**Appendix 3 – Thoracentesis Literature Search**

**Specific Search Strings for Draft Recommendations:**

D2S2S1: Thoracentesis complication rates have been demonstrated to be lower when the procedure is performed by experienced operator and with ultrasound guidance.

* PubMed: ("Pneumothorax"[Mesh] OR complicat\*[tiab]) AND ("Pleural Effusion/ultrasonography"[Mesh]) OR (thoracentesis AND ultrasound)
* Embase: 'ultrasound'/exp AND guidance:ti AND thoracentesis:ti AND (complicat\*:ti OR pneumothorax:ti)
* CINAHL: (MH "Pneumothorax/CO" AND ultrasound ) AND AB guidance AND AB thoracentesis
* Cochrane & Google Scholar: ultrasound AND guidance AND thoracentesis AND complication\*

D2S2S2: Thoracentesis is safe in mechanically ventilated patients when performed by an experienced operator using ultrasound guidance.

* PubMed: ("Respiration, Artificial"[Mesh] OR mechanical\* OR ventil\*) AND (thoracentesis[tiab] OR "pleural effusion\*"[tiab] OR "pleural drainage"[tiab] OR "pleural fluid analysis"[tiab] OR "tube thoracostomy"[tiab] OR pleuracentesis[tiab] OR pleurocentesis[tiab] OR thoracocentesis[tiab]) AND ("Ultrasonography"[Mesh] OR ultrasound[tiab] OR sonograph\*[tiab] OR echograph\*[tiab] OR echocardiograph\*[tiab])
* Embase: 'artificial ventilation'/exp OR 'artificial ventilation' OR mechanical\*:ti OR ventil\*:ab AND (thoracentesis:ti OR 'pleural effusion':ti OR 'pleural drainage':ti OR 'pleural fluid analysis':ti OR thoracostomy:ti OR pleuracentesis:ti OR pleurocentesis:ti OR thoracocentesis:ti) AND ('ultrasound'/exp OR 'ultrasound')
* CINAHL: (MH "Respiration, Artificial" OR "mechanical ventil\*") AND TX ( (thoracentesis OR "pleural effusion" OR "pleural drainage" OR "pleural fluid analysis" OR thoracostomy OR pleuracentesis OR pleurocentesis OR thoracocentesis) ) AND ultrasound
* Cochrane & Google Scholar: (mechanical OR mechanically OR ventil\*) AND thoracentesis AND guidance.

D2S2S3: A low frequency ultrasound transducer is used initially to evaluate the chest wall, pleura, diaphragm, lung, and solid organs below the diaphragm throughout the respiratory cycle prior to mark the needle insertion site.

* PubMed: (thoracentesis[tiab] OR "pleural effusion\*"[tiab] OR "pleural drainage"[tiab] OR "pleural fluid analysis"[tiab] OR "tube thoracostomy"[tiab] OR pleuracentesis[tiab] OR pleurocentesis[tiab] OR thoracocentesis[tiab]) AND ("Ultrasonography"[Mesh] OR ultrasound [tiab] OR sonograph\*[tiab] OR echograph\*[tiab] OR echocardiograph\*[tiab] OR "thoracic ultrasound"[tiab]) AND (thickness OR diaphragm\* OR “chest wall” OR puncture)
* Embase: 'ultrasound'/exp AND (thoracentesis:ti OR 'pleural effusion':ti OR 'pleural drainage':ti OR 'pleural fluid analysis':ti OR thoracostomy:ti OR pleuracentesis:ti OR pleurocentesis:ti OR thoracocentesis:ti) AND (thickness:ti OR diaphragm:ti OR 'chest wall':ti OR puncture:ti)
* CINAHL: ultrasound AND TX (thoracentesis OR "pleural effusion" OR "pleural drainage" OR "pleural fluid analysis" OR thoracostomy OR pleuracentesis OR pleurocentesis OR thoracocentesis) AND ( (thickness OR diaphragm OR "chest wall" OR puncture)
* Cochrane & Google Scholar: Thoracentesis AND ultrasound AND (thickness OR diaphragm OR “chest wall” OR puncture)

D2S2S4: Pre-procedural pleural ultrasound evaluation, including a qualitative assessment of pleural fluid volume and character, guides clinical decision-making.

