Recommendations on the Use of Ultrasound Guidance for Adult Thoracentesis: A Position Statement of the Society of Hospital Medicine

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Executive Summary: 1) We recommend that ultrasound should be used to guide thoracentesis to reduce the risk of complications, the most common being pneumothorax. 2) We recommend that ultrasound guidance should be used to increase the success rate of thoracentesis. 3) We recommend that ultrasound-guided thoracentesis should be performed or closely supervised by experienced operators. 4) We suggest that ultrasound guidance be used to reduce the risk of complications from thoracentesis in mechanically ventilated patients. 5) We recommend that ultrasound should be used to identify the chest wall, pleura, diaphragm, lung, and subdiaphragmatic organs throughout the respiratory cycle before selecting a needle insertion site. 6) We recommend that ultrasound should be used to detect the presence or absence of an effusion and approximate the volume of pleural fluid to guide clinical decision-making. 7) We recommend that ultrasound should be used to detect complex sonographic features, such as septations, to guide clinical decision-making regarding the timing and method of pleural drainage. 8) We suggest that ultrasound be used to measure the depth from the skin surface to the parietal pleura to help select an appropriate length needle and determine the maximum needle insertion depth. 9) We suggest that ultrasound be used to evaluate normal lung sliding pre- and postprocedure to rule out pneumothorax. 10) We suggest avoiding delay or interval change in patient position from the time of marking the needle insertion site to performing the thoracentesis. 11) We recommend against performing routine postprocedure chest radiographs in patients who have undergone thoracentesis successfully with ultrasound guidance and are asymptomatic with normal lung sliding postprocedure. 12) We recommend that novices who use ultrasound guidance for thoracentesis should receive focused training in lung and pleural ultrasonography and hands-on practice in procedural technique. 13) We suggest that novices undergo simulation-based training prior to performing ultrasound-guided thoracentesis on patients. 14) Learning curves for novices to become competent in lung ultrasound and ultrasound-guided thoracentesis are not completely understood, and we recommend that training should be tailored to the skill acquisition of the learner and the resources of the institution. *Journal of Hospital Medicine* 2018;13:126-135. © 2018 Society of Hospital Medicine

Approximately 1.5 million people develop a pleural effusion in the United States annually, and approximately 173,000 people (12%) undergo thoracentesis.[1] A recent review of thoracenteses performed at 234 University Health System Consortium hospitals between January 2010 and September 2013 demonstrated that 16% of 132,472 thoracenteses were performed by general internists and hospitalists, 33.1% were performed by interventional radiologists, and 20.3% were performed by pulmonologists.[2] The iatrogenic pneumothorax rate was not significantly different between interventional radiologists and internists (2.8% and

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****A complete list of the Society of Hospital Medicine Point-of-Care Ultrasound Task Force members appears at the end of this article.**

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2.9% risk, respectively); however, the admissions associated with bedside thoracentesis were less expensive than the admissions associated with thoracentesis performed in radiology suites, even after controlling for clinical covariates.[2] In addition, the use of ultrasound guidance has been associated with a reduced risk of complications and cost of thoracentesis.[3,4] In most of the early published studies on ultrasound-guided thoracentesis, the procedures were performed by radiologists.[5-12] However, in 2010, the British Thoracic Society published guidelines on pleural procedures and thoracic ultrasound geared toward any trained provider.[13] The purpose of this guideline is to review the literature and present evidence-based recommendations on the performance of ultrasound-guided thoracentesis at the bedside.

