Ultrasound-guided Interventions in Pulmonology

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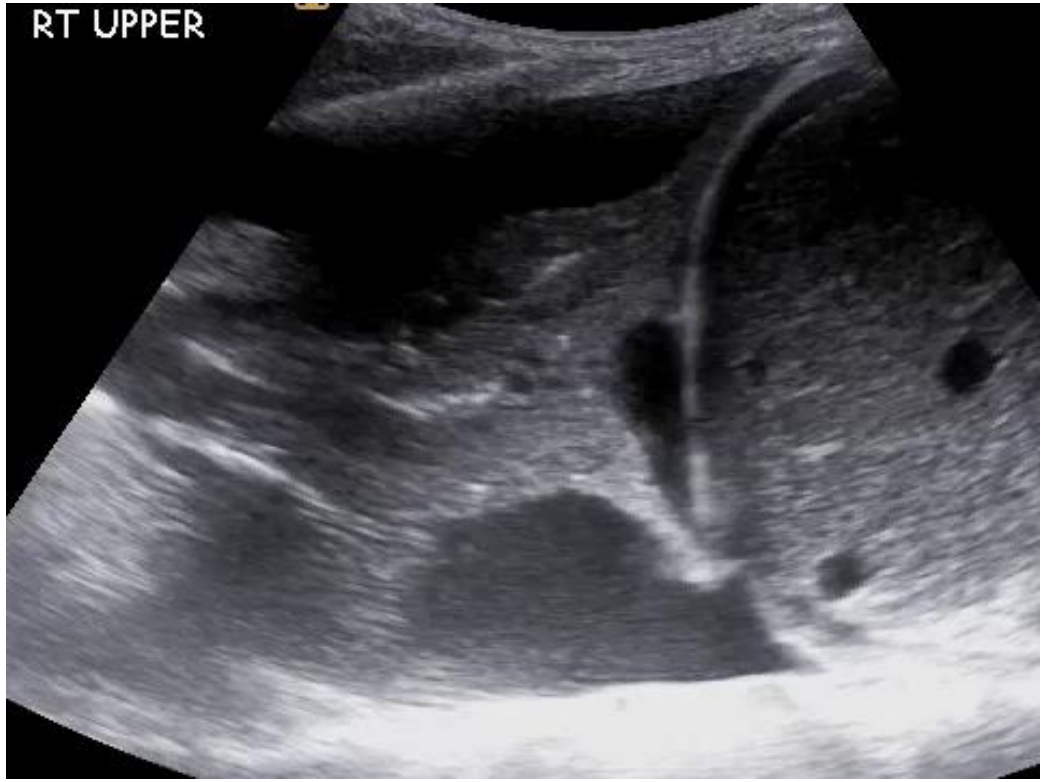
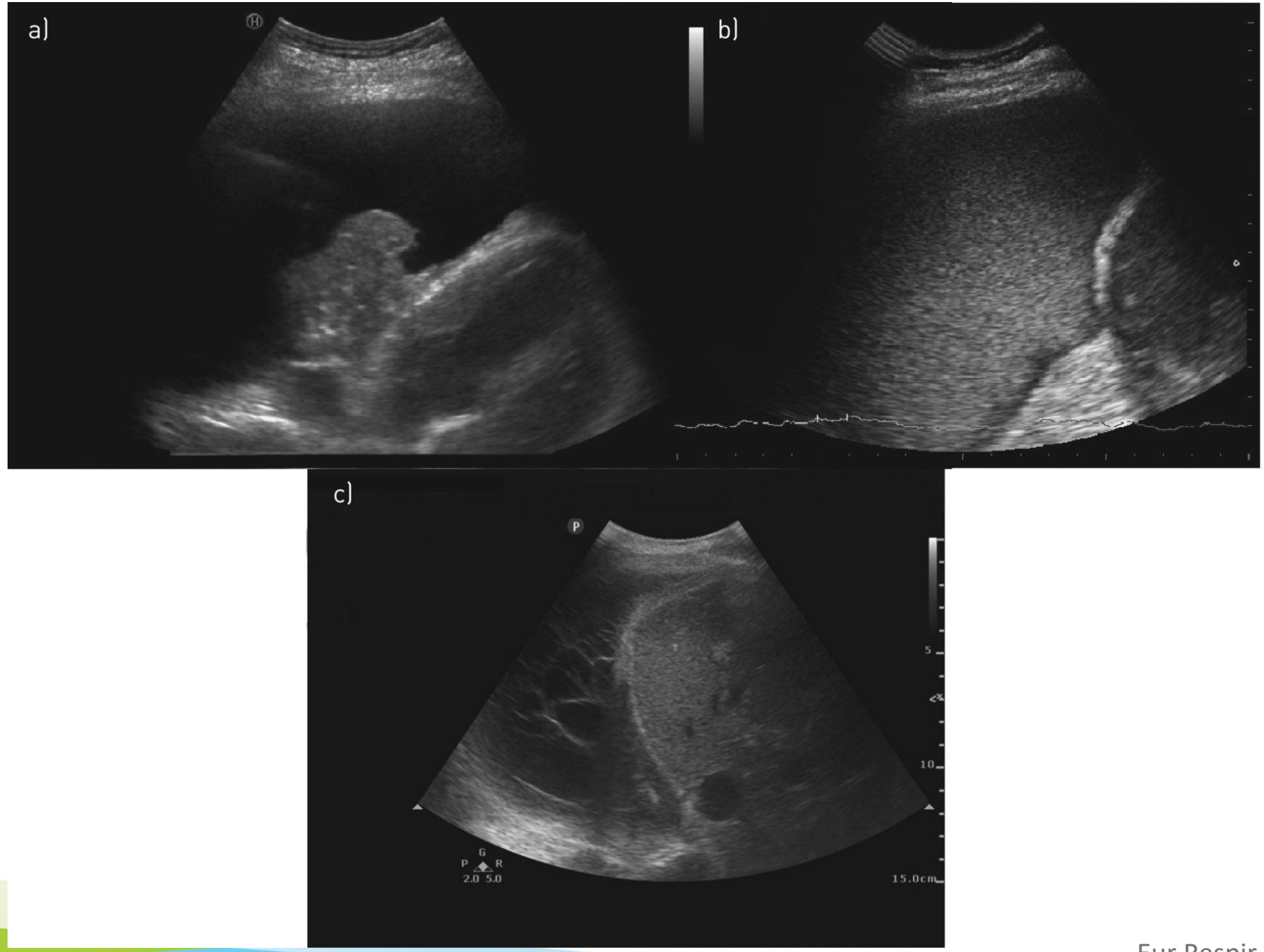
Contents

- Pleural effusion drainage
- Peripheral lung mass & pleural biopsy
- Percutaneous dilatational tracheostomy
- Others

Pleural effusion drainage

Sonographic findings of pleural effusion





Eur Respir Rev. 2020;29(156).

Ultrasound-guided thoracentesis

- Reduced complications, and increased the yield of thoracentesis
  - High rate of postprocedural pneumothorax without im
  - Lower pneumothorax rate with ultrasound (3~4.9%)
  - Regardless of clinician seniority
  - Superiority of US-guided thoracentesis

    -> confirmed by meta-analysis and a large retrospectiv

    -> adopted into practice guidelines
- Further management: placement of chest tubes

BTS guidelines

Image guidance

- A recent chest radiograph should be available prior to performing a pleural aspiration. (✓)
- Thoracic ultrasound guidance is strongly recommended for all pleural procedures for pleural fluid. (B)
- The marking of a site using thoracic ultrasound for subsequent remote aspiration or chest drain insertion is not recommended except for large pleural effusions. (C)

Table 1 Complication rates of pleural aspiration by operator and image guidance

Ultrasound guidance	Operator	Frequency of post-procedure pneumothorax	Frequency that a chest drain was required post procedure	Frequency of dry tap/procedure failure
Yes	Radiologist in training	2.7%	1.8%	2.7%
Yes	Senior physician	3.6%	0.9%	3.2%
Yes	Radiologist	2.7%	0.5%	
No	Physician in training	15.0%	4.7%	12.9%
No	Senior physician	5.7%	1.4%	1.6%

AJR Am J Roentgenol. 1991;156(5):917-20.
J Clin Ultrasound. 2005;33(9):442-6.
Pleural procedures and thoracic ultrasound: British Thoracic Society Pleural Disease Guideline 2010. Thorax. 2010;65 Suppl 2:ii61-76.

CHEST Patient Safety Forum

Ultrasound Guidance Decreases Complications and Improves the Cost of Care Among Patients Undergoing Thoracentesis and Paracentesis

Catherine J. Mercaldi, MPH; and Stephan F. Lanes, PhD

- Large retrospective cohort study (n=61,261 for thoracentesis, n=69,859 for paracentesis)
- 44% of the procedures were ultrasound guided thoracentesis
- Pneumothorax occurred in 2.7% (n=1,670)
- After adjustment, ultrasound guidance reduced the risk of pneumothorax after thoracentesis by 19% (OR, 0.81; 95% CI 0.74-0.90).

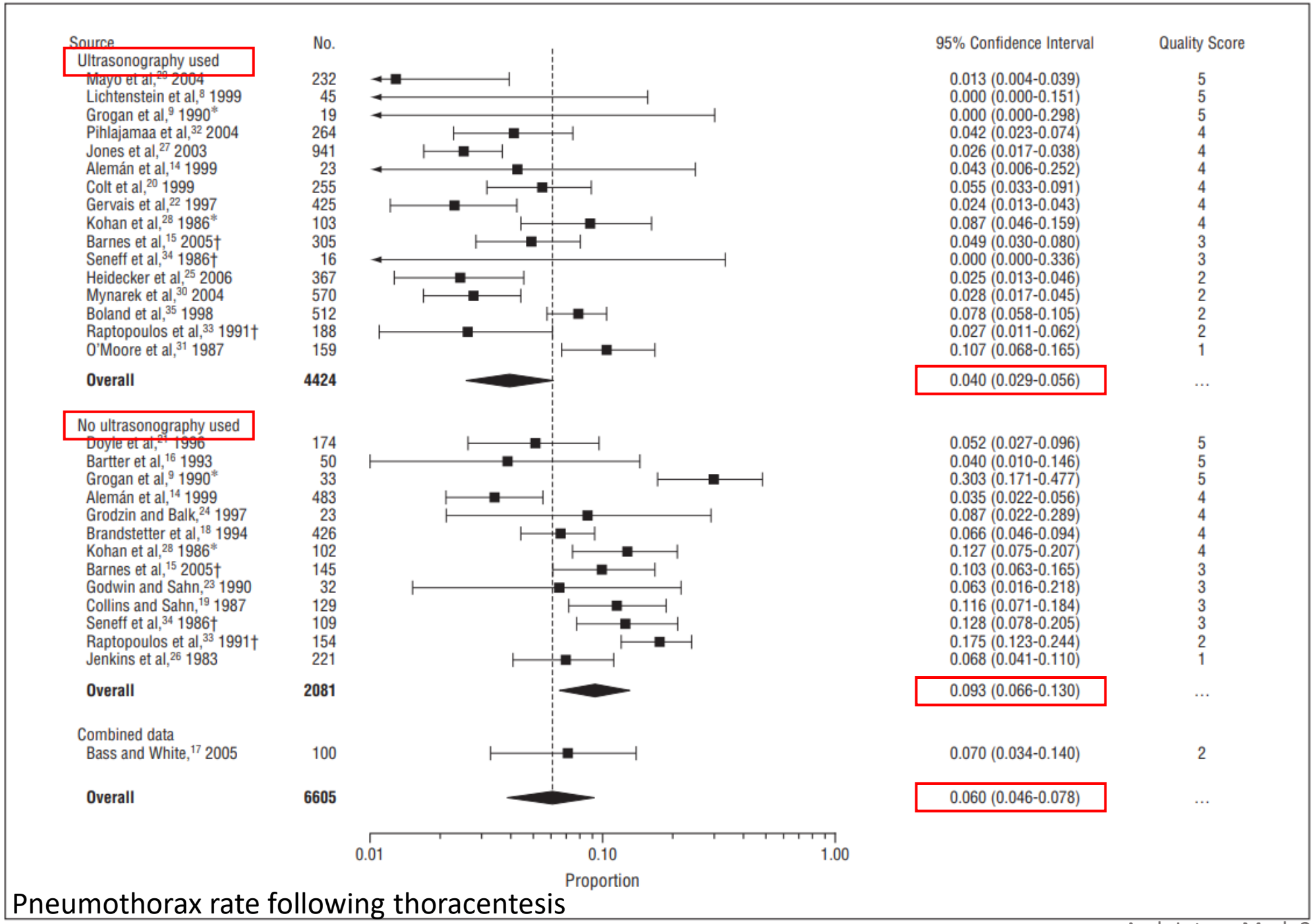
Table - Risk of Identified Clinical Outcomes in Thoracentesis Procedures by Ultrasound Guidance

	Risk of Pneumothorax in Patients Undergoing Thoracentesis			
Exposure Group	No. of Events	No. At Risk	%	95% CI
All patients	1,670	61,261	2.73	2.66-2.79
Ultrasound guidance	606	26,838	2.26	2.20-2.32
No ultrasound guidance	1,064	34,423	3.09	3.02-3.16

Table - Relative Risk of Identified Clinical Outcomes in Thoracentesis Procedures by Ultrasound Guidance

	Risk of Pneumothorax in Patients Undergoing Thoracentesis		
Risk Measures	Estimate	95% CI	*P* Value
Crude RR	0.73	0.66-0.81	< .0001
Adjusted RR[a]	0.81	0.74-0.90	< .0001

