

# Recommendations for Use of Ultrasound to Guide Thoracentesis - SHM POCUS Task Force

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 Appropriateness 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

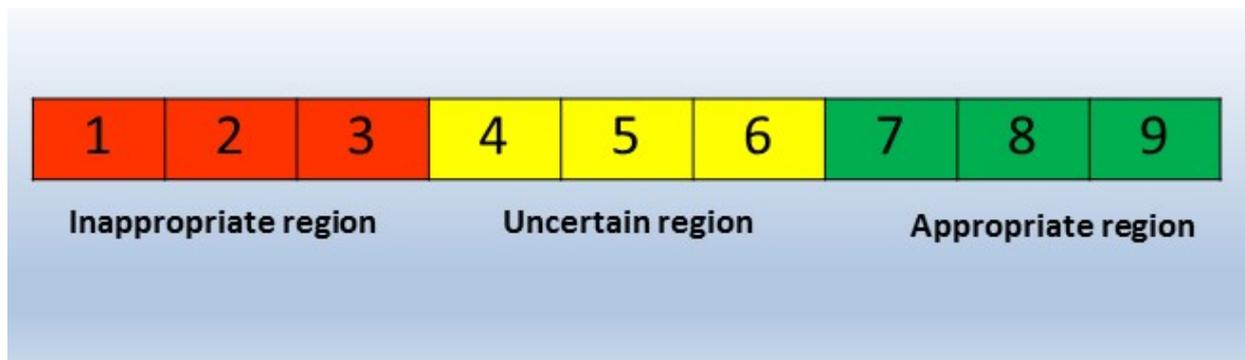
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## Recommendation Ranking Instructions

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"]

Definitions:

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

Ultrasound guidance refers to static guidance for site marking, as opposed to real-time ultrasound guidance, unless otherwise specified.

Last Name:

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First Name:

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## Clinical Outcomes

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

1	2	3	4	5	6	7	8	9
<b>Inappropriate region</b>			<b>Uncertain region</b>			<b>Appropriate region</b>		

Recommendation:

Use ultrasound to guide thoracentesis to reduce the risk of post-procedure pneumothorax, the most common major complication of thoracentesis. (Round 1 voting: Strong recommendation with very good consensus = "SHOULD use...") Level of Quality of Evidence: Moderate (D2S2S1).

Please rank the appropriateness of this recommendation:

(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 use is associated with a reduced rate of post-procedure pneumothorax as demonstrated by several retrospective and prospective observational studies and one randomized control trial (R41, R42, R43, R52, R86). A meta-analysis of 24 studies that included 6,605 thoracenteses showed a significant decrease in the chance of a post-procedure pneumothorax with the use of ultrasound guidance (OR 0.3 [0.2-0.7]) (R1). A large retrospective cohort study of over 61,000 patients that underwent thoracentesis also showed that ultrasound guidance reduced the odds of pneumothorax (OR 0.81 [0.74-0.9]), reduced the cost of hospitalization by \$2800, and reduced the length of stay by 1.5 days (R44). A second retrospective cohort study of 19,339 procedures showed a reduced odds of pneumothorax (OR 0.84 [0.74-0.96]), a reduced risk of hemorrhage (OR 0.61 [0.36-1.04]), and a \$622 reduction in the total cost of hospitalization ( $p < 0.001$ ), without a change in length of stay (R45). Another retrospective cohort study of 342 thoracenteses found ultrasound-guided site selection reduced the rate of pneumothorax from 18% to 3% ( $p < 0.0001$ ) (R43). A randomized controlled trial of 160 patients showed that ultrasound guidance reduced the relative risk of pneumothorax by 90% (12.5% vs 1.25%;  $p = 0.009$ ) and a number need to treat of 9 (R86). Ultrasound may reduce the risk of pneumothorax through several mechanisms, including identifying patients in whom thoracentesis cannot be safely performed, choosing the safest needle insertion site, or revealing the optimal depth of needle insertion.