METHODS

Detailed methods are described in Appendix 1. The Society of Hospital Medicine (SHM) Point-of-care Ultrasound (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. The expert panel members were divided into working group members, external peer reviewers, and a methodologist. All the Task Force members were required to disclose any potential conflicts of interests (Appendix 2). The literature search was conducted in two independent phases. The first phase included literature searches conducted by the four working group members themselves. Key clinical questions were prepared prior to conducting a systematic literature search by a medical librarian. The Medline, Embase, CINAHL, and Cochrane medical databases were searched from 1975 to September 2015 initially. Updated searches were conducted in November 2016 and in August 2017 (Appendix 3). All article abstracts were first screened for relevance by at least two members of the working group. Full-text versions of the screened articles were reviewed, and the articles focusing on the use of ultrasound to guide thoracentesis were selected. Articles that discussed thoracentesis without ultrasound guidance were excluded. In addition, the following article types were excluded: non-English language, nonhuman, subjects' age <18 years, meeting abstracts, meeting posters, letters, and editorials. All relevant systematic reviews, meta-analyses, randomized controlled trials, and observational studies of ultrasound-guided thoracentesis were screened and selected. Final article selection was based on working group consensus, and the selected literature was incorporated into draft recommendations.

We used the RAND Appropriateness Method that required panel judgment and consensus.[14] The 30 voting members of the SHM POCUS Task Force reviewed and voted on the draft recommendations considering the following five transforming factors: 1) Problem priority and importance, 2) Level of quality of evidence, 3) Benefit/harm balance, 4) Benefit/burden balance, and 5) Certainty/concerns about PEAF (Preferences/Equity Acceptability/Feasibility). Panel members participated in two rounds of electronic voting using an internet-based electronic data collection tool (Redcap™) in December 2016 and January 2017 (Appendix 4). Voting on appropriateness was conducted using a 9-point Likert scale, and the degree of consensus was assessed using the RAND algorithm. Establishing a recommendation required at least 70% agreement and a strong recommendation required 80% agreement according to the RAND rules (Appendix 1, Figure 1). Disagreement was defined as >30% of panelists voting outside of the zone of the median (appropriate, uncertain, inappropriate).

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 (Appendix 1, Table 2). The revised consensus-based recommendations underwent internal and external review by POCUS experts from different subspecialties. The final review of the guideline document was performed by all the members of the SHM POCUS Task Force, the SHM Education Committee, and the SHM Board of Directors. The SHM Board of Directors endorsed the document prior to submission to the Journal of Hospital Medicine.

RESULTS

Literature search

A total of 1,556 references were pooled from the following four different sources: a search by a certified librarian in September 2015 (1066 citations) that was updated in November 2016 (165 citations) and again in August 2017 (9 citations), working group members' literature searches (47 citations), and a search focused on training (269 citations). The final selection included 94 articles that were abstracted into a data table and incorporated into the draft recommendations. The details of the literature search strategy are given in Appendix 3.

Recommendations

Four domains (clinical outcomes, technique, training, and knowledge gaps) with 20 draft recommendations were generated based on an initial review of the literature. The quality of evidence was appraised after assigning references to each draft recommendation. After two rounds of panel voting, five recommendations did not achieve agreement based on the RAND rules (failure of achieving a threshold of at least 70% and/or uncertainty expressed by panel median voting in the uncertain region),[14] and 15 statements received final approval. The degree of consensus based on the median score and the dispersion of voting around the median are shown in Appendix 5. Ten statements were approved as strong recommendations, and five were approved as conditional recommendations. Recommendation 3 was deleted due to its similarity to the first two statements. This yielded a final recommendation count of 14. For each recommendation, the strength of the recommendation and the degree of consensus are summarized in Table 1.

Terminology

- Thoracentesis is a procedure of aspiration of fluid from the pleural space by percutaneous insertion of a needle through the chest wall with or without the insertion of a catheter.

- In this document, ultrasound guidance refers to static guidance and site marking performed at the bedside immediately before the procedure, as opposed to real-time (dynamic) ultrasound guidance or radiology performed site marking. The static method is the most commonly used method of ultrasound guidance and is supported by current evidence.