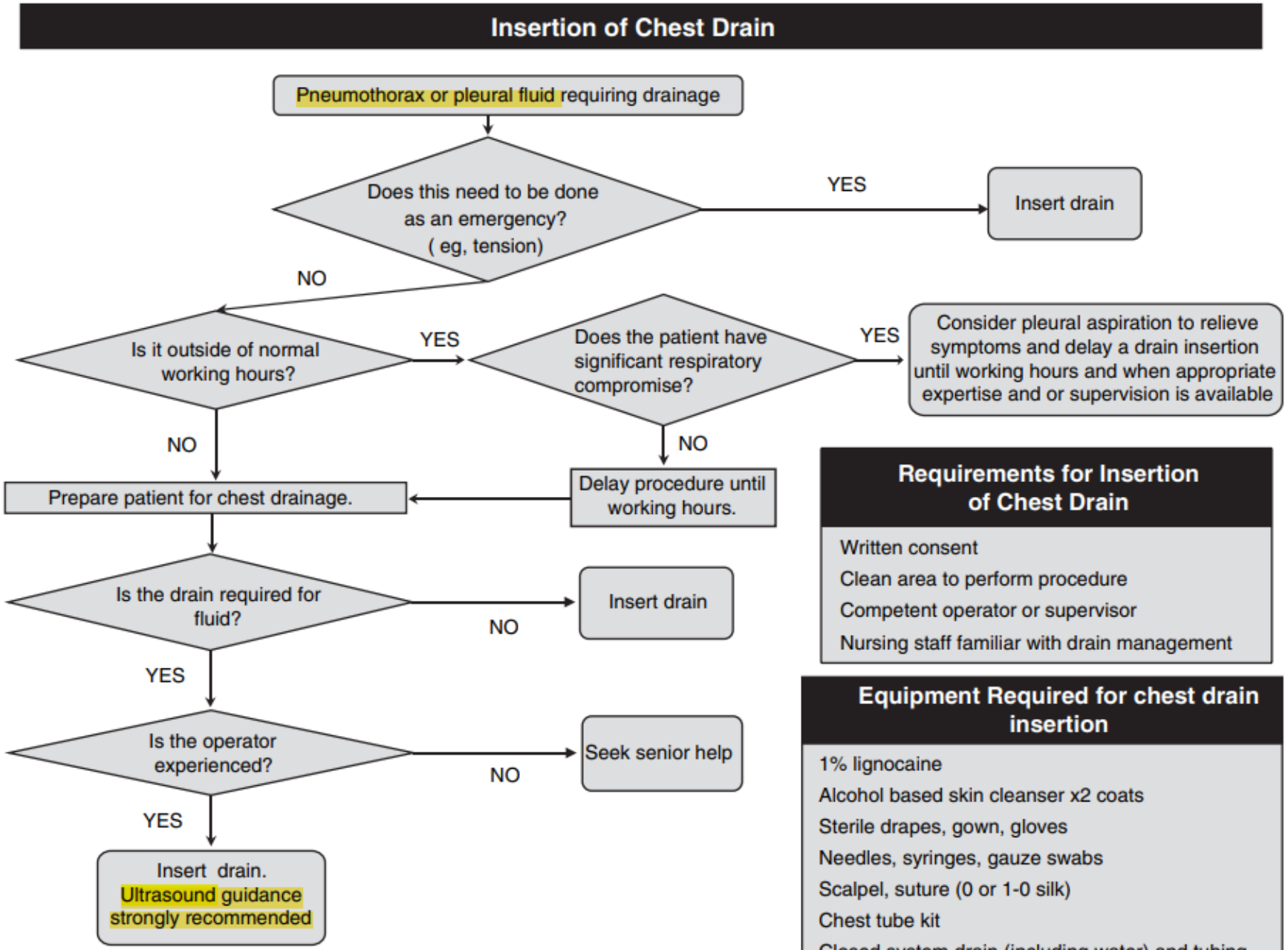
Chest. 2013;143(2):532-8.



Pneumothorax rate following thoracentesis

Arch Intern Med. 2010;170(4):332-9.

Figure 1 Algorithm for the insertion of a chest drain.



Pleural procedures and thoracic ultrasound: British Thoracic Society Pleural Disease Guideline 2010. Thorax. 2010;65 Suppl 2:ii61-76.

Unilateral pleural effusion diagnostic pathway

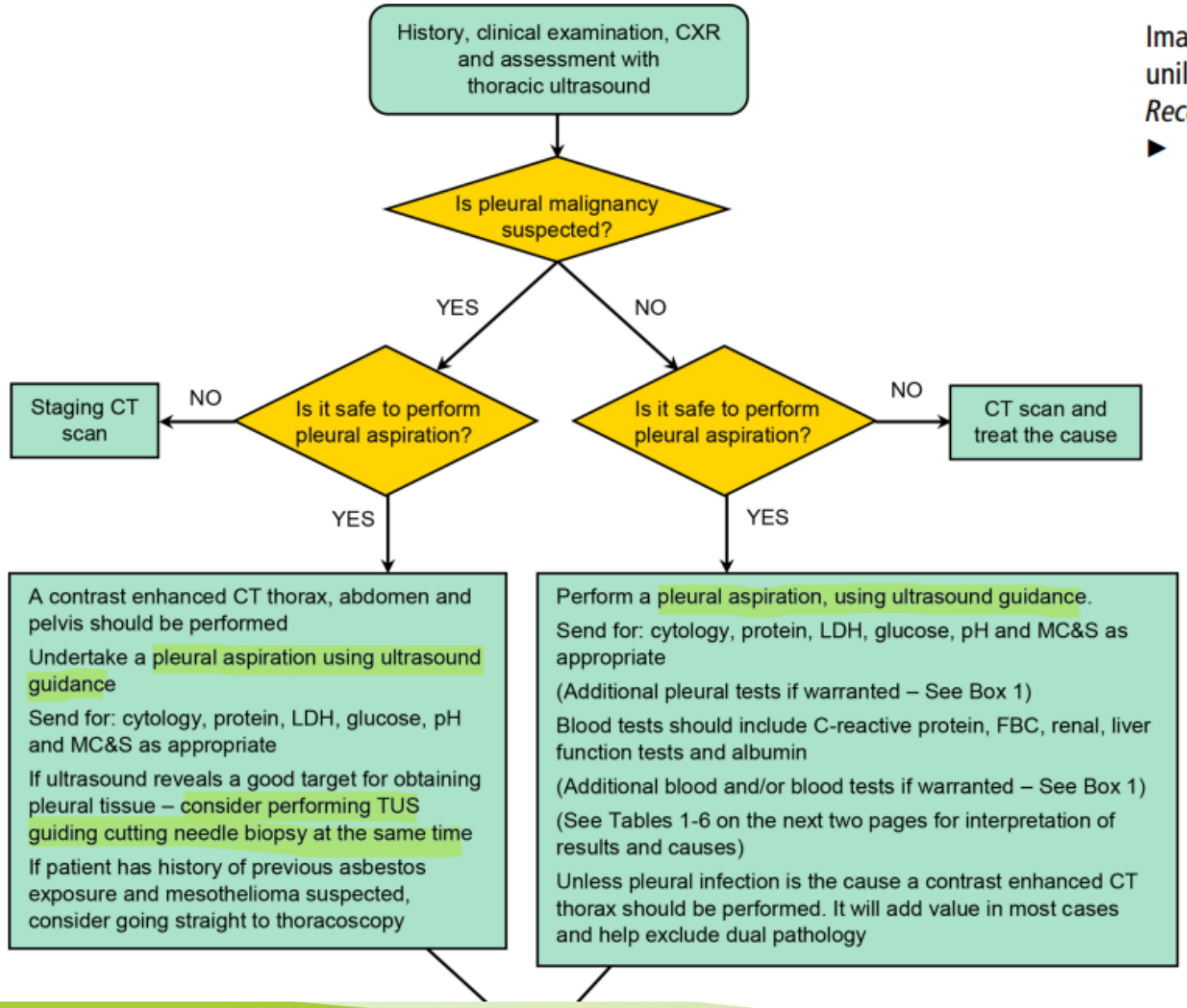


Image guided versus non-image guided intervention for suspected unilateral pleural effusion

Recommendation

- Image-guided thoracentesis should always be used to reduce the risk of complications. (Strong – by consensus)

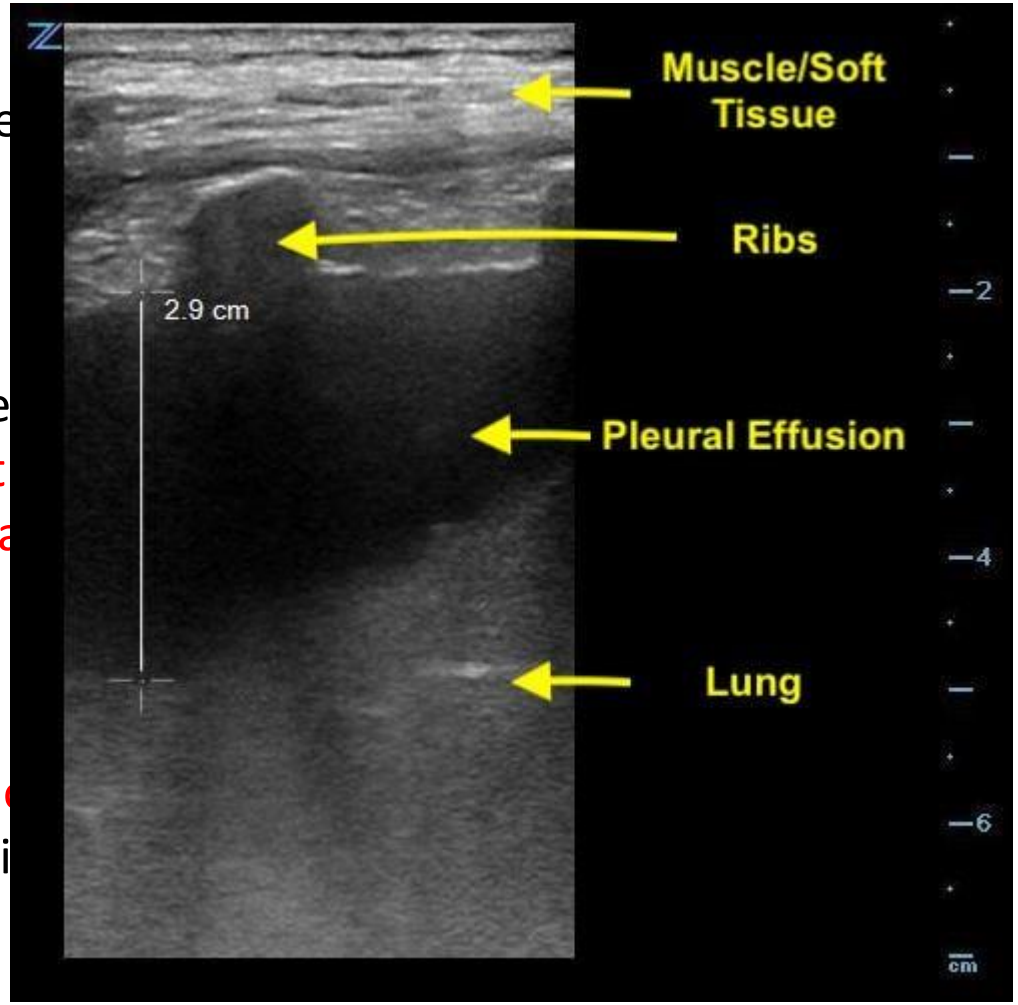
British Thoracic Society Guideline for pleural disease. Thorax. 2023;78(11):1143-56.

Pleural drainage procedures

- The optimal site, angle, and depth of needle insertion are

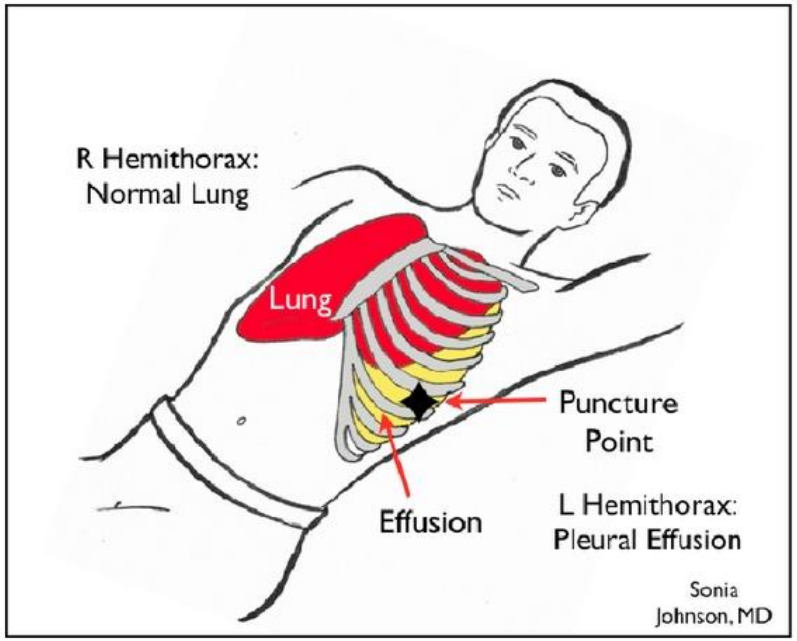
- Optimal site
  - Patient's position
  - PLAPS point → all free fluids collect in a supine patie
  - Where operator can visualize each anatomical struct
  - Where the operator can measure the maximum dista pleural (increasing the safety margin)

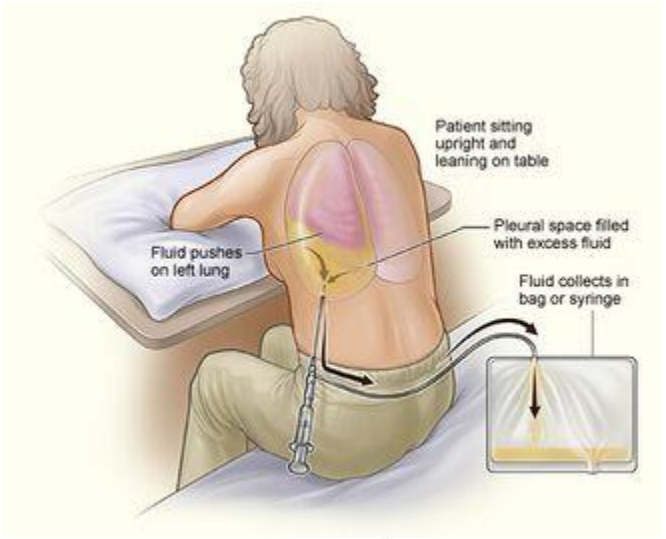
- Depth of needle
  - Depth of insertion is calculated from a frozen image
  - Needle trajectory must replicate the angle and positi acquisition



Pleural drainage - Position

- The position of the patients is dependent on the operator preference
- Upright sitting position with arms elevated
- Supine position with trunk elevation of 40–45° with arm elevated behind the head
- Supine, arms be fixed to the other side of the bed in a direction to the opposite shoulder
- Never rotate patient to the opposite site to create room for the procedure → fluid moves towards the paravertebral zone
  - Puncture might be more dangerous
  - Patient could lie on the insertion site -> infection complications





Crit Ultrasound J 2018;10(1):18.

