Appendices: Supplementary Online Content

Franco-Sadud R, Schnobrich D, Mathews M, et al. Recommendations on the use of ultrasound guidance for adult vascular access: a position statement of the Society of Hospital Medicine

This supplementary material has been provided by the authors to give readers additional information about their work. It was last updated on July 6, 2019.

Appendix 1 – Detailed Methods

Expert Panel Formulation

The Society of Hospital Medicine (SHM) Board of Directors delegated the SHM Education Committee with the task of developing recommendations on the use of ultrasound to guide bedside procedures. The chair of the SHM Education Committee appointed two chairs to lead the guideline development project, a subject matter expert in POCUS, and a senior member of the education committee. An additional subject matter expert co-chair was added given the broad scope of the project.

The SHM POCUS Task Force was assembled to carry out this guideline development project under the direction of the SHM Board of Directors, Director of Education, and Education Committee. All expert panel members were physicians or advanced practice providers with expertise in POCUS. Expert panel members were divided into working group members, external peer reviewers, and a methodologist. All expert panel members and two members of the SHM education committee were voting members. Working group members were required to be hospitalists per the SHM definition (1) and have expertise in POCUS. External peer reviewers were nationally recognized physicians with expertise in POCUS from different specialties, including emergency medicine, critical care, anesthesiology, pulmonary/critical care, internal medicine, and cardiology. All external peer reviewers had to have past experience in developing point-of-care ultrasound guidelines, either serving as a chair or member of a guideline development panel. Non-voting Task Force members included a medical librarian, the SHM Education Committee Chair, and the SHM Director of Education (see Acknowledgements).

Disclosures

This project did not receive any funding from any external sponsors or SHM. All Task Force members voluntarily participated, and none received an honorarium for participation. There was no industry input in the development of these guidelines, nor industry presence during any conference calls or meetings. All SHM POCUS Task Force members were required to disclose any potential conflicts of interests. Signed disclosure statements of all members were reviewed by the SHM Director of Education and an SHM POCUS Task Force chair prior to inclusion on the Task Force. One of the vascular access working group members reported a financial relationships that was reviewed and determined to not preclude participation in the working group.

One working group member (not in the vascular access working group), three external peer reviewers, and one chair reported financial relationships. Decisions to approve participation were guided by the 2008 and 2011 Institute of Medicine (IOM) reports on development of trustworthy Clinical Practice Guidelines (2,3). Prior to submission of this manuscript, all Task Force members were required to submit an updated conflict of interest disclosure statement for inclusion as an author or collaborator on the final manuscript. Conflict of Interest disclosures are included in Appendix 2.

Literature Search Strategy

The literature search was conducted in two independent phases. The first phase included independent literature searches conducted by working group members themselves. Each vascular access working group member and two co-chairs independently performed literature searches to avoid selection bias. Potentially relevant references were compiled, discussed during conferences calls every 2-4 weeks, and selected references were summarized in a shared, online data table. Based on the references gathered during the first phase of literature searches, key clinical questions and draft recommendations were prepared. The purpose of the first phase of the literature search was to identify key topics to guide the systematic literature search performed by the certified medical librarian.

The second phase was the systematic literature search conducted by a certified medical librarian. The Medline, Embase, CINAHL, and Cochrane medical databases were first searched from 1975 to October 2015 initially, and an updated literature searches were conducted to include November 2015 to November 2017. Search limiters were English language and adults only. Google Scholar was also searched without any limiters. Search terms and specific search strings for each draft recommendation are shown in Appendix 3. Articles identified by the comprehensive literature search were systematically screened and selected. All article abstracts were first screened for relevance by at least two members of the vascular access working group. Full-text versions of screened articles were reviewed, and articles on the use of ultrasound to guide vascular access were selected. Articles that discussed vascular access without ultrasound guidance were excluded. Additionally, the following article types were excluded: non-English language, non-human, age<18, meeting abstracts, meeting posters, letters, case reports, and editorials. All systematic reviews, meta-analyses, randomized controlled trials, and observational studies of ultrasound-guided vascular access were

screened and selected. References listed in narrative review articles were reviewed to ensure no important studies were missed. All full text articles were shared electronically amongst the working group members. Any disagreements about article selection were discussed during conference calls and final selection was based on consensus of the vascular access working group. Findings from the selected articles were abstracted into a data table. The selected literature was incorporated into the rationales of the draft recommendations during a series of weekly conference calls.

Development of Clinical Recommendations and Consensus

These recommendations were developed using the RAND Appropriateness Method that required panel judgment and consensus. Details about the RAND Appropriateness Method to gather consensus have been previously published (4). Voting members of the SHM POCUS Task Force reviewed and voted on the draft recommendations using the RAND appropriateness method. Panel members were advised to vote on appropriateness based on these 5 transforming factors: 1) Problem priority and importance, 2) Level of quality of evidence, 3) Benefit / harm balance, 4) Benefit / burden balance, 5) Certainty / concerns about PEAF (Preferences / Equity Acceptability / Feasibility).

The draft recommendations were uploaded into an internet-based electronic data collection tool (Redcap™) (Appendix 4). An invitation email was sent to panel members that included a link to vote and the data table with hyperlinks to view full-text PDF's of the reference articles. Panel members participated in two rounds of electronic voting in August 2018 and October 2018. Voting was conducted using a 9-point Likert scale, where 1 denotes extremely inappropriate and 9 denotes extremely appropriate with three zones: 1–3 points = inappropriate zone; 4–6 points = uncertain zone; and 7–9 points = appropriate zone. Minor modifications were made to the draft recommendations based on the feedback from the first round of voting. The RAND appropriateness method was applied using expert consensus for recommendations. The degree of consensus was assessed using the RAND algorithm after the second round of voting (Figure 1). Establishing a recommendation required at least 70% agreement that a recommendation was "appropriate." Disagreement was defined as >30% of panelists voting outside of the zone of the median. A strong recommendation required at least 80% of the votes within one integer of the median, following the RAND rules (Table 1).

The Vascular access Working Group members reviewed the voting results and narrative comments, to revise the draft recommendations. Any recommendations with disagreement were removed. Some phrases and references from recommendations with disagreement were incorporated in relevant recommendations without disagreement, or added to the Knowledge Gaps section. Recommendations were classified as strong or weak/conditional based on preset rules defining the panel's level of consensus, which determined the wording for each recommendation (Table 2). For strong recommendations, the phrase ''we recommend'' was used, along with the verb ''must'' or ''should'' depending upon whether or not the degree of consensus was perfect vs. very good, respectively. For weak or conditional recommendations, the phrase ''we suggest'' was used, along with the verb "can" or ''may'' depending on whether or not there was "good" vs. "some" consensus, respectively (4).

The final recommendations were reviewed and revised by a writing committee, which consisted of the Vascular access Working Group, chairs of all 5 working groups, and 2 of the Task Force co-chairs. The writing group was tasked with final review of each recommendation's wording, clinical relevance, usability, and feasibility. The revised manuscript underwent external peer review by POCUS experts from different subspecialties that are members of SHM POCUS Task Force. Final review of these recommendations was performed by all members of the SHM POCUS Task Force, SHM Education Committee, and SHM Executive Committee. The SHM Executive Committee endorsed this document prior to submission to the Journal of Hospital Medicine.

Figure 1 – RAND Algorithm

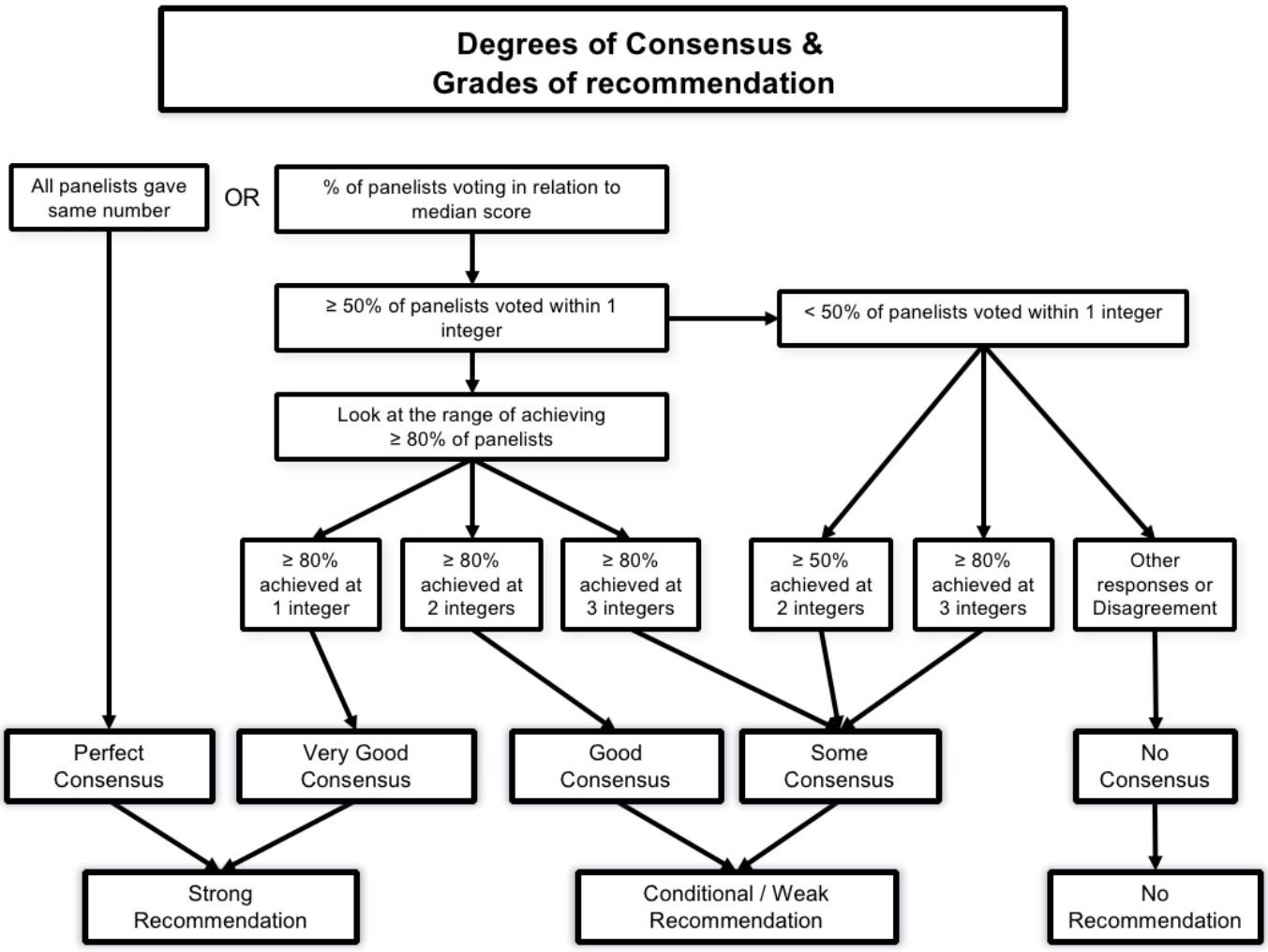


Table 1 – Definitions of Levels of Consensus

Term	Definition
Perfect consensus	All respondents agree on one number between 7-9
Very good consensus	Median and middle 50% (interquartile range) of respondents are found at one integer (*e.g.*, median and interquartile range are both at 8) or 80% of respondents are within one integer of the median (*e.g.*, median is 8, 80% respondents are from 7 to 9)
Good consensus	50% of respondents are within one integer of the median (*e.g.*, median is 8, 50% of respondents are from 7 to 9) or 80% of the respondents are within two integers of the median (*e.g.*, median is 7, 80% of respondents are from 5 to 9).
Some consensus	50% or respondents are within two integers of the median (*e.g.*, median is 7, 50% of respondents are from 5 to 9) or 80% of respondents are within three integers of the median (*e.g.*, median is 6, 80% of respondents are from 3 to 9).
No consensus	All other responses. Any median with disagreement

Table 2 – Degree of Consensus, Strength of recommendation, and Wording

Degree of consensus	Strength of recommendation	Wording [Function of voting]
Perfect consensus	Strong	recommend – must/to be/will
Very good consensus	Strong	recommend – should be/can
Good consensus	Weak/Conditional	suggest – to do
Some consensus	Weak/Conditional	suggest - may do
No consensus Disagreement	NO	No recommendation was made regarding

References

1. Definition of hospitalist available at: https://www.hospitalmedicine.org. Accessed May 15, 2015.

2. (IOM) IoM. Clinical Practice Guidelines We Can Trust. Washington, DC: The National Academies Press, 2011.

3. (IOM) IoM. Knowing What Works in Health Care: A Roadmap for the Nation. Washington, DC2008.

4. Fitch, Kathryn, Steven J. Bernstein, Maria Dolores Aguilar, Bernard Burnand, Juan Ramon LaCalle, Pablo Lazaro, Mirjam van het Loo, Joseph McDonnell, Janneke Vader and James P. Kahan. The RAND/UCLA Appropriateness Method User's Manual. Santa Monica, CA: RAND Corporation, 2001. http://www.rand.org/pubs/monograph_reports/MR1269.html.

Appendix 2 – Conflict of Interest Disclosures of SHM Point-of-care Ultrasound Task Force

Task Force Member	Voting Member	Disclosure	Company	Relationship	Related to project
Chairs					
Jeff Bates	Yes	No	--	--	--
Ricardo Franco	Yes	No	--	--	--
Nilam Soni	Yes	Yes	Elsevier-Saunders	Royalty	No
Vascular Access Working Group Members					
Ricardo Franco (chair)	Yes	No	--	--	--
Saaid Abdel-Ghani	Yes	No	--	--	--
Benji Matthews	Yes	No	--	--	--
Martin Perez	Yes	No	--	--	--
Sophia Rodgers	Yes	Yes	NCNP	Honorarium	No
Carolina Candotti	Yes	No	--	--	--
Dan Schnobrich	Yes	No	--	--	--
Other Working Group Members*					
Anjali Bhagra	Yes	No	--	--	--
Joel Cho	Yes	No	--	--	--
Ria Dancel	Yes	No	--	--	--
Trevor Jensen	Yes	No	--	--	--
Venkat Kalidindi	Yes	No	--	--	--
Ketino Kobaidze	Yes	No	--	--	--
Josh Lenchus	Yes	No	--	--	--
Brian Lucas	Yes	No	--	--	--
Nitin Puri	Yes	Yes	Fujifilm-Sonosite	Honorarium	No
Kreegan Reierson	Yes	No	--	--	--
Gerard Salame	Yes	No	--	--	--
David Tierney	Yes	No	--	--	--
Peer Reviewers					
Robert Arntfield	Yes	Yes	Fujifilm-Sonosite Elsevier-Saunders	Honorarium Royalty	No No
Michael Blaivis	Yes	No	--	--	--
Richard Hoppmann	Yes	Yes	Echonous	Advisory Board	No
Paul Mayo	Yes	No	--	--	--
Vicki Noble	Yes	Yes	Cambridge University Press	Royalty	No
Aliaksei Pustavoitau	Yes	No	--	--	--
Kirk Spencer	No	No	--	--	--
Vivek Tayal	Yes	No	--	--	--
Methodologist					
Mahmoud El-Barbary	No	No	--	--	--
Medical Librarian					
Loretta Grikis	No	No	--	--	--
SHM Education Committee					
Daniel Brotman	No	No	--	--	--
Susan Hunt	Yes	No	--	--	--
Satyen Nichani	No	No	--	--	--
SHM Staff					
Nick Marzano	No	No	--	--	--

*Thoracentesis, lumbar puncture, paracentesis, and credentialing working groups

Appendix 3 -- Vascular Access Literature Search Strings

A comprehensive literature search was performed of the following databases: Medline, Embase, CINAHL, and Cochrane. After searching Medline, duplicate references were removed from Embase and CINAHL. The following article types were excluded: non-English language, non-human, age<18, conference abstracts and posters, letters, case reports, and editorials. All relevant systematic reviews, meta-analyses, randomized controlled trials, and observational studies were included. Search strings for each database are listed below.

