheter access ports should be wiped with an appropriate antiseptic before each access	55	69.1*	21.8	7.3	1.8	0.0
23. Needleless catheter access ports may be used on a case-by-case basis	55	30.9	47.3*	12.7	3.6	5.5
24. Central venous catheter stopcocks should be capped when not in use	54	81.5*	18.5	0.0	0.0	0.0

(*continued*)

Table 2. Continued

	N	Percent Responding to Each Item: Strongly Agree	Agree	Equivocal	Disagree	Strongly Disagree
III. Prevention of mechanical trauma or injury						
25. Please indicate your preferred central venous catheter insertion site to minimize catheter cannulation-related risk of injury or trauma (check one)	55	Percentage				
Internal jugular		81.8				
Subclavian		9.1				
Femoral		3.6				
No preference		5.6				
26. Please indicate your preferred central venous catheter insertion site to minimize catheter-related risk of thromboembolic injury or trauma (check one)	55	Percentage				
Internal jugular		76.4				
Subclavian		7.3				
Femoral		0.0				
No preference		16.3				
27. When clinically appropriate and feasible, central venous access in the neck or chest should be performed in the Trendelenburg position	54	51.9*	33.3	9.6	5.6	0.0
28. Selection of catheter type (*i.e.,* gauge, length, number of lumens) and composition (*e.g.*, polyurethane, Teflon) should be based on the clinical situation and skill/experience of the operator	55	49.1	38.2*	9.1	3.6	0.0
29. Selection of a modified Seldinger technique *vs.* a Seldinger technique should be based on the clinical situation and the skill/experience of the operator	55	36.4	49.1*	5.4	7.3	1.8
30. The number of insertion attempts should be based on clinical judgment	55	45.5	32.7*	3.6	16.4	1.8
31. The decision to place two catheters in a single vein should be made on a case-by-case basis	55	55.6*	40.0	3.6	1.8	0.0
32. Ultrasound imaging (*i.e.*, static) should be used in elective situations for pre-puncture identification of anatomy and vessel localization when the internal jugular vein is selected for cannulation	53	49.1	26.4*	11.3	9.4	3.8
33. Ultrasound imaging (*i.e.*, static) should be used in elective situations for pre-puncture identification of anatomy and vessel localization when the subclavian vein is selected for cannulation	55	12.7	18.2	32.7*	25.5	10.9
34. Ultrasound imaging (*i.e.*, static) should be used in elective situations for pre-puncture identification of anatomy and vessel localization when the femoral vein is selected for cannulation	55	18.2	32.7*	21.8	23.6	3.6
35. When available, real-time ultrasound should be used for guidance during venous access when the internal jugular vein is selected for cannulation	54	44.4	33.3*	13.0	9.3	0.0
36. When available, real-time ultrasound should be used for guidance during venous access when the subclavian vein is selected for cannulation	53	11.3	17.0	37.7*	28.3	5.7

(*continued*)

Table 2. Continued

	Percent Responding to Each Item					
	N	Strongly Agree	Agree	Equivocal	Disagree	Strongly Disagree
37. When available, real-time ultrasound should be used for guidance during venous access when the femoral vein is selected for cannulation	54	14.8	35.2*	33.3	14.8	1.9
38. Before insertion of a dilator or large bore catheter over a wire, venous access should be confirmed for the catheter or thin-wall needle that accesses the vein	54	57.4*	25.9	7.4	9.3	0.0
39. Before insertion of a dilator or large bore catheter over a wire, venous access should be confirmed for the wire that subsequently resides in the vein after traveling through a catheter or thin-wall needle	55	29.1	29.1*	25.5	12.7	3.6
40. When feasible, both the location of the catheter or thin-wall needle *and* wire should be confirmed	55	25.4	38.2*	18.2	15.6	3.6
41. A chest radiograph should be performed to confirm the location of the catheter tip as soon after catheterization as clinically appropriate	55	30.9	41.8*	9.1	14.5	3.6
42. For central venous catheters placed in the operating room, a confirmatory chest radiograph may be performed in the early postoperative period	55	47.3	50.9*	0.0	1.8	0.0
43. If a chest radiograph will be deferred to the postoperative period, pressure/waveform analysis, blood gas analysis, ultrasound or fluoroscopy should be used to confirm venous positioning of the catheter before use	55	56.4*	30.9	5.4	7.3	0.0
IV. Management of arterial trauma or injury arising from central venous						
44. When unintended cannulation of an arterial vessel with a large bore catheter occurs, the catheter should be left in place and a general or vascular surgeon should be consulted	55	45.4	36.4*	7.3	9.1	1.8

* N = number of consultants who responded to each item. An asterisk next to a percentage score indicates the median.