Pleural drainage – Probes and puncture site

- Any kind of ultrasound machine and probe can be used to scan the chest
- Most frequently used probes : high frequency linear probe, phased array probe
- Ultrasound setting : either on the same side or on the other side, based on the operator's preference

Pleural drainage
– Probes and puncture site

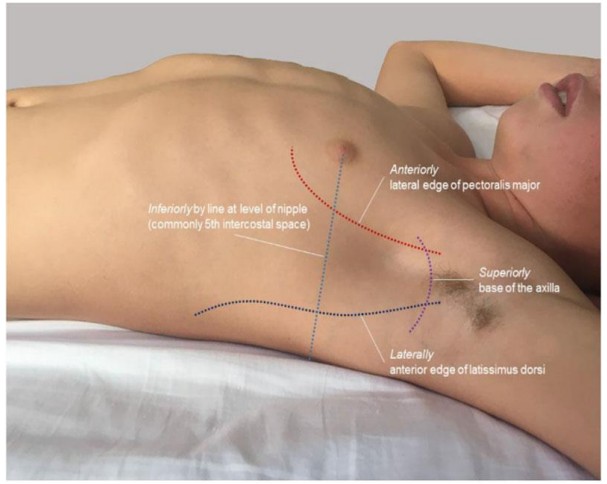
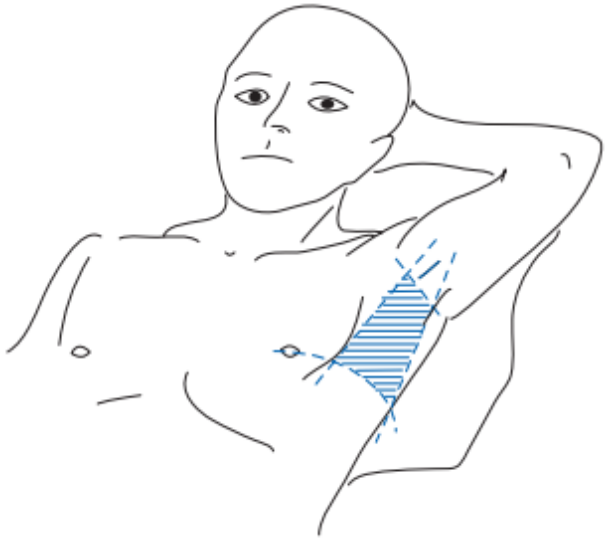


Table 2 Position of the probe and indications on how to measure pleural effusion by ultrasound, according to different studies

Authors	Probe position	How to measure (end-expiration)
Vignon et al. [29]	Along the dorsolateral part of the chest wall, as posteriorly as possible between the mattress and the patient's back without lifting the hemithorax, in all IC from the base to the apex	Choose the maximal perpendicular interpleural distance from the leading edge of the dependent surface of the lung to the trailing edge of posterior chest wall, at the apex and at the base
Roch et al. [30]	Along the posterior axillary line between the ninth and eleventh ribs to identify the liver on the right side, the spleen on the left side, and the diaphragm To visualize the effusion, the transducer was advanced cranially and a longitudinal view was chosen	Use the mean of three measurements obtained by distance between: - Lung and diaphragm - Lung and posterior chest wall at base - Lung and posterior chest wall at fifth IC
Balik et al. [31]	Along the posterior axillary line moving the probe cranially, obtaining transverse sections perpendicular to the body axis	Choose the maximal distance between parietal and visceral pleura at lung base (minimum requirement: distance ≥ 10 mm)
Usta et al. [32]	Along mid-scapular line moving cranially (dorsal scanning)	Choose the maximal distance between mid-height of the diaphragm and visceral pleura (minimum requirement: distance ≥ 30 mm)
Remérand et al. [33]	Along each paravertebral intercostal space, slipping the probe between the patient's back and mattress	The lower and upper intercostal spaces where PLEFF is detected should be drawn on the patient's skin to establish PLEFF paravertebral length (L_{US}) At the half point of L_{US} the PLEFF area should be manually delineated

IC intercostal space

Pleural drainage – Probes and puncture site



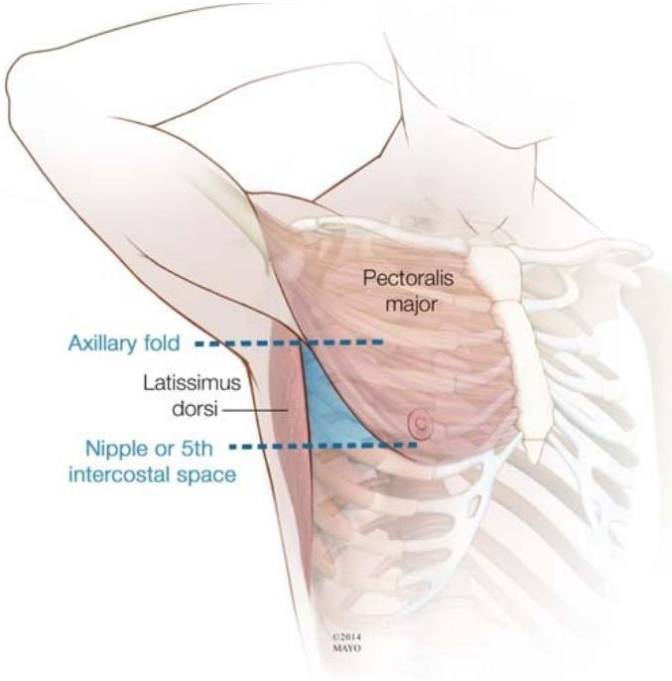
Patient position and site of insertion

- **The preferred site for insertion of the needle for pleural aspiration should be the triangle of safety. (✓)**

- Triangle of safety
  - Anterior : lateral border of the pectoralis major muscle
  - Lateral : lateral border of the latissimus dorsi
  - Inferior : the line of the 5th intercostal space
  - Superior : the base of the axilla

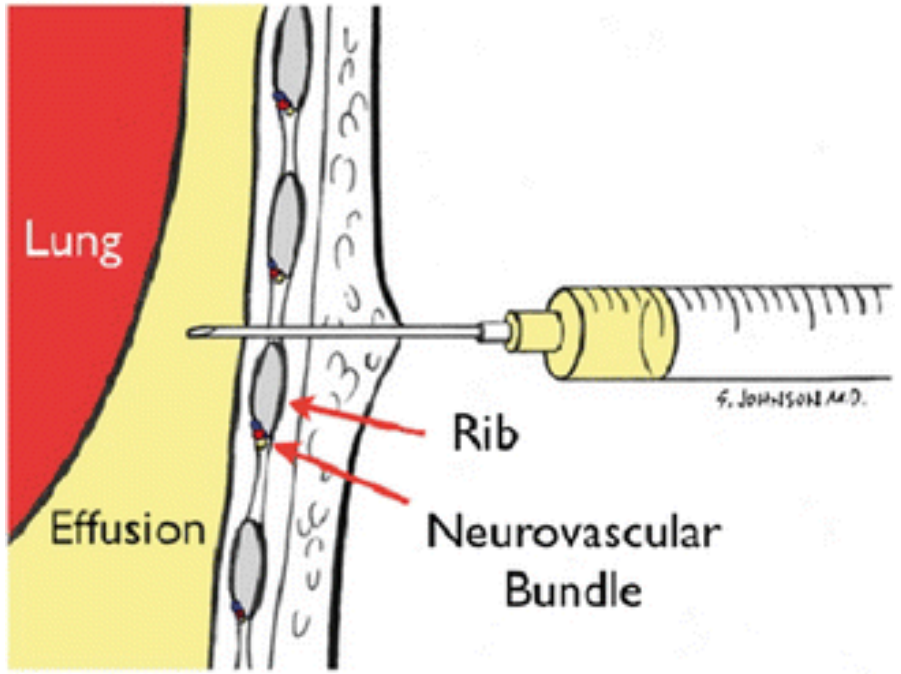
  ➔ Minimize the risk to blood vessels, muscle and breast tissue

  ➔ The preferred site for insertion of the needle for pleural aspiration



Thorax. 2010;65 Suppl 2:ii61-76.

Pleural drainage
– Probes and puncture site



Advance the needle over the upper margin of the lower rib

Pleural drainage - Preparation

Aseptic technique

- **Pleural aspiration should take place in a clean area using full aseptic technique. (✓)**

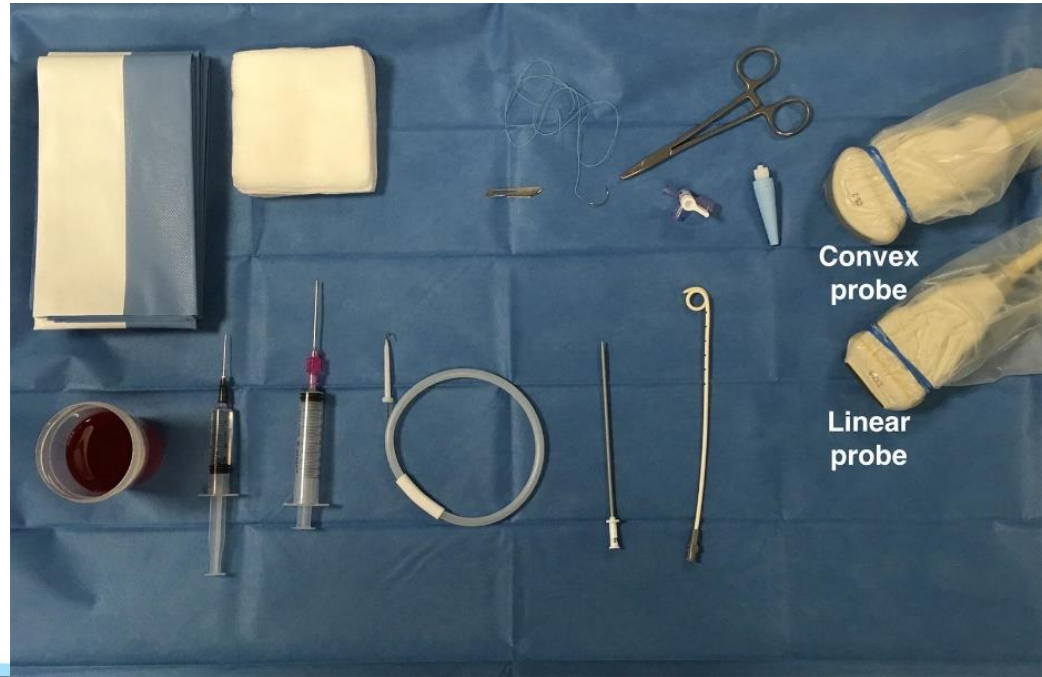
For the operator	Over the tray
Medical hat	Sterile drapes
Medical mask	Sterile towels
Hand disinfection	Syringes (5–10 mL)
Sterile gown	Local anaesthetics
Sterile gloves	Sterile water
	Phased array probe or convex and linear probe
	Sterile US probe cover
	Introducer needle
	Guidewire
	Scalpel and dilator
	Catheters (8–14F)
	Trocar
	Suture and medical dressing

Size of needle

- **Pleural aspiration with large-bore needles should be avoided. (C)**

Size of drain

- **Small drains should be used as first-line therapy for pneumothorax, free flowing pleural effusions and pleural infection. (C)**



Pleural drainage – Thoracentesis technique

Real-time needle guidance

- Position of the needle is monitored by ultrasound constantly
- More technically challenging
- did not seem to be a safer procedure in comparison to the site marking technique

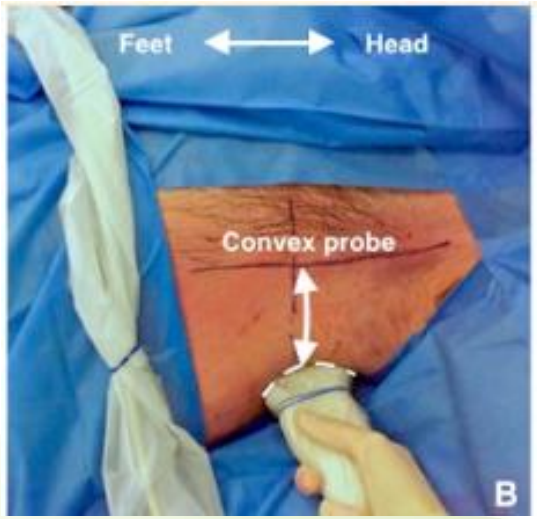
Site-marking

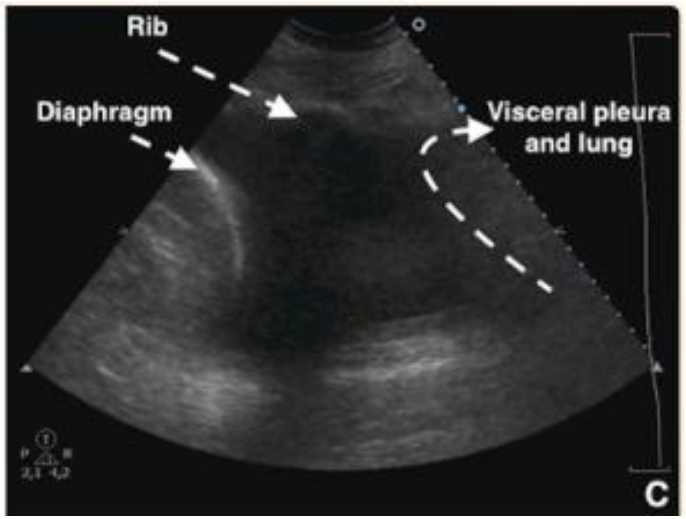
- Define optimal location point, without using real-time visualization
- Drain insertion should be performed instantly after site marking
- As long as done correctly, very low complication rate, even in mechanically ventilated patients

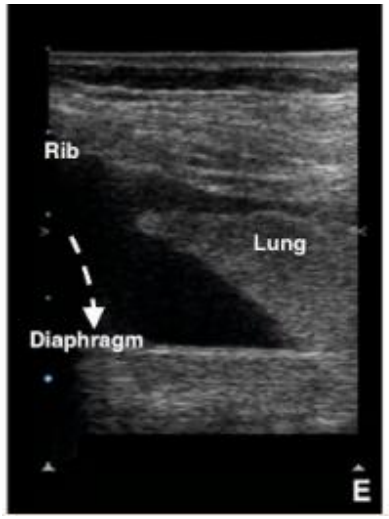
Chest 2004;125(3):1059-62.