Please add any comments:

**Recommendation:**

Use ultrasound to guide thoracentesis to increase the procedure success rate. (Round 1 voting results: Strong recommendation with very good consensus = "SHOULD use...") Level of Quality of Evidence: High (D2S2S2).

**Please rank the appropriateness of this recommendation:**

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

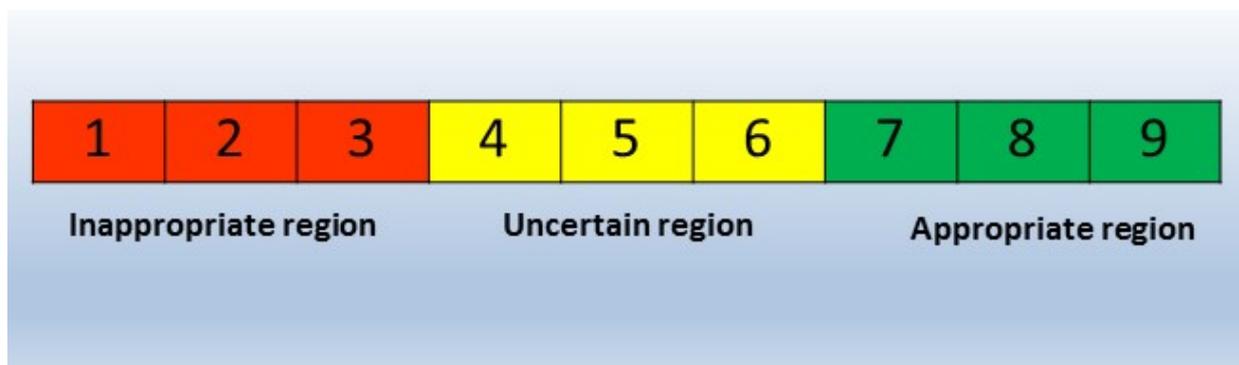
1  2  3  4  5  6  7  8  9  ABSTAIN. I know nothing about this topic.

**o Comment:**

Preprocedure evaluation of pleural effusions with ultrasound has been shown to decrease the rate of failed attempts, or "dry-taps," compared to thoracenteses guided solely by clinical examination. One study comparing thoracentesis site selection by physical exam vs. ultrasonography showed that ultrasound increased the rate of accurate site selection by 26%, avoided unnecessary attempts at drainage in 2%, and avoided potential laceration of a solid organ in 10% of patients (R6). Another study demonstrated that 6 complex effusions (empyema or loculated effusion) were successfully drained using ultrasound guidance after failed attempts at drainage based on physical examination alone (R60). One study of 26 failed thoracenteses based on physical exam alone demonstrated that 20 of 26 (88%) were due to incorrect site selection (15 sites were below the diaphragm and 5 sites were above the pleural effusion or into consolidated lung). The use of ultrasound in this series allowed successful sampling in 14 of 16 patients that had a prior failed thoracentesis (R46). A randomized controlled trial of 160 patients showed that successful drainage of pleural fluid was approximately 9 times greater when using ultrasound guidance vs. physical exam alone to perform thoracentesis (OR 8.8) (R86).

Please add any comments:

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

**Recommendation:**

Use ultrasound to guide thoracentesis, which may decrease the risk of bleeding. (Round 1 voting results: Disagreement with no consensus = No recommendation can be made) Level of Quality of Evidence: Low (D2S2S3).

**Please rank the appropriateness of this recommendation:**

(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 large retrospective cohort study of 19,339 thoracenteses suggests that ultrasound guidance is associated with a 38.7% reduction in hemorrhage, although this reduction did not reach statistical significance (OR 0.613 [0.36-1.04]) (R45). Ultrasound may reduce the risk of bleeding by reducing the number of attempts and needle passes, and potentially avoiding tortuous intercostal vessels, especially in patients with a coagulopathy.