Table 3. ASA Member Survey Responses*

		Percent Responding to Each Item				
	N	Strongly Agree	Agree	Equivocal	Disagree	Strongly Disagree
I. Resource preparation						
1. Central venous catheterization should be performed in a location that permits the use of aseptic techniques	529	78.1*	19.1	2.1	0.8	0.0
2. A standardized equipment set should be available for central venous access	530	64.5*	30.0	4.2	0.9	0.4
3. A trained assistant should be present during placement of a central venous catheter	526	24.1	35.6*	24.0	13.1	3.2
4. A checklist or protocol should be used for The placement and maintenance of central venous catheters	528	35.6	37.5*	16.3	8.9	1.7
II. Prevention of infectious complications						
5. Intravenous antibiotic prophylaxis should not be administered routinely	526	29.7	44.5*	16.9	7.0	1.9
6. For immunocompromised patients and high-risk neonates, intravenous antibiotic prophylaxis may be administered on a case-by-case basis	523	25.0	54.1*	15.9	4.2	0.8
7. The practitioner should use the following aseptic techniques in preparation for the placement of central venous catheters (check all that apply)	524	Percentage				
Hand washing		96.0				
Sterile full-body drapes		73.8				
Sterile gowns		87.8				
Gloves		100.0				
Caps		94.7				
Masks covering both mouth and nose	98.1					
8. Chlorhexidine with alcohol should be used for skin preparation	522	57.3*	34.1	7.8	0.8	0.0
9. Catheters coated with antibiotics or a combination of chlorhexidine and silver sulfadiazine may be used in selected patients based on infectious risk, cost, and anticipated duration of catheter use	526	24.3	54.8*	19.2	1.7	0.0
10. Please indicate your preferred central venous catheter insertion site to minimize catheter-related risk of infection (check one)	524	Percentage				
Internal jugular		51.3				
Subclavian		44.3				
Femoral		0.0				
No preference		4.4				
11. Femoral catheterization should be avoided when possible to minimize the risk of infection	525	33.9	49.7*	9.3	4.7	2.3
12. An insertion site should be selected that is not contaminated or potentially contaminated (*e.g.*, burned or infected skin, inguinal area, adjacent to tracheostomy or open surgical wound)	523	58.9*	37.9	2.5	0.7	0.0

(*continued*)

Table 3. Continued

	Percent Responding to Each Item					
	N	Strongly Agree	Agree	Equivocal	Disagree	Strongly Disagree
13. Please indicate your preferred catheter fixation technique to minimize catheter-related risk of infection (check one)	524	Percentage				
Sutures		80.2				
Staples		5.7				
Tape		3.6				
No preference		10.5				
14. Transparent bio-occlusive dressings should be used to protect the site of central venous catheter insertion from infection	522	46.9	44.4*	6.5	1.3	0.8
15. Dressings containing chlorhexidine may be used to reduce the risk of catheter-related infection	525	18.7	37.9*	41.3	1.9	0.2
16. The duration of catheterization should be based on clinical need	523	49.5	44.5*	3.1	2.5	0.4
17. The clinical need for keeping a catheter in place should be assessed daily	523	65.8*	32.5	1.3	0.4	0.0
18. Catheters should be promptly removed when deemed no longer clinically necessary	521	78.7*	20.9	0.4	0.0	0.0
19. The catheter site should be inspected daily for signs of infection	521	79.1*	19.6	1.1	0.2	0.0
20. The catheter should be changed or removed when infection is suspected	524	72.7*	24.4	2.5	0.2	0.2
21. When catheter-related infection is suspected, replacing the catheter using a new insertion site is preferable to changing the catheter over a guidewire	525	64.8*	30.7	3.8	0.8	0.0
22. Catheter access ports should be wiped with an appropriate antiseptic before each access	522	64.6*	31.0	3.4	1.0	0.0
23. Needleless catheter access ports may be used on a case-by-case basis	522	33.9	51.3*	12.3	1.7	0.8
24. Central venous catheter stopcocks should be capped when not in use	527	70.6*	26.2	2.6	0.6	0.0
III. Prevention of mechanical trauma or injury						
25. Please indicate your preferred central venous catheter insertion site to minimize catheter cannulation-related risk of injury or trauma (check one)	525	Percentage				
Internal jugular		79.4				
Subclavian		10.7				
Femoral		2.7				
No preference		7.2				
26. Please indicate your preferred central venous catheter insertion site to minimize catheter-related risk of thromboembolic injury or trauma (check one)	525	Percentage				
Internal jugular		67.6				
Subclavian		12.8				
Femoral		1.9				
No preference		17.7				