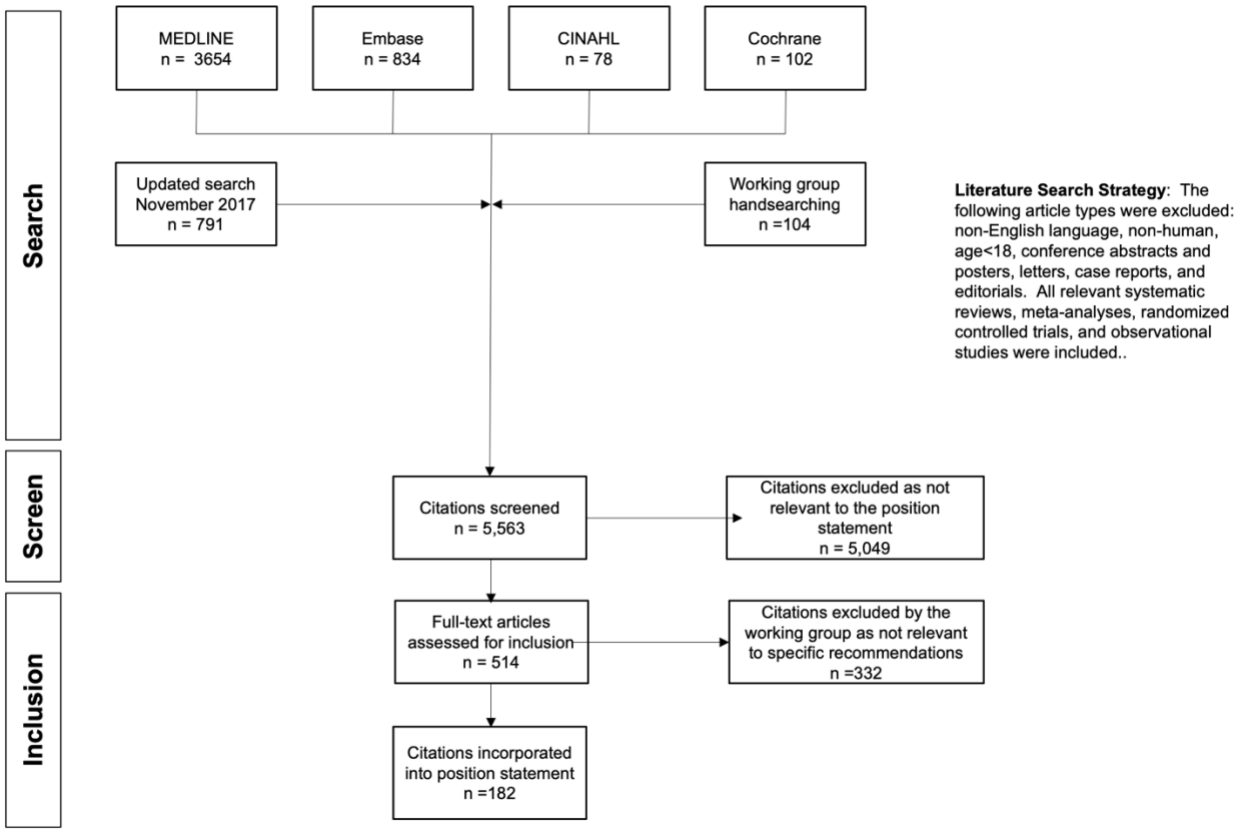
- **Medline** (PubMed)**:** ("Vascular Access Devices"[Mesh] OR "Central Venous Catheters"[Mesh] OR "Catheterization, Peripheral"[Mesh] OR "vascular catheter*"[tiab] OR "central venous access"[tiab] OR "central line"[tiab] OR "peripheral venous access"[tiab] OR "central venous catheter*"[tiab] OR "peripheral venous catheter*"[tiab] OR "arterial access"[tiab] OR "port catheter*"[tiab] OR "venous access"[tiab] OR "Port-A-Cath"[tiab] OR "arterial lines"[tiab] OR "intra-arterial lines"[tiab] OR PICC[tiab] OR "peripherally inserted central catheter"[tiab]) AND ("Ultrasonography"[Mesh] OR ultrasound[tiab] OR "Radiography"[Mesh]OR imaging[tiab] OR sonograph*[tiab] OR ultrasonic[tiab])

- **Embase:** 'catheterization'/mj OR 'intravascular catheter'/mj OR 'peripheral venous catheter'/mj OR 'central venous catheter'/mj OR 'peripherally inserted central venous catheter'/mj OR 'vascular catheter':ti OR 'central venous access':ti OR 'peripheral venous access':ti OR 'central venous catheter':ti OR 'peripheral venous catheter':ti OR 'arterial access':ti OR 'port catheter':ti OR 'venous access':ti OR 'port a cath':ti OR 'arterial line':ti OR 'intra-arterial line':ti OR picc:ti AND ('ultrasound'/mj OR ultrasonography:ti OR ultrasound:ti OR 'radiography'/mj OR imaging:ti OR sonography:ti OR ultrasonic:ti)

- **CINAHL:** (MH "Vascular Access Devices" OR (MH "Central Venous Catheters" OR MH "Peripherally Inserted Central Catheters" OR MH "Catheters, Vascular" OR MH "Catheterization, Peripheral Central Venous" OR MH "Catheterization, Central Venous" OR "vascular access device*" (ti) OR "central venous catheter*"(ti) OR "vascular catheter*"(ti) OR "central venous access"(ti) OR "central line*"(ti) OR "peripheral venous access"(ti) OR "central venous catheter*"(ti) OR "peripheral venous catheter*"(ti) OR "arterial access"(ti) OR "port catheter*"(ti) OR "venous access"(ti) OR Port-A-Cath(ti) OR "arterial line*"(ti) OR intra-arterial line*"(ti) OR PICC(ti)) AND (ultrasonography(ti) OR ultrasound(ti) OR ultrasound(ab) OR radiography (ti) OR image(ti) OR imaging(ti) OR sonograph*(ti)OR ultrasonic(ti))

- **Cochrane:** (catheterization or "intravascular catheter" or "peripheral venous catheter" or "peripherally inserted central venous catheter" or "vascular catheter" or "central venous access" or "peripheral venous access" or "central venous catheter" or "peripheral venous catheter" or "arterial access" or "port catheter" or "venous access" or "port a cath" or "arterial line" or "intra-arterial line" or PICC) and (ultrasound or ultrasonography or radiograph* or imaging or sonograph* or ultrasonic)

Figure 1 – Literature search strategy



Appendix 4 - Vascular Access Recommendations - SHM POCUS Guidelines - Round 2 Voting

Instructions: Please rate your level of agreement with each of the recommendations on the use of ultrasound to guide thoracentesis. A detailed literature review is provided in the "Comment" box.

We have included background information on the RAND Appropriateness Method below. It is NOT required that you read about RAND RAM before proceeding.

Introduction to RAND Appropriatenss Method (RAM)

RAM provides a structured method to obtain feedback regarding ranking or agreement of a statement or clinical procedure. RAND corporation, in conjunction with UCLA developed this method to evaluate scientific evidence and expert opinion in health care procedures and best practice guidelines. This method has become a leading standard for quality assessment in medicine. More information about the RAND Appropriateness Method, its uses and how it was developed can be found at:

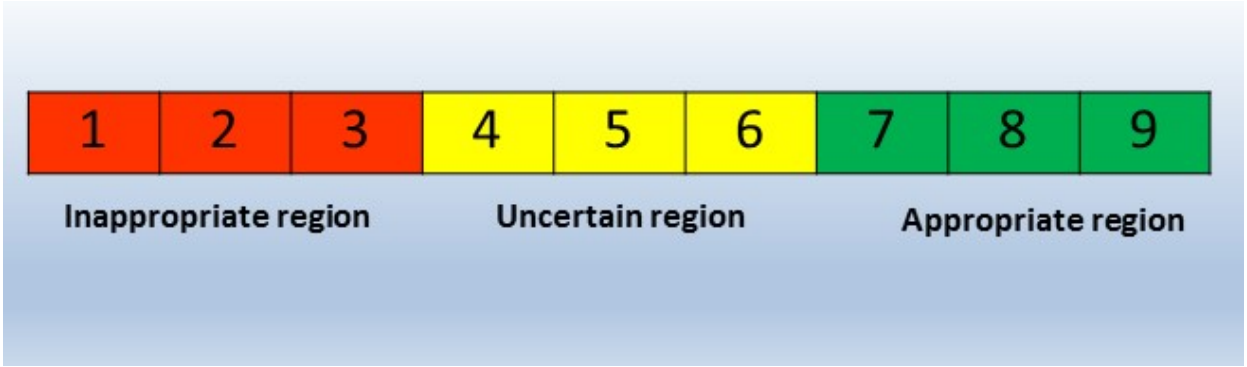
RAND/UCLA Appropriateness Method User's Manual

RAND Rules for Voting

Recommendation Ranking Instructions

Please rank the recommendations according to the RAND Appropriateness Scale.

1 = Extremely Inappropriate vs. 9 = Extremely Appropriate



When voting please consider the 5 transforming factors with stronger recommendations fulfilling more of these factors.

5 Transforming Factors:

1) Problem Priority / Importance - How critical is the potential outcome of this recommendation?
2) Level of Quality of Evidence (LQE) - How high is the Level of Quality of Evidence?
3) Benefit / Harm balance - How large is the net benefit/harm of the outcome of the recommendation?
4) Benefit / Burden balance - Is the burden worth the benefit?
5) Certainty / Concerns about PEAF (Preferences / Equity Acceptability / Feasibility) - How certain are you this recommendation would be feasible, equitable, acceptable, and preferred by patients?

[Attachment: "RAND EtD table.pdf"]

Central & Peripheral Venous and Arterial Vascular Access

Definitions

Central Venous Catheterization (CVC) - Central venous catheterization refers to insertion of tunneled or non-tunneled, large bore vascular catheters that are most commonly inserted in the internal jugular, subclavian, or femoral veins with the catheter tip located in a central vein. These vascular access catheters are synonymously referred to as central lines or central venous catheters (CVCs). (Note: For this guideline document, PICC lines, although considered central lines, will be referred to specifically as PICC lines and should not be included in statements about central venous catheters.)

Peripherally inserted central catheter (PICC) Catheterization - Peripherally inserted central catheters, or PICC lines, are inserted most commonly in the basilic, brachial, or cephalic veins in adult patients, and the catheter tip terminates in the distal superior vena cava or cavo-atrial junction (CAJ). These catheters are designed to remain in place for a duration of several weeks, as long as it is clinically indicated.

Midline Catheterization - Midline catheters are a type of peripheral venous catheter that is an intermediary between a PIV and PICC line. Midline catheters are most commonly inserted in the brachial or basilic veins, but unlike PICC lines, the tips of these catheters terminate in the axillary or subclavian vein. Midline catheters are typically 8 to 20 cm in length and inserted for a duration < 30 days.

Peripheral Intravenous Catheterization (PIV) - Peripheral intravenous catheters, or PIV lines, refer to insertion of non-tunneled, small bore venous catheters that are most commonly 14G to 24G in adult patients for short-term peripheral venous access. Common sites of ultrasound-guided PIV include superficial and deep veins of the hand, forearm, and arm.

Arterial Catheterization - Arterial catheters are commonly used for reliable blood pressure monitoring, frequent arterial blood sampling, and cardiac output monitoring. The most common arteries accessed are the femoral and radial arteries in adults.

Last Name:

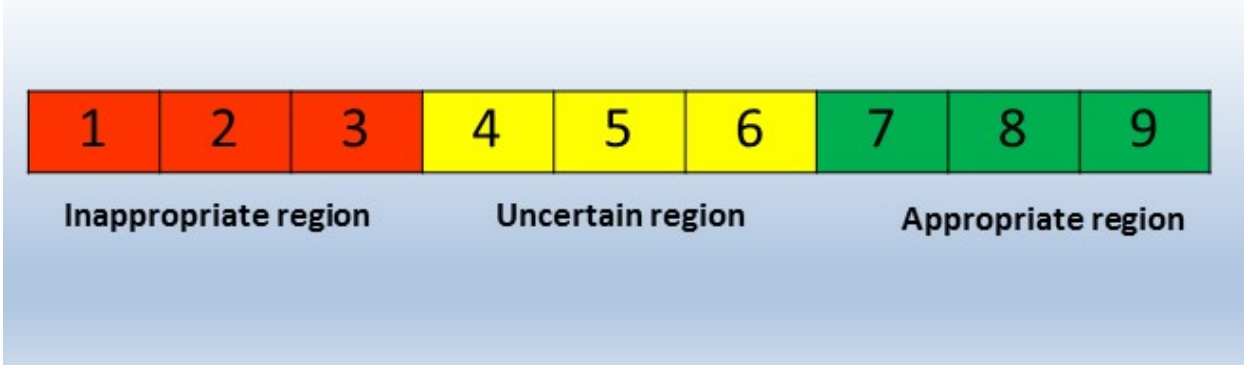
_____

First Name:

_____

Technique

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

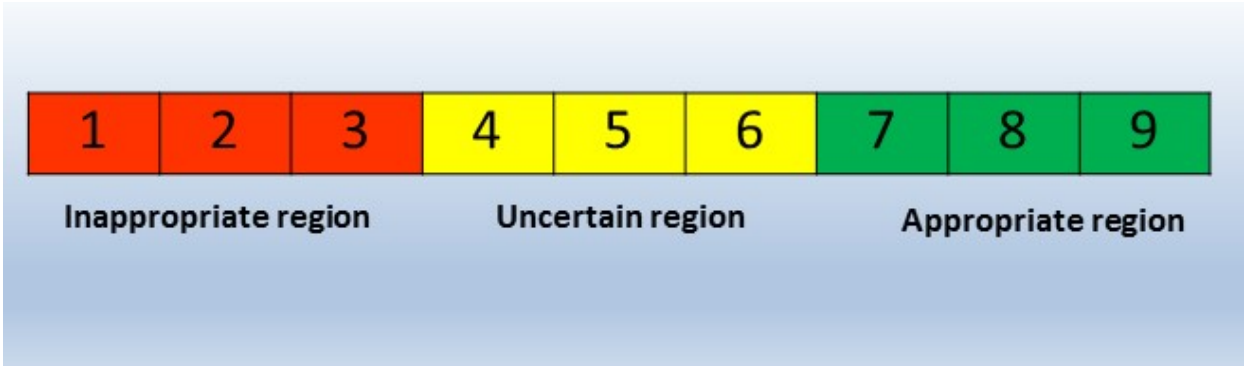
1) Providers are to be familiar with operation of the specific model of ultrasound machine, prior to initiation of the procedure.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
Prior to starting the procedure, the provider performing the procedure should be familiar with the knobology of the specific make and model of the ultrasound machine. Minimizing adjustments of the machine during the procedure may reduce the risk of contaminating the sterile field.

Please add any comments:

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

2) Providers are to use a high-frequency linear transducer with a sterile sheath and sterile gel to perform vascular access procedures.

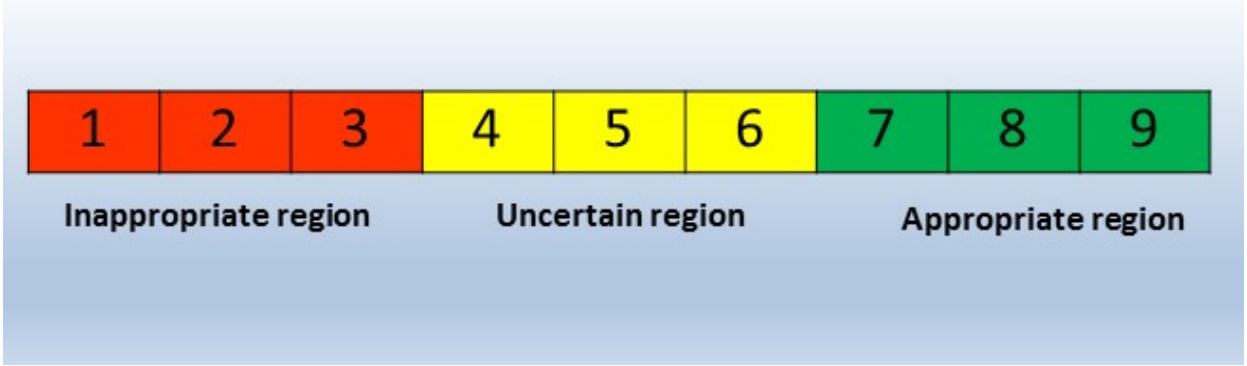
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
High-frequency linear-array transducers are preferred for the vast majority of vascular access procedures due to their superior resolution compared to other transducer types. Vascular access procedures should be performed using full sterile barrier precautions. A sterile transducer cover and sterile gel must be utilized, and providers must be trained in sterile preparation of the ultrasound transducer.1,10,109 There is a direct correlation between the depth of femoral vessels and BMI.138 Thus, among morbidly obese patients with a thigh circumference >60 cm and vessel depth >8 cm, a curvilinear probe might be preferred.

Please add any comments:

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

3) Providers are to use two-dimensional ultrasound to evaluate for anatomical variations and absence of thrombosis of arteries and veins during pre-procedural site selection.