Please add any comments:

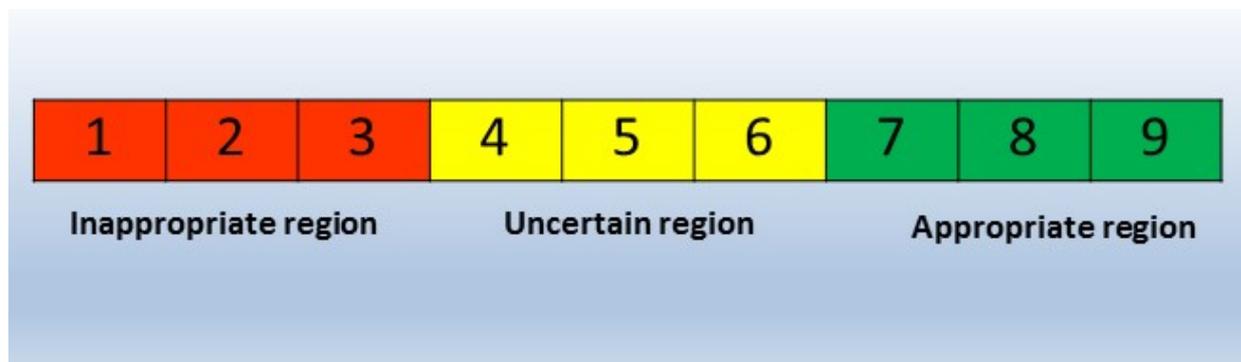
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**Technique**

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



Recommendation:

Use ultrasound guidance when performing pleural drainage procedures, including thoracentesis. (Round 1 voting results: Strong recommendation with very good consensus = "SHOULD use...") Level of Quality of Evidence: High (D2S3S1).

Please rank the appropriateness of this recommendation:

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

Comment:

All pleural procedures to aspirate pleural fluid, including simple needle drainage and insertion of small or large bore chest tubes, should be performed with ultrasound guidance for the benefits described in the Clinical Outcomes section above (R33).

Please add any comments:

Recommendation:

Ultrasound-guided thoracentesis is recommended to be performed, or closely supervised, by experienced operators. (Round 1 voting results: Strong recommendation with very good consensus = "SHOULD use...") Level of Quality of Evidence: Moderate (D2S3S2).

Please rank the appropriateness of this recommendation:

(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:

Evidence from a systematic review, a quality improvement study, and a large prospective observational study suggest that complication rates are lower when thoracentesis is performed by experienced healthcare providers. A systematic review of 6,605 thoracenteses showed significantly lower pneumothorax rate when thoracentesis was performed by an experienced healthcare providers vs. an inexperienced provider (3.9% vs 8.5%;  $p = 0.04$ ), but this finding was non-significant in studies directly comparing this factor (R1). A study of pulmonology and critical care physicians bundled multiple quality improvement initiatives to maintain competency, and this approach decreased the rate of pneumothorax from 8.6% to 1.1% (R2). Finally a prospective study of 9,320 ultrasound-guided thoracenteses performed by an expert provider over 12 years resulted in a composite complication rate of 0.98% (pneumothorax, re-expansion pulmonary edema, hemothorax, site bleeding, hematoma, splenic laceration, and vasovagal reaction). The pneumothorax rate was 0.61%. (R3).

Please add any comments:

**Recommendation:**

Use ultrasound guidance to reduce the risk of complications from thoracentesis in mechanically ventilated patients. (Round 1 voting results: Strong recommendation with very good consensus = "SHOULD use...") Level of Quality of Evidence: Low (D2S3S3).