RECOMMENDATIONS

Clinical Outcomes

1. *We recommend that ultrasound should be used to guide thoracentesis to reduce the risk of complications, the most common being pneumothorax.*

Rationale: Both static ultrasound guidance and dynamic ultrasound guidance have been reported to be associated with a reduced risk of pneumothorax.[4-7,15-18] A meta-analysis of 24 studies that included 6,605 thoracenteses showed a significant decrease in the risk of postprocedure pneumothorax with the use of ultrasound guidance compared to the risk associated with thoracentesis performed based on landmarks alone (OR 0.3, 95% CI 0.2–0.7).[3] The meta-analysis included both prospective and retrospective studies conducted using both static and dynamic ultrasound guidance.[3] A large retrospective cohort study conducted by Mercaldi et al. comprising more than 61,000 patients who underwent thoracentesis also showed that ultrasound guidance was associated with reduced odds of pneumothorax (OR 0.8 [0.7–0.9]).[4] When pneumothorax did occur during that hospitalization, the cost of hospitalization increased by $2800 and the length of stay increased by 1.5 days.[4] A 2008 review of 19,339 thoracenteses conducted by Patel et al. also demonstrated an association between ultrasound guidance and reduced odds of pneumothorax (OR 0.8 [0.7–0.96]).[18] Although these findings were significant, it is important to note that the studies of both Mercaldi et al. and Patel et al. were reviews of administrative databases conducted using the International Classification of Diseases, 9th Revision (ICD-9) codes for thoracentesis and Current Procedure Terminology–4th edition (CPT) codes for the use of ultrasound.[4,18] Patel et al. identified pneumothorax using ICD-9 codes for "pneumothorax–iatrogenic" and "pneumothorax–not specified as due to the procedure." The association between ultrasound guidance and the reduced odds of pneumothorax was driven by the latter code.[18] However, as with most retrospective studies using administrative data, granular data about the patients, procedure, proceduralists, and complications were not available in these reviews and conclusions may be limited by erroneous coding or documentation.[4,18] In a third retrospective cohort study, Raptopoulos et al. compared 154 landmark-based thoracenteses performed by "clinical physicians" and 188 ultrasound-guided thoracenteses performed by radiologists and found that ultrasound-guided site selection reduced the rate of pneumothorax from 18% to 3% ($P < .0001$).[6] Finally, one single-center randomized controlled trial of 160 thoracenteses performed by pulmonologists showed that ultrasound guidance reduced the relative risk of pneumothorax by 90% (12.5% vs 1.3%; $P = .009$) with a number needed to treat of 9.[15] It was not possible to blind the operators to the use of ultrasound guidance, but the data analysis was blinded.[15] Furthermore, while there was no explicit comparison of the intervention vs. the control groups, randomization would have presumably rendered both groups similar in terms of patient characteristics and effusion characteristics.[15] Ultrasound may reduce the risk of pneumothorax through several mechanisms, including identifying patients in whom thoracentesis cannot be safely performed, allowing selection of the safest needle insertion site, and revealing the optimal depth of needle insertion.

2. *We recommend that ultrasound guidance should be used to increase the success rate of thoracentesis.*

Rationale: Thoracentesis guided by ultrasound has lower rates of failed attempts, or "dry taps," compared to thoracentesis guided solely by physical examination. In 1977, Ravin described a method of using ultrasound to guide successful drainage of six complex pleural effusions (empyema or loculated effusion) after multiple (5–7) failed attempts by clinicians using physical examination alone.[8] In a second study by radiologists, Weingardt et al. demonstrated that 20 of 26 failed landmark-based thoracenteses were due to incorrect site selection by physical examination–15 sites were below the diaphragm and 5 sites were above the pleural effusion or in the consolidated lung–and the use of ultrasound allowed successful sampling in 14 of 16 patients who had a failed landmark-based thoracentesis.[9] Diacon et al. asked 30 physicians, ranging from junior housestaff to pulmonologists, to mark 172 potential thoracentesis sites in 67 patients with pleural effusions using physical examination alone. Ultrasound was then used to evaluate the proposed puncture sites. They found that using ultrasound would have avoided puncture on "dry chests" in 2% and avoided potential laceration of a solid organ in 10% of patients compared to site selection by physical examination alone.[19] Finally, Perazzo et al. randomized 160 patients to landmark-based thoracentesis and ultrasound-guided thoracentesis and demonstrated that half of the eight dry taps that occurred in the control group could be successfully drained using subsequent ultrasound guidance.[15]