(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
Several ultrasound studies have elucidated the anatomic variations between the internal jugular vein (IJV) and common carotid artery (CCA), particularly in terms of vessel overlap.33,40,41,42 Troianos et al. found >75% overlap of the IJV and CCA among 54% of all patients whose heads were rotated to the contralateral side. Additionally, two thirds of older patients (age> 60 years) had >75% overlap of the IJV and CCA.40 One study suggested rotating the head 75 degrees to maximize the vertical separation between the CCA and the IJV.111 Benter et al found that 36% of patients showed anatomical variation in the IJV and surrounding tissue.112 Another study found significant variability in the internal jugular vein position and internal jugular vein diameter (0.5 cm to > 2 cm) among 58 patients studied.110 In another study, the use of ultrasound during internal jugular vein cannulation reduced inadvertent carotid artery punctures (10% vs. 3%) with the use of ultrasound guidance.123

A study that included 126 patients showed that among 58 patients who had undergone central venous catheterization previously (9-19 weeks earlier) 29 (50%) had IJV occlusion thus leading to an alternative site being selected for cannulation. In this study, the use of ultrasound reduced unnecessary attempts at catheterizing occluded veins.161

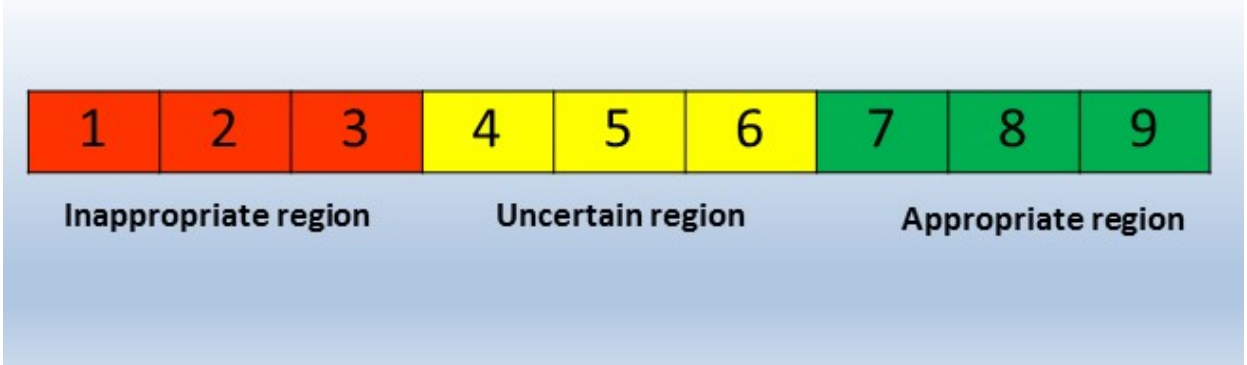
During subclavian vein access, pre-procedural evaluation of contralateral infraclavicular subclavian/axillary veins showed a significant absolute cross-sectional area difference of 26.7 mm2 with statistical significance P< 0.001. This difference had no correlation with hand dominance or anthropomorphic indices.113

Though used extensively in the past, the use of continuous wave Doppler ultrasound alone for guidance for IJV cannulation is discouraged because it does not offer benefit over 2-dimensional (B-mode) ultrasound imaging.44 A prospective randomized study of 338 patients getting internal jugular CVC placement split them into Doppler (189) vs ultrasound guided group (149). The ultrasound group showed significant improvement in first pass rates and significantly outperforms doppler in patients with BMI>30.114

Please add any comments:

Technique

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

4) Providers are to evaluate the target vessel size and depth during the pre-procedural ultrasound evaluation.

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
A thorough ultrasound examination of the target vessel is warranted prior to catheter placement, especially in patients with previous temporary or tunneled venous catheters that may have resulted in stenosis and/or thrombosis of the vein. Acute or chronic upper extremity deep venous thrombosis or stenosis is most often identifiable only by ultrasound examination. Contrary to traditional teaching, the internal jugular vein is located 1 cm anterolateral to the common carotid artery in only about 2/3 of patients.113,110,124,125

In one study, 75% of hemodialysis patients had sonographic venous abnormalities that required a change in venous access approach 121; and in another 19 of 51 bariatric patients had anatomical variations for the IJV and 4/51 patients had an asymptomatic thrombosis 122. An additional assessment of collateral blood flow and perfusion should be conducted prior to arterial cannulation.

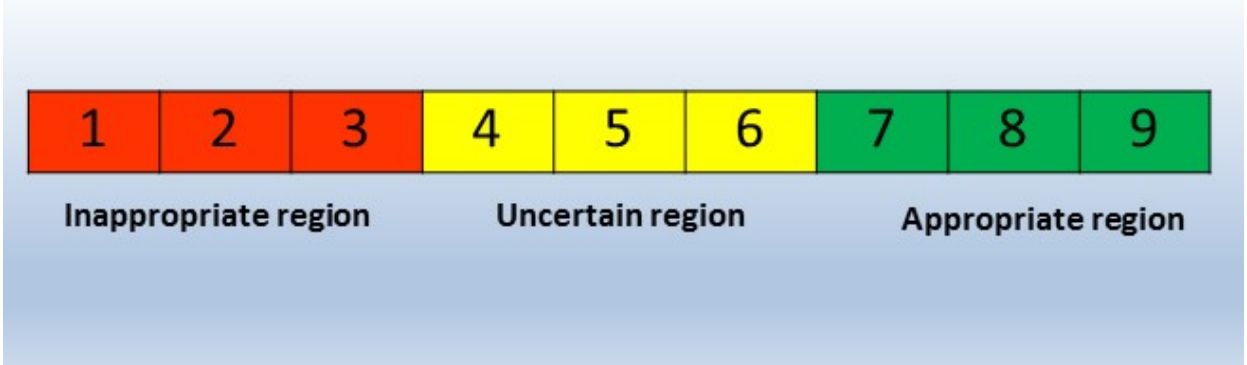
Assessment of internal jugular vein in supine position versus. trendelenburg at 15 degrees resulted in a change from 11.2+/- 1.5 mm to 15.4 +/-1.5mm in vein diameter ($p < 0.001$).123 Another study found significant variability in internal jugular position and internal jugular vein diameter (0.5 cm to > 2 cm) among 58 patients studied.110 A cohort of high-risk neurosurgical patients studied by Brederlau et al found that 39% of patients had anomalous IJV anatomy, with 100% success in cannulation, with no complications when ultrasound guidance was used.148

Pre-procedural evaluation of contralateral infraclavicular subclavian/axillary veins showed a significant absolute cross-sectional area difference of 26.7 mm2 with statistical significance $P < 0.001$. This difference had no correlation with hand dominance or anthropomorphic indices.113 Another study noted that among 80 patients, the anatomy of the right IJV was typical in only 57 (71%). In 7 (9%) of patients, the vein was thrombosed.124

An observational study of 50 patients receiving a femoral vein CVC demonstrated the frog-leg position with reverse Trendelenburg increased femoral vein size, and reduced the common surface area with the common femoral artery compared to the neutral position. This observational study results implied that overall catheterization success rate may be increased in difficult access patients when frog-leg plus reverse Trendelenburg position is selected.172

Please add any comments:

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

5) Real-time ultrasound-guided vascular access procedures can be performed using either a transverse (short-axis) or longitudinal (long-axis) approach.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
In clinical practice, the phrases transverse, short-axis, or out-of-plane approach are synonymous, as well as longitudinal, long-axis, and in-plane approach. The short-axis approach involves tracking the needle tip as it approximates the target vessel with the ultrasound beam oriented in a transverse plane, or perpendicular to the target vessel. The vessel is visualized as a circular structure on the ultrasound screen as the needle tip approaches the vessel from above. This approach is also called an out-of-plane technique since the needle passes through the ultrasound plane. The advantages of the short-axis approach include better visualization of adjacent vessels or nerves relative to the needle, and the ease of skill acquisition for novice operators 15. When using a short-axis approach, extra care must be taken to track the needle from the point of insertion and into the vessel lumen. Some case reports and simulation-based studies have identified frequent unintended posterior wall puncture of the target vessel.10

High success rates have been reported using a transverse approach for insertion of peripherally inserted central catheters (PICC).17 A prospective, randomized trial among patients with 2 or more failed PIV attempts compared short-axis to the long-axis approach. Success rate was 95% (19/20; 95% confidence interval, 85%-100%) in the short-axis group compared with 85% (17/20; 95% confidence interval, 69%-100%) in the long-axis group. All 3 subjects with failed PIV placement in the long-axis group had successful rescue placement in short axis; short-axis technique required less insertion time than the long-axis technique.176

In contrast to the short-axis approach, the long-axis approach is performed with the ultrasound beam aligned parallel to the vessel. The vessel appears as a long tubular structure and the entire needle is visualized as it traverses across the ultrasound screen to approach the target vessel. The long-axis approach is also called an in-plane technique because the needle is maintained within the plane of the ultrasound beam. The advantage of a long-axis approach is the ability to visualize the entire needle as it is inserted into the vessel.16 A randomized trial using simulation models showed decreased time to cannulation, number of needle redirections, and fewer posterior wall penetrations using a long-axis approach. A randomized prospective study by Fragou compared long-axis ultrasound guided versus landmark based approach, for subclavian vein catheterization with significant improvement in success rate (100% vs 87.5%) and reduction in mechanical complication rate, signaling that a longitudinal approach may be preferred for subclavian vein catheterization.106 Vogel performed a prospective, randomized crossover study to compare long-axis to short-axis approach in both internal jugular vein and subclavian vein. A longitudinal approach for subclavian vein catheterization resulted in less posterior wall punctures, which may translate to fewer catheter-related complications.118

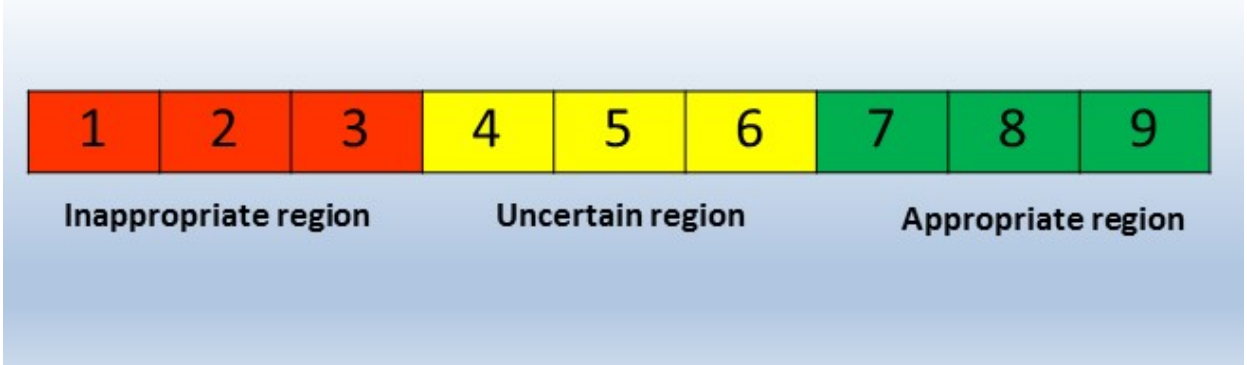
One study comparing short-axis and oblique approach argued for consideration of a medial-oblique probe position, as it showed an increased transverse diameter of the IJV; and less overlap with the carotid artery; however, no difference in anteroposterior diameter of the IJV was seen .119 A prospective randomized trial compared SAX (short-axis), LAX (long-axis), and OAX (oblique axis). This trial showed a lower rate of posterior wall puncture with an oblique axis approach than a short-axis approach. And a higher first pass success rate with an oblique access than a long-axis .120

A randomized prospective trial that compared long-axis, short-axis and landmark technique for cannulation of the internal jugular vein showed successful cannulation in all patients using ultrasound vs 90% using landmark technique. Average access time, and number of attempts were comparable between the short-axis and long-axis approaches, while significantly reduced in both US groups compared to the landmark group ($p < 0.001$). The incidence of complications in the landmark group (carotid puncture 16.7%, hematoma 23.3%, pneumothorax 3.3%,and CLA-BSI 20% were all significantly increased when compared to the US group ($p < 0.05$). A prospective observational study by Caridi et al showed that ultrasound guidance for internal jugular veins was safer and more efficient than the traditional landmark approach.124

In radial artery cannulation, one study found that an in plane long-axis approach had higher first pass success rates, shorter cannulation time, and decreased complications.191

Please add any comments:

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

6) Providers are to avoid using static ultrasound alone to mark the needle insertion site for vascular access. (Please use the Appropriateness Scale above to select your recommendation)

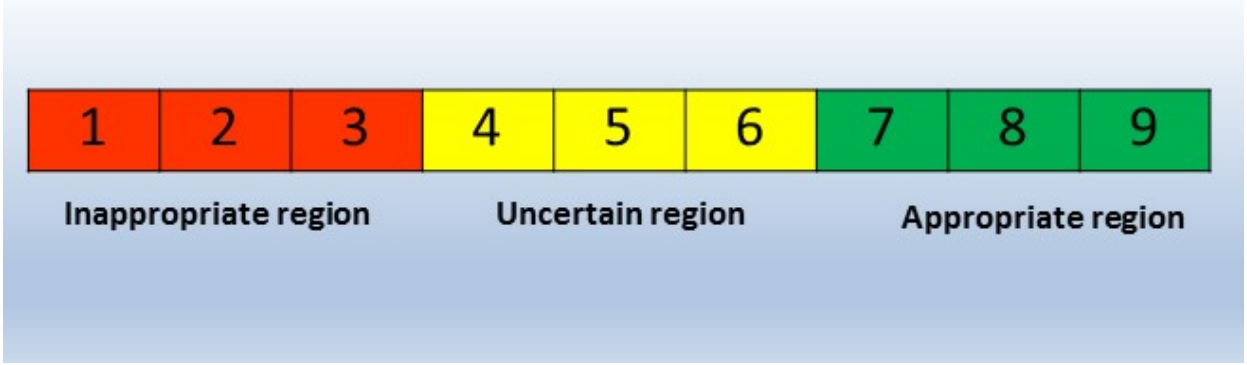
◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
Benefits of ultrasound guidance for vascular access are attained when ultrasound is used to track the needle tip in real-time as it is advanced toward the target vessel. One prospective, randomized study compared ultrasound guided (UG), landmark (LM), ultrasound marked (UM) technique among 118 patients. It found that the success rate was higher in the UG group than in the LM and UM groups (100, 74, and 73 %, respectively; p = 0.01). The total number of mechanical complications was higher in the LM and UM groups than in the UG group (24 and 36 versus 0 %, respectively; p = 0.01).105 In a prospective observational study of 100 patients success rates were: 91.5% vs 87.2% when comparing ultrasound-guided to ultrasound assisted (x-marks the spot) technique.125 A concealed, randomized controlled study comparing dynamic versus static versus landmark technique for central line placement showed unadjusted success rate of 98%, 82% and 64% respectively, with dynamic ultrasound outperforming static ultrasound in this study of 201 patients.35

Overall, static ultrasound alone for marking of the needle insertion site is not recommended because normal anatomical relationships of vessels vary, and site marking can be inaccurate with subtle changes in patient position, especially in the neck.38,104,125

Please add any comments:

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

7) Providers are to visualize the needle tip and guidewire in the target vein prior to vessel dilatation.
(Please use the Appropriateness Scale above to select your recommendation)

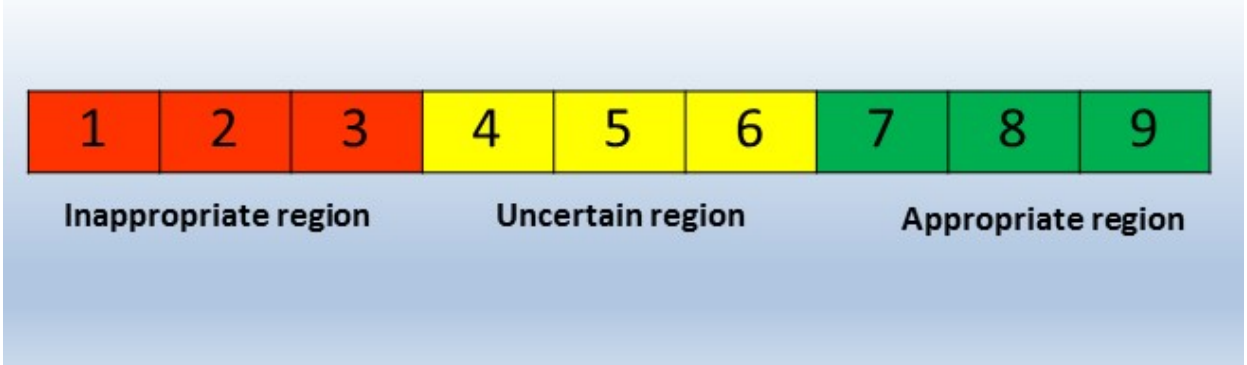
◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
When real-time ultrasound guidance is used, visualization of the needle tip within the vein is the first step to confirm cannulation of the vein and not the artery. After the guidewire is advanced, the provider can use transverse and longitudinal views to reconfirm cannulation of the vein. In a longitudinal view, the guidewire is readily seen positioned within the vein where it enters the anterior wall and lies alongside the posterior wall of the vein. Unintentional perforation of the posterior wall of the vein with entry into the underlying artery can be detected by ultrasound, allowing prompt removal of the needle or guidewire before proceeding to dilation of the vessel. A randomized prospective observational study that reviewed 41 ultrasound-guided internal jugular central line insertions showed that physicians can visualize the guidewire sometimes more readily than the needle.32 A study designed to determine the degree of accuracy with which the guidewire can be identified by novice operators showed an overall accuracy of 97%.127 US visualization of the guidewire predicted venous central catheter placement with 100% sensitivity and 100% specificity in this study (CI: 80-100% for both).128

A retrospective review of prospectively collected database of central line insertions where the guidewire position was confirmed in the target vessel in 53 central line insertions prior to dilation resulted in no incidents of arterial dilation. This study concluded that ultrasound confirmation of guidewire position has the potential to eliminate the morbidity and mortality associated with arterial dilation during the insertion of a CVC.