Please rank the appropriateness of this recommendation:

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

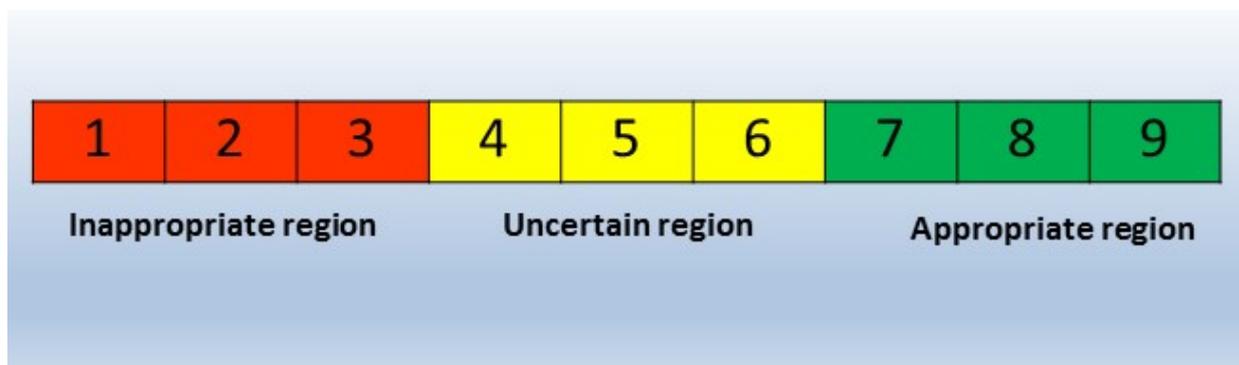
1  2  3  4  5  6  7  8  9  ABSTAIN. I know nothing about this topic.

**o Comment:**

Two prospective observational studies have shown no increase in complications when thoracentesis is performed on mechanically ventilated patients, as compared to spontaneously breathing patients. One study of 45 patients had no complications, while the second study had 232 patients with a 1.3% pneumothorax rate. In both studies, providers had training in ultrasound prior to performing the procedure and trainees performed the procedure under supervision. Positioning and puncture site were at the discretion of the physician in both studies, and most patients were in a supine position (R4, R5). In a large retrospective cohort study (n=9,320), mechanically ventilated patients (n=1,377) did not have a higher rate of pneumothorax rate (0.80%) compared to spontaneously breathing patients (R3). The overall pneumothorax rate was low (1.2%) in a prospective observational trial with 388 thoracentesis that included 83 mechanically ventilated surgical patients (R103). A meta-analysis of 19 observational studies with 1,124 mechanically ventilated patients that underwent thoracentesis showed a low rate of pneumothorax (3.4%) and hemothorax (1.9%) (R54).

Please add any comments:

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

**Recommendation:**

Use ultrasound to identify the chest wall, pleura, diaphragm, lung, and subdiaphragmatic organs throughout the respiratory cycle before selecting a needle insertion site. (Round 1 voting results: Strong recommendation with very good consensus = "SHOULD use...") Level of Quality of Evidence: Low (D2S3S4).

Please rank the appropriateness of this recommendation:

(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 ultrasound improves the healthcare provider's ability to choose a safe needle insertion site because a significant number of sites chosen without ultrasound guidance may be below the diaphragm, over solid organs (R6), or in locations that may risk puncture of the lung (R46). The operator should evaluate for the curtain sign throughout the respiratory cycle. The curtain sign is seen when aerated lung is interposed between the transducer and the diaphragm. Visualization of the chest wall, diaphragm, and lung, which define the boundaries of a pleural effusion, allow the clinician to confirm that the fluid collection is within the thoracic cavity. Other pathologies, such as ascites or tumor, may be mistaken for an effusion, if these structures are not definitively identified (R114, R7).

Please add any comments:

**Recommendation:**

Use ultrasound to detect the presence or absence of an effusion and approximate the volume of pleural fluid to guide clinical decision-making. (Round 1 voting results: Strong recommendation with very good consensus = "SHOULD use...") Level of Quality of Evidence: Moderate (D2S3S5).