Technique

3. *We recommend that ultrasound-guided thoracentesis should be performed or closely supervised by experienced operators.*

Rationale: Current evidence suggests lower complication rates when thoracentesis is performed by experienced healthcare providers. A systematic review of 6,605 thoracenteses showed a significantly lower pneumothorax rate when thoracentesis was performed by pulmonology or radiology faculty versus resident physicians (3.9% vs 8.5%; $P = .04$), although this finding was not significant in the four studies that directly com-

TABLE 1. **Summary of Recommendations**

No.	Topic of Recommendation	Strength of Recommendation	Degree of Consensus
Clinical Outcomes			
1	Risk of postprocedure pneumothorax	Strong	Very good
2	Thoracentesis procedure success rates	Strong	Very good
	Risk of bleeding	N/A	N/A
Technique			
3	Operator experience needed	Strong	Very good
4	Complications in mechanically ventilated patients	Conditional	Good
5	Identification of critical structures	Strong	Very good
6	Detect and approximate pleural fluid volume	Strong	Very good
7	Sonographic features guide management	Strong	Very good
	Indications for additional imaging	N/A	N/A
8	Measurement of fluid depth	Conditional	Good
9	Lung sliding preprocedure and postprocedure	Conditional	Good
	Detection of vessels with Doppler ultrasound	N/A	N/A
10	Avoid position changes after marking	Conditional	Good
	Real-time ultrasound guidance	N/A	N/A
11	Postprocedure chest X-rays	Strong	Very good
	Postprocedure ultrasound examination	N/A	N/A
Training			
12	Training in lung and pleural ultrasound	Strong	Very good
13	Simulation practice before real patient	Conditional	Good
14	Learner skill acquisition curves vary	Strong	Very good

Grayed out recommendations did not achieve consensus. Abbreviations: N/A, Statements without recommendations due to lack of agreement/uncertainty

pared this factor.[3] In a quality improvement study performed by Duncan et al., pulmonology and critical care physicians combining multiple quality improvement initiatives to achieve and maintain competency decreased the rate of pneumothorax from 8.6% to 1.1% (P =.0034).[20] Interventions included ultrasound training, performance of 10 thoracenteses under expert supervision, and restriction of privileges to proceduralists who perform 10 or more thoracenteses per year.[20] Finally, a series of 9,320 ultrasound-guided thoracenteses performed or supervised by a single expert internist over a period of 12 years resulted in a pneumothorax rate of 0.6% and a composite complication rate of 0.98% (pneumothorax, reexpansion pulmonary edema, hemothorax, site bleeding, hematoma, splenic laceration, and vasovagal reaction).[21] Notably, pneumothorax rate in resident physician hands was reported to be 8.5% in the meta-analysis performed by Gordon et al., which is similar to the initial rate in the pulmonologists who participated in the study by Duncan et al.[3,20] However, after instituting formal ultrasound training and other initiatives aimed at maintaining competency, the pneumothorax rate in the study by Duncan et al. decreased to 1.1%, similar to the rate observed in the series by Ault et al.[21] This suggests that training and supervision are necessary to achieve competency and reduce the rate of complications.[3,20,21]

4. *We suggest that ultrasound guidance be used to reduce the risk of complications from thoracentesis in mechanically ventilated patients.*