Please add any comments:

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

8) Providers can utilize echogenic needles, plastic needle guides, and ultrasound beam steering to increase success rates of ultrasound-guided vascular access procedures.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
Although evidence is limited, some providers report higher procedural success rates when using echogenic needles, plastic needle guides, and ultrasound beam steering software. Echogenic needles have a ridged areas near the tip that appears brighter on the screen, allowing better visualization of the needle tip. Plastic needle guides help stabilize the needle alongside the transducer when using either a transverse or longitudinal approach. Augustides evaluated ultrasound guided cannulation of the internal jugular with or without a needle guide. Its use significantly enhanced cannulation success after first (68.9%-80.9%, P=.0054) and second (80%-93.1%. P=.0001) needle passes.34 One other study compared the use of needle guide vs short axis and long axis approach, showing improved needle-visualization with the long-axis technique while using the needle guide, though no improvement in puncture of the target vessel during simulation was demonstrated.128 A prospective randomized study by Maecken examined the use of needle guide, finding a higher rate of first and second pass success rate when the needle guide was used. Use of the needle guide reduced the access time from a median (IQR [range]) of 30 (18-76 [6-1409]) s to 16 (10-30 [4-295]) s; p = 0.0001, and increased needle visibility from 31.8% (9.7%-52.2% [0-96.67]) to 86.2% (62.5%-100% [0-100]); p < 0.0001.168 One study evaluated a novel, sled-mounted needle guide for ultrasound-guided vessel cannulation. Fifty novice operators (medical students) were randomly assigned to use ultrasound with or without the sled. In this study, the novel sled improved the success rate and efficiency of ultrasound-guided phantom vessel cannulation.205

Please add any comments:

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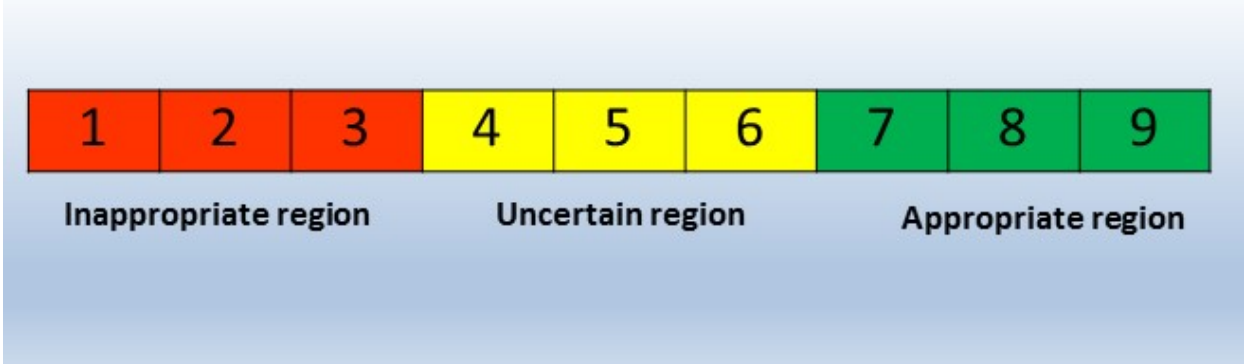


Recommendation:

9) Post-procedure pneumothorax can be ruled out using a high frequency, linear array transducer to detect bilateral lung sliding before and after neck, chest, or upper extremity vein cannulation.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

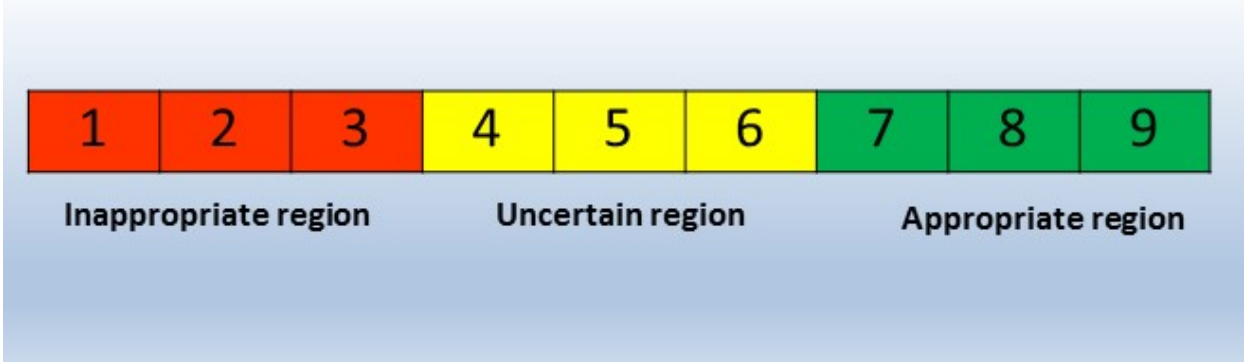
o Comment:
Detection of pleural sliding with 2-dimensional ultrasound rules out pneumothorax.
Following a vascular access procedure, the disappearance of lung pleural sliding in an area where it was previously seen is a strong indicator of a post-procedure pneumothorax.

Previous studies have described lung sliding as an accurate tool to detect pneumothorax in the critically ill patient. In this published series, sensitivity was 95.3%, specificity 91.1% and negative predictive value 100% (p< 0.001).131 One other study by the same author showed that horizontal artifacts (absent comet-tail artifact) and absent lung sliding, when combined, had a sensitivity and negative predictive value of 100% with a specificity of 96.5% for the detection of pneumothorax.45

In a retrospective study of 85 central line insertions where ultrasound was used as a diagnostic tool to detect catheter misplacement and pneumothorax, 1 pneumothorax (the only pneumothorax) and 9/10 of the 10 catheter misplacements were diagnosed using ultrasound. Importantly, the mean time of the entire ultrasonic examination was 6.8 +/- 3.5 min, whereas 80.3 +/- 66.7 min were needed for the radiography (p< 0.0001).130 Vezzani et al conducted a prospective observational trial, where ultrasound was used to assess catheter position and to detect pneumothorax in 111 patients. Combining ultrasonography and agitated saline enhanced (RASS= rapid atrial swing sign) ultrasonography resulted in 96% sensitivity, 93% sensitivity for the detection of misplaced catheter (intracardiac tip), concordance was 96%. In this study, the concordance for detection of pneumothorax was 98%.63

Please add any comments:

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

10) Ultrasound visualization of the right atrium with rapidly agitated saline infusion (RASS) can be used to determine catheter misplacement and optimize catheter tip positioning during CVC insertion.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

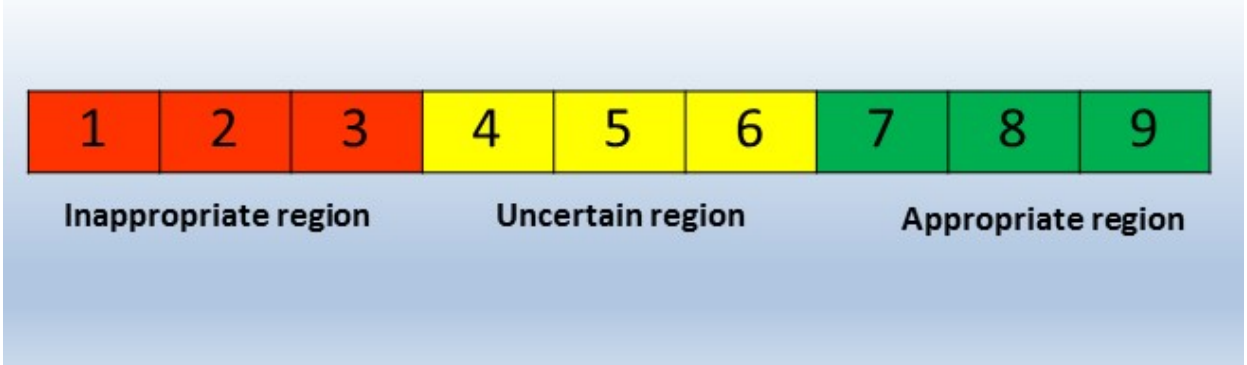
o Comment:
Transthoracic Echocardiography (TTE) is a reliable tool to detect catheter misplacement and to optimize catheter tip positioning during the procedure of CVC insertion. In one study, catheter misplacement was detected by TTE with a sensitivity of 96% and a specificity of 83% (PPV: 98%, NPV: 55%). This technique prevented an excessively distal position of the catheter tip in all cases.68 In a prospective observational study, the presence of rapid atrial swirl sign (RASS: defined as an immediate appearance of turbulence entering the right atrium via superior cava after a rapid saline flush of the distal CVC port) was used to exclude catheter malposition. In this study, ultrasound identified all correct CVC placements. Ultrasound also identified 3 of 4 catheter misplacements. Median times for completion of US and CXR were 1.1 (IQR:0.7) and 20 (IQR:30)minutes respectively. Median difference was 23.8 (95% CI 19.6 to 29.3) minutes, p< 0.0001.132

In an observational study designed to assess the right atrium (RA) using transthoracic echocardiogram (limited), and identify the guidewire, microbubbles or both. They used TEE as the gold standard, and determined that the examiners could view the right atrium in 94% of patients, and both microbubbles + guidewire in 91% of patients.47 Vezzani et al conducted a prospective observational trial, where ultrasound was used to assess catheter position and to detect pneumothorax in 111 patients. Combining ultrasonography and contrast enhanced (RASS= rapidly agitated saline infusion) ultrasonography resulted in 96% sensitivity, 93% specificity for the detection of misplaced catheter (intracardiac tip), concordance was 96%.63

Please add any comments:

Clinical Outcomes

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

11) Use of ultrasound guidance, combined with aseptic technique and maximal sterile barrier precautions, reduces the incidence and costs of infectious complications from CVC insertions.

(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
The use of real-time ultrasound has demonstrated an overall reduction in CLABSI and in the cost to treat infectious complications. Use of real-time ultrasound guidance for CVC placement has demonstrated a statistically significant reduction in CLABSIs compared to the landmark technique.19 A companion cost effectiveness analysis estimated the marginal cost for the use of ultrasound in central venous catheterization to be about $16 per procedure, assuming the machine was used for 15 procedures each week. The scenario also estimated that for every 1000 patients, 90 complications would be avoided, with a net cost savings of approximately $3200.20

The most recent CDC guidelines for the prevention of intravascular catheter-related infections recommends the use of ultrasound guidance to reduce the number of cannulation attempts and mechanical complications to minimize the risk of catheter related infections.6 A prospective, three arm study comparing ultrasound guided long-axis, short-axis, and landmark approach showed a CLABSI rate of 20% in the landmark group vs. 10% in each of the US groups.133 Another prospective, randomized study of 194 patients using US guidance technique for internal jugular access demonstrated lower significantly lower CLABSI rates when compared to the landmark technique (2 vs 10%). This same study also demonstrated a lower number of mechanical complications, and lower number of attempts.156

Use of ultrasound guidance must be combined with use of aseptic technique and maximal sterile barrier precautions to reduce risk of infectious complications. A complete review of preventive measures to reduce the risk of CLABSI is beyond the scope of this review, but a few key points will be mentioned. Aseptic technique includes proper hand hygiene and skin sterilization and is essential to reduce cutaneous colonization of the insertion site and the risk of CLABSIs.2 In a systematic review and meta-analysis of 8 trials including over 4000 catheter insertions, skin antisepsis with chlorhexidine was associated with a 50% reduction in risk of CLABSI compared with povidone iodine.21 Therefore, a chlorhexidine-containing solution is recommended for skin preparation prior to CVC insertion per existing guidelines from HICPAC/CDC, SHEA/IDSA, and ASA.6,21-23 Maximal sterile barrier precautions refers to use of sterile gowns, sterile gloves, caps, masks covering both mouth and nose, and full-body patient drapes. Use of maximal sterile barrier precautions during insertion of a central venous catheter (CVC) has been shown to reduce the incidence of central line-associated bloodstream infection (CLABSI) compared to standard precautions.1-5 Additionally, catheters containing antimicrobial agents may be considered for hospital units with CLABSI rates higher than the institutional goal despite a comprehensive preventive strategy and may be considered in specific patient populations at risk for severe complications from a CLABSI.6,21,22

Please add any comments:

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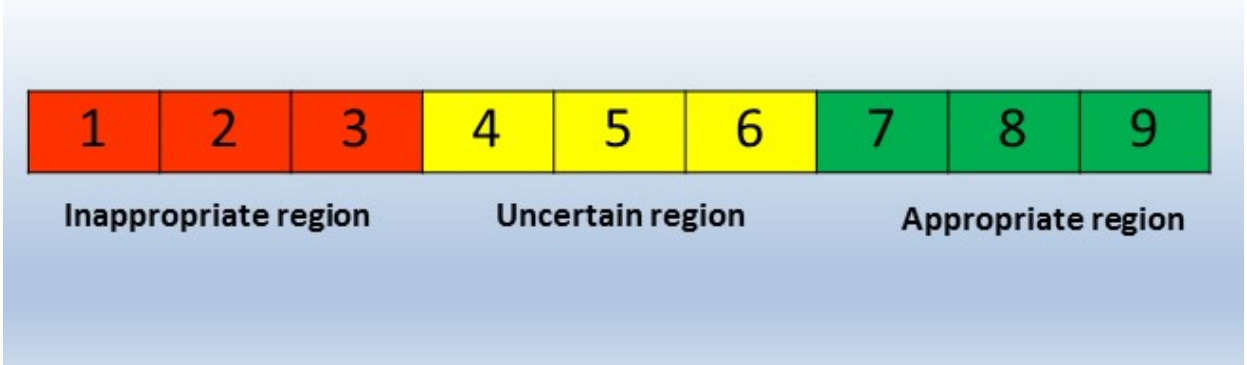


Recommendation:

12) A standardized ultrasound machine set-up and technique for using ultrasound can reduce the risk of Central Line Associated Bloodstream Infection (CLABSI).

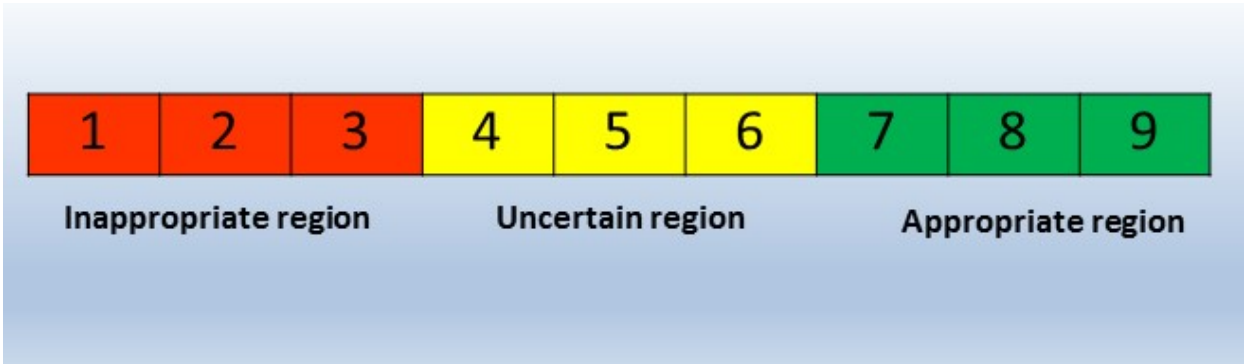
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
A few studies have found that a systems-based intervention featuring a standardized catheter kit or catheter bundle significantly reduced CLABSI rates.7-9 The operator should confirm availability and proper functioning of ultrasound equipment prior to commencing the procedure. Availability of a procedure cart with sterile ultrasound probe covers and gel, catheter kits, and all other necessary supplies minimizes interruptions during the procedure, and ultimately reduces risk of CLABSI by ensuring maintenance of a sterile field during catheter insertion.10 A prospective, randomized study of 194 patients using US guidance technique for internal jugular access demonstrated lower CLABSI, lower number of mechanical complications, and lower number of attempts vs landmark technique, with a cumulative $p < 0.05$.155

Please add any comments:

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

13) A standardized procedure checklist that includes use of ultrasound guidance reduces the risk of CLABSI from central venous catheters.