Please rank the appropriateness of this recommendation:

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

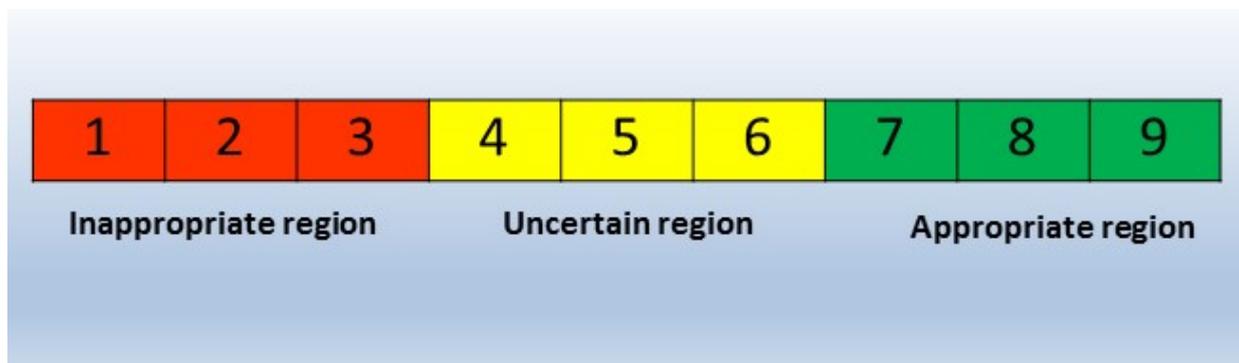
1  2  3  4  5  6  7  8  9  ABSTAIN. I know nothing about this topic.

**o Comment:**

Ultrasonography has higher sensitivity and specificity for detecting small pleural effusions compared to chest radiography (R8, R9, R10-15, R49, R62). Volume of pleural effusions is well estimated semi-quantitatively to determine if therapeutic thoracentesis may be performed, and identify situations in which a chest tube may be preferred for drainage over a prolonged time period (R17, 18, 19). In a prospective study of 45 patients, a measurement of >9.9 cm by ultrasound between the chest wall and V-point, the intersection of the diaphragm and chest wall, correlated with a pleural fluid volume >1L (R51). Another prospective study of 73 patients showed that a pleural effusion spanning >3.2 intercostal spaces by ultrasound correlated with a pleural fluid volume of >1L (R56). Ultrasonography better differentiates effusions from consolidations and other potential mimics compared to chest radiography (R20, 101). In a prospective cohort study with 189 mechanically ventilated patients, detection of moderate or large pleural effusions changed the management in nearly all patients (95%) (R16).

Please add any comments:

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

**Recommendation:**

Use ultrasound to detect complex sonographic features, such as septations, to guide decision-making regarding timing and method of pleural drainage. (Round 1 voting results: Strong recommendation with very good consensus = "SHOULD use...") Level of Quality of Evidence: Low (D2S3S6).

Please rank the appropriateness of this recommendation:

(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:

Pleural effusions can be broadly categorized sonographically as simple or complex with or without septations. Simple effusions are anechoic and are often, but not invariably, transudative (R67, R65, R104). Features of complex pleural effusions include fibrin stranding and septations and may be better visualized by ultrasound than CT (R23). Detection of complex features may prompt consideration of pleural fluid sampling (R21, R22). Exudative effusions from tuberculosis (R64), malignancy, or other etiologies more often include debris, cavitation, or other complex features (R111). Certain features, such as a swirling debris or pleural thickening, may be more often associated with malignancy (R111, R22), and advanced ultrasound techniques may be used to detect a trapped lung prior to attempting drainage of a malignant pleural effusion (R115). Complex septated pleural effusions are invariably exudative (R67-68) and drainage is unlikely to be successful without placement of a chest tube (R65, R67, R68, R69).

Chest tube placement with alteplase administration or video-assisted thoracoscopic surgery (VATS) may be more appropriate in the management of complex septated pleural effusions (R63, R69), and expert consultation with a thoracic specialist is recommended in these cases.