Rationale: The rest of this guideline refers to ultrasound-guided thoracentesis performed in spontaneously breathing patients; however, this recommendation is specific to mechanically ventilated patients. Two prospective observational studies have shown no increase in complications when ultrasound-guided thoracentesis is performed on mechanically ventilated patients compared to patients not receiving positive pressure ventilation. A feasibility study of 45 thoracenteses performed on ventilated patients reported no complications,[22] whereas another study on 232 patients reported a pneumothorax rate of 1.3%.[23] In a larger study conducted by Mayo et al., medicine housestaff performed thoracentesis under the supervision of intensivists who had undergone training in ultrasound prior to performing the procedure.[23] In both studies, most of the patients were in a supine position, although positioning and puncture site were at the discretion of the physician, and both studies employed use of static ultrasound guidance.[22,23] A large series of 9,320 ultrasound-guided thoracenteses that included 1,377 mechanically ventilated patients did not report a higher rate of pneumothorax (0.8%) compared to that in spontaneously breathing patients (0.61%).[21] Finally, a meta-analysis of 19 observational studies comprising 1,124 mechanically ventilated patients who underwent pleural drainage procedures showed a low rate of pneumothorax (3.4%) and hemothorax (1.9%).[24] Although the rate of complication was reported to be low in this meta-analysis, ultrasound was not employed in all studies and its use was not associated with a significant reduction in pneumothorax.[24] This may be because 8 of the 19 studies used pigtail catheters or large-bore thoracostomy tubes which treat pneumothorax as they occur.[24]

5. *We recommend that ultrasound should be used to identify the chest wall, pleura, diaphragm, lung, and subdiaphragmatic organs throughout the respiratory cycle before selecting a needle insertion site.*

Rationale: The use of ultrasound improves the selection of a safe needle insertion site because sites chosen without ultrasound guidance may be below the diaphragm, over solid organs,[9,19] or in locations that risk puncture of the lung.[9] Visualization of the chest wall, diaphragm, and lung, which define the boundaries of a pleural effusion, allows the clinician to confirm the presence of a drainable pleural effusion and assess for other pathologies, such as ascites and tumor, that may be mistaken for a pleural effusion.[22,25,26] Hypoechoic lesions can represent small loculated pleural effusions but also pleural plaques, pleural masses, peripheral lung masses, or abscesses.[27,28]

6. *We recommend that ultrasound should be used to detect the presence or absence of an effusion and approximate the volume of pleural fluid to guide clinical decision-making.*

Rationale: The presence and approximate size of pleural fluid collections are important determinants of whether thoracentesis, another procedure, or no procedure should be performed. Ultrasonography has higher sensitivity and specificity for detecting pleural effusions and better differentiates effusions from consolidations compared with chest radiography.[29-42] Ultrasound allows semiquantitative estimation of pleural fluid volume to determine whether thoracentesis should be performed.[41-45] When using ultrasound to choose a site for thoracentesis, the British Thoracic Society Pleural Disease guidelines recommend ≥10 mm of pleural fluid between the visceral and parietal pleura.[13] Pleural effusions of <10–15 mm are considered too small to tap.[22,23] In a prospective study of 45 patients, a measurement of >9.9 cm by ultrasound between the chest wall and the "V-point," the intersection of the diaphragm and the collapsed lung, correlated with a pleural fluid volume of >1 liter.[46] Another prospective study of 73 patients showed that a pleural effusion spanning >3 intercostal spaces by ultrasound also correlated with a pleural fluid volume of >1 liter.[47] Anticipating the volume of fluid to be removed may aid in preplanning and procurement of larger capacity drainage containers prior to starting the procedure. Lung ultrasound can also change the management if the characteristic of the effusion suggests that an invasive procedure is unsafe or another diagnostic or therapeutic option is more appropriate.[39] In a prospective cohort study of 189 mechanically ventilated patients, lung ultrasound guided the management in all patients with suspected effusion, leading to chest tube placement in 7 patients and thoracentesis in 34 patients.[48]

7. *We recommend that ultrasound should be used to detect complex sonographic features, such as septations, to guide clinical decision-making regarding the timing and method of pleural drainage.*