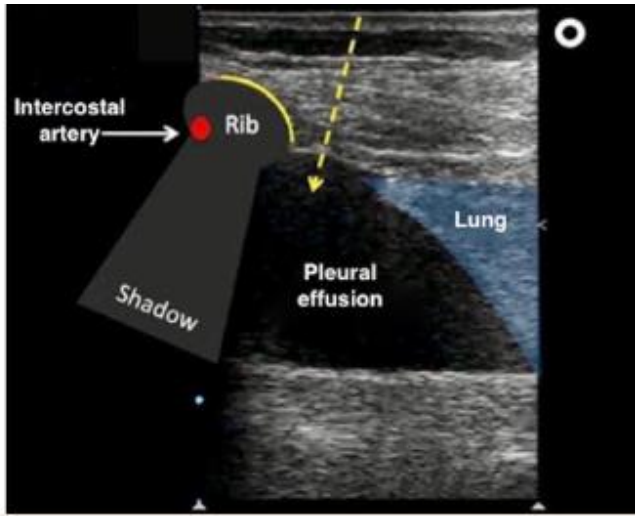
Pleural drainage – Thoracentesis technique

1) Identify the best site for the puncture
   - with low-frequency (3.5-5 MHz) transducer (convex for phased array probe)
   - Transverse position between two ribs
   - Then, shift to the high-frequency (7-15 MHz) transducer (linear probe)
   - Intercostal artery







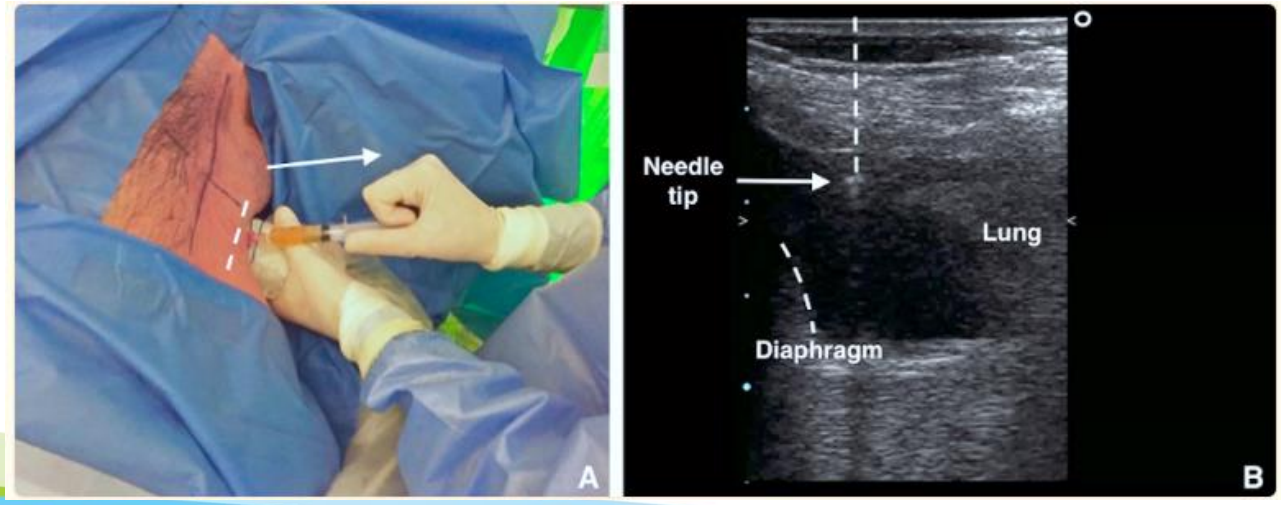


Crit Ultrasound J. 2018;10(1):18.

Pleural drainage – Thoracentesis technique

2) Ultrasound-guided puncture

- Needle must be aim to the upper rib margin perpendicular to pleura
- Transducer to follow the needle trajectory
- Needle must be advanced slowly under direct visualization
- Confirming the correct position
  - Site marking technique : Aspiration of fluid with a syringe
  - Direct needle guidance : Needle tip is visualize in real-time

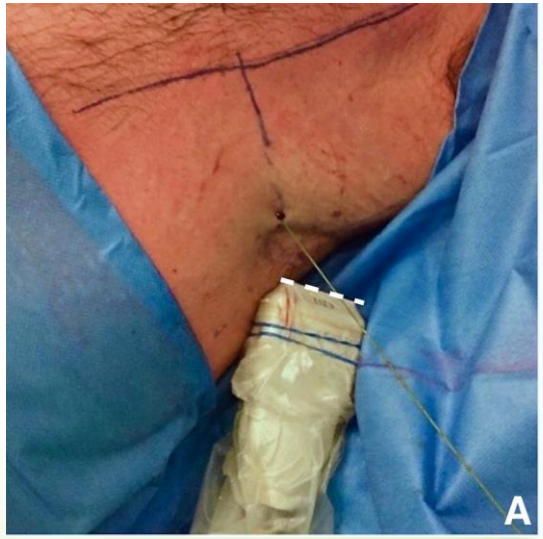


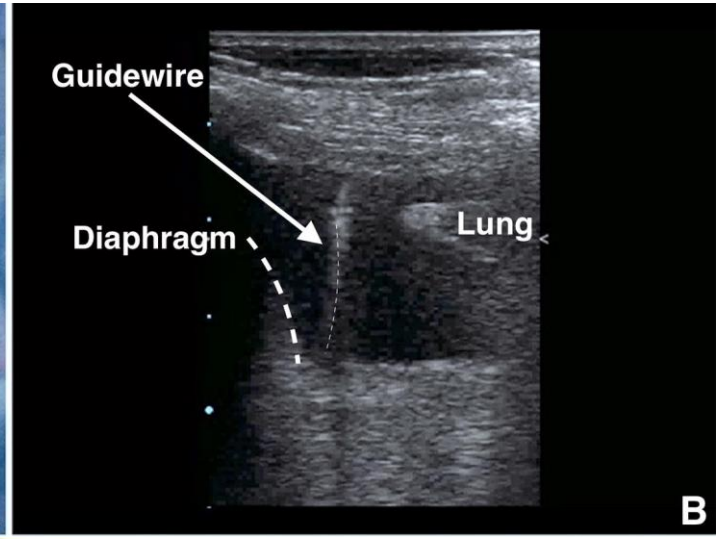
Crit Ultrasound J. 2018;10(1):18.

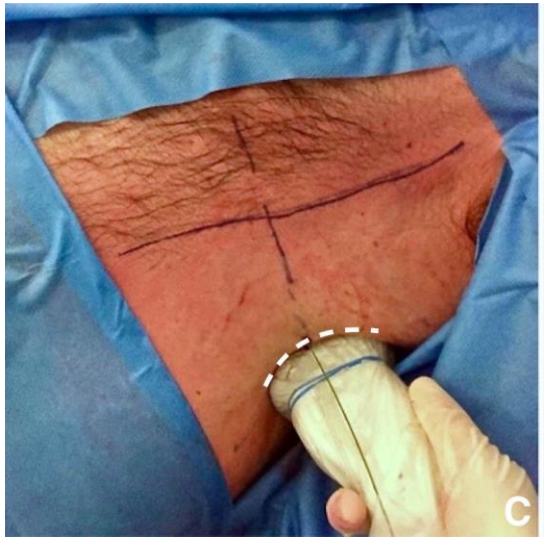
Pleural drainage – Thoracentesis technique

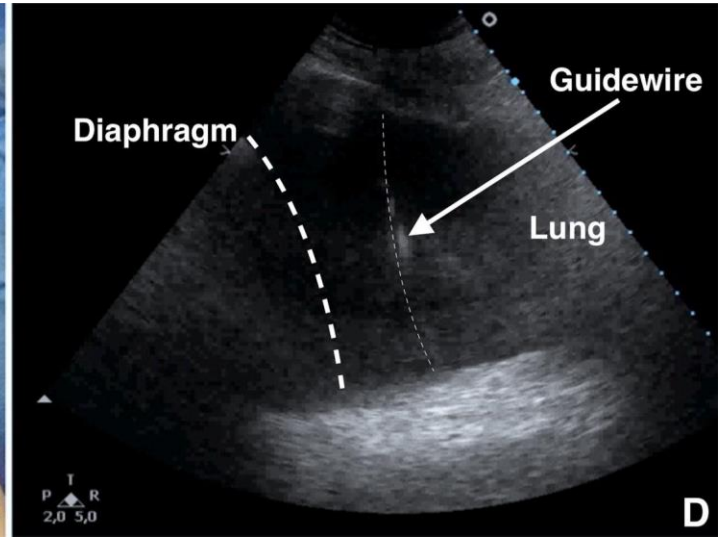
3) Guidewire insertion and guidewire position check

- Remove the syringe from the needle and pass the guidewire through the needle
- Remove the needle, leaving the guidewire in place
- Define the final position of the guidewire using US prior to proceeding with dilation







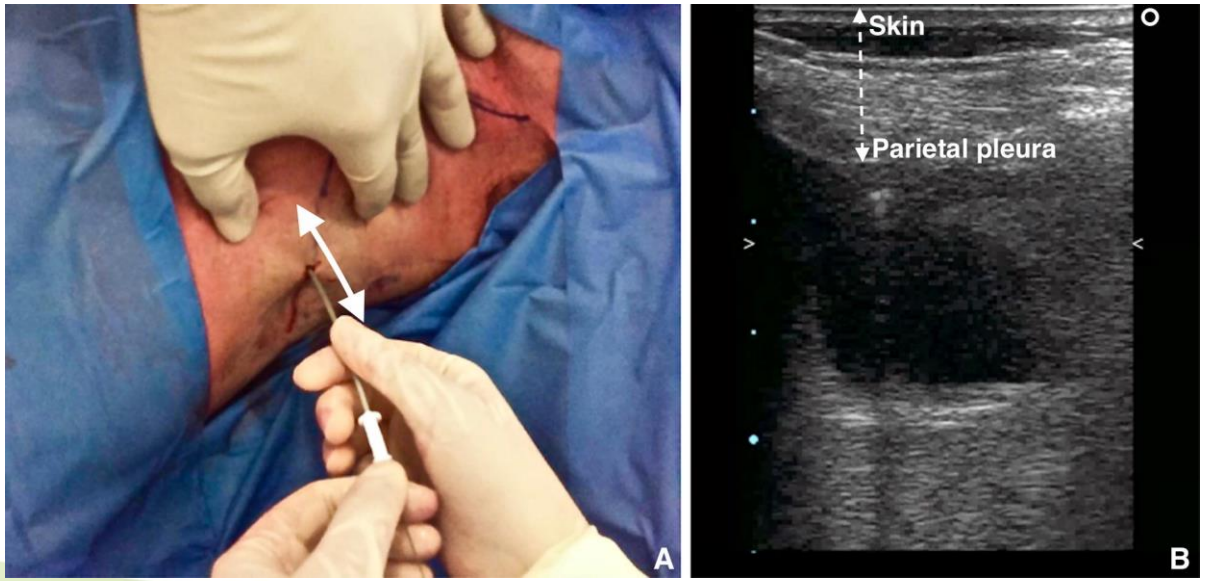


Crit Ultrasound J. 2018;10(1):18.

Pleural drainage – Thoracentesis technique

4) Dilation

- Make a small incision adjacent to the guidewire with the scalpel
- Pass the dilator through the guidewire into the pleural space
- The dilator should not be introduced further than 1 cm beyond the depth from skin to parietal pleura; excessive dilator insertion increases the risk of visceral injury

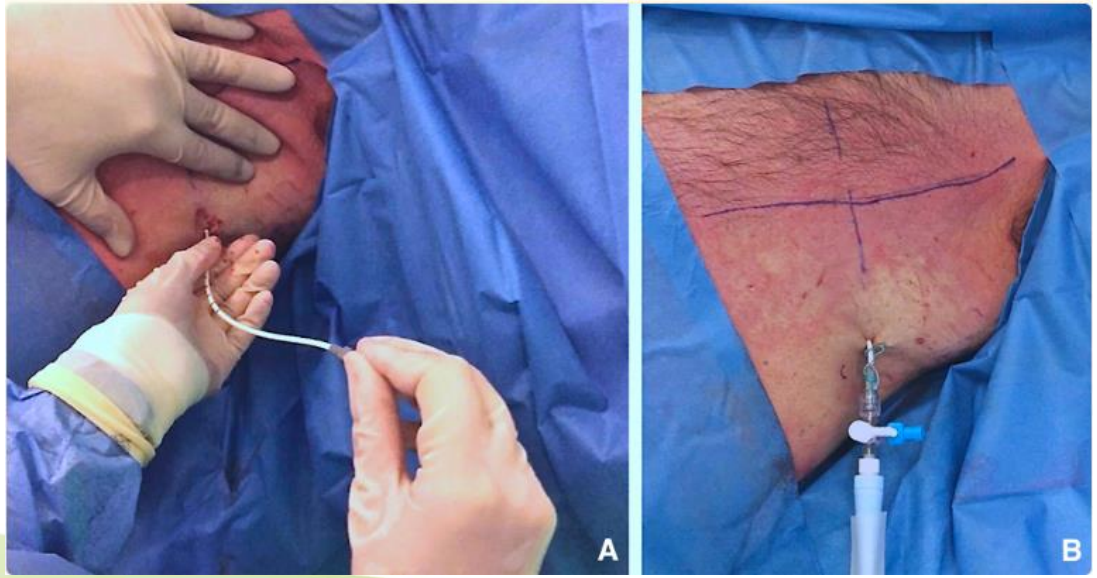


Crit Ultrasound J. 2018;10(1):18.