* PubMed: (thoracentesis[tiab] OR "Pleural Effusion/ultrasonography"[Mesh]) AND (thoracic[tiab] OR ultrasound[tiab] OR radiologic[tiab] OR radiography[tiab]) AND effusion[tiab]
* Embase: 'ultrasound'/exp AND (thoracentesis:ti OR 'pleural effusion':ti OR 'pleural volume':ti) AND
* CINAHL: ultrasound AND (thoracentesis OR "pleural effusion" OR "pleural volume")
* Cochrane & Google Scholar: thoracentesis AND ultrasound AND (effusion OR diagnose\* OR “pleural fluid” OR “pleural volume”)

D2S2S5: Complex sonographic features, such as debris or septations, are highly suggestive of exudative effusion.

* PubMed: (thoracentesis[tiab] OR "pleural effusion\*"[tiab] OR "pleural drainage"[tiab] OR "pleural fluid analysis"[tiab] OR "tube thoracostomy"[tiab] OR pleuracentesis[tiab] OR pleurocentesis[tiab] OR thoracocentesis[tiab]) AND ("Ultrasonography"[Mesh] OR ultrasound[tiab] OR sonograph\*[tiab] OR echograph\*[tiab] OR echocardiograph\*[tiab] OR "thoracic ultrasound"[tiab]) AND (debris OR exudat\* OR septation\* OR "fluid sampling")
* Embase: 'ultrasound'/exp AND (thoracentesis:ti OR 'pleural effusion':ti OR 'pleural drainage':ti OR 'pleural fluid analysis':ti OR thoracostomy:ti OR pleuracentesis:ti OR pleurocentesis:ti OR thoracocentesis:ti) AND (debris:ti OR exudat\*:ti OR septation:ti OR 'fluid sampling':ti)
* CINAHL: ultrasound AND TX (thoracentesis OR "pleural effusion" OR "pleural drainage" OR "pleural fluid analysis" OR thoracostomy OR pleuracentesis OR thoracentesis) AND TX (debris OR exudat\* OR septation OR "fluid sampling")
* Cochrane & Google Scholar: thoracentesis AND ultrasound AND (effusion OR debris OR exudat\* OR septation OR “fluid sampling”)

D2S2S6: Hypoechoic pleural or parenchymal lung lesions detected on ultrasound warrant work up and expert consultation.

* PubMed: (thoracentesis[tiab] OR "pleural effusion\*"[tiab] OR "pleural drainage"[tiab] OR "pleural fluid analysis"[tiab] OR "tube thoracostomy"[tiab] OR pleuracentesis[tiab] OR pleurocentesis[tiab] OR thoracocentesis[tiab]) AND ("Ultrasonography"[Mesh] OR ultrasound [tiab] OR sonograph\*[tiab] OR echograph\*[tiab] OR echocardiograph\*[tiab] OR "thoracic ultrasound"[tiab]) AND (parenchyma\* OR hypoechoic OR echogenic OR "pleural densit\*")
* Embase: 'ultrasound'/exp AND (thoracentesis:ti OR 'pleural effusion':ti OR 'pleural drainage':ti OR 'pleural fluid analysis':ti OR thoracostomy:ti OR pleuracentesis:ti OR pleurocentesis:ti OR thoracocentesis:ti) AND (parenchyma\*:ti OR hypoechoic:ti OR echogenic:ti OR 'pleural densities':ti)
* CINAHL: ultrasound AND TX (thoracentesis OR "pleural effusion" OR "pleural drainage" OR "pleural fluid analysis" OR thoracostomy OR pleuracentesis OR pleurocentesis OR thoracocentesis) ) AND TX ( (parenchyma\* OR hypoechoic OR echogenic OR "pleural densit\*")
* Cochrane & Google Scholar: thoracentesis AND ultrasound AND (parenchyma\* OR “plural densit\*” OR hypoechoic OR echogenic)

D2S2S7: Pre-procedural measurement of the depth from the skin surface to the parietal pleura allows selection of an appropriate length needle or catheter and determines maximum insertion depth.