(*continued*)

Table 3. Continued

	Percent Responding to Each Item					
	N	Strongly Agree	Agree	Equivocal	Disagree	Strongly Disagree
27. When clinically appropriate and feasible, central venous access in the neck or chest should be performed in the Trendelenburg position	528	57.0*	37.7	3.0	1.9	0.4
28. Selection of catheter type (*i.e.*, gauge, length, number of lumens) and composition (*e.g.*, polyurethane, Teflon) should be based on the clinical situation and skill/experience of the operator	530	52.1*	38.1	6.2	3.4	0.0
29. Selection of a modified Seldinger technique *vs.* a Seldinger technique should be based on the clinical situation and the skill/experience of the operator	531	47.8	36.9*	9.8	4.7	0.8
30. The number of insertion attempts should be based on clinical judgment	528	47.3	43.6*	4.2	3.8	1.1
31. The decision to place two catheters in a single vein should be made on a case-by-case basis	527	45.9	36.2*	12.1	4.4	1.3
32. Ultrasound imaging (*i.e.*, static) should be used in elective situations for pre-puncture identification of anatomy and vessel localization when the internal jugular vein is selected for cannulation	526	28.9	25.1*	21.3	18.8	5.9
33. Ultrasound imaging (*i.e.*, static) should be used in elective situations for pre-puncture identification of anatomy and vessel localization when the subclavian vein is selected for cannulation	528	9.7	14.2	41.5*	26.5	8.1
34. Ultrasound imaging (*i.e.*, static) should be used in elective situations for pre-puncture identification of anatomy and vessel localization when the femoral vein is selected for cannulation	527	11.9	29.8	30.6*	21.4	6.3
35. When available, *real time* ultrasound should be used for guidance during venous access when the *internal jugular* vein is selected for cannulation	525	24.0	24.2	23.2*	21.5	7.1
36. When available, *real time* ultrasound should be used for guidance during venous access when the *subclavian* vein is selected for cannulation	530	8.1	13.4	42.1*	27.9	8.5
37. When available, real-time ultrasound should be used for guidance during venous access when the femoral vein is selected for cannulation	528	13.5	23.5	31.4*	25.0	6.6
38. Before insertion of a dilator or large bore catheter over a wire, venous access should be confirmed for the catheter or thin-wall needle that accesses the vein	524	52.9*	32.1	8.4	6.3	0.4
39. Before insertion of a dilator or large bore catheter over a wire, venous access should be confirmed for the *wire* that subsequently resides in the vein after traveling through a catheter or thin-wall needle	524	24.0	25.4	25.6*	22.9	2.1

(*continued*)

Table 3. Continued

	Percent Responding to Each Item					
	N	Strongly Agree	Agree	Equivocal	Disagree	Strongly Disagree
40. When feasible, *both* the location of the catheter or thin-wall needle *and* wire should be confirmed	526	23.8	32.5*	22.1	19.4	2.3
41. A chest radiograph should be performed to confirm the location of the catheter tip as soon following catheterization as clinically appropriate	525	39.8	45.5*	7.1	7.0	0.6
42. For central venous catheters placed in the operating room, a confirmatory chest radiograph may be performed in the early postoperative period	524	46.8	48.1*	2.5	1.9	0.8
43. If a chest radiograph will be deferred to the postoperative period, pressure/waveform analysis, blood gas analysis, ultrasound or fluoroscopy should be used to confirm venous positioning of the catheter before use	527	33.0	35.3*	12.7	16.7	2.3
IV. Management of arterial trauma or injury arising from central venous						
44. When unintended cannulation of an arterial vessel with a large bore catheter occurs, the catheter should be left in place and a general or vascular surgeon should be consulted	526	28.5	35.6*	16.3	17.9	1.7

* Number of ASA members who responded to each item. An asterisk next to a percentage score indicates the median.