Please add any comments:

## Recommendation:

Obtain cross-sectional imaging, such as a computed tomography (CT) scan, or expert consultation when a hypoechoic pleural or parenchymal lung lesion is detected by ultrasound. (Round 1 voting results: Disagreement with no consensus = No recommendation can be made) Level of Quality of Evidence: Low (D2S3S7).

Please rank the appropriateness of this recommendation:

(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:

Hypoechoic lesions can represent pleural plaques, small loculated pleural effusions, pleural masses, peripheral lung masses, or abscesses (R25). In a descriptive study of 210 patients with exudative pleural effusions, patients were placed into 5 categories based on sonographic appearance of the fluid as having: echoes within the fluid, septations within the fluid, sheet-like pleural masses, nodular pleural masses, or associated lesions of the lung. Only the presence of nodular pleural masses was characteristic of malignant pleural effusions (R66).

Please add any comments:

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

1	2	3	4	5	6	7	8	9
<b>Inappropriate region</b>			<b>Uncertain region</b>			<b>Appropriate region</b>		

## Recommendation:

Use ultrasound 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. (Round 1 voting results: Strong recommendation with very good consensus = "SHOULD use...") Level of Quality of Evidence: Low (D2S3S8).

Please rank the appropriateness of this recommendation:

(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:

Using ultrasound, the distance from the skin to parietal and visceral pleura can be measured to determine whether thoracentesis can be safely performed, and to guide selection of an adequate length needle (R49). The length of needle needed to penetrate the pleural space varies based on thickness of the chest wall. Percussion of the chest wall is limited when there is more than 6 cm of subcutaneous tissue (R26), making physical exam in obese patients unreliable for selecting an appropriate length needle for thoracentesis. Ultrasound penetrates soft tissue to depths well exceeding the limits of percussion and allows accurate measurement of the pleural space depth.

Please add any comments:

## Recommendation:

Use ultrasound to evaluate for normal lung sliding pre- and post-procedure to rule out pneumothorax. (Round 1 voting results: Weak recommendation with some consensus = "MAY use...") Level of Quality of Evidence: High (D2S3S9).

Please rank the appropriateness of this recommendation:

(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:

Normal lung sliding, indicating normal apposition and movement of visceral and parietal pleura, rules out pneumothorax. Numerous studies have shown that lack of lung sliding is sensitive but not specific for pneumothorax (Ding).<sup>27</sup> Only detection of a lung point can rule in a pneumothorax conclusively (R83). A pre-procedural ultrasound examination is needed for purposes of comparison because pleural adhesions, pleurodesis, and chest wall radiation can cause absence of lung sliding. Provided that a pre-procedure lung ultrasound exam was performed and showed normal lung sliding, an immediate post-procedure exam can be used to evaluate for pneumothorax. This modality does not use ionizing radiation, is less expensive than computed tomography, and can be performed faster than bedside chest radiography. In an observational, cross-sectional study of 185 image-guided pleural procedures, ultrasound was performed 13 minutes before chest radiography and had 88% sensitivity and 97% specificity (R28). If pneumothorax is detected, iterative ultrasound can be done to assess change in size of a pneumothorax.

Please add any comments:

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

1	2	3	4	5	6	7	8	9
<b>Inappropriate region</b>			<b>Uncertain region</b>			<b>Appropriate region</b>		

Recommendation:

Prior to thoracentesis, a high frequency transducer with color flow or power Doppler may be used to evaluate the proposed needle trajectory above the target rib to avoid intercostal vessels. (Round 1 voting results: Disagreement with no consensus = No recommendation can be made) Level of Quality of Evidence: Low (D2S3S10).