Rationale: Pleural effusions can be broadly categorized sonographically as simple or complex. Complex effusions are further categorized as with or without septation. Simple effusions are anechoic and are often, but not invariably, transudative.[49-51] The use of sonography and computerized tomography (CT) is complementary, but features of complex pleural effusions (fibrin stranding and septations) may be better visualized by ultrasound than by CT of the thorax.[52] Detection of complex features should prompt the consideration of pleural fluid sampling.[53,54] Exudative effusions from tuberculosis, malignancy, or other etiologies more often include debris, septations, or other complex features.[55,56] Certain features such as a swirling debris, pleural thickening, and nodularity may be more often associated with malignancy,[54,56] and advanced ultrasound techniques may be used to detect a trapped lung prior to attempting drainage of a malignant pleural effusion.[57] Two studies found complex septated pleural effusions to be invariably exudative[50,58] and drainage was unlikely to be successful without the placement of a chest tube.[50,58-60] Chest tube placement through fibrinolytic administration or video-assisted thoracoscopic surgery (VATS) may be more appropriate in the management of complex septated pleural effusions,[59-61] and expert consultation with a thoracic specialist is recommended in these cases.

8. *We suggest that ultrasound can be used to measure the depth from the skin surface to the parietal pleura to help select an appropriate length needle and determine the maximum needle insertion depth.*

Rationale: The distance from the skin to the parietal and visceral pleura can be measured by ultrasound to determine whether thoracentesis can be safely performed and to guide selection of an adequate length needle.[38] The length of needle required to penetrate the pleural space varies based on the thickness of the chest wall. Percussion of the chest wall is limited when there is more than 6 cm of subcutaneous tissue,[62] making physical examination in obese patients unreliable for selecting an appropriate site or needle length for thoracentesis. Ultrasound allows visualization of deep soft tissues, well beyond the limits of percussion, and allows an accurate measurement of the chest wall.[63]

9. We suggest that ultrasound can be used to evaluate normal lung sliding pre- and postprocedure to rule out pneumothorax.

Rationale: Normal lung sliding indicates normal apposition and movement of visceral and parietal pleura and rules out pneumothorax with a sensitivity that exceeds that of chest radiography, according to a meta-analysis of 20 studies using computed tomography or escape of intrapleural air at the time of drainage as the gold standard.[64] In this meta-analysis, the pooled sensitivity of ultrasound was reported to be 88% (85-91%) compared to 52% (49-55%) for radiography, although the analysis also suggests that the test characteristics are dependent on operator skill.[64] However, although lung sliding rules out pneumothorax, absence of lung sliding is not specific for pneumothorax and other conditions, including pleural adhesions, pleurodesis, and bronchial obstruction, can cause the absence of lung sliding.[64] Detection of a lung point conclusively rules in a pneumothorax.[65] Provided that the preprocedure lung ultrasound examination revealed normal lung sliding, a postprocedure examination can be performed to effectively evaluate for pneumothorax. This modality does not use ionizing radiation, is less expensive than computed tomography, can be performed faster than bedside chest radiography, and is more sensitive than supine or upright chest radiography.[64,66-71]

10. We suggest avoiding delay or interval change in patient position between the time of marking the needle insertion site and performing the thoracentesis.