* PubMed: (thoracentesis[tiab] OR "pleural effusion\*"[tiab] OR "pleural drainage"[tiab] OR "pleural fluid analysis"[tiab] OR "tube thoracostomy"[tiab] OR pleuracentesis[tiab] OR pleurocentesis[tiab] OR thoracocentesis[tiab]) AND ("Ultrasonography"[Mesh] OR ultrasound [tiab] OR sonograph\*[tiab] OR echograph\*[tiab] OR echocardiograph\*[tiab] OR "thoracic ultrasound"[tiab]) AND (measure\* OR depth OR “physical exam\*”)
* Embase: 'ultrasound'/exp AND (thoracentesis:ti OR 'pleural effusion':ti OR 'pleural drainage':ti OR 'pleural fluid analysis':ti OR thoracostomy:ti OR pleuracentesis:ti OR pleurocentesis:ti OR thoracocentesis:ti) AND (measure\*:ti OR depth:ti OR 'physical exam':ti OR 'physical examination':ti)
* CINAHL: ultrasound AND TX (thoracentesis OR "pleural effusion" OR "pleural drainage" OR "pleural fluid analysis" OR thoracostomy OR pleuracentesis OR pleurocentesis OR thoracocentesis) AND TX (measure\* OR depth OR "physical exam\*" OR "physical examination")
* Cochrane & Google Scholar: (Thoracentesis OR “pleural effusion”) AND ultrasound AND (measure\* OR depth OR “physical exam\*”)

D2S2S8: A high frequency ultrasound transducer is used to evaluate for normal lung sliding pre- and post-procedure to rule out pneumothorax.

* PubMed: ("Ultrasonography"[Mesh] OR ultrasound OR "Pleural Effusion/ultrasonography"[Mesh]) AND ("lung sliding" OR “sliding lung”)
* Embase: 'ultrasound'/exp AND ('lung sliding':ti OR 'sliding lung':ti)
* CINAHL: ultrasound AND TX ( ("lung sliding" OR "sliding lung")
* Cochrane & Google Scholar: Ultrasound AND pneumothorax AND sliding

D2S2S9: A high frequency ultrasound transducer with color or power Doppler is used to evaluate the proposed needle trajectory above the target rib to avoid arterial vessels.

* PubMed: ("Ultrasonography"[Mesh] OR ultrasound) AND thoracentesis AND (artery OR arteries OR arterial OR intercostal AND (laceration OR lacerate)
* Embase: 'ultrasound'/exp AND thoracentesis:ti AND (artery:ti OR arteries:ti OR arterial:ti OR intercostal:ti) AND (lacerate:ti OR laceration:ti)
* CINAHL: TX ultrasound AND TX thoracentesis AND TX (artery OR arteries OR arterial OR intercostal) AND (lacerate OR laceration)
* Cochrane & Google Scholar: ultrasound AND thoracentesis AND (artery OR arteries OR arterial OR intercostal AND (laceration OR lacerat\*)

D2S2S10: Interval change in patient position should be avoided after the needle insertion site has been marked.

* PubMed: (thoracentesis[tiab] OR "pleural effusion\*"[tiab] OR "pleural drainage"[tiab] OR "pleural fluid analysis"[tiab] OR "tube thoracostomy"[tiab] OR pleuracentesis[tiab] OR pleurocentesis[tiab] OR thoracocentesis[tiab]) AND ("Ultrasonography"[Mesh] OR ultrasound [tiab] OR sonograph\*[tiab] OR echograph\*[tiab] OR echocardiograph\*[tiab] OR "thoracic ultrasound”[tiab]) AND (position\* OR supine OR lateral)
* Embase: 'ultrasound'/exp AND (thoracentesis:ti OR 'pleural effusion':ti OR 'pleural drainage':ti OR 'pleural fluid analysis':ti OR thoracostomy:ti OR pleuracentesis:ti OR pleurocentesis:ti OR thoracocentesis:ti) AND (position\*:ti OR supine:ti OR lateral:ti)
* CINAHL: ultrasound AND TX (thoracentesis OR "pleural effusion" OR "pleural drainage" OR "Pleural fluid analysis" OR thoracostomy OR pleuracentesis OR pleurocentesis OR thoracocentesis) AND TX (position\* OR supine OR lateral)
* Cochrane & Google Scholar: (thoracentesis OR "pleural effusion") AND ultrasound AND (position\* OR supine OR lateral) AND ("needle insertion" OR "needle placement")

D2S2S11(a): Experienced operators competent in needle tip tracking with ultrasound may perform real-time ultrasound-guided thoracentesis of pleural effusions measuring as little as 10 mm of interpleural space throughout the respiratory cycle.