(Please use the Appropriateness Scale above to select your recommendation)

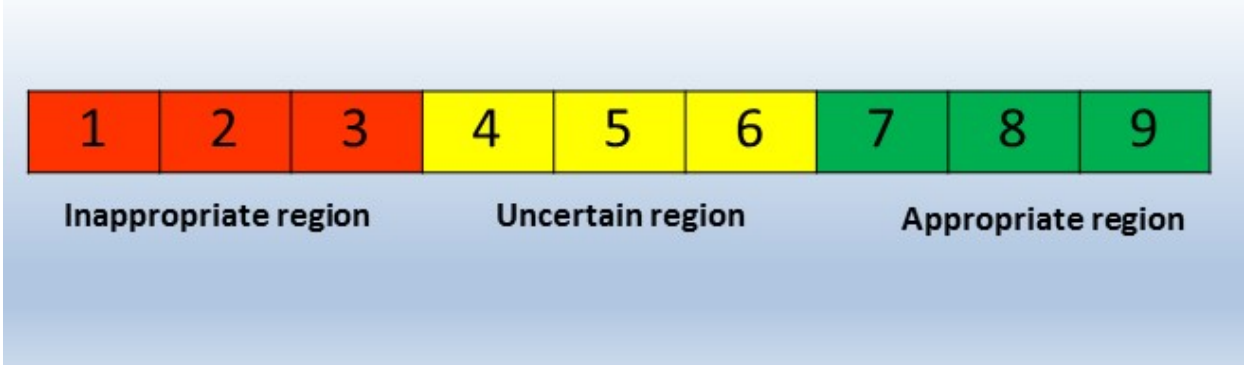
◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
A standardized checklist or protocol should be developed to ensure compliance with all recommendations for insertion of CVCs. Evidence-based protocols address periprocedural issues, such as indications for CVC, and procedural techniques, such as use of maximal sterile barrier precautions to reduce the risk of infection. Protocols and checklists that follow established guidelines for CVC insertion have been shown to decrease CLABSI rates.6,12 Similarly, development of checklists or protocols for maintenance of central venous catheters has been effective in reducing CLABSIs.13 Although no externally-validated checklist has been universally accepted nor endorsed by national safety organizations, a few internally-validated checklists are available through peer-reviewed publications. An observational educational cohort of internal medicine residents who received simulation-based training in the entire process of CVC insertions was able to demonstrate that there were fewer CLABSIs after the simulator-trained residents entered the ICU (0.50 infections/1000 catheter-days) compared to 3.2 infections/1000 catheter-days, p=0.001).61

Please add any comments:

Clinical Outcomes

Please use this scale to rank the appropriateness of the recommendation below:



Internal Jugular Venous Access

Recommendation:

14) Real-time ultrasound guidance during internal jugular vein catheterization has been shown to reduce mechanical and infectious complications, reduce the number of needle passes and time to cannulation, and increase the overall procedure success rate.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
The use of real-time ultrasound has been assessed and has repeatedly demonstrated better outcomes than the landmark-based methods for central venous catheterization in adults .10 A meta-analysis by Hind comprising 18 randomised controlled trials favoured US guidance versus landmark techniques, with reduced failure rates (relative risk 0.14, 95% CI: 0.06-0.33;P < 0.0001), increased first-attempt success (relative risk 0.59; 95% CI: 0.39-0.88; P 1⁄4 0.009), reduced complication rates (relative risk 0.43, 95% CI: 0.22-0.87, P 1⁄4 0.02) and faster procedure time (P < 0.0001).18

A Cochrane systematic review compared landmark techniques versus ultrasound to guide the insertion of a catheter into the internal jugular vein. Use of two-dimensional ultrasound reduced the rate of total complications overall by 71% (14 trials, 2406 participants, risk ratio (RR) 0.29, 95% confidence interval (CI) 0.17 to 0.52; P value < 0.0001), and the number of inadvertent arterial puncture by 72% (22 trials, 4388 participants, RR 0.28, 95% CI 0.18 to 0.44; P value < 0.00001). Overall success rates were modestly increased in all groups combined at 12% (23 trials, 4340 participants, RR 1.12, 95% CI 1.08 to 1.17; P value < 0.00001). The number of attempts needed for successful cannulation was decreased overall (16 trials, 3302 participants, mean difference (MD) -1.19 attempts, 95% CI -1.45 to -0.92; P value < 0.00001). Use of two-dimensional ultrasound increased the chance of success at the first attempt by 57% (18 trials, 2681 participants, RR 1.57, 95% CI 1.36 to 1.82; P value < 0.00001) and reduced the chance of haematoma formation (overall reduction 73%, 13 trials, 3233 participants, RR 0.27, 95% CI 0.13 to 0.55; P value 0.0004).104

Several randomized trials have demonstrated that real-time ultrasound guidance for internal jugular vein cannulation reduces the risk of procedure-related mechanical and infectious complications, and improves first-pass and overall success rates in diverse care settings.19,33-39,43,109,155,156,163
Mechanical complications that are reduced with ultrasound guidance include pneumothorax and carotid artery puncture.18,19,30-32,37-39,43,104,134,136,155,156,163 A prospective observational study of five hundred consecutive patients undergoing elective CVC insertion demonstrated an overall rate of procedural complications that were significantly higher if the operator was inexperienced (25.2% vs 13.6%). Arterial punctures occurred significantly more frequently when ultrasound was not used (7.2% vs 2.1%).158 One study specifically demonstrated that the success rate and the frequency of complications are decisively influenced most by the physician acting as a sonographer, independent of the experience of the physician performing the puncture, or other independent risk factors.160

The impact of ultrasound guidance in improving success and reducing complications is greatest in difficult patients, particularly in patients who are obese, have short necks, are hypovolemic, or are uncooperative.136 In addition, several studies have demonstrated decreased needle passes and decreased time to cannulation compared to the landmark technique.37,39,43,104,105,134, 136,155 A randomized controlled trial among patients receiving a CVC in the IJV looked at ultrasound guidance among expert and novice operators. This trial demonstrated reduced complication rates and improved success among patients with "difficult necks" with most of the benefit observed among novice users.154

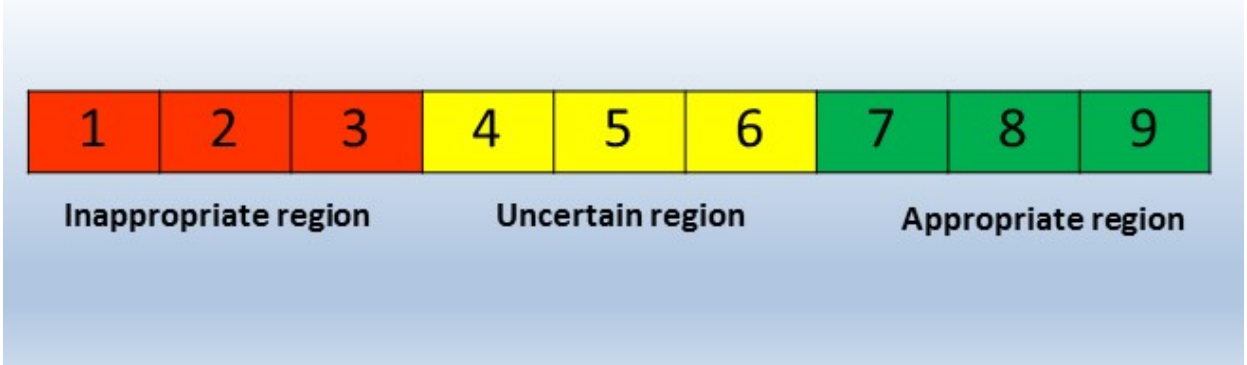
Patients with Higher Risk:
Ultrasound-guided placement of internal jugular vein catheters can safely be performed in high-risk patients, including patients with disorders of hemostasis and patients with previous multiple catheter insertion in the same vein.15 Ultrasound-guided placement of central vein catheters in patients with disorder of hemostasis is safe with high technical success and low complication rates. In this study by Tercan et al, the vein selected was IJV in 97% of cases.116 In a case series of 421 liver patients (699 USG lines) with deranged coagulation parameters (mean INR 2.17+/- 1.16, median platelet count 149.5 (range 12-683) the use of US guidance for central venous access was found to be safe and highly successful. (minor oozing only).108

A cohort of high-risk neurosurgical patients studied by Brederlau et al found 100% success in cannulation, with no complications when ultrasound guidance was used, despite doing the procedure at 30 degree head elevation and 39% of patients having anomalous IJV anatomy.148 Furthermore, a prospective, randomized control study of 1332 patients demonstrated that US guided cannulation in the neutral position is as safe as the 45 degree rotated position.153
A study of nephrology patients found a high degree of success and low complications even in the 38% of patients with a history of multiple previous catheterizations, poor compliance, skeletal deformities, previous failed cannulations, morbid obesity, and disorders of hemostasis.147 A prospective observational study of 200 ultrasound guided central catheters inserted for apheresis showed 100% success rate, with 92% of them being on first pass, and with confirmed anterior wall puncture only, with a complication rate (arterial puncture) of 3%.157 Noting these results, a strong recommendation was made for use of US during internal jugular placement by several medical societies.14,16,21,150-152

Please add any comments:

Clinical Outcomes

Please use this scale to rank the appropriateness of the recommendation below:



Subclavian Vein Access

Recommendation:

15) Real-time ultrasound guidance for subclavian vein cannulation is associated with a reduction in mechanical complications, including pneumothorax and hematoma; a reduction in the number of needle passes; and an increase in overall success rate when compared to the landmark-based technique.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
Advantages of using the subclavian vein for central venous access include consistent surface anatomic landmarks and vein location, patient comfort, and lower potential for infection.50 There are reports to confirm that the use of ultrasound guidance for subclavian access is feasible and safe.45-47 A Cochrane review of ultrasound guided subclavian vein cannulation (nine studies, 2030 participants, 2049 procedures), demonstrated that real time two-dimensional ultrasound reduced the risk of inadvertent arterial puncture (three trials, 498 participants, risk ratio (RR) 0.21, 95% confidence interval (CI) 0.06 to 0.82; p=0.02, I2 = 0%) and hematoma formation (three trials, 498 participants, RR 0.26, 95% CI 0.09 to 0.76; p=0.01, I2 = 0%).170 A systematic review published in 2015 analyzed 5 trials, including 638 patients that compared the landmark method to 2D ultrasound-guidance. Results showed a reduction in the risk of arterial puncture, hematoma, pneumothorax, and failed catheterization.164 A prospective randomized subclavian vein cannulation study favored the ultrasound-guided over the landmark-guided approach, with a higher success rate (92% vs 44%), fewer minor complications (1 vs. 11), fewer punctures (1.4 vs 2.5) and fewer catheter kits (1.0 vs 1.4) per cannulation.139

A prospective randomized study in 2011 showed 100% success rate with ultrasound versus 87.5% with landmark. Average access time and number of attempts were significantly lower in the US group.106 Noting these results, a strong recommendation was made for use of US during subclavian placement by Société Française d'Anesthésie et de Réanimation using GRADE methodology.150

A prospective randomized controlled trial that compared real-time ultrasound guidance vs landmark technique for subclavian vein cannulation in 400 patients showed that subclavian vein cannulation was achieved in 100% of patients in the ultrasound group as compared with 87.5% in the landmark one ($p < .05$). Average access time and number of attempts were significantly reduced in the ultrasound group of patients compared with the landmark group ($p < .05$). In the landmark group, artery puncture and hematoma occurred in 5.4% of patients, respectively, hemothorax in 4.4%, pneumothorax in 4.9%, brachial plexus injury in 2.9%, phrenic nerve injury in 1.5%, and cardiac tamponade in 0.5%, which were all increased compared with the ultrasound group ($p < .05$).106

A retrospective review of 297 central venous catheter insertions, analyzing 176 landmark-based insertions and 121 ultrasound guided insertions showed 23 mechanical complications (8 pneumothorax, 15 arterial punctures) in the landmark group and none in the ultrasound group. The analysis demonstrates a statistical significance ($p = 0.01$ for pneumothorax and $p = 0.001$ for arterial puncture) in favor of the ultrasound-guided technique.165

A supraclavicular approach is rarely used in clinical practice. Given the anatomy of the supraclavicular approach, properly positioning a transducer while manipulating the needle is quite challenging.

There is a range of US-guided techniques described that all, despite differences in nomenclature, involve puncture of the subclavian, or axillary vein in close proximity. In a large analysis of US-guided central venous access among a complex patient group, the majority of patients were cannulated successfully and safely. The subset of patients undergoing axillary vein cannulation (1923 cases) demonstrated a low rate of complications 17 (0.7%) . The axillary vein route of access appears to be a safe and effective alternative to the internal jugular vein.166

Please add any comments:

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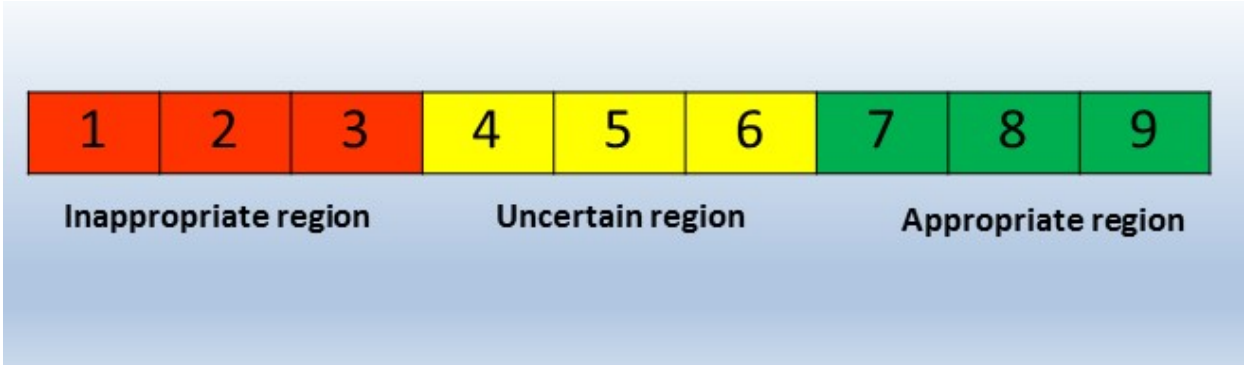

Femoral Venous Access

Recommendation:

16) Use of ultrasound guidance for femoral venous access reduces the risk of arterial punctures and the total procedure time, and increases the overall procedure success rates.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

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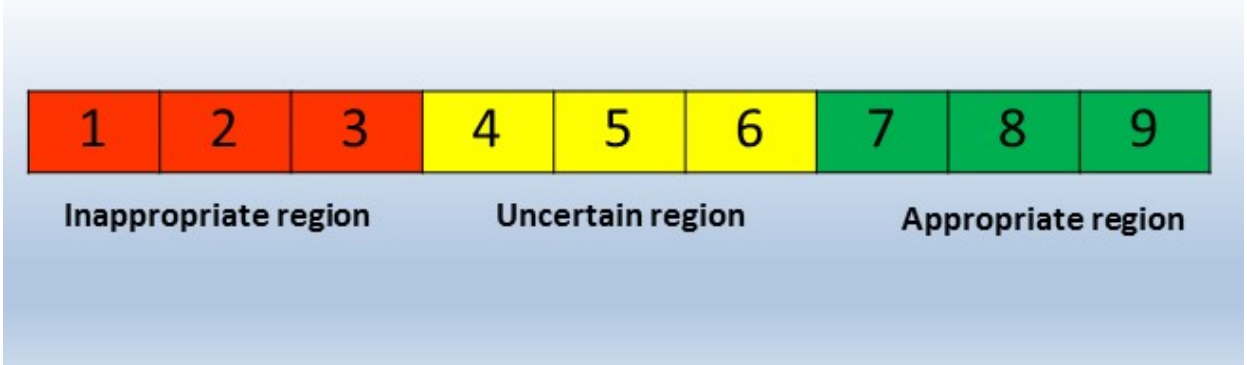
o Comment:
Anatomy in the femoral region shows considerable variation and there is often significant overlap of the femoral vein and artery.169 Use of ultrasound guidance for femoral venous access leads to a significant reduction in arterial puncture (15% in landmark vs 7 % in US group), reduction in total procedure time, and increase in success rate.135 Even in the setting of cardiopulmonary resuscitation, the use of ultrasound guidance led to faster procedures, with higher success rate and less arterial punctures.137 A Cochrane review of ultrasound guided cannulation of the femoral vein analyzed four studies, 311 participants, and 311 procedures. No evidence was found of a difference in inadvertent arterial puncture or other complications. However, success on the first attempt was more likely with ultrasound (three trials, 224 participants, RR 1.73, 95% CI 1.34 to 2.22; P value < 0.0001), and a small increase in the overall success rate was noted (RR 1.11, 95% CI 1.00 to 1.23; P value 0.06). No data on mortality or participant-reported outcomes were provided.170 A prospective observational study of 145 pts looking at LM vs USG for femoral CVCs showed a trend towards reduced adverse events, reduced arterial puncture, and reduced number of attempts among the USG group.171

In a prospective randomized study, the use of a novel wireless probe used in prospective study comparing USG vs landmark for femoral access. US group showed reduction in unsuccessful attempts, reduced complications and reduced total time to cannulation.174

Please add any comments:

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

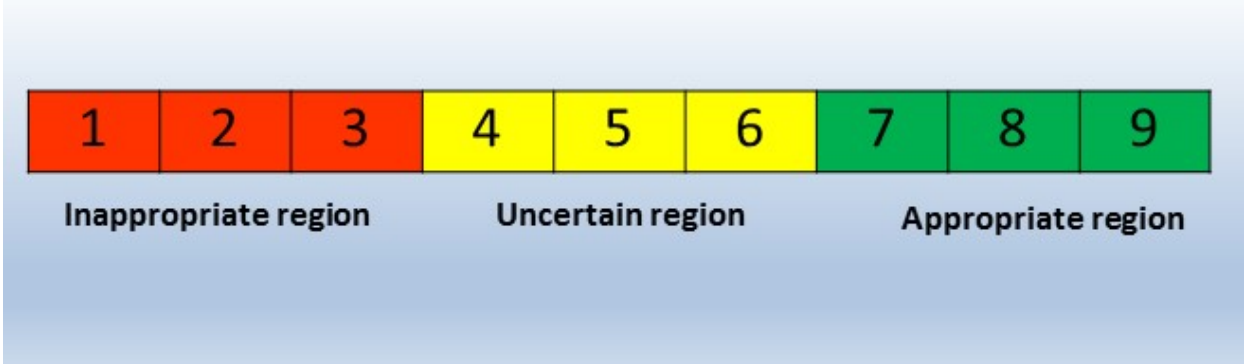
17) Use of real-time (dynamic) 2-dimensional ultrasound with a high-frequency linear transducer is recommended in all cases of central line insertion in the femoral vein.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
Ultrasound guidance has also been shown to provide more benefit to operators less experienced with central venous catheter insertion, although ultrasound may still provide benefit to clinicians experienced with CVC insertion when the operator is adequately trained in the use of ultrasound guidance (Rothschild, Agency for Healthcare Research and Quality, 2001)43. A prospective observational study followed five hundred consecutive patients undergoing elective CVC insertion found an overall procedure complication rate of 19.5%. Operators with < 25 insertions caused significantly more complications (25.2% vs. 13.6%), prompting the operators to advocate improved training and supervision, along with promoting the use of ultrasound. Inexperienced operators combined with SCV approach were significant predictors for increased risk of procedure-related complications.158

Please add any comments:

Please use this scale to rank the appropriateness of the recommendation below:



Peripherally Inserted Central Catheter (PICC) Access

Recommendation:

18) Placement of PICC lines with ultrasound guidance is associated with high success rates and may be more cost effective than placement using landmarks.
(Please use the Appropriateness Scale above to select your recommendation)

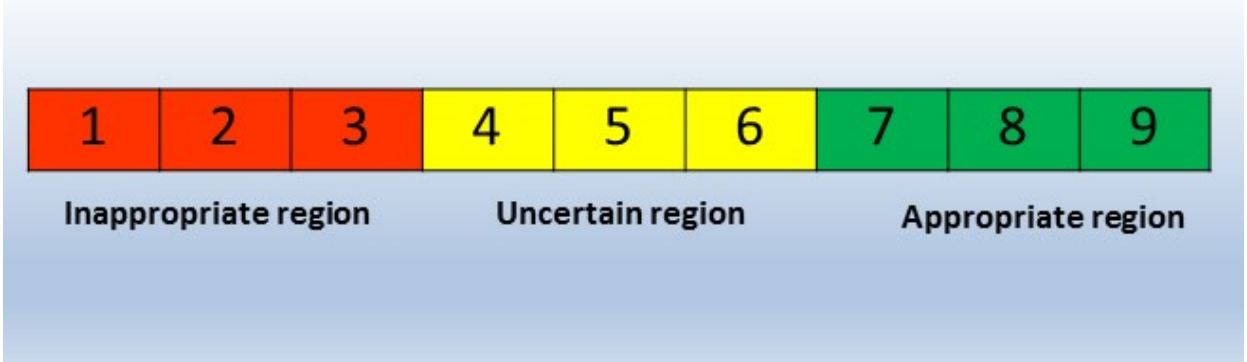
◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
Experienced providers proficient in using ultrasound guidance will improve overall success rate, decrease wait time, complication rates, and overall placement costs. Robinson et al demonstrated having a dedicated PICC team using ultrasound in their institution increased the insertion success rates from 73% to 94%. They also reduced the patient wait time for a catheter. Cost was also reduced for overall placement and usage of catheters by disapproving inappropriate requests.52 A randomized controlled trial compared USG vs non-USG PICC insertion. When compared with the control group, the experimental group had a lower rate of unplanned catheter removal (4.0% vs. 18.7%; p 1⁄4 0.02), a lower incidence of mechanical phlebitis (0% vs.22.9%; p < 0.001), a lower incidence of venous thrombosis (0% vs. 8.3%; p 1⁄4 0.037), and a higher incidence of catheter migration (32% vs. 2.1%; p < 0.001). Compared with the control group, the experimental group experienced significantly less severe contact dermatitis (p 1⁄4 0.038), had improved comfort at 1 week, 1 month, 2 months, and 3 months after PICC placement (p < 0.001), and had lower costs for PICC maintenance at 2 months, 3 months and when the catheter was removed (p < 0.05).175 A prospective observational report of 350 PICC insertions, using US guidance found 99% success rate, with an average number of punctures of 1.2. In this study, the cost of US guidance was compared to venogram guidance, resulting in significant cost-saving.179 A review and analysis of 500 PICCs at a single hospital in Georgia that were done by designated specialty nurses revealed an overall success rate of 94.6%, no evidence of phlebitis and only one CLABSI among the catheters removed.177 A retrospective review of prospectively collected data for PICC compared several variables, including incidence of thrombosis and success rate with/without US guidance among 538 patients. Success rate was 98.9% vs 76.9% (US vs palpation, respectively) and incidence of thrombosis was 9.3% with palpation method vs 1.9% with the ultrasound method.180

Routine post procedure chest x-ray is generally not necessary if PICC is inserted under real time ultrasound guidance along with the use of newer devices like the magnetic navigation system with intracardiac electrode in patients with a discernible P-wave. (Lamperti, M, Bodenham, A, Pittiruti M, et al. International evidence-based recommendations on ultrasound-guided vascular access. Intensive Care Med 2012; 38:1105-1117).15 The use of ultrasound can be expanded to include evaluation of possible malpositioning of PICC. In a randomized controlled study of 300 pts comparing post PICC CXR vs ipsilateral internal jugular US to look for malpositioning, 10 of 11 catheters that were identified in the ipsilateral IJV were repositioned before completion of the procedure, resulting in only 1 malpositioned catheter, compared to 11 in the control (non US evaluation of the IJV) group. This study suggests post procedure US can identify malpositioning of the catheter and allow for repositioning during the initial procedure, thereby reducing the need for an additional procedure to correct malpositions as with current standard of care with post procedure CXR.178

Please add any comments:

Please use this scale to rank the appropriateness of the recommendation below:



Peripheral Venous Access

Recommendation:

19) Ultrasound-guided peripheral intravenous (PIV) cannulation requires less overall procedure time, fewer needle insertion attempts, and fewer needle redirections compared to traditional approaches, and ultrasound-guided PIV cannulation is an effective alternative to central venous catheter placement in patients with difficult venous access.

(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
Difficult venous access refers to patients that have had 2 unsuccessful traditional attempts at PIV access or a history of difficult access (i.e. edema, obesity, intravenous drug use, chemotherapy, diabetes, hypovolemia, chronic illness, vasculopathy, multiple prior hospitalizations, etc.). In a systematic review and meta analysis 7 trials were identified (289 participants). This meta analysis concluded that ultrasound guidance increases the likelihood of successful cannulation (pooled OR 2.42; 95% CI 1.26 to 4.68; p< 0.008).181 A second meta analysis and systematic review analyzed 7 studies (6 RCT's). US guidance improved success rate in patients where ultrasound guidance was used (OR: 3.96; 95%CI 1.75-8.94).184

In a prospective observational study evaluating the success rate of PIV placement among emergency medicine physicians, use of real-time ultrasound guidance was compared to traditional approaches in difficult-access patients. Use of ultrasound guidance for peripheral venous access had higher success rate than traditional techniques (97% vs. 33%), required less time (13 vs. 30 min), decreased the number of percutaneous punctures (1.7 vs. 3.7), and improved patient satisfaction in the subgroup of patients who had difficult intravenous access.55 In another prospective observational study, modified Seldinger technique with ultrasound guidance was used among a select group of emergency room patient who had 2 failed PIV attempts using the traditional approach. Among these patients, the success rate was 96% (24/25). The mean number of needle sticks was 1.32 (95% confidence interval 1.12-1.52). Median time from skin to catheter insertion was 68 s (SD 70.5 s).183 A prospective study of 101 patients demonstrated that US guidance of the brachial and basilic vein had high success rates among patients with difficult PIV access, defined as two or more failed attempts.17 One last study also showed a high success rate (87%) of ultrasound guided PIV among difficult access patients.185

Since US guided PIV access can have high placement success rates this can translate to fewer central line days and less reliance on central venous catheters for access-only purposes. In one study of patients with two failed attempts, a peripheral IV was placed with US guidance in 84% of patients that otherwise would have had a central line placement for IV access.186 A prospective observational study with 75 patients showed US guided PIV was an effective alternative to central line placement in ED patients with difficult access, with only one patient requiring a central venous catheter, due to failure of PIV placement.182 Ultrasound use for PIV placement has also been shown to increase speed, patient satisfaction, and reduce the amount of physician intervention required.187 In a prospective observational study where ultrasound guided PIV was selected among 146 patients with difficult access, a survey regarding patient experience with USG PIV showed an average satisfaction score of 9.2/10 on a Likert scale, with 76% of patients rating it a 10. Here, the majority of patients reported a better experience than with previous IV's.188 A strong recommendation for use of US in the case of difficult IV placement by Société Française d'Anesthésie et de Réanimation using GRADE methodology.150

Please add any comments:

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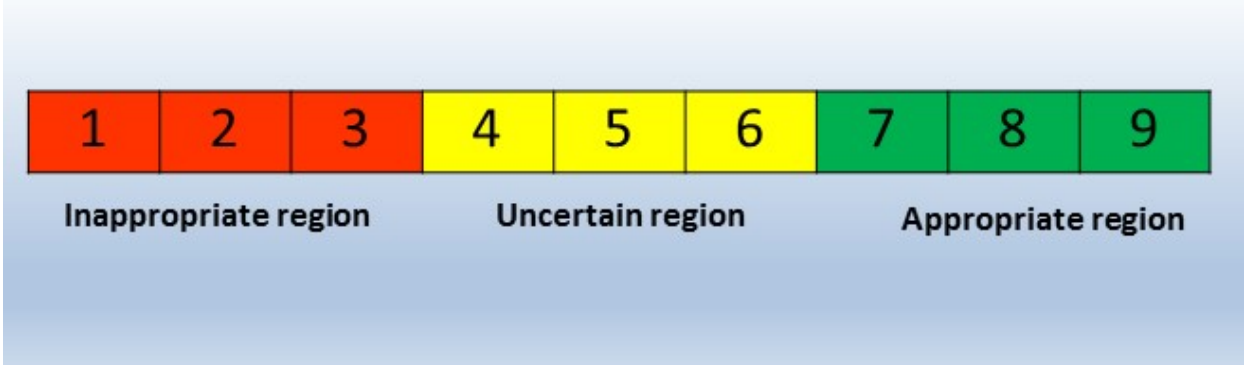


Recommendation:

20) Use of ultrasound guidance reduces the risk of vascular, infectious, and neurological complications during insertion of PIVs, particularly in patients with difficult venous access.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

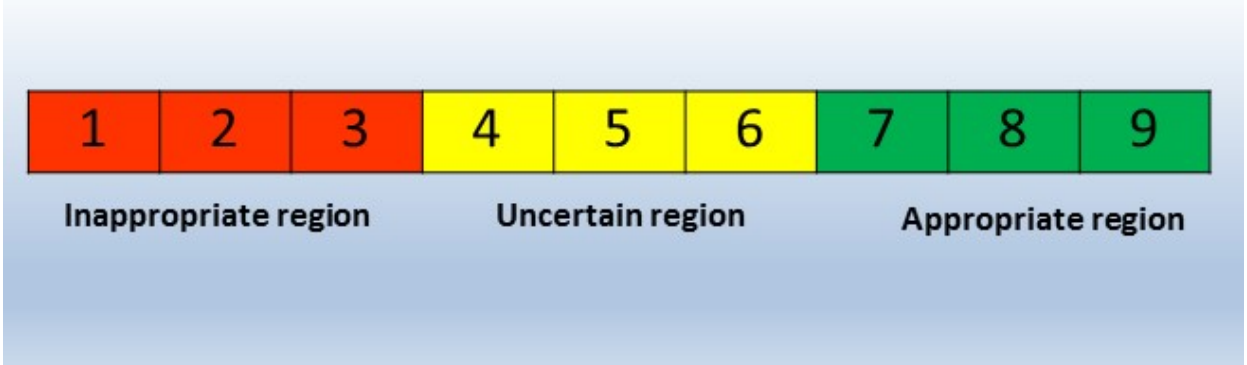
o Comment:
Paresthesias due to nerve irritation and local infiltration is the most common complication, although no long-term nerve damage has been reported. Vascular complications include arterial puncture and formation of hematoma, local infiltration or extravasation of fluid, and superficial or deep vein thrombosis. The most common infectious complications with US guided IV access are phlebitis and cellulitis. A retrospective review of prospectively collected data on 59 ICU patients by a single physician. US guidance of PIV resulted in high success rates (99%) of placement with low rates of phlebitis/cellulitis (0.7%). There was an assumed benefit of risk reduction due to the patient no longer requiring a central line after successful PIV placement. Also, the PIV placement utilized a catheter-over-guidewire technique only in the forearm.

Another study found very low rates of infection with both traditional and US-guided PIV placement, suggesting that there is no increased risk of infection with ultrasound guidance for peripheral IV lines.189

Please add any comments:

Clinical Outcomes

Please use this scale to rank the appropriateness of the recommendation below:



Arterial Access

Recommendation:

21) Use of ultrasound guidance for arterial access increases the first-pass success rate, reduces time to cannulation, and reduces the risk of hematoma development compared to landmark-based techniques.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
Several randomized controlled trials (RCTs) have assessed the value of US in arterial catheter insertion. Shiver et al randomized 60 patients admitted to a tertiary center emergency department to either palpation or US-guided arterial cannulation. They demonstrated a first-pass success rate of 87% in the US group compared with 50% in the landmark technique group. In the same study, the use of US was also associated with reduced time needed to establish arterial access and a 43% reduction in the development of hematoma at the insertion site.117 Levin et al demonstrated a first-pass success rate of 62% using US versus 34% by palpation alone in 69 patients requiring intra-operative invasive hemodynamic monitoring.144 Additional randomized-controlled studies (RCT's) have demonstrated that ultrasound guidance increases first-attempt success rates compared to traditional palpation.140-142

Please add any comments:

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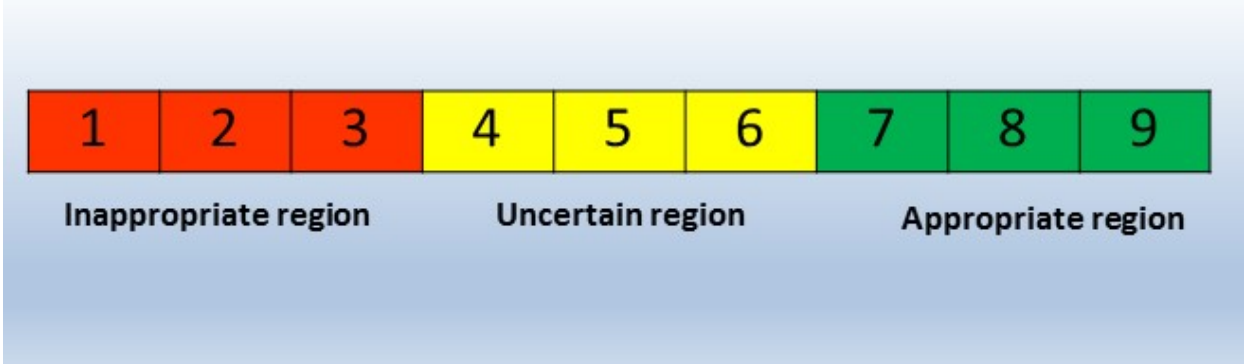

Recommendation:

22) Use of ultrasound guidance for femoral arterial access increases the first-pass success rate and reduces the risk of vascular complications.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
In a meta-analysis by Sobolev et al that analyzed a total of 1422 femoral artery catheterizations (719 by ultrasound guidance vs. 703 by palpation), the use of ultrasound guidance was associated with a 49% reduction in overall complications (RR 0.52, 95%CI 0.28-0.91) and 42% improvement in first attempt success.143 Fewere pseudoaneurysms formed in patients undergoing femoral artery catheterization by ultrasound guidance vs. palpation (2.6% vs. 4.5%).146

The FAUST trial 145 was a multicenter RCT of 1004 pts comparing fluoroscopic vs US guidance for femoral artery access demonstrated that US guidance of femoral arterial access improved rate of CFA (common femoral artery) cannulation in pts with high CFA bifurcations (82.6% vs 69.8%, $p < 0.01$). US guidance resulted in an improved first-pass success rate (83% vs. 46%, p 0.0001), reduced number of attempts (1.3 vs. 3.0, $p < 0.0001$), reduced risk of venipuncture (2.4% vs. 15.8%, $p < 0.0001$), and reduced median time to access (136 s vs.148 s, $p = 0.003$). Vascular complications occurred in 7 of 503 and 17 of 501 in the US and fluoroscopy groups, respectively (1.4% vs. 3.4% $p = 0.04$).