Pleural drainage – Thoracentesis technique

5) Pigtail insertion

- The pigtail is passed over the guidewire, making sure that the last side hole is within the pleural space
- Remove the guidewire, leaving the pigtail catheter in place
- After the guidewire has been removed, the drain is connected to the drainage system.
- Suture the pigtail to the chest wall



Crit Ultrasound J. 2018;10(1):18.

Pleural drainage – Thoracentesis technique

6) Ultrasound confirmation

- At the end of the procedure, bilateral lung ultrasound scan to exclude possible complications (e.g., pneumothorax) and confirm the pigtail position.

Pleural drainage – Complications

- Intercostal artery bleeding
  - Not amenable to external compression
  - Bleeding into a large negative pressure space
  - The risk of injury is greatest within 6 cm from the spinal column

    ➔ Guideline recommendation : “safe triangle”
  - Color Doppler to identify the intercostal vessels prior to needle insertion
- Pneumothorax
  - Insertion site should have sufficient depth of pleural fluid (≥ 10 mm)
  - Ultrasound assessment after the procedure to exclude pneumothorax
- Re-expansion pulmonary edema
  - A maximum of 1.5 L should be drained in the first hour after insertion of the drain

Chest. 2013;143(3):634-9.

Pleural drainage – Complications

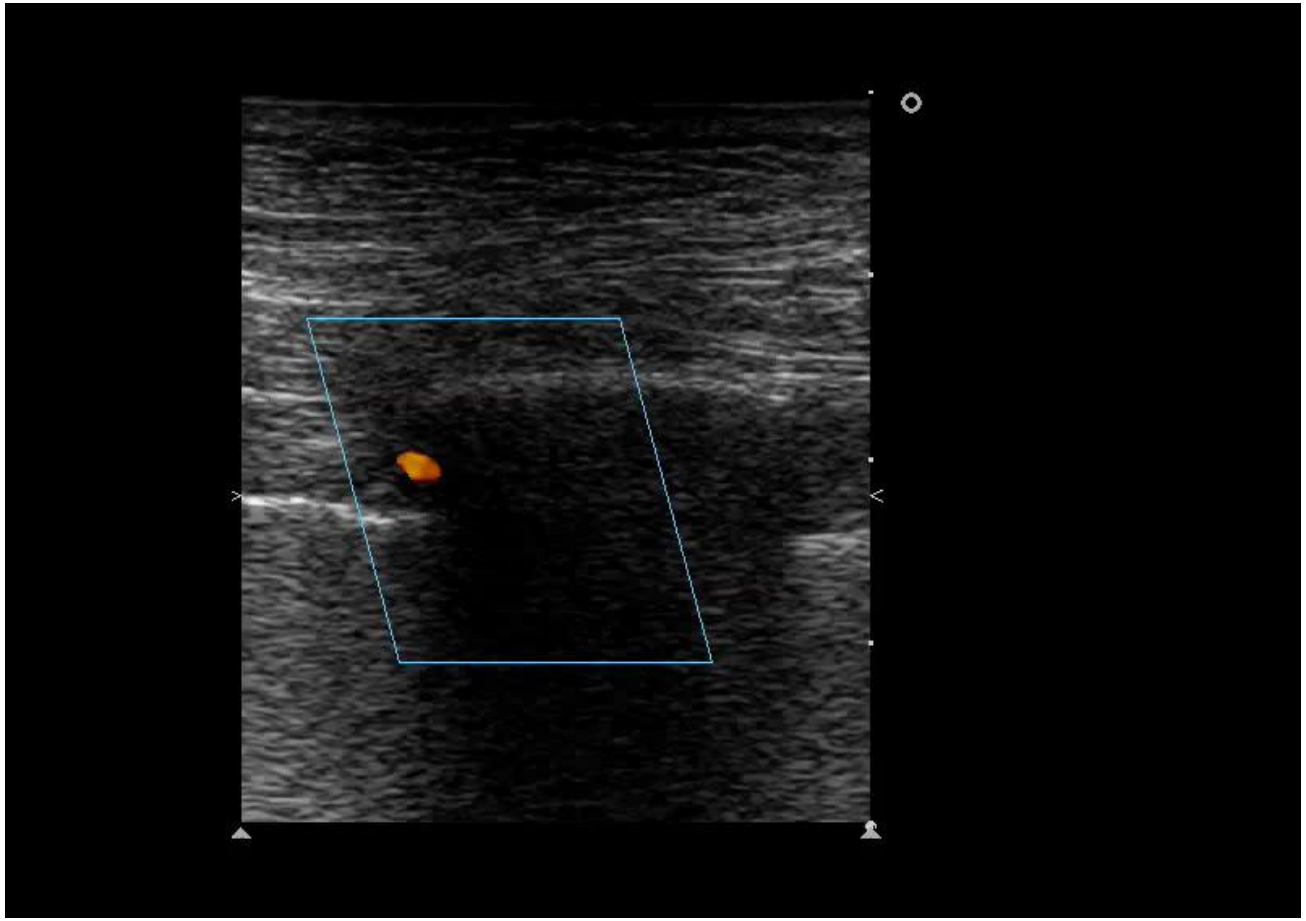
- Complications after chest drain tube insertion

Table 2 Frequency of post-insertion complications for small drains (≤16 F)

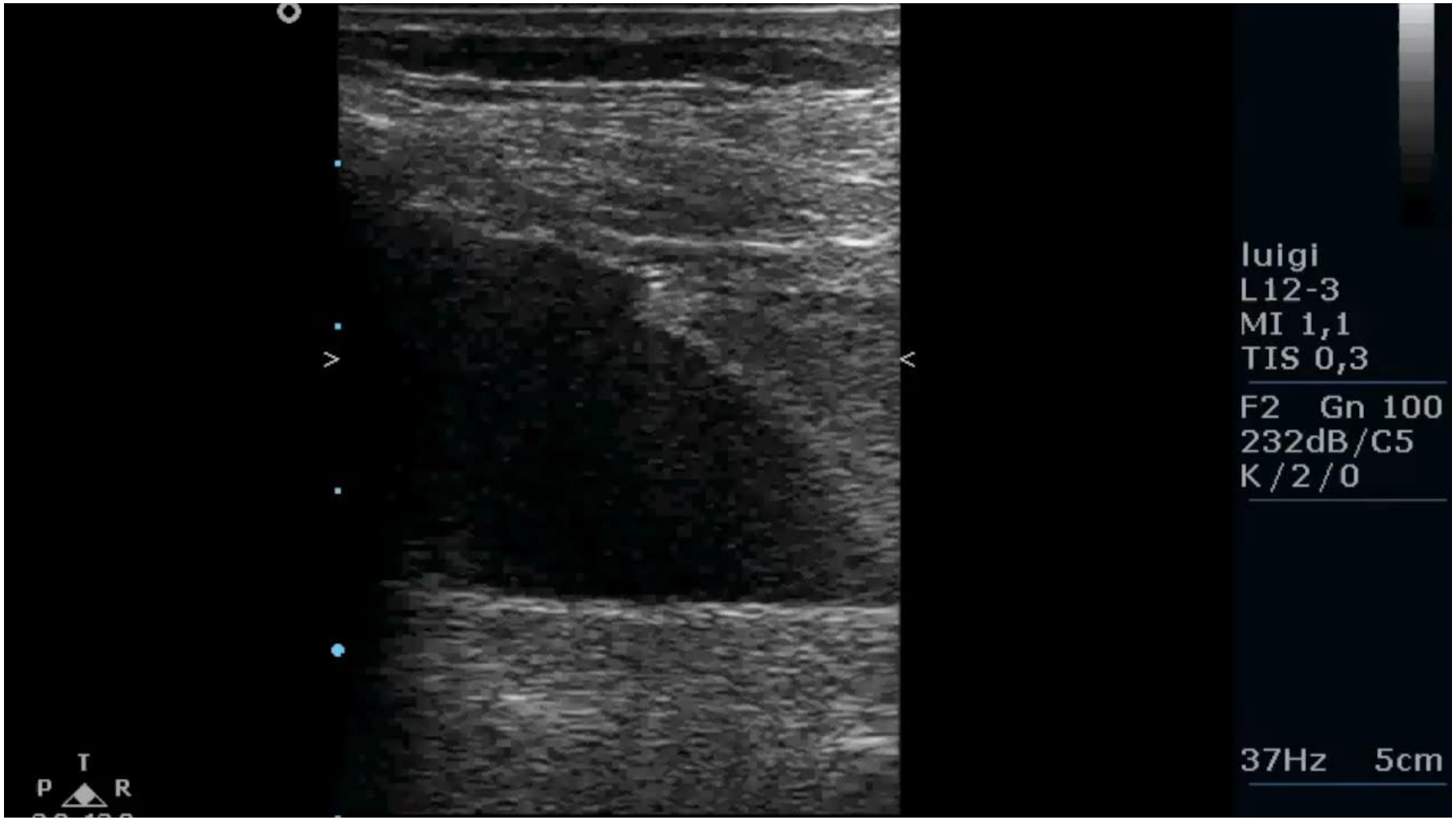
Complication	Total no.*	Calculated frequency	Range	Studies
Injury	582	0.2%	0–2%	44–51
Malposition	593	0.6%	0–9%	45–52
Empyema	395	0.2%	0–2%	45, 48–51
Drain blockage	341	8.1%	2–18%	45, 48–52

Table 3 Frequency of post-insertion complications for large-bore drains (≥20 F or stated 'large-bore drain')

Complication	Total no.*	Calculated frequency	Range	Studies
Injury	1572	1.4%	0–7.9%	44, 52–60
Malposition	1778	6.5%	1.1–31%	53–61
Empyema	1778	1.4%	0–2%	53–61
Drain blockage	115	5.2%	5.2%	52



Visualization of the vascular bundles, minimizing the risk of damage to nerves and vessels.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Peripheral lung mass & pleural biopsy

Ultrasound-guided pleural biopsy

- UGBx -> traditionally by specialized radiologists
- First pleural biopsy by respiratory physicians (Diacon et al., 2004)
  - Lesions >20 mm, under US guidance with 14G cutting needle
  - Sensitivity for malignancy of 85.5%, low complication (4%)
- Yields and complication rates comparable to those reported by radiologists
- After failed local anesthetic thoracoscopy (LAT) with high diagnostic yield (Halllifax et al.)

Chest. 2003;123(2):436-41.
Chest. 2014;146(4):1001-6.

Diagnostic accuracy

Table 17 Evidence review summary of 'What is the diagnostic accuracy of pleural biopsy?'

Comparison	Summary of evidence review
Medical versus surgical thoracoscopic pleural biopsy	No difference in diagnostic yield, sensitivity or specificity*
Medical rigid versus medical s	ained' diagnostic yield
Thoracoscopic pleural biopsy v	copic pleural biopsy
Thoracoscopic pleural biopsy v	copic pleural biopsy
CT-guided closed pleural biops	
Closed pleural biopsy using co	
Image-guided closed pleural b	sy (p=0.01)
Medical—awake thoracoscopl	

*Based on a single study.

- Higher diagnostic yield with thoracoscopy in pleural biopsy.
- If not available, closed pleural biopsy can be considered.
- For closed pleural biopsy, the image-guided biopsy is superior than the blind biopsy.
- For image-guided biopsy, no difference in diagnosis between image modalities (CT = US).

British Thoracic Society Guideline for pleural disease. Thorax. 2023;78(11):1143-56.

Advantages of UGBx

- Low rate of adverse events (3%) – compared to CT (7%)
  - Postprocedural pneumothorax : 5.8% (US) vs. 14.7% (CT)
- No radiation risk – compared to CT
- Time-saving – compared to CT
  - Significant reduction in procedural time compared to CT-guided (median 321 sec vs. 556 sec, $p < 0.001$)
- No requirement of patient sedation – compared to LAT
- Cost-effective
- Minimal additional need for support staff

Radiology 2013;266(3):930-5.

Diagnostic accuracy of US in malignancy

Table 22 Summary of the diagnostic accuracy of thoracic ultrasound (TUS), CT and PET-CT

	Diagnostic accuracy		
Modality	**Pooled sensitivity (95% CI)**	**Pooled specificity (95% CI)**	**No. studies**
TUS*	0.80 (0.70 to 0.87)	0.90 (0.81 to 0.94)	2
CT	0.80 (0.62 to 0.90)	0.81 (0.72 to 0.88)	6
PET-CT	0.89 (0.80 to 0.95)	0.92 (0.88 to 0.95)	2

*Studies performed in patients with pleural effusion suspected of pleural malignancy.

Evidence statements

- Ultrasound allows detailed evaluation of the peripheral pleura in the presence of a pleural effusion and has a moderate sensitivity and high specificity for diagnosing pleural malignancy. (Moderate)

British Thoracic Society Guideline for pleural disease. Thorax. 2023;78(11):1143-56.