Rationale: Optimal patient positioning and ultrasound-guided site marking should be performed by the primary operator immediately before beginning an invasive procedure. Remote sonographic localization in which a radiologist marks a needle insertion site using ultrasound and the thoracentesis is performed at a later time by a different provider is an antiquated practice. Two early studies demonstrated that this practice is no safer than landmark-based thoracentesis.[6,72] One prospective study of 205 patients performed in 1986 showed no significant decrease in the incidence of complications from thoracentesis performed using remote sonographic localization versus landmark-based drainage.[72] Complications in that study included a total of 22 pneumothoraces and 1 hematoma. The rate of complications in the group of patients who had site marking performed by radiology faculty and subsequent thoracentesis by medicine housestaff or attending physicians was 9.7% versus a complication rate of 12.7% in the landmark-based group.[72] In addition, Raptopoulos et al. observed no significant difference in the pneumothorax rate between 106 patients with landmark-based thoracenteses and 48 patients who were sonographically marked by radiology faculty and then returned to the ward for completion of the thoracentesis by medicine housestaff (19% vs. 15%, respectively).[6] Both groups had significantly higher rates of pneumothorax compared to those who underwent thoracentesis performed using real-time ultrasound guidance by radiology trainees (3%).[6] The authors speculated that changing the patient's position shifted the position of the pleural effusion, ultimately leading to the reliance on physical examination for the tap site.[6]

11. We recommend against performing routine postprocedure chest radiographs in patients who have undergone thoracentesis successfully with ultrasound guidance and are asymptomatic with normal lung sliding postprocedure.

Rationale: Chest radiography post-thoracentesis is unlikely to add information that changes management, especially if performed routinely, but does add expense, radiation, and inconvenience.[73] The most common serious complication of thoracentesis is pneumothorax, which is often accompanied by symptoms, particularly in those patients with pneumothorax large enough to warrant chest tube placement.[10,74,75] Pihlajamaa et al. retrospectively studied 264 ultrasound-guided thoracenteses performed by radiologists or radiology residents and noted that of 11 pneumothoraces, only 1 necessitated chest tube placement.[10] Aleman et al. prospectively studied 506 ultrasound-guided and physical examination-guided thoracenteses and found that only 1% of asymptomatic patients developed a pneumothorax.[74] Eight of the 18 symptomatic patients required chest tube placement as opposed to 1 of the 488 asymptomatic patients.[74] A large prospective study of 941 ultrasound-guided thoracentesis reported that only 0.3% of asymptomatic patients with no suspicion of pneumothorax required tube thoracostomy.[5] Postprocedure chest radiographs may be considered when thoracentesis is performed on mechanically ventilated patients, particularly when high airway pressures exist. In a study of 434 patients undergoing thoracentesis, only 10 patients had a pneumothorax (2.3%).[11] Six of these pneumothoraces occurred in 92 mechanically ventilated patients (6.5%), and 2 of these 6 patients required a chest tube.[11] None of the 4 spontaneously breathing patients with pneumothorax required a chest tube.[11]

Training

12. We recommend that novices who use ultrasound guidance for thoracentesis should receive focused training in lung and pleural ultrasonography and hands-on practice in procedural technique.

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

Rationale: Healthcare providers have to gain various skills to safely perform ultrasound-guided thoracentesis independently. Trainees should learn how to use ultrasound to identify important structures (chest wall, ribs, lung, pleura, diaphragm, and subdiaphragmatic organs); detect pleural effusions with complex features, such as septations; identify consolidated lung tissue; and rule out a pneumothorax. Prospective studies done with novice learners have shown that focused training combining didactics and hands-on practice using simulation or live models improves skills to assess pleural effusions.[76-84] Several additional procedural techniques such as patient positioning and needle insertion are also important but are beyond the scope of these guidelines.

13. *We suggest that novices undergo simulation-based training prior to performing ultrasound-guided thoracentesis on patients.*

Rationale: Simulation-based training for thoracentesis has been studied in providers with different levels of medical training, ranging from medical students and internal medicine residents to practicing pulmonologists. Studies suggest that training in a zero-risk environment with simulation task trainers leads to increased knowledge and skills without subjecting the patients to inexperienced operators.[85-87] One study on simulator-based training in medical students showed skill retention at 6 months and these skills were at least partially transferred to increased competency on live patients.[88] Checklists to train providers in ultrasound-guided thoracentesis have been published.[89,90] An experiential training program for attending physicians that utilized task trainers, along with standardized equipment and procedural technique, resulted in a reduction in the pneumothorax rate from 8.6% to 1.1%.[20]