A retrospective review of 7359 procedures where the CFA was accessed revealed that the routine use of US guidance decreased the incidence of hematoma formation (rate ratio [RR], 0.62; 95% confidence interval [CI], 0.46-0.84; P < .01).195

Please add any comments:

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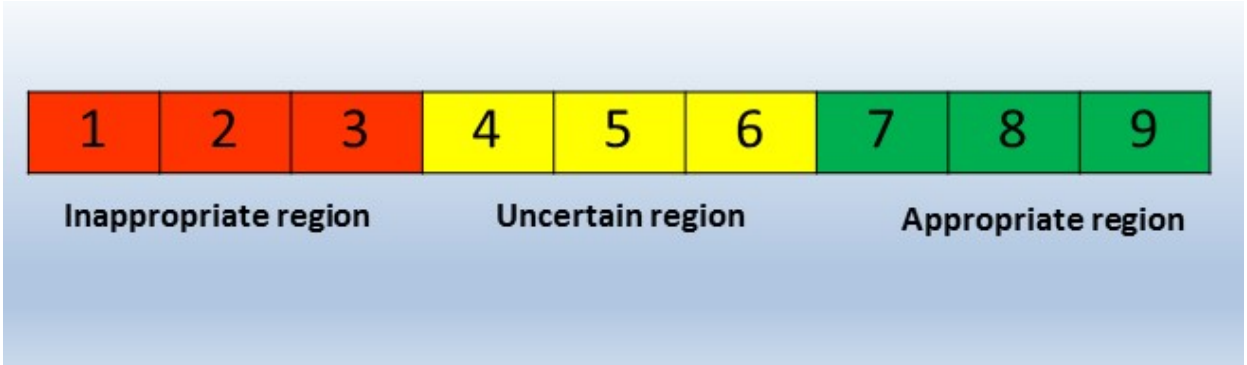


Recommendation:

23) Use of ultrasound guidance for radial artery access increases the first-pass success rate, reduces the time to success cannulation, and reduces complications compared to landmark-based techniques.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:

The RAUST trial was a prospective multicenter RCT of 698 pts undergoing radial artery catheterization were randomized to needle insertion using US guidance (USG) vs palpation. In this trial, the number of attempts was reduced with US guidance (1.65+/-1.2 vs. 3.05 +/-3.4, p < 0.0001), and the first-pass success rate improved (64.8% vs. 43.9%, p < 0.0001). The time to access was reduced (88+/-78 s vs. 108+/-112 s, p=0.006.) USG was found to be particularly useful in patients with difficult access with palpation alone.190

A prospective, blinded, randomized crossover trial by Hansen et al compared ultrasound guided radial artery cannulation to the traditional palpation technique. In the traditional palpation technique group, a higher number of skin perforations (57 vs. 40, P = 0.003), catheters (46 vs. 40, P = 0.025) and attempts targeting the vessel (104 vs. 43, P < 0.001) were necessary compared with the ultrasonography dynamic needle tip positioning group. First attempt success rate was significantly higher in the ultrasonography dynamic needle tip positioning group (23/40 vs. 38/40, P < 0.001).192

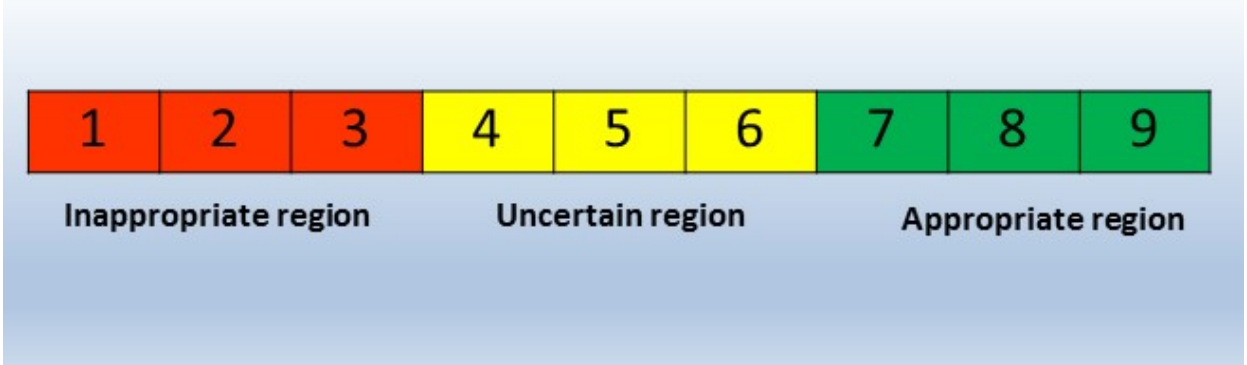
In a meta-analysis that analyzed seven RCT with 482 patients, US guidance significantly increased first-attempt success rate of radial artery catheterization (RR 1.51; 95%CI 1.07-2.14, P:0.02). Ultrasound guidance significantly reduced mean-attempts to success, mean time to success,and occurrence of hematoma: (RR 0.17, 95%CI 0.07-0.41; P=0.0001).141

Another meta-analysis that included non-english RCT's, involving 803 patients. Ultrasound guided radial artery catheterization was generally associated with a 47% improvement in the rate of first-attempt success (RR, 1.47; 95% CI, 1.22-1.76; P< .0001). Specifically, the ultrasound-guided technique significantly improved the rate of first-attempt success for adult (RR, 1.39; 95% CI, 1.13-1.72; P = .002) patients.193 Ultrasound guidance is particularly useful in patients with altered anatomy, obesity, nonpulsatile blood flow, low perfusion, and previously unsuccessful cannulation attempts using a landmark-guided approach.194 A prospective study of 50 patients undergoing USG radial artery access by interventional cardiologist with little previous experience with US showed that the use of US improved success rates of first time cannulation and reduced time from puncture to sheath introduction, compared with historical data of palpation directed access.196

Please add any comments:

Training

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

24) All providers placing ultrasound-guided CVCs should complete a systematic training program before attempting insertions on patients to reduce the risk of mechanical and infectious complications.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
Cumulative experience is not a proxy for clinical skill.59 According to recommendations of the National Institute for Clinical Excellence (NICE), providers placing CVCs using ultrasound guidance should undertake appropriate training to achieve competence.60 Surveys indicate that a lack of education in ultrasound is a frequent reason that it may not be used.197,198 Educational programs on CVC placement reduce the occurrence of infections and mechanical complications.61-65 The use of ultrasound, checklists, bundle programs and simulation labs in conjunction with organized educational programs improves patient safety related to CVC insertion.15,66-71 Training courses including simulation accelerated learning of all trainees, but especially of novice trainees, thus mitigating the risk to the patients by allowing trainees to achieve a minimal level of proficiency earlier, prior to the introduction of CVC procedures on real patients72,73Providing a simulation-based CVC training program experience before CVC placement on clinical rotations allows novice learners to learn without risk and may enhance patient safety.69,73 There is evidence on efficacy but no consensus on timing, duration, and content of training for medical house-staff on CVC placement.

In a randomized controlled trial of educational intervention, simulation combined with didactic training was superior to didactic training alone for acquisition of clinical skills such as US-guided CVC insertion. After combined didactic and simulation-based training, novices outperformed experienced residents in aseptic technique as well as in measurements of knowledge.207

Please add any comments:

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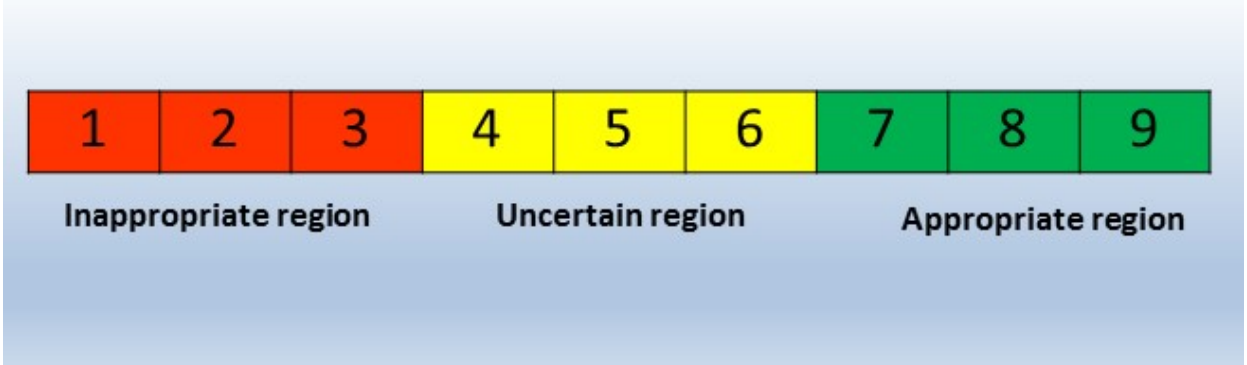


Recommendation:

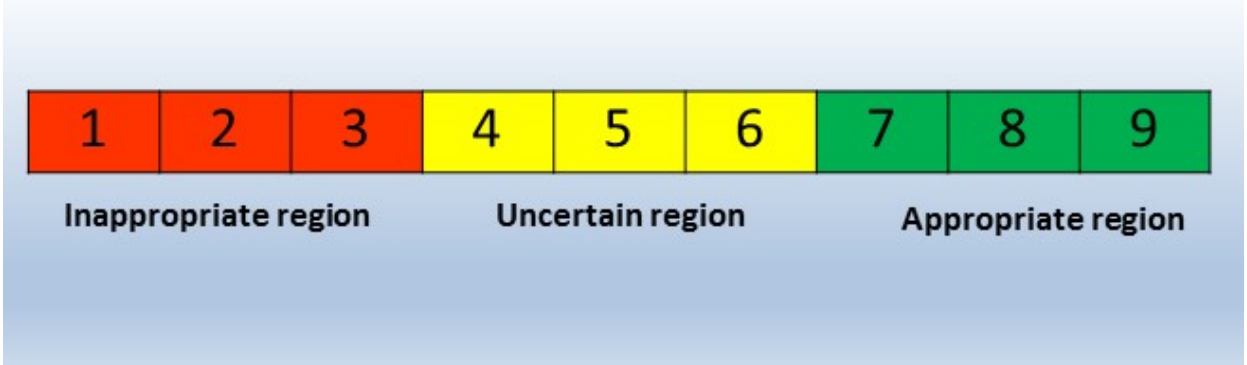
25) Educational courses on ultrasound-guided CVC placement should review relevant basic anatomy, ultrasound physics, "knobology", image acquisition and interpretation, detection and management of major and minor complications, infection prevention strategies, and techniques to master venous cannulation and CVC insertion. (Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
Knowledge of anatomy affects decision-making and may help to avoid insertion complications (inadvertent nerve, arterial, or lung puncture). 66,74 Inexperience leads to more attempts and therefore more trauma during insertion procedures, increasing the risk of infections.200 Infection and thrombosis can both be impacted by the insertion site selection, skin integrity, and catheter-vein ratio (CVR).6,75,76 The content of anatomy and physiology training should include vessel anatomy, location, size, and path,15 vessel differentiation with ultrasound,6,15 blood flow dynamics,6 Virchow's triad,6 skin integrity, colonization,66 peripheral nerve identification and distribution,15 respiratory anatomy,6,15 upper and lower extremity, axillary, neck, and chest anatomy.6,15 Education should also include physics of ultrasound (piezoelectric effect, frequency, resolution, attenuation,echogenicity, Doppler flow patterns that identify arterial and venous flow characteristics), image optimization, image analysis and instrumentation in image acquisition (image mode, focus, dynamic range, probe types), including artifacts (reverberation, side lobe, mirror, shadowing, enhancement). Physicians with training in US-guided placement of CVCs report significantly higher comfort in its use than those without training.197 Learners find these sessions worthwhile and acceptable and had increased skill level,85 and skills from simulation based mastery learning have been demonstrated to be substantially retained over time.201 Central catheter-related infection remains a high source of morbidity and mortality in the acute and long-term care environment.6 Training to reduce the infection complications includes site selection and the ability of the inserter to maintain a sterile environment during CVC placement (use of maximal barrier precautions, hand hygiene, appropriate use of skin antiseptic solutions). The insertion procedure should be deconstructed into readily understood steps, aided by demonstration of CVC insertion techniques with video clips. Professional organization guidelines and literature give suggestions for proper device insertion and use.15,71 Landmark techniques are also components of CVC education programs in case circumstances arise that do not permit the use of ultrasound. Web-based training provides an alternative to face-to-face training and is currently being used in medical training centers and was at least as effective as traditional teaching methods.77 Additional cognitive instruction can be provided via textbooks, continuing medical education courses/syllabi, digital video, and Web-based curricula.202,203

Please add any comments:

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

26) Hands-on training for ultrasound-guided CVC insertion should include a combination of simulation-based training, mastering of procedural checklists, and bedside proctoring and evaluation by an expert.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
Simulation-based training has been used in multiple areas of medical education to provide opportunities for deliberate and safe practice and shape the development of clinical skills in a controlled learning environment.78-80,201 In addition, simulation allows exposure to procedures or scenarios that may occur infrequently in clinical practice. Studies also show the transfer of skills acquired in the simulated environment to the clinical setting, resulting in improved patient care in CVC insertion.81,82 Simulator-trained residents preferentially select the internal jugular site,62 and more reliably use ultrasound to guide their procedures.82,83 These methods are effective; and in one intervention learners actually had higher scores on testing after using simulation than with a traditional apprenticeship method.203

An US-guided CVC training workshop demonstrated improved simulated CVC placement performance immediately after training and three months later compared to baseline performance. The improvement was the greatest in those who placed the least CVCs in actual patients. 73

There are a variety of inanimate models useful for simulating vessel anatomy visualization with ultrasound for the most common sites of CVC placement, including the internal jugular, subclavian and PICC sites.202,204 The best simulation models should include vessels and also mimic the normal body anatomy with muscles, soft tissues, and bones. For this reason, inanimate animal models such as turkey or chicken breasts may be effective for simulation practice with ultrasound and cost-effective.84,85 Inanimate models with human anatomy allow for training of ultrasound-appearance of the human anatomy in addition to the step-by-step procedure itself. Ultrasound training on human anatomy can also be acquired with the use of healthy volunteers or standardized patients. The recommended technical skills a trainee should master include: ability to operate ultrasound equipment and controls to produce quality information to identify the target vessel, dexterity to coordinate needle guidance in the desired direction and depth on the basis of image data, ability to insert the catheter into target vessel using ultrasound information and ability to confirm catheter placement into the target vessel and the absence of the catheter in unintended vessels and structures.71 Ideally, some of the laboratory training would include visualization of abnormal anatomy (i.e. the obese patient, intraluminal thrombus, or significant overlay of the carotid artery by the internal jugular vein)

Please add any comments:

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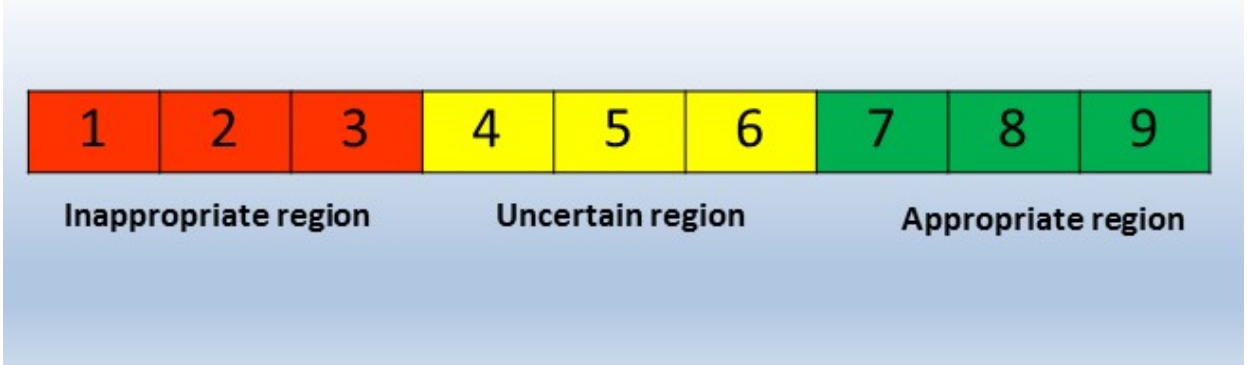


Recommendation:

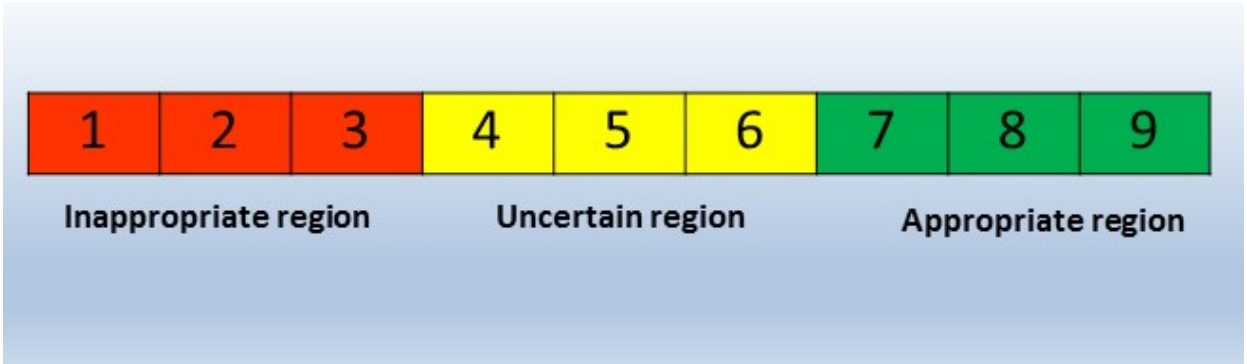
27) Prior to placing ultrasound-guided central venous catheters independently, trainees should demonstrate minimal competence. A minimum number of insertions may inform this determination but a proctored assessment of competence is most important.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
With the landmark technique, the suggested minimal CVC placements required to achieve minimal experience was 50 insertions.208 Although there is a lack of consensus and evidence for standards of training and certification in USG CVC, several recent recommendations have advocated a formal and comprehensive training program in USG CVC, emphasizing the importance of mentoring by a skilled user.15,70,71 Expert users have recommended, based on experience, that training should include at least 10 USG CVCs to be performed under the guidance of an experienced user.71 Most recently a consensus task force from the World Congress of Vascular Access (WoCOVA) was established to provide definitions and recommendations for training and insertion of CVCs. This Consensus Task Force recommends 6-8 h of didactic education, 4 h hands-on training on inanimate models, then 6 h hands-on training on normal human volunteers for detection of normal ultrasound anatomy.199 This training should be followed by supervised ultrasound cannulations, coaching the trainee during the procedure in order to achieve the required minimal skill competence with the lowest rate of complications.153 These numbers are clearly subjective, as are other procedural recommendations based on numbers, and the main determinant in determining competence should be the evaluation by the proctor.102

Please add any comments:

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

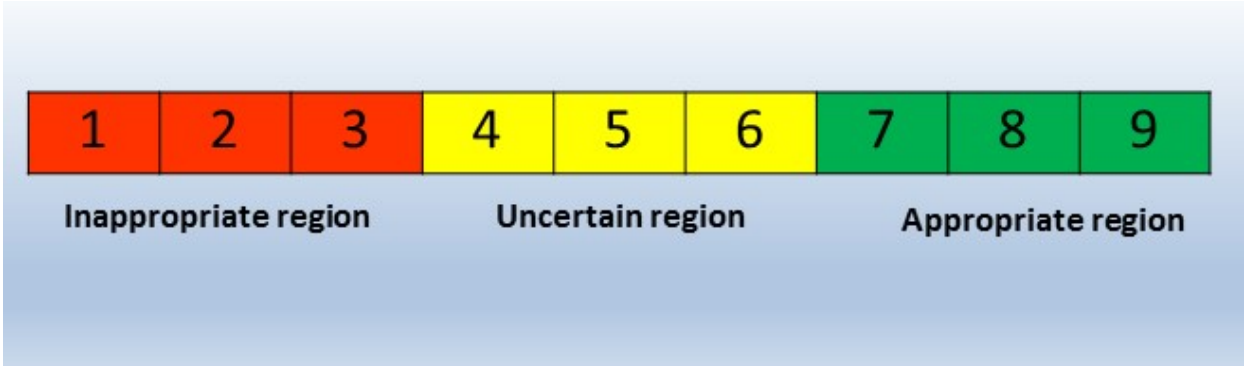
28) The timing of didactic and hands-on training should coincide with times of anticipated increase in number of procedures performed by trainees and "refresher" courses should be repeated periodically.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
Training courses result in a rapid improvement in skills immediately after the simulation, but long periods of non-use of newly learned and complex skills lead to rapid deterioration.72,73,86,87 Thus, a single training exercise is insufficient to reach a threshold of mastery. Furthermore, an insidious decay in skills may go unrecognized by the learner as comfort or self-confidence do not always correlate with actual performance,62,88-90,201 leading to increased medical error.206 Consequently, the most important factor in acquiring expertise is sustained, deliberate practice with feedback.91 To prevent decline in skill level, simulation training sessions would be the most effective if they occur in close temporal proximity to times when those skills would likely be used clinically, for example, just prior to or at the beginning of a critical care rotation.69 Frequently scheduled training sessions and ongoing teaching, monitoring, feedback by experts are needed to reinforce and advance procedural skills and prevent decay. Some experts recommend that at least 10 ultrasound-guided CVCs should be performed each year in order to maintain proficiency.70

Please add any comments:

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

29) A competency assessment should include formal evaluation of knowledge and technical skills using standardized assessment tools.