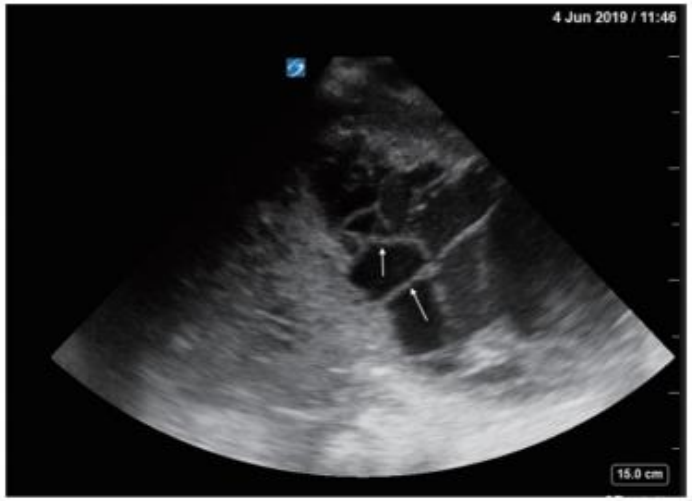
Role of US in pleural infection

- The presence of septation features on ultrasound in adults with pleural infection

→ ↑ length of hospital stay, ↑need for thoracic surgery

- The presence of complex septated ultrasound features

→ ↑ mortality rate, ↑ treatment failure rate, ↑ length of hospital stay



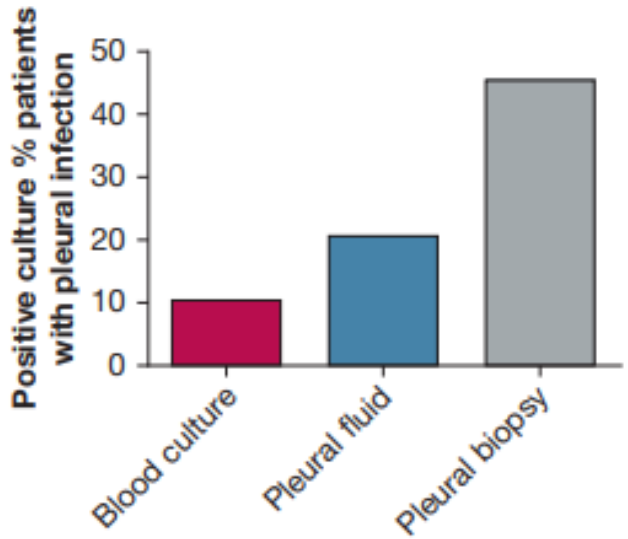
- Use of image-guided parietal pleural biopsy for microbiological assessment

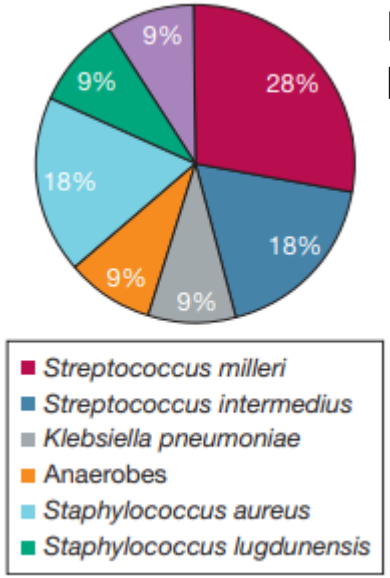
J Thorac Dis. 2021;13(8):5343-61.

A Pilot Feasibility Study in Establishing the Role of Ultrasound-Guided Pleural Biopsies in Pleural Infection (The AUDIO Study)

CHEST

- A feasibility interventional clinical study
- To assess the safety and significance of US-guided pleural biopsy culture to increase microbiological yield
- 22 patients with clinically established pleural infection
- Results : higher microbiological yield (45%) compared with pleural fluid and blood culture (20% and 10%)





Results of pleural biopsy culture

Chest. 2018;154(4):766-72.

Factors affecting diagnostic yield

- Underlying pathology (infectious, notably TB vs. malignancy, and type of malignancy)
- Extent of disease (localized vs. diffuse)
- Number of samples taken (≥ 6)
- Operator experience
- Cutting needles -> no robust data

For suspicious of malignancy,

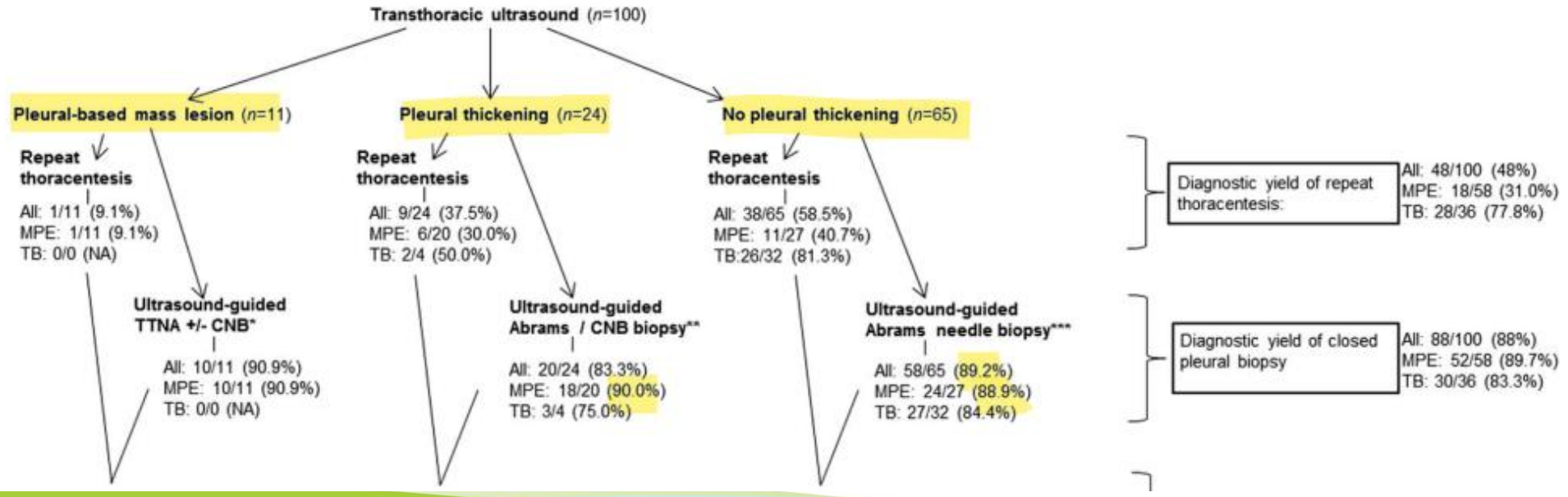
- Pleural thickening (> 10 mm)
- The selection of a low/supra-diaphragmatic biopsy site
- Pleural nodularity
- Solid mass at the biopsy site
- Number of samples taken

Indicative radiology

- Pleural thickening would increase the diagnostic yield in USGBx

→ but, presence of pleural thickening is <u>not mandatory</u> for a diagnostic pleural biopsy

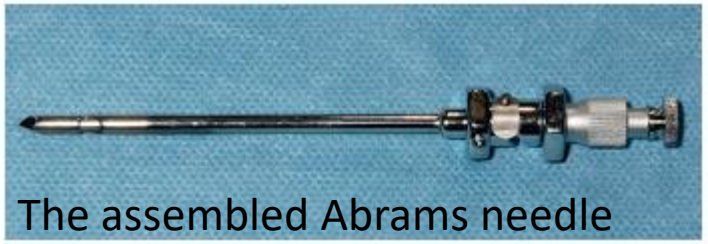
- Patients with no pleural thickening on US : sensitivity of 89.2%
- For <u>malignancy</u>, sensitivity 88.9% without pleural thickening, <u>90% with pleural thickening</u>
- Pleural thickening was <u>not a prerequisite</u> to pleural biopsy for <u>microbiology</u> (AUDIO study)



Thorax. 2015;70(10):995-7.

Cutting needles

Abrams needle
Consists of three separate components



The assembled Abrams needle

- High yield in diffuse pleural disease, typically tuberculosis (~90%)
- Lower yield in malignancy (sensitivity < 60%)

Temno needle

Tru-cut needle

- Lower diagnostic yield for pleural TB compared to Abrams needle (US-assisted, sensitivity 65.2% vs. 81.8 %)
- Higher diagnostic yield for malignant disease compared to Abrams needle

Clinical practice

- Patient position : lateral decubitus
- Biopsy should be targeted along the mid-axillary line to minimize complications
- Site identification using a low frequency probe (2-5 MHz)
- Screening of the intercostal vessels with Doppler ultrasound
- Real-time, freehand technique

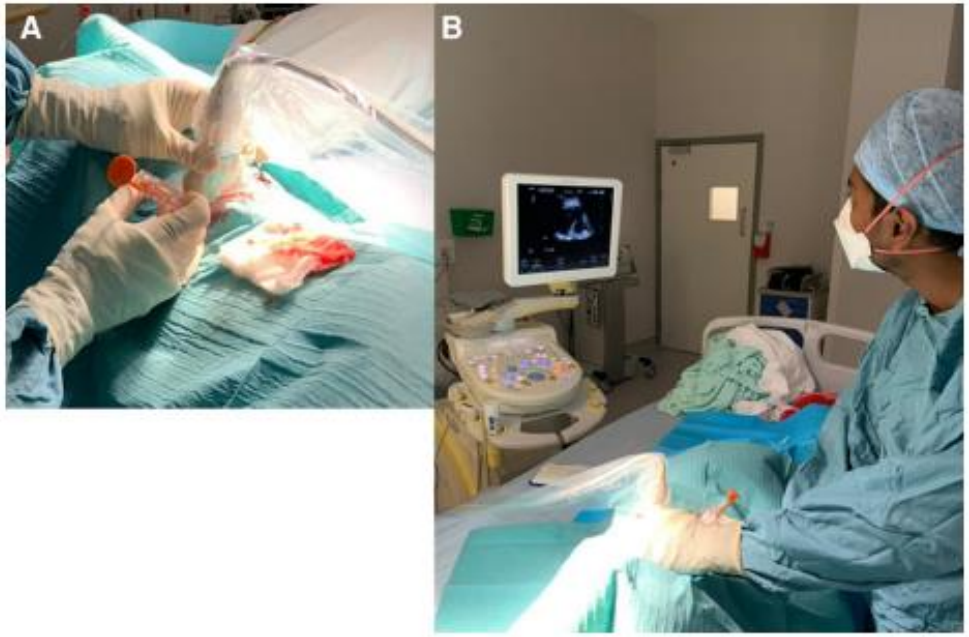


Figure 7 Real-time free-hand technique demonstrated with dominant hand controlling the cutting needle (A). Operator should be positioned facing the ultrasound machine with patient in lateral decubitus position in between (B).

Clinical practice

- Inferior biopsy sites closer to the diaphragm

  -> anatomical preference of secondary metastases
- Biopsy site with underlying pleural effusion

  -> act as a buffer, reducing the risk of pneumothorax
- Cutting needle angled to contain the full thickness of pleura to obtain core tissue
- Needle tip ends in the pleural fluid creating an oblique biopsy tract
- Usually at least 6 cores are obtained
- Intermittently check for any evidence of bleeding (echogenic material in pleural space, or use of Doppler)

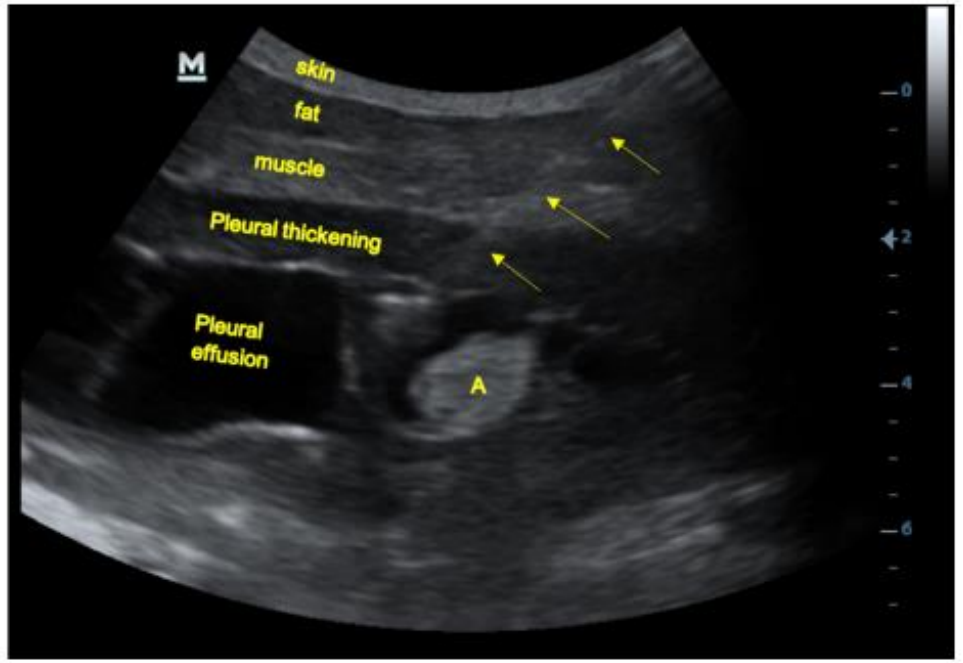


Figure 6 Ultrasound anatomy during cutting needle biopsy. Yellow arrows=biopsy needle track; A=meshwork of closely interlaced septations.