* PubMed: ("Ultrasonography"[Mesh]OR ultrasound) AND thoracentesis AND guid\*
* Embase: 'ultrasound'/exp OR 'ultrasound' AND thoracentesis:ti AND guidance:ti AND 'real time'
* CINAHL: TX ultrasound AND TX ( thoracentesis AND guidance ) AND TX real-time
* Cochrane & Google Scholar: ultrasound AND thoracentesis AND guidance AND real-time

D2S2S119(b): Routine post-procedure chest radiography is not inidicated in patients that have successfully undergone thoracentesis with ultrasound guidance and are asymptomatic.

* PubMed: ("Pneumothorax/radiography"[Mesh] OR "Pneumothorax/ultrasonography"[Mesh]) AND thoracentesis
* Embase: (thoracentesis:ti OR pneumothorax:ti) AND 'ultrasound'/exp AND routine
* CINAHL: (MH "Pneumothorax/US") AND TX (thoracentesis OR "pleural effusion") AND TX routine
* Cochrane & Google Scholar: chest AND (roentgenography OR radiology) AND thoracentesis AND (routine OR ultrasound)

D2S2S12: Post-procedural pleural ultrasonography can assess residual pleural fluid and lung re-expansion, and monitor for re-expansion pulmonary edema.

* PubMed: ("Pleural Effusion/radiography"[Mesh] OR "Pleural Effusion/ultrasonography"[Mesh]) AND re-expansion
* Embase: 'ultrasound'/exp AND 'pleural effusion':ti AND 're expansion':ti
* CINAHL: TX ultrasound AND TX ( (thoracentesis OR "pleural effusion") ) AND TX re-expansion
* Cochrane & Google Scholar: ultrasound AND (postoperative OR post-*procedure*\*) AND re-expansion

D2S3S1: Ultrasound guidance of thoracentesis is associated with a reduced risk of post-procedure pneumothorax, the most common major complication of thoracentesis.

* PubMed: "Pneumothorax"[Mesh] AND thoracentesis AND guidance
* Embase: pneumothorax:ti AND thoracentesis:ti AND ultrasound:ti AND guidance:ti
* CINAHL: TX pneumothorax AND TX thoracentesis AND TX ( ultrasound AND guidance )
* Cochrane & Google Scholar: Pneumothorax AND thoracentesis AND guidance

D2S3S2: Ultrasound guidance of thoracentesis increases the success rate of the procedure.

* PubMed: "Treatment Outcome"[Mesh] AND thoracentesis AND ("Ultrasonography"[Mesh] OR ultrasound)
* Embase: 'ultrasound'/exp AND ('treatment outcome'/exp OR success:ti OR failure:ti) AND thoracentesis AND guidance
* CINAHL: (MH "Treatment Outcomes" OR success OR failure) AND ultrasound AND TX ( thoracentesis AND guidance )
* Cochrane & Google Scholar: ultrasound AND guidance AND thoracentesis AND (success\*[tiab] OR failure[tiab]) AND outcome\*

D2S3S3: Ultrasound guidance of thoracentesis decreases the risk of bleeding.

* PubMed: ("Hemorrhage"[Mesh] OR bleeding) AND ("Ultrasonography"[Mesh] OR ultrasound) AND thoracentesis)
* Embase: thoracentesis AND 'bleeding'/exp AND 'ultrasound'/exp
* CINAHL:TX ultrasound AND TX thoracentesis AND TX ( (bleeding OR blood OR hemorrhage)
* Cochrane & Google Scholar: ultrasound AND thoracentesis AND (bleeding OR blood OR hemorrhage)

D2S4S1: Healthcare providers novice to the use of ultrasound to guide thoracentesis require training in focused lung and pleural ultrasonography, in addition to hands-on training in procedural technique.

* PubMed: (thoracentesis OR "pleural effusion\*" OR pleuracentesis[tiab] OR pleurocentesis[tiab] OR thoracocentesis[tiab]) AND ("Ultrasonography"[Mesh] OR ultrasound[tiab] OR sonograph\*[tiab] OR echograph\*[tiab] OR echocardiograph\*[tiab]) AND (competence OR competency OR competencies OR simulat\* OR train\* OR education)
* Embase: 'ultrasound'/exp AND (thoracentesis:ti OR 'pleural effusion':ti OR pleuracentesis:ti OR pleurocentesis:ti OR thoracocentesis:ti) AND (competence:ti OR competency:ti OR competencies:ti OR simulat\*:ti OR train:ti OR educat\*:ti)
* CINAHL: TX ultrasound AND TX (thoracentesis OR "pleural effusion" OR pleuracentesis OR pleurocentesis OR thoracocentesis) ) AND TX ( (competence OR competency OR competencies OR simulat\* OR train\* OR educat\*)
* Cochrane & Google Scholar: thoracentesis AND ("ultrasonography OR ultrasound OR sonograph\* OR echograph\* OR echocardiograph\*) AND (competence OR competency OR competencies OR simulat\* OR train\* OR education)

D2S4S2: Simulation-based training is an essential component of training prior to performing thoracentesis on a live patient.