Table 4. SPA Member Survey Responses*

		Percent Responding to Each Item				
	N	Strongly Agree	Agree	Equivocal	Disagree	Strongly Disagree
1. A chlorhexidine-containing solution should be used for skin preparation in neonates†	250	17.2	26.0	31.6*	17.2	8.0
2. A chlorhexidine-containing solution should be used for skin preparation in infants‡	248	46.0	40.3*	11.3	2.4	0.0
3. A chlorhexidine-containing solution should be used for skin preparation in children§	249	62.7*	30.9	5.2	1.2	0.0
4. Dressings containing chlorhexidine may be used in neonates	243	7.0	14.0	52.2*	20.2	6.6
5. Dressings containing chlorhexidine may be used in infants	249	22.5	36.6*	35.3	4.8	0.8
6. Dressings containing chlorhexidine may be used in children	249	38.6	35.3*	24.5	1.2	0.4
7. When unintended cannulation of an arterial vessel with a large bore catheter occurs in neonates (check one)	244	Percentage				
The catheter should be left in place[5]		54.9				
The catheter may be nonsurgically removed‖		45.1				
8. When unintended cannulation of an arterial vessel with a large-bore catheter occurs in infants (check one)	249	Percentage				
The catheter should be left in place		43.8				
The catheter may be nonsurgically removed		56.2				
9. When unintended cannulation of an arterial vessel with a large bore catheter occurs in children (check one)	244	Percentage				
The catheter should be left in place		30.0				
The catheter may be nonsurgically removed		70.0				

* Number of SPA members who responded to each item. An asterisk beside a percentage score indicates the median response. † Younger than 44 gestational weeks. ‡ Younger than 2 yr. § 2–16 yr of age. ‖ The complete wording of the response category is: The catheter should be left in place and a general surgeon, vascular surgeon, or interventional radiologist should be immediately consulted before deciding on whether to remove the catheter, either surgically or nonsurgically. # The complete wording of the response category is: The catheter may be nonsurgically removed without consulting a general surgeon, vascular surgeon, or interventional radiologist.

Table 5. Evidence Summary*

Interventions	Evidence Category[1]	Consultant Survey[2]	ASA Member Survey[2]	SPA Member Survey[2]	Guideline Recommendation
I. Resource preparation					
Catheterization in environment that permits use of aseptic techniques	D	Strongly agree	Strongly agree		Should be performed
Standardized equipment set	D	Strongly agree	Strongly agree		Should be available
An assistant	D	Agree (trained)	Agree (trained)		Should be used
A checklist or protocol	B2[3]	Strongly agree	Agree		Should be used
II. Prevention of infectious complications					
Intravenous antibiotic prophylaxis					
Prophylactic intravenous antibiotics should not be administered routinely	D	Agree	Agree		Should not be routinely administered
Prophylactic intravenous antibiotics should be administered to immunocompromised patients and high-risk neonates	A2[4]	Agree	Agree		Administer on a case-by-case basis
Aseptic techniques and barrier precautions:					
Maximal barrier *vs.* gloves and small drape only	C2[5,6]				
"Bundled" elements: hand-washing, sterile full body drapes, sterile, gloves, caps, and masks	B2[3]				
Specific activities:					
Hand washing	D	100% agreement	96% agreement		Use
Sterile full-body drape	D	87% agreement	74% agreement		Use
Sterile gown	D	100% agreement	88% agreement		Use
Sterile gloves	D	100% agreement	100% agreement		Use
Caps	D	100% agreement	95% agreement		Use
Masks covering both mouth and nose	D	100% agreement	98% agreement		Use
Skin preparation:					
Solutions containing chlorhexidine:					
Chlorhexidine with alcohol (patient age not specified)	D	Strongly agree	Strongly agree		Should be used for adults, infants and children
Antiseptic solutions containing chlorhexidine for:					
Neonates	D			Equivocal	Should be based on clinical judgment and Institutional protocol
Infants	D			Agree	Should be used
Children	D			Strongly agree	Should be used
Solutions containing alcohol:					
Chlorhexidine *without* alcohol *vs.* povidone-iodine without alcohol	C2[5,7]				
Chlorhexidine *with* alcohol *vs.* Povidone-iodine with alcohol	D				
Skin preparation solutions with vs. without alcohol:					
Chlorhexidine	D				