Sonographic findings

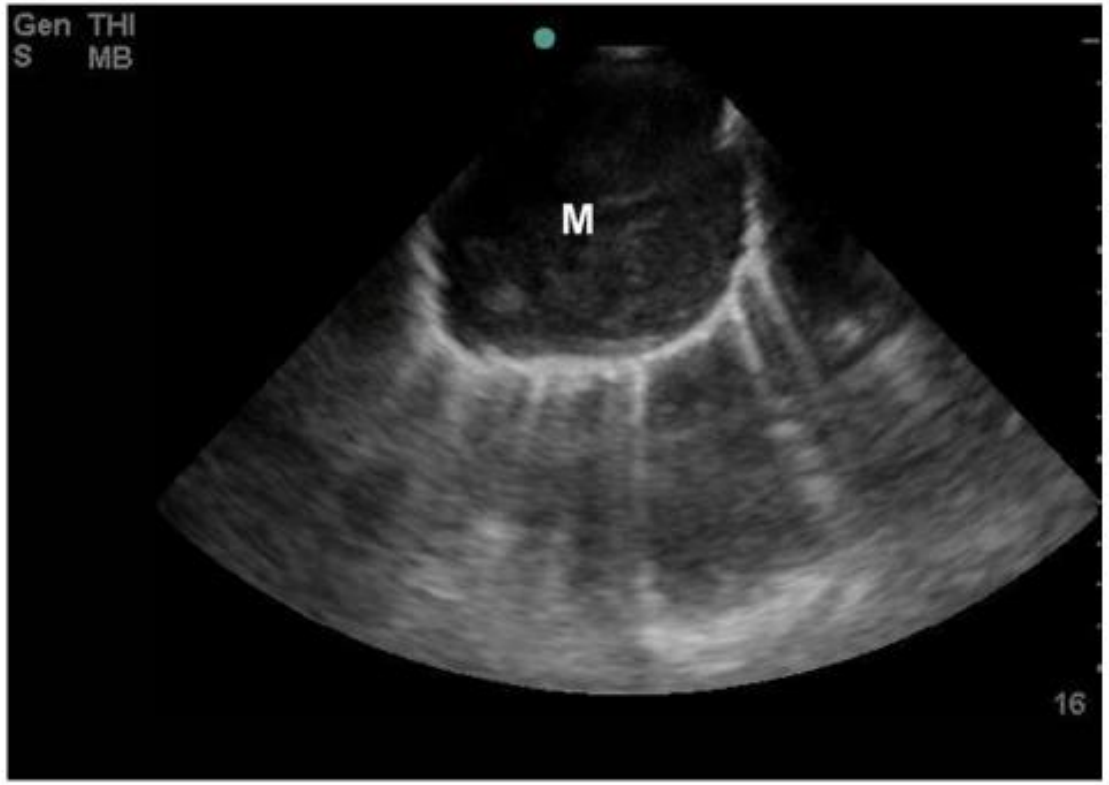
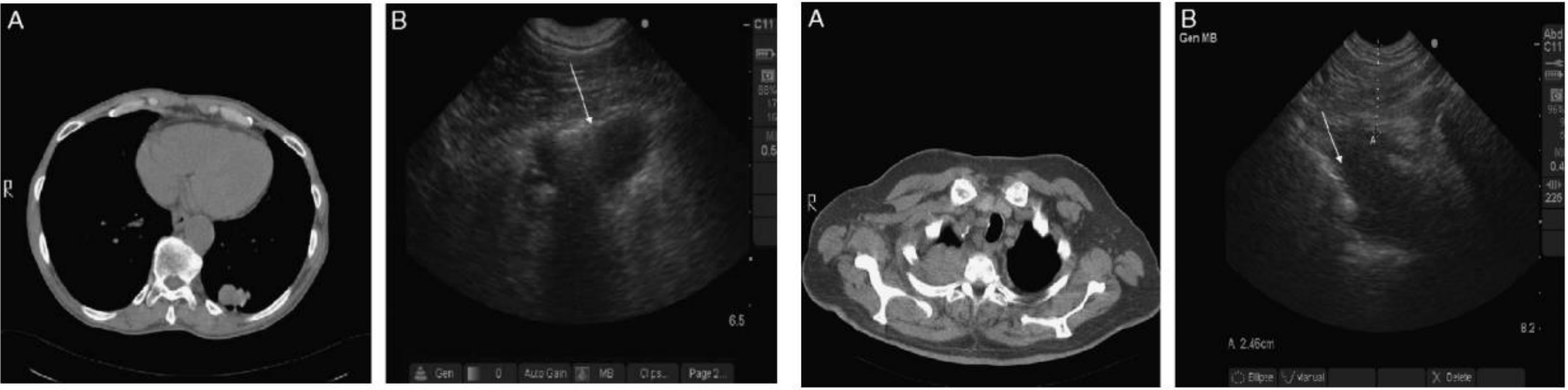


Fig. 2 A low-frequency ultrasound scan revealing a mass (M) arising from the chest wall. With the aid of an ultrasound-guided biopsy, this mass was found to be a poorly differentiated non-small cell lung cancer

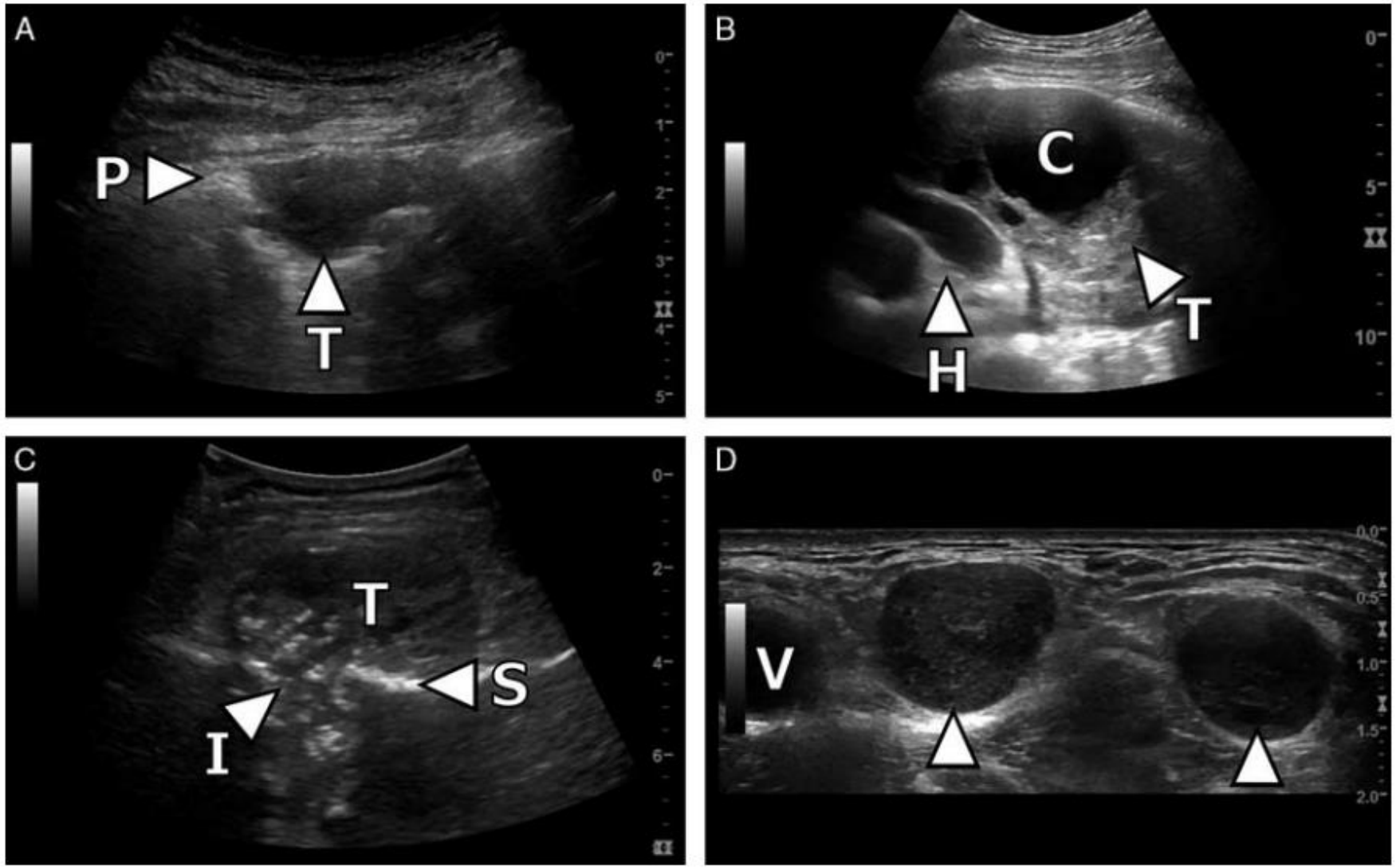
Current Respiratory Care Reports. 2014;3:45-51.

Sonographic findings



J Bronchology Interv Pulmonol. 2009;16(2):87-90.

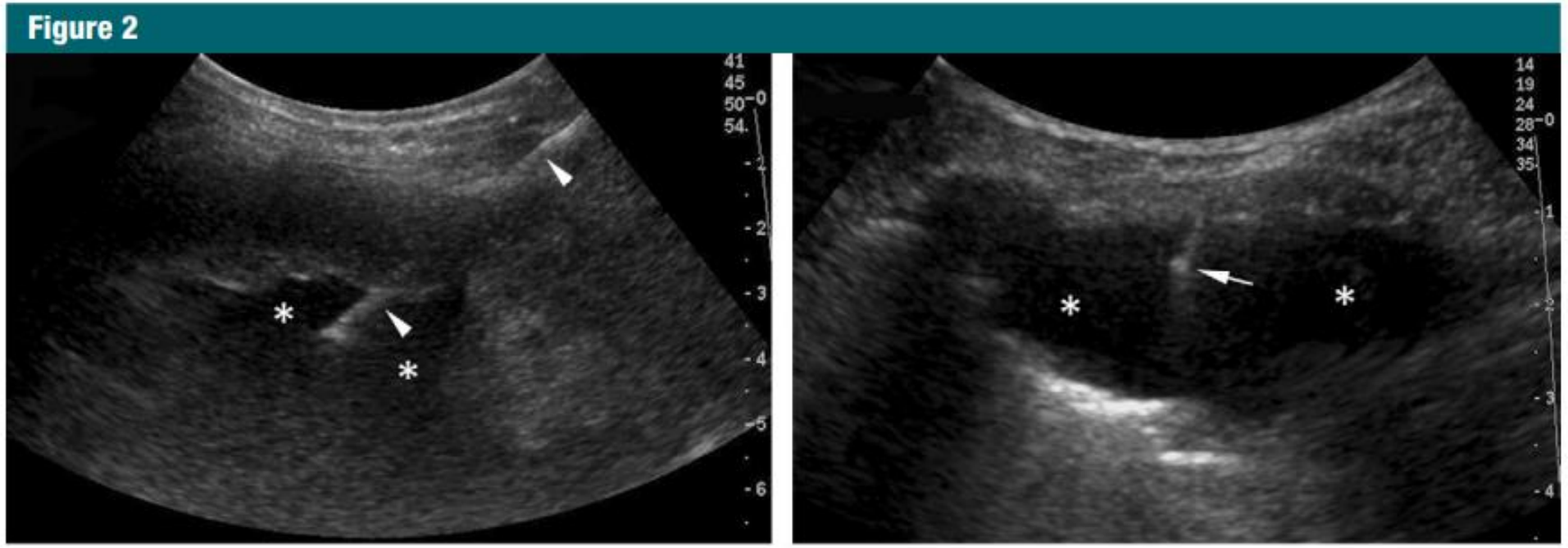
Sonographic findings



J Bronchology Interv Pulmonol. 2016;23(3):220-8.

Sonographic findings during cutting needle biopsy

Figure 2



a. b.

Figure 2: US-guided biopsy of a peripheral lung lesion (*) performed with the **(a)** lateral or **(b)** out-of-plane freehand approach. The needle (arrowheads in **a**) can be clearly seen along its whole course in the lateral approach, while the out-of-plane approach allows for needle tip visualization only (arrow in **b**).

Radiology. 2013;266(3):930-5.

Limitations of UGBx

- Areas inaccessible to ultrasound (eg, behind ribs) cannot be biopsied
- Pleural thickening smaller than 1cm -> lower diagnostic yields

=> CT-guided biopsy may be preferred (lesions as small as 5mm can be effectively biopsied)

Percutaneous dilatational tracheostomy

Role of ultrasound in PDT

- **Preprocedural** : neck screening
- **Intraprocedural real-time**
  - US-guided puncture, PDT with bronchoscopy
  - US-guided PDT without bronchoscopy

Figure 2: Ultraperc and Blue Rhino set

Role of ultrasound in PDT

Preprocedural neck screening

- Landmark recognition :
  - Proximal trachea, cricoid cartilage, cricothyroid membrane, thyroid gland, thyroid cartilage
  - Estimate the distance from the surface of the skin to the trachea
- Identify patients unsuitable for the procedure (difficult anatomy)
- Prevent puncture of aberrant vessels

Figure 18 Trachea in the transverse plane (B-mode, linear probe)

Figure 19 Trachea in the longitudinal plane with endotracheal tube in the lumen (B-mode, linear probe).

J Thorac Dis. 2021;13(8):5343-61.