14. *Training curves for novices to become competent in lung ultrasound and ultrasound-guided thoracentesis are not completely understood. We recommend that training should be tailored to the skill acquisition of the learner and the resources of the institution.*

Rationale: Understanding the rates at which novices progress from performing procedures under direct supervision to performing them independently would be highly desirable to ensure patient safety, guide supervision, and maximize efficiency of training. However, there is limited research describing the rate of progression of learners through these stages, either with regard to time or number of procedures performed. Two studies have shown that with brief training programs, medical students[88] and internal medicine residents[87] can achieve high levels of proficiency to perform thoracentesis on simulators, which is durable over time; however, whether these findings in a simulated environment translate into clinically significant outcomes is largely unknown, and neither of these studies incorporated the use of ultrasound guidance in their training curricula.[87,88] Another study of pulmonary and critical care physicians combined multiple quality improvement initiatives with a half day of ultrasound-guided thoracentesis training, a requirement to perform 10 supervised thoracenteses prior to independent practice, and an additional requirement to perform 10 thoracenteses per year to maintain privileges.[20] These interventions resulted in a concentration of competency among a few proceduralists, decreasing the rate of pneumothorax from 8.6% to 1.1%.[20] Degradation of skills with disuse may also occur[84]; thus, procedures performed infrequently should at a minimum be subjected to increased supervision and/or retesting.

KNOWLEDGE GAPS

The process of developing these guidelines revealed important gaps in the literature regarding the use of ultrasound guidance for thoracentesis. First, it is uncertain whether the use of ultrasound reduces the risk of bleeding with thoracentesis. A retrospective cohort study of 19,339 thoracenteses suggests that ultrasound guidance is associated with a 38.7% relative reduction in the odds of hemorrhage, although this reduction did not reach statistical significance (OR 0.6 [0.4–1.04]).[18] Ultrasound may reduce the risk of bleeding by reducing the number of attempts and needle passes and potentially avoiding tortuous intercostal vessels, which can be found especially in elderly patients and more cephalad rib spaces.[91] In an observational study of 22 patients undergoing thoracentesis, the intercostal artery (ICA) was identified by a high-frequency ultrasound transducer in 74 of 88 intercostal spaces.[92] The ICA is more exposed in the intercostal space within the first 6 cm lateral to the spinous processes and can be seen as far lateral as the midaxillary line.[92-95] Thus, the ICA will most likely be avoided if a procedure site is selected >6 cm lateral to the spinous processes and the needle is inserted above the rib.

Second, although all three studies conducted using real-time (dynamic) ultrasound guidance reported a pneumothorax rate of <1%, it is uncertain whether real-time ultrasound guidance confers any additional benefit compared to static guidance for site marking as direct comparisons were not made.[17,96,97] It is possible that real-time ultrasound guidance may be superior to static guidance in certain situations, such as small pleural effusions of <10–15 mm that have historically been considered too small to tap.[13,22,23,96]

Third, although one study suggests that general internists can safely perform thoracentesis with low complication rates similar to those of interventional radiologists,[2] limited data exists on how to train practicing hospitalists to use ultrasound to guide thoracentesis. The effectiveness of different training protocols to acquire competence in ultrasound-guided thoracentesis has not been compared.

Finally, the impact of ultrasound use on patient experience has yet to be explored.

CONCLUSION

The use of ultrasound guidance for thoracentesis has been associated with increased success rates and decreased complication rates. Ultrasound can be used to estimate the pleural fluid volume, characterize the effusion as simple or complex, identify an optimal needle insertion site, and reduce the need for postprocedural chest radiographs. Training and experience are essential to reap the benefits of using ultrasound for thoracentesis, although our understanding of optimal educational strategies and learning curves is limited. Once training has occurred and competence is achieved, hospitalists can perform ultrasound-guided thoracentesis as safely as radiologists, pulmonologists, and other specialists.

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