(*continued*)

Table 5. Continued

Interventions	Evidence Category[1]	Consultant Survey[2]	ASA Member Survey[2]	SPA Member Survey[2]	Guideline Recommendation
Povidone-iodine	A3[5]/C2[8]				
Skin preparation solutions containing alcohol					Use unless contraindicated
Catheters containing antimicrobial agents:					
Antibiotic-coated catheters	A1[5]	Agree (selected pts)	Agree (selected pts)		Should be used for selected patients
Silver-impregnated catheters	C1[3]/C2[5]				No recommendation
Chlorhexidine and silver sulfadiazine coated catheters	A1[5]/B3[9]/C1[3]	Agree (selected pts)	Agree (selected pts)		Should be used for selected patients
Selection of catheter insertion site:					
Internal jugular *vs.* subclavian	C2[3,5]/C3[3,5]	Majority prefer subclavian site	Majority prefer internal jugular site		Site selection should be based on clinical need to minimize risk of catheter-related infection
Subclavian *vs.* femoral	A3[5]/C2[4]	Agree (avoid femoral)	Agree (avoid femoral)		Site selection should be based on clinical need. In adults, upper body site should be considered to minimize risk of infection
Catheter fixation:					
Risk of catheter-related infections with suture, staple, tape	D	Majority prefer suture	Majority prefer suture		Should be determined on a local or institutional basis
Catheter insertion site dressings:					
Transparent bio-occlusive	D	Strongly agree	Strongly agree		Should be used
Chlorhexidine sponge dressings (patient age not specified)	C2[3,5]	Agree	Agree		May be used unless contraindicated
Chlorhexidine-impregnated transparent dressings for neonates	A3[10]				Should be based on clinical judgment and institutional protocol
Chlorhexidine sponge dressings					
For neonates				Equivocal	Should be based on clinical judgment and institutional protocol
For infants				Agree	May be used, unless contraindicated
For children				Agree	May be used, unless contraindicated
Silver-impregnated transparent dressings	C2[5]				No recommendation
Catheter maintenance:					
Duration of catheterization related to higher colonization/infection rates	B2[4,5]				
Duration of catheterization should be based on clinical need		Strongly agree	Agree		Duration should be based on clinical need
Specific time intervals between insertion site inspections	D				
Catheter change interval 3-days *vs.* 7-days	C2[5]				
Daily assessment of clinical need for continuing catheterization		Strongly agree	Strongly agree		Clinical need for keeping catheter in place should be assessed daily

(*continued*)

Table 5. Continued

Interventions	Evidence Category[1]	Consultant Survey[2]	ASA Member Survey[2]	SPA Member Survey[2]	Guideline Recommendation
Conduct daily catheter site inspections		Strongly agree	Strongly agree		Catheter insertion site should be inspected daily for signs of infection
Change or remove catheter when infection is suspected		Strongly agree	Strongly agree		Catheter should be changed or removed when Catheter insertion site infection is suspected
When catheter-related infection is suspected, replace catheter using new insertion site *vs.* catheter change over a guidewire	C1[5]	Strongly agree (Suspected infection)	Strongly agree (Suspected infection)		When catheter-related infection is suspected, replacing the catheter using a new insertion site is preferred
Promptly remove catheter when deemed no longer clinically necessary		Strongly agree	Strongly agree		Promptly remove catheter when deemed no longer clinically necessary
Aseptic techniques using an existing central venous catheter:					
Wipe port with an appropriate antiseptic before access	D	Strongly agree	Strongly agree		Catheter access ports should be wiped with an appropriate antiseptic before each access
Cap stopcocks or access ports when not in use		Strongly agree	Strongly agree		Central venous catheter stopcocks or access ports should be capped when not in use
Needleless catheter connectors/access ports *vs.* standard caps					
Needleless catheter connectors/ports *vs.* standard caps	A2[11]/C2[3]	Agree (case-by case basis)	Agree (case-by case basis)		Needless catheter access ports may be used on a case-by-case basis
III. Prevention of mechanical trauma or injury					
Selection of catheter insertion site:					
Internal jugular *vs.* subclavian	C2[13,14,15,16]/C3[17]				
Subclavian *vs.* femoral	A3[12]				
Preferred catheter insertion site		Majority prefer internal jugular	Majority prefer internal jugular		Insertion site selection should be based on clinical need and practitioner judgment, experience and skill. In adults, selection of an upper body insertion site should be considered to minimize the risk of thromboembolic injury or trauma
Positioning the patient for needle insertion and catheter placement:					
Trendelenburg *vs.* normal supine	B2[18]	Strongly agree	Strongly agree		When clinically appropriate and feasible, central venous access in the neck or chest should be performed with the patient in the Trendelenburg position