AND

D2S5S1: Training curves at which novice users of ultrasound become competent to perform lung ultrasound and thoracentesis independently are incompletely understood.

* PubMed: (“Thoracentesis”[Mesh] OR thoracentesis[tiab] OR thoracic[tiab] OR "pleural effusion\*"[tiab] OR "pleural drainage"[tiab] OR "pleural fluid analysis"[tiab] OR "tube thoracostomy"[tiab] OR pleuracentesis[tiab] OR pleurocentesis[tiab] OR thoracocentesis[tiab]) AND ("Ultrasonography"[Mesh] OR "Radiography"[Mesh] OR imaging [tiab] OR sonograph\*[tiab] OR echograph\*[tiab] OR echocardiograph\*[tiab] OR "thoracic ultrasound"[tiab]) AND (competent[ti] OR competence[ti] OR competency[ti] OR competencies [ti] OR simulat\*[ti] OR train\*[ti] OR educat\*[ti] OR technique\*[ti] OR skill\*[ti] OR method\*[ti] OR curriculum[ti] OR teach\*[ti])
* Embase: ('thoracocentesis'/mj OR thoracentesis:ti OR thoracic:ti OR 'pleural effusion':ti OR 'pleural drainage':ti OR 'pleural fluid analysis':ti OR 'tube thoracostomy':ti OR pleuracentesis:ti OR pleurocentesis:ti OR thoracocentesis:ti) AND ('ultrasound'/mj OR ultrasound:ti OR ultrasonography:ti OR radiography:ti OR imaging:ti OR sonograph:ti OR sonography:ti OR echography:ti OR echocardiograph:ti OR echocardiography:ti OR 'thoracic ultrasound':ti) AND (competent:ti OR competence:ti OR competency:ti OR competencies:ti OR simulation:ti OR simulate:ti OR simulating:ti OR train\*:ti OR educat\*:ti OR skill\*:ti OR method\*:ti OR curriculum:ti OR teach\*:ti)
* CINAHL: (MH "Thoracentesis" OR thoracentesis(ti) OR thoracic(ti) OR "Pleural effusion"(ti) OR "pleural drainage"(ti) OR "Pleural fluid analysis"(ti) OR "tube thoracostomy"(ti) OR pleuracentesis(ti) OR pleurocentesis(ti) OR thoracocentesis(ti))AND (ultrasonography(ti) OR ultrasound(ti) OR radiography(ti) OR imaging(ti) OR sonography(ti) OR echograph(ti) OR echography(ti) OR echocardiograph(ti) OR "thoracic ultrasound"(ti)) AND (competent(ti) OR competence(ti) OR competency(ti) OR competencies(ti) OR simulate(ti) OR simulation(ti) OR train\*(ti) OR educat\*(ti) OR skill\*(ti) OR method\*(ti)OR curriculum(ti) OR teach\*(ti))
* Cochrane: (thoracentesis OR thoracic OR "Pleural effusion" OR "pleural drainage" OR "Pleural fluid analysis" OR "tube thoracostomy" OR pleuracentesis OR pleurocentesis OR thoracocentesis) AND (ultrasonography OR ultrasound OR radiography OR imaging OR sonography OR echograph OR echography OR echocardiograph OR "thoracic ultrasound") AND (competent OR competence OR competency OR competencies OR simulate OR simulation OR train\* OR educat\* OR skill\* OR method\*OR technique OR curriculum OR teach\*)
* Google scholar: (thoracentesis OR thoracic OR "Pleural effusion" OR "pleural drainage" OR "Pleural fluid analysis" OR "tube thoracostomy" OR pleuracentesis OR pleurocentesis OR thoracocentesis) AND (ultrasonography OR ultrasound OR radiography OR imaging OR sonography OR echograph OR echography OR echocardiograph OR "thoracic ultrasound") AND (competent OR competence OR competency OR competencies OR simulate OR simulation OR train OR educat\* OR skill\* OR method OR technique OR curriculum OR teach)

**Figure 1: Literature search strategy**