Please rank the appropriateness of this recommendation:

(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:

While no prospective trials studying whether this intervention decreases the risk of significant bleeding or hemothorax, there have been observational studies showing the variability of the intercostal artery (ICA) in the intercostal space (ICS) using ultrasound. In a prospective cohort study of 22 patients undergoing thoracentesis, the ICA was identified in 74 of 88 intercostal spaces, supporting the feasibility of finding the ICA with a high-frequency ultrasound transducer (R29). Another prospective cohort study of 133 intercostal spaces of 50 patients showed that ultrasound had 86% sensitivity of detecting the ICA using CT angiography as the gold standard (R30). The ICA is most visible in the ICS close to the spine and can be seen as far lateral as the midaxillary line (R29). In a retrospective review of CT pulmonary angiograms from 47 patients, the intercostal artery was exposed within the first 6 cm lateral to the spinous processes with increased tortuosity in elderly patients (R31). The ICA will most likely be avoided if the healthcare provider chooses a site >6 cm lateral from the spinous processes and ensures the needle is inserted above the rib in the ICS.

Please add any comments:

Recommendation:

During thoracentesis, avoid delay or interval change in patient position after the needle insertion site has been marked. (Round 1 voting results: Strong recommendation with very good consensus = "SHOULD use...") Level of Quality of Evidence: Low (D2S3S11).

Please rank the appropriateness of this recommendation:

(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:

Remote sonographic localization to guide thoracentesis is not safer than thoracentesis without ultrasound guidance. A prospective study of 205 patients showed no decrease in incidence of complications from thoracentesis with remote sonographic localization versus blind drainage, likely due to change in patient position between sonographic marking and initiation of the procedure (R43, R32).

Please add any comments:

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

1	2	3	4	5	6	7	8	9
<b>Inappropriate region</b>			<b>Uncertain region</b>			<b>Appropriate region</b>		

Recommendation:

Consider performing real-time (dynamic) ultrasound-guided thoracentesis of small pleural effusions measuring at least 10 mm in depth throughout the respiratory cycle. (Round 1 voting results: Disagreement with no consensus = No recommendation can be made) Level of Quality of Evidence: Low (D2S3S12).

Please rank the appropriateness of this recommendation:

(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 choosing a site for thoracentesis, the British Thoracic Society guidelines recommend there be at least 10 mm of pleural fluid between visceral and parietal pleura on ultrasonography. Pleural effusions < 10mm are considered too small to tap (R33, R4, R5). In a prospective study of 101 real-time ultrasound-guided thoracenteses, a 100% feasibility rate and 0.7% pneumothorax rate was achieved even with small effusions measuring at least 10 mm in depth (R50). Although no studies have compared real-time ultrasound guidance to static pre-procedural site marking, one retrospective study of 310 procedures using real-time guidance showed a pneumothorax rate of < 1% with real-time ultrasound guidance when performed by experienced healthcare providers (R34).

Please add any comments:

Recommendation:

Routine post-procedure chest radiographs are not indicated in patients that have successfully undergone thoracentesis with ultrasound guidance that are asymptomatic and demonstrate normal lung sliding post-procedure. (Round 1 voting results: Strong recommendation with very good consensus = "SHOULD use...") Level of Quality of Evidence: Low (D2S3S13).

Please rank the appropriateness of this recommendation:

(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:

Chest radiography is unlikely to add information that changes management, especially if performed routinely; but does add expense, radiation, and inconvenience (R35). The most common serious complication of thoracentesis is pneumothorax, which is typically accompanied by symptoms, particularly in those cases severe enough to warrant chest tube placement (R36, R37, R53). In a study of 174 thoracenteses, there were 9 pneumothoraces, 5 of which were suspected based on signs and symptoms. Only 4 of these 5 required tube thoracostomy. No patient in whom pneumothorax was unsuspected required a chest tube (R38). A large prospective study of 941 patients that underwent ultrasound-guided thoracentesis showed a low rate (0.3%) of pneumothorax in asymptomatic patients (R52). Post-procedure chest radiographs may be considered when thoracentesis is performed on mechanically ventilated patients, particularly when high pressures are being used. A study of 434 patients, of whom 92 were mechanically ventilated, found only 10 (2.3%) had pneumothoraces. Six of the ten pneumothoraces were in intubated patients, two of whom required chest tube. Chest tubes were not necessary in the 4 non-intubated patients (R39).