(*continued*)

Table 5. Continued

Interventions	Evidence Category[1]	Consultant Survey[2]	ASA Member Survey[2]	SPA Member Survey[2]	Guideline Recommendation
Needle insertion, wire and catheter placement:					
Selection of catheter size and type		Strongly agree	Strongly agree		Should be based on the clinical situation and the skill and experience of the practitioner; selection of the smallest size catheter appropriate for the clinical situation should be considered
Large-bore catheters associated with unintentional arterial cannulation	B3[19]				Select the smallest size catheter appropriate for the clinical situation
Modified Seldinger *vs.* Seldinger technique	D	Agree	Agree		Should be based on the clinical situation and the skill and experience of the operator; the decision to use a catheter-over-the- needle (modified Seldinger) technique or a thin-wall needle (Seldinger) technique should be based 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
Limiting the number of insertion attempts	D	Agree	Agree		Should be based on clinical judgment
Introducing two catheters in the same central vein	B2[20]/C3[13,15]	Strongly agree (case-by-case)	Agree (case-by-case)		Should be decided on a case-by-case basis
Guidance of needle placement in elective situations:					
Static ultrasound for preprocedural vessel localization *vs.* landmark approach:					
Internal jugular vein access	A3[21]/C2[22]	Agree (elective situations)	Agree (elective situations)		Use
Subclavian vein access	C2[22]	Equivocal (elective situations)	Equivocal (elective situations)		May be used
Femoral vein access	D	Agree (elective situations)	Equivocal (elective situations)		May be used
Real-time ultrasound for guiding needle *vs.* landmark approach:					
Internal jugular vein access	A1[13,21,22,23]/A2[24]	Agree (when available)	Equivocal (when available)		Use
Subclavian vein access	A2[24]/A3[13,15,16,23]	Equivocal (when available)	Equivocal (when available)		May be used
Femoral vein access	A3[21,24]	Agree (when available)	Equivocal (when available)		May be used

(*continued*)

Table 5. Continued

Interventions	Evidence Category[1]	Consultant Survey[2]	ASA Member Survey[2]	SPA Member Survey[2]	Guideline Recommendation
Verification of venous access:					
Confirm that catheter or thin-wall needle is in a vein		Strongly agree	Strongly agree		Confirm venous access after insertion of catheter that went over the needle or a thin-wall needle
Ultrasound	D				An identified method
Manometry	B2[13]				An identified method
Pressure waveform analysis	D				An identified method
Venous blood gas	D				An identified method
Absence of pulsatility, blood color	D				Should not be relied upon to confirm venous access (based on Task Force opinion)
Confirm venous residence of the wire		Agree	Equivocal		When using the thin-wall needle technique, confirm venous residence of the wire after the wire is threaded
Ultrasound	B2[25]				An identified method
Transesophageal ultrasound	B3[25]				An identified method
Continuous electrocardiography	D				An identified method (based on Task Force opinion)
Fluoroscopy	D				An identified method (based on Task Force opinion)
Confirm both the location of the catheter or thin-wall needle and wire		Agree (when feasible)	Agree (when feasible)		Confirm if there is any uncertainty that the catheter or wire resides in the vein
Verification of catheter placement:					
Confirmation of final position of tip of catheter					Confirm the final position of the catheter tip as soon as clinically appropriate (based on Task Force opinion)
Fluoroscopy	B2[26]	Strongly agree	Agree		An identified method
Chest radiograph	B2[26]	Agree	Agree		An identified method
Continuous electrocardiography	A2[26]				An identified method
Unintended cannulation of an arterial vessel with a large bore catheter:					
Leave catheter in place (patient age not specified)	B3[27]	Agree	Agree		For adults, the catheter should be left in place and a general surgeon, a vascular surgeon, or an interventional radiologist should be immediately consulted
For neonates				Majority prefer leaving in place	Should be based on clinical judgment
For infants				Majority prefer nonsurgical removal	Should be based on clinical judgment