(Please use the Appropriateness Scale above to select your recommendation)

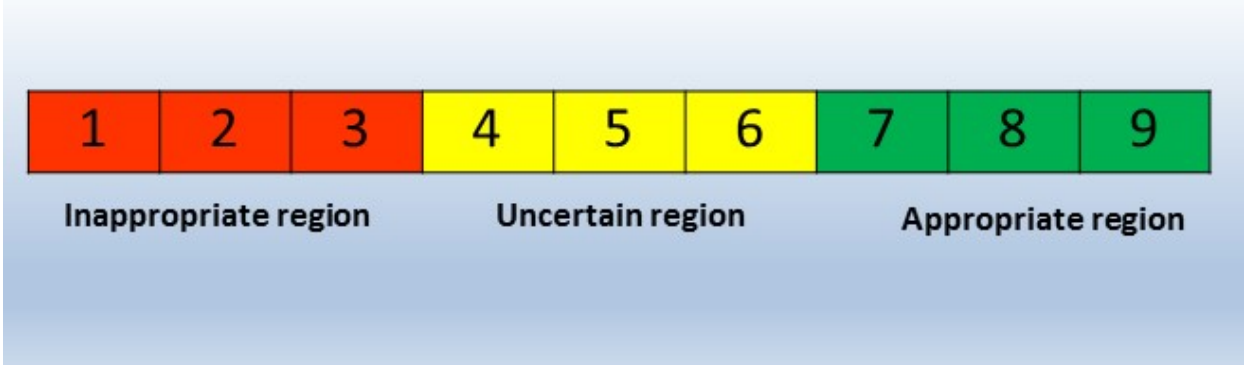
◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
Competency validation requires application of clinical experience, education of the skills to be attained, completion of procedural demonstration, and supervision of a specified number of successful procedures.92,93 The educational competence should be evaluated with a multiple-choice test, assessing the practitioner's cognitive level of the procedure.199 This written exam should be in conjunction with a visual exam to test the knowledge of normal vs abnormal vessels. Minimum passing standards should be set according to similar educational courses.

The final practical assessment should be objective, and the trainee should pass all the critical steps of the procedure. If the trainee fails the final assessment, he/she should continue practicing with supervision until demonstration of all critical steps. A commonly used approach to rating technical performance is the use of checklists, which provide objective criteria for evaluation and identify specific areas in need of improvement,94,95 to determine a trainee's readiness to perform procedures. The goal of checklists is to guide behavior by confirming standardized routine, especially useful in a sequential and predictable procedure. Formal evaluation of competence is performed using instruments such as the Ottawa Crisis Resource Management (CRS) checklist which both demonstrate effectiveness in multiple domains.96 Although passing scores on both the knowledge and practical tests do not imply the ability to perform the procedure independently, it provides a metric by which educators can ensure a minimum level of proficiency before allowing trainees to perform such procedures on patients under supervision.97

Please add any comments:

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

30) Competency assessments should evaluate proficiency in the knowledge and skills to insert CVCs including the following aspects:

a) Anatomy of the target vein, proper vessel identification and recognition of anatomical variants.

d) Needle cannulation under ultrasound guidance (visualization of the needle tip entering the vessel and cannulation on the first attempt in at least five consecutive simulations).

b) Complete CVC insertion with no technical errors based on procedural checklist.

c) Recognition and management of acute complications, including emergency management of life-threatening complications.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
Ultrasound-guided access should focus not only on vein puncture but also on assessment and selection of veins based on size, patency, and risk reduction.100 Ultrasound visualization identifies variant anatomy, vessel size and patency, thus identifying and avoiding high-risk procedures.199

US technique is arguably not systematically taught in either undergraduate nor graduate education. It is important that trainees demonstrate ability to operate ultrasound equipment and controls to produce quality information to identify the target vessel, guide the procedure and identify complications.71,199

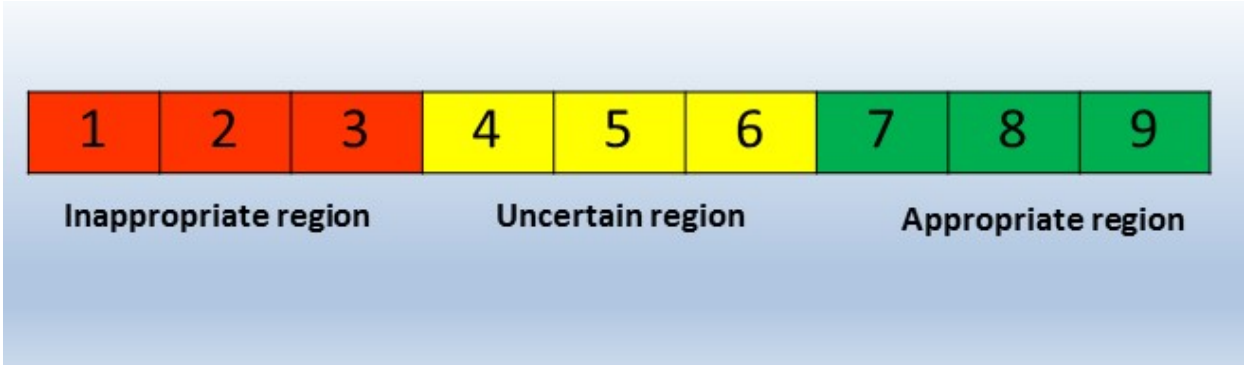
Trainees have to demonstrate ability to insert the catheter into the target vessel using ultrasound information and ability to confirm catheter placement into the target vessel. 71,199 A minimum passing score has been used by some.20

Trainees need to demonstrate the ability to recognize complications such as arterial cannulation, hematoma, pneumothorax.71,199 Trainees should be aware of recommended evaluation and treatment algorithms, which include prompt surgical and sometimes neurological consultation.101

Trainees need to demonstrate dexterity to coordinate needle guidance in the desired direction and depth on the basis of image data.71,199

Please add any comments:

Please use this scale to rank the appropriateness of the recommendation below:



Recommendation:

31) Periodic proficiency assessments of trainees and supervisors should be conducted to ensure maintenance of competence.
(Please use the Appropriateness Scale above to select your recommendation)

◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯ 6 ◯ 7 ◯ 8 ◯ 9 ◯ ABSTAIN. I know nothing about this topic.

o Comment:
Studies evaluating the relationship between clinical knowledge and experience have concluded that the decline in knowledge after initial training is accompanied by a decrease in quality of care.149 An insidious decay in skills may go unrecognized by the learner as comfort or self-confidence do not always correlate with actual performance leading to increased medical error.62,88-90,201,206 Competency extends to periodic assessment and not merely an initial evaluation at the time of training.99 A systematic approach is required to continually measure outcomes and provide feedback relevant to competence as a function of safety.

Competency assessment includes assessment of proficiency of instructors/supervisors and ideally all whom perform this procedure. Often practitioners supervise procedures before they feel confident and competent in their own practice. 98 Supervisors require full and certified competence in CVC placement and must maintain their skills through their clinical activity.199 Supervisors should be certified with an educational course for trainers before starting their teaching activity. One study of ultrasound use by emergency medicine residents at 5 institutions showed that trainees indicated that a lack of faculty comfort impeded their own use, for example.209

Please add any comments:

Final Comments

Please provide any final thoughts about the appropriateness and completeness of our recommendations.

Appendix 5 – Final Voting Results for Vascular Access Recommendations

Approved Recommendations with strong endorsement
Approved Recommendations with weak endorsement
Unapproved Recommendations, with disagreement

Recommendation	# of Panelists	Median	Zone	# of votes out of Zone	# of votes within X of median			Consensus
					1 pt	2 pts	3 pts	
1: Providers are to be familiar with operation of the specific model of ultrasound machine, prior to initiation of the procedure.	27	9	Appropriate	0 (0%)	26 (96%)	→	→	Very Good
2: Providers are to use a high-frequency linear transducer with a sterile sheath and sterile gel to perform vascular access procedures that require full sterile precautions, such as central lines, arterial lines and peripherally inserted central catheters.	27	9	Appropriate	3 (11%)	23 (85%)	→	→	Very Good
3: Providers are to use two-dimensional ultrasound to evaluate for anatomical variations and absence of thrombosis of arteries and veins during pre-procedural site selection.	27	9	Appropriate	0 (0%)	24 (89%)	→	→	Very Good
4: Providers are to evaluate the target vessel size and depth during the pre-procedural ultrasound evaluation.	27	9	Appropriate	1 (4%)	25 (93%)	→	→	Very Good
5: Providers are to avoid using static ultrasound alone to mark the needle insertion site for vascular access.	27	9	Appropriate	1 (4%)	25 (93%)	→	→	Very Good

6: Use of real-time (dynamic) 2-dimensional ultrasound with a high-frequency linear transducer is recommended in all cases of central line insertion in the femoral vein.	27	8	Appropriate	5 (19%)	22 (81%)		→	Very Good
7: Real-time ultrasound-guided vascular access procedures can be performed using either a transverse (short-axis) or longitudinal (long-axis) approach.	27	8	Appropriate	7 (26%)	20 (74%)	24 (89%)	→	Good
8: Providers are to visualize the needle tip and guidewire in the target vein prior to vessel dilatation.	27	9	Appropriate	1 (4%)	23 (85%)		→	Very Good
9: Providers can utilize echogenic needles, plastic needle guides, and ultrasound beam steering to increase success rates of ultrasound-guided vascular access procedures.	27	8	Appropriate	5 (19%)	22 (81%)		→	Very Good
10: A standardized procedure checklist that includes use of real-time ultrasound guidance reduces the risk of CLABSI from central venous catheters.	27	8	Appropriate	2 (7%)	25 (93%)		→	Very Good
11: Use of real-time ultrasound guidance, combined with aseptic technique and maximal sterile barrier precautions, reduces the incidence and costs of infectious complications from CVC insertions.	27	9	Appropriate	1 (4%)	25 (93%)		→	Very Good
(This recommendation was merged with the recommendation #11 during the peer review process.) A standardized ultrasound machine set-up and technique for using ultrasound can reduce the risk of Central Line Associated Bloodstream Infection (CLABSI).	27	8	Appropriate	2 (7%)	25 (93%)		→	Very Good

12: Internal Jugular Venous Access: Real-time ultrasound guidance during internal jugular vein catheterization has been shown to reduce mechanical and infectious complications, reduce the number of needle passes and time to cannulation, and increase the overall procedure success rate.	26	9	Appropriate	0 (0%)	25 (96%)			Very Good
13: Subclavian Vein Access: Real-time ultrasound guidance for subclavian vein cannulation is associated with a reduction in mechanical complications, including pneumothorax and hematoma; a reduction in the number of needle passes; and an increase in overall success rate when compared to the landmark-based technique.	25	9	Appropriate	2 (8%)	20 (80%)			Very Good
14: Femoral Venous Access: Use of real-time ultrasound guidance for femoral venous access reduces the risk of arterial punctures and the total procedure time, and increases the overall procedure success rates.	27	9	Appropriate	1 (4%)	24 (89%)			Very Good
15: Peripherally Inserted Central Catheter (PICC) Access: Placement of PICC lines with real-time ultrasound guidance is associated with high success rates and may be more cost effective than placement using landmarks.	27	9	Appropriate	0 (0%)	25 (93%)			Very Good

16: Peripheral Venous Access: Real-time ultrasound-guided peripheral intravenous (PIV) cannulation requires less overall procedure time, fewer needle insertion attempts, and fewer needle redirections compared to traditional approaches, and ultrasound-guided PIV cannulation is an effective alternative to central venous catheter placement in patients with difficult venous access.	26	9	Appropriate	0 (0%)	23 (88%)			Very Good
17: Use of real-time ultrasound guidance reduces the risk of vascular, infectious, and neurological complications during insertion of PIVs, particularly in patients with difficult venous access.	25	8	Appropriate	6 (24%)	19 (76%)	24 (96%)		Good
18: Use of real-time ultrasound guidance for arterial access increases the first-pass success rate, reduces time to cannulation, and reduces the risk of hematoma development compared to landmark-based techniques.	26	9	Appropriate	1 (4%)	24 (92%)			Very Good
19: Use of real-time ultrasound guidance for femoral arterial access increases the first-pass success rate and reduces the risk of vascular complications.	25	9	Appropriate	0 (0%)	24 (96%)			Very Good
20: Use of real-time ultrasound guidance for radial artery access increases the first-pass success rate, reduces the time to success cannulation, and reduces complications compared to landmark-based techniques.	26	9	Appropriate	0 (0%)	26 (100%)			Very Good

21: Post-procedure pneumothorax can be ruled out using a high frequency, linear array transducer to detect bilateral lung sliding before and after neck, chest, or upper extremity vein cannulation.	26	8	Appropriate	2 (8%)	24 (92%)			Very Good
22: Ultrasound visualization of the right atrium with rapidly agitated saline infusion (RASS) can be used to determine catheter misplacement and optimize catheter tip positioning during CVC insertion. The use of RASS to detect the catheter tip can be considered an advanced skill that requires specific training and expertise.	25	8	Appropriate	4 (16%)	21 (84%)			Very Good
23: All providers placing ultrasound-guided CVCs should complete a systematic training program before attempting insertions on patients to reduce the risk of mechanical and infectious complications.	27	9	Appropriate	2 (7%)	24 (89%)			Very Good
(This recommendation was merged with the recommendation #23 during the peer review process.) Hands-on training for ultrasound-guided CVC insertion should include a combination of simulation-based training, mastering of procedural checklists, and bedside proctoring and evaluation by an expert.	27	9	Appropriate	3 (11%)	24 (89%)			Very Good

24: Educational courses on ultrasound-guided CVC placement should review relevant basic anatomy, ultrasound physics, 'knobology', image acquisition and interpretation, detection and management of major and minor complications, infection prevention strategies, and techniques to attain competency in venous cannulation and CVC insertion.	27	9	Appropriate	2 (7%)	24 (89%)			Very Good
25: Prior to placing ultrasound-guided central venous catheters independently, trainees should demonstrate minimal competence. A minimum number of insertions may inform this determination but a proctored assessment of competence is most important.	27	9	Appropriate	2 (7%)	24 (89%)			Very Good
26: The timing of didactic and hands-on training should coincide with times of anticipated increase in number of procedures performed by trainees and 'refresher' courses should be repeated periodically.	27	8	Appropriate	3 (11%)	24 (89%)			Very Good
27: A competency assessment should include formal evaluation of knowledge and technical skills using standardized assessment tools.	27	8	Appropriate	4 (15%)	23 (85%)			Very Good

28: Competency assessments should evaluate proficiency in the knowledge and skills to insert CVCs including the following aspects: a) Anatomy of the target vein, proper vessel identification and recognition of anatomical variants. b) Complete CVC insertion with no technical errors based on procedural checklist. c) Recognition and management of acute complications, including emergency management of life-threatening complications. d) Needle cannulation under ultrasound guidance (visualization of the needle tip entering the vessel and cannulation on the first attempt in at least five consecutive simulations).	27	8	Appropriate	3 (11%)	24 (89%)			Very Good
29: Periodic proficiency assessments of trainees and supervisors should be conducted to ensure maintenance of competence.	27	8	Appropriate	4 (15%)	23 (85%)			Very Good