Please add any comments:

## Recommendation:

Consider using post-procedural ultrasonography to assess for residual pleural fluid and lung re-expansion, and monitor for re-expansion pulmonary edema. (Round 1 voting results: Disagreement with no consensus = No recommendation can be made) Level of Quality of Evidence: Low (D2S3S14).

Please rank the appropriateness of this recommendation:

(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:

Early termination of therapeutic thoracentesis due to cough or chest pain may signify non-expandable "trapped lung," while termination due to cessation of flow of fluid may be due to loculated fluid. Post-procedural ultrasonography can quantify the amount of residual effusion, as well as assess the re-expanding lung for edema, which will manifest as multiple B-lines suggestive of interstitial syndrome (R40). Though little specific evidence exists particular to post-thoracentesis detection of these entities, ultrasound is very likely at least non-inferior compared to post-procedure chest radiograph.

Please add any comments:

## Training & Competency

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

1	2	3	4	5	6	7	8	9
Inappropriate region			Uncertain region			Appropriate region		

Recommendation:

Healthcare providers that are novices in ultrasound-guided thoracentesis need focused training in lung and pleural ultrasonography and hands-on practice in procedural technique. (Round 1 voting results: Strong recommendation with very good consensus = "SHOULD use...") Level of Quality of Evidence: Low (D2S4S1).

Please rank the appropriateness of this recommendation:

(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:

Healthcare providers need to gain various skills in order 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 or debris; identify consolidated lung tissue; and rule out a pneumothorax. Prospective studies done with trainees have shown that focused training combining didactics and hands-on practice using simulation or live models improves skills to assess pleural effusions and perform thoracentesis with ultrasound guidance (R61, R87, R88, R89, R130). Many additional procedural techniques, such as patient positioning and needle insertion, are also important, but are beyond the scope of this document.

Please add any comments:

Recommendation:

Novices can undergo simulation-based training prior to performing ultrasound-guided thoracentesis on a live patient. (Round 1 voting results: Strong recommendation with very good consensus = "SHOULD...") Level of Quality of Evidence: Low (D2S4S2).

Please rank the appropriateness of this recommendation:

(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 for thoracentesis has been studied in providers with different levels of medical training - from medical students to internal medicine residents to pulmonologists. Studies suggest that training in a zero-risk environment with simulation task trainers leads to increased knowledge without subjecting patients to inexperienced operators (R92, R47). Establishing competency during an experiential training program utilizing task trainers, along with standardization of the equipment and procedure, resulted in a reduction in pneumothorax from 8.6% to 1.1% as part of a prospectively studied quality improvement initiative among attending physicians. (R2).

Please add any comments:

## Recommendation:

Training curves for novices to become competent to perform lung ultrasound and ultrasound-guided thoracentesis are not completely understood, and training should be tailored to the skill acquisition of the learner and resources of the institution. (Round 1 voting results: Strong recommendation with very good consensus = "SHOULD use...") Level of Quality of Evidence: Low (D2S5S1).

Please rank the appropriateness of this recommendation:

(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:

It is generally agreed upon that less experienced providers have higher rates of complications than do more experienced providers (R1). Understanding rates at which novices are able to 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, little research describes the rate of progression of learners through these stages, either with regard to time or number of procedures performed. Two studies showed that with brief training programs, medical students (R48) and internal medicine residents (R47) can achieve high levels of proficiency to perform thoracentesis on simulators that is durable over time; However, whether or not these findings in a simulated environment translate into clinically significant outcomes is unknown, and neither of these studies incorporated use of ultrasound guidance. Another study of pulmonary and critical care physicians bundled 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 a further requirement to perform 10 thoracenteses per year to maintain privileges. This concentration of competency among a few proceduralists decreased the rate of pneumothorax from 8.6% to 1.1% (R2).

Please add any comments:

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## Final Comments

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