(*continued*)

Table 5. Continued

Interventions	Evidence Category[1]	Consultant Survey[2]	ASA Member Survey[2]	SPA Member Survey[2]	Guideline Recommendation
For children				Majority prefer Nonsurgical removal	Should be based on clinical judgment

* Categories of evidence for literature: Category A: Supportive Literature. Randomized controlled trials report statistically significant ($P < 0.01$) differences between clinical interventions for a specified clinical outcome. Level 1: The literature contains multiple randomized controlled trials, and aggregated findings are supported by meta-analysis. † Level 2: The literature contains multiple randomized controlled trials, but the number of studies is insufficient to conduct a viable meta-analysis for the purpose of these Guidelines. Level 3: The literature contains a single randomized controlled trial. Category B: Suggestive Literature. Information from observational studies permits inference of beneficial or harmful relationships among clinical interventions and clinical outcomes. Level 1: The literature contains observational comparisons (*e.g.*, cohort, case-control research designs) of clinical interventions or conditions and indicates statistically significant differences between clinical interventions for a specified clinical outcome. Level 2: The literature contains noncomparative observational studies with associative (*e.g.*, relative risk, correlation) or descriptive statistics. Level 3: The literature contains case reports. Category C: Equivocal Literature. The literature cannot determine whether there are beneficial or harmful relationships among clinical interventions and clinical outcomes. Level 1: Meta-analysis did not find significant differences ($P > 0.01$) among groups or conditions. Level 2: The number of studies is insufficient to conduct meta-analysis, and (1) randomized controlled trials have not found significant differences among groups or conditions or (2) randomized controlled trials report inconsistent findings. Level 3: Observational studies report inconsistent findings or do not permit inference of beneficial or harmful relationships. Category D: Insufficient Evidence from Literature. The lack of scientific evidence in the literature is described by the following terms. Inadequate: The available literature cannot be used to assess relationships among clinical interventions and clinical outcomes. The literature either does not meet the criteria for content as defined in the "Focus" of the Guidelines or does not permit a clear interpretation of findings due to methodological concerns (*e.g.*, confounding in study design or implementation). Silent: No identified studies address the specified relationships among interventions and outcomes. [1] 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. [2] Survey data recorded on a 5-point scale: strongly agree - agree - equivocal - disagree - strongly disagree; reported findings represent the median survey response. [3] Catheter-related bloodstream infection. [4] Catheter-related infection and sepsis. [5] Catheter colonization. [6] Catheter-related septicemia. [7] Catheter-related bacteremia. [8] Catheter-related infection and clinical signs of infection. [9] Anaphylactic shock. [10] Localized contact dermatitis. [11] Microbial contamination of stopcock entry ports. [12] Thrombotic complications. [13] Arterial puncture. [14] Deep vein thrombosis. [15] Hematoma. [16] Successful venipuncture. [17] Pneumothorax, hemothorax, or arrhythmia. [18] Diameter and cross sectional area of right internal jugular vein for patients older than 6 yr. [19] Severe injury (*e.g.*, hemorrhage, hematoma, pseudoaneurysm, arteriovenous fistula, arterial dissection, neurologic injury including stroke, and severe or lethal airway obstruction) may occur. [20] Dysrhythmia. [21] First insertion attempt success rate. [22] Overall successful cannulation rate. [23] Access time. [24] Number of insertion attempts. [25] Confirmation of venous placement of wire. [26] Identifying the position of the catheter tip. [27] Fewer severe complications in adult patients.

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‡‡ A complete bibliography used to develop these Guidelines, arranged alphabetically by author, is available as Supplemental Digital Content 1, http://links.lww.com/ALN/A783.

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