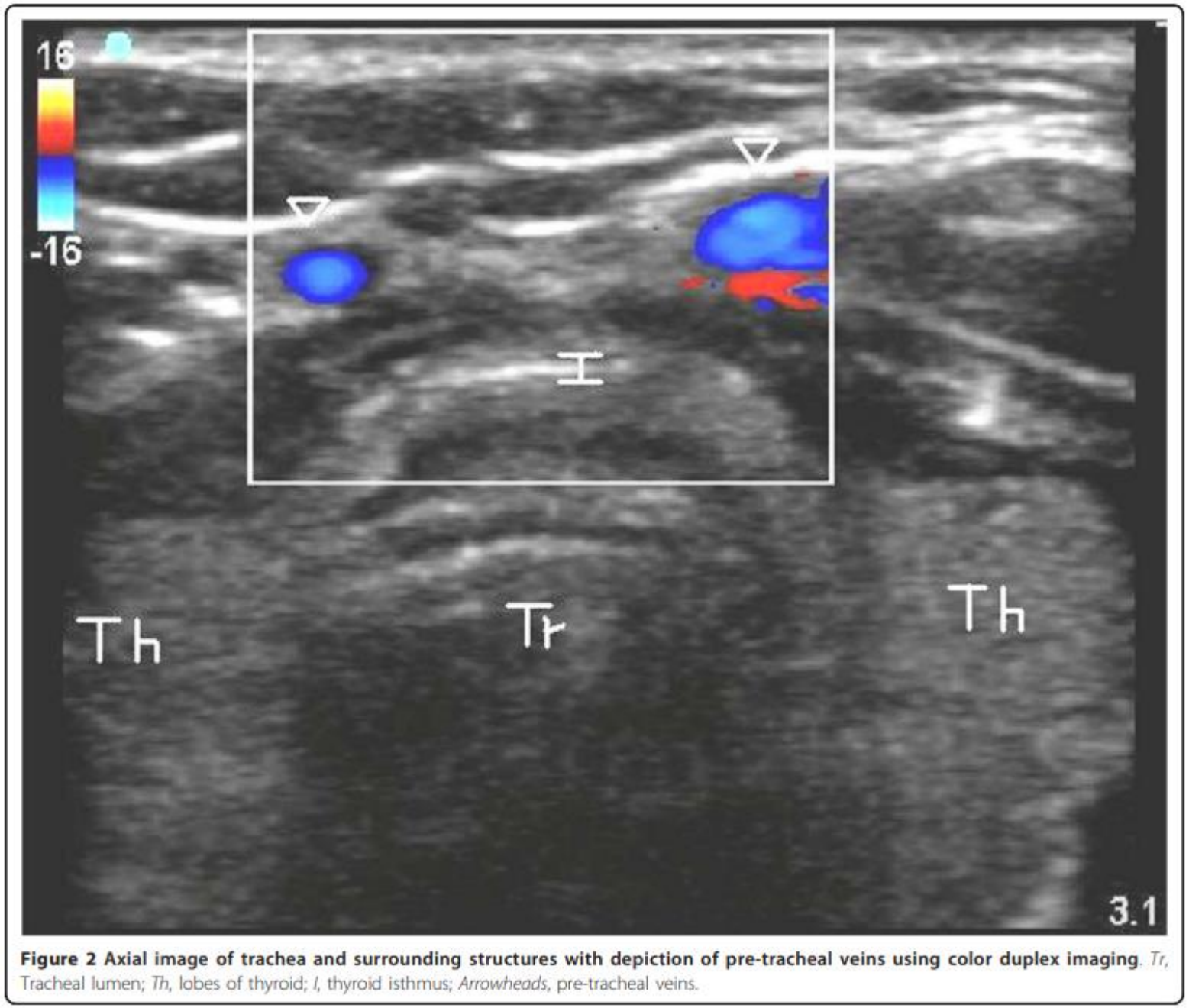


Figure 2 Axial image of trachea and surrounding structures with depiction of pre-tracheal veins using color duplex imaging. *Tr*, Tracheal lumen; *Th*, lobes of thyroid; *I*, thyroid isthmus; *Arrowheads*, pre-tracheal veins.

Crit Care. 2011;15(1):R67.

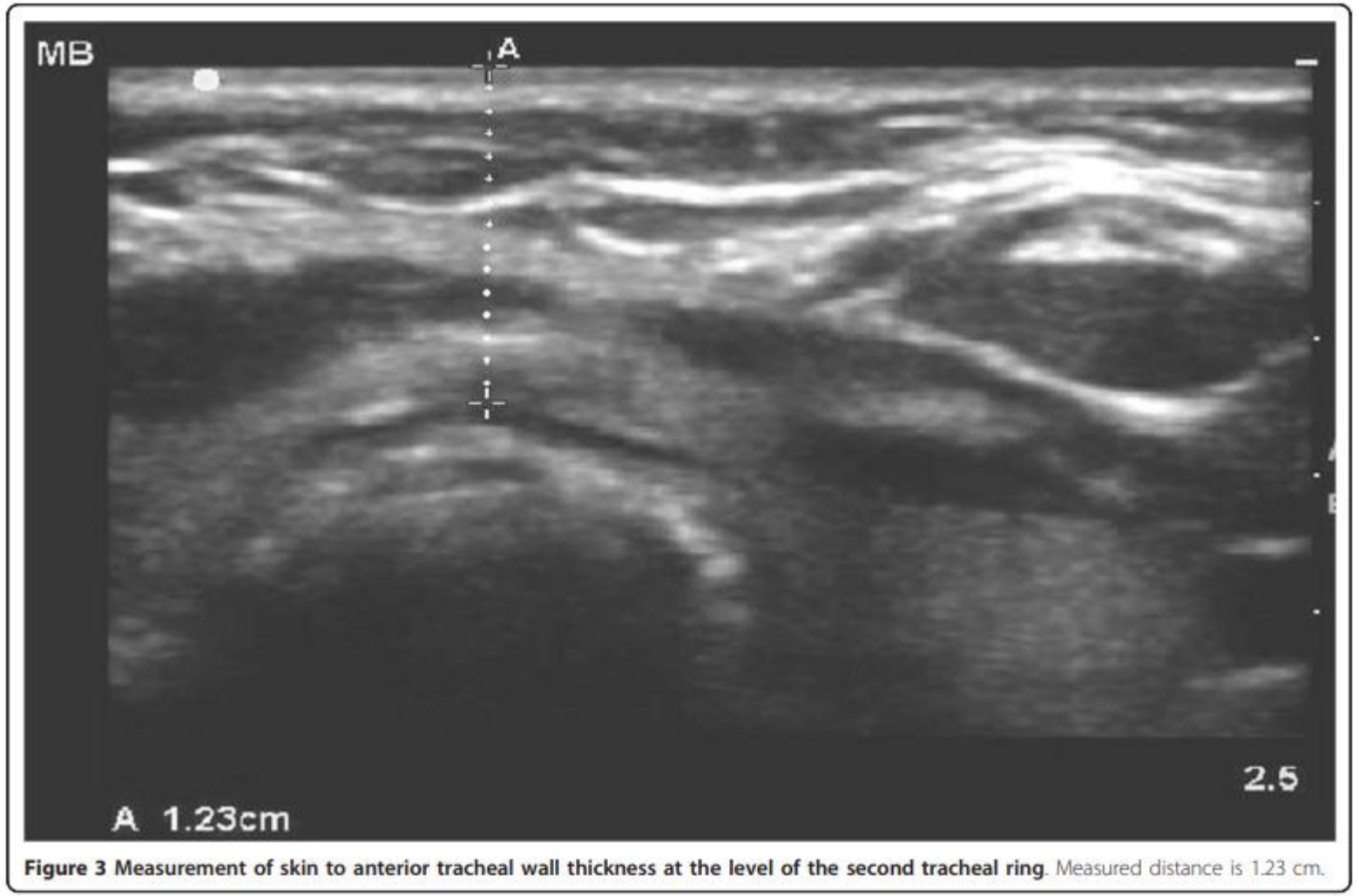
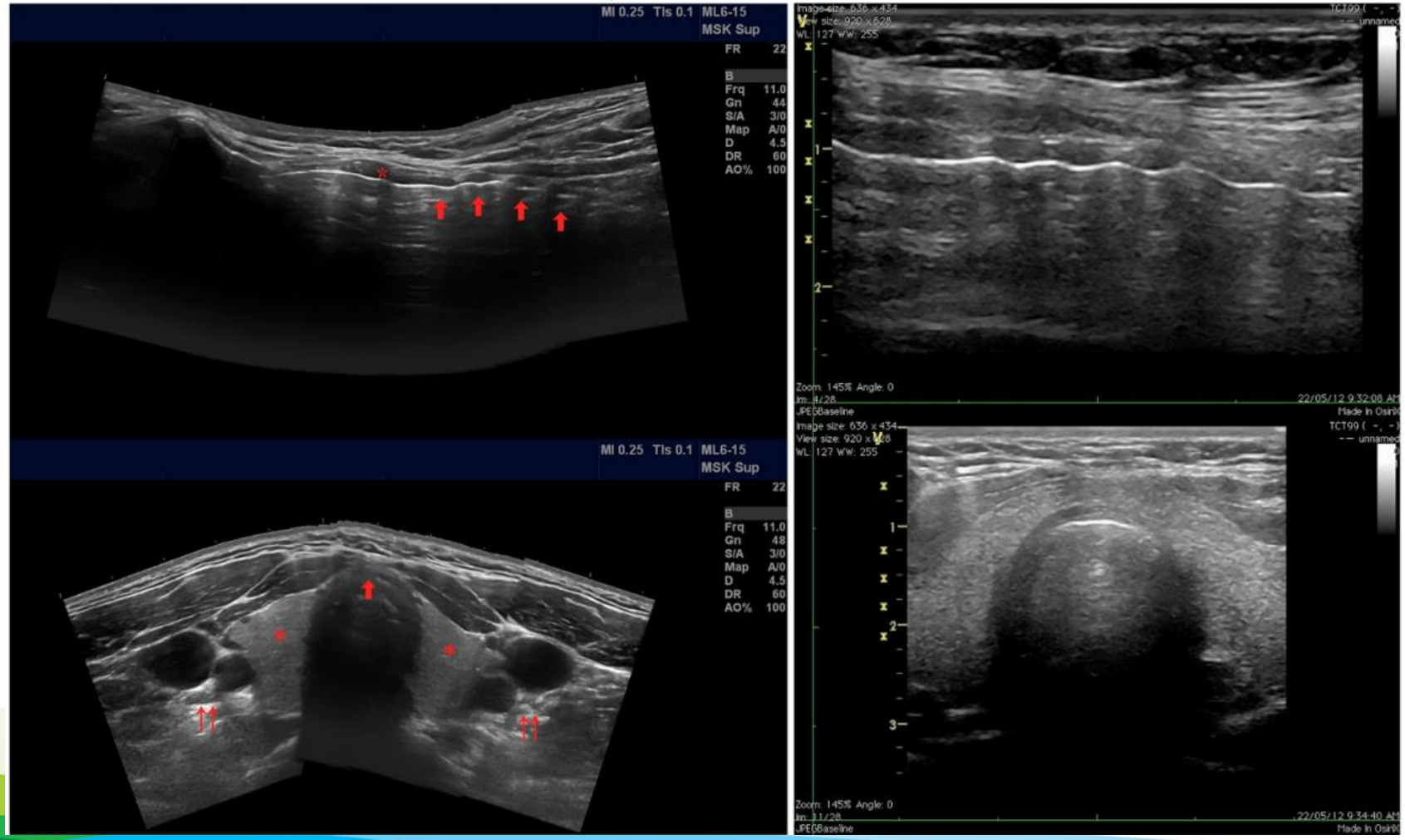


Figure 3 Measurement of skin to anterior tracheal wall thickness at the level of the second tracheal ring. Measured distance is 1.23 cm.

Crit Care. 2011;15(1):R67.

Role of ultrasound in PDT

- **Intraprocedural real-time US-guided puncture**



Crit Care. 2014;18(5):514.

Traditional landmark versus ultrasound guided tracheal puncture during percutaneous dilatational tracheostomy in adult intensive care patients: a randomised controlled trial

Máté Rudas[1,2*], Ian Seppelt[2,4,5], Robert Herkes[1], Robert Hislop[1], Dorrilyn Rajbhandari[4] and Leonie Weisbrodt[2,3]

CRITICAL CARE

- Prospective RCT (The TARGET study) (n=50)
- To compared real-time ultrasound-guidance to landmark-guided tracheal puncture during PDT
- Primary outcome : accuracy of tracheal puncture (less than 30° deviation from the midline, appropriate longitudinal puncture between the first and fourth tracheal rings)
  - Intervention : Tracheal puncture was carried out using a previously described transverse probe position and real-time out-of-plane technique
  - Control : palpation of anatomical landmarks was used to carry out the tracheal puncture, which is normal practice at the participating institutions
  - Bronchoscopy had to take place only after the guidewire was inserted
  - Bronchoscopy during needle puncture is not considered standard practice in either of the participating units
- Secondary outcome : the first-pass success rate
- Safety outcome : periprocedural and intermediate-term complication rates

Crit Care. 2014;18(5):514.

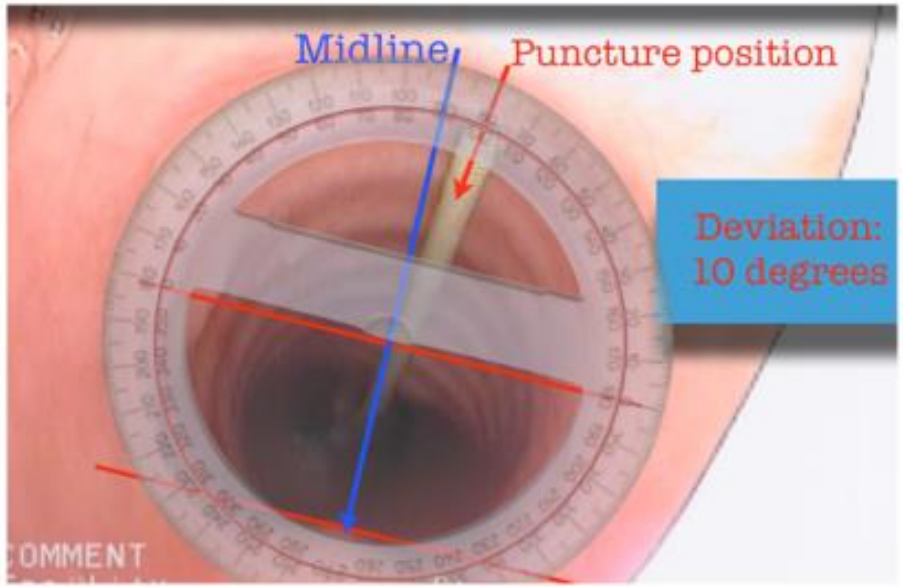


Figure 1 Measuring puncture deviation from the tracheal midline. Aligning the protractor with the anterior tracheal wall at the level of the puncture, followed by rotating so that the transverse axis is parallel with the posterior tracheal wall, defines the geometrical anterior tracheal midline. Deviation of the puncture was then determined in degrees.

- Mean midline deviation
  - US group : 15 ± 3°
  - Landmark group : 35 ± 5°
  - P = 0.001, Difference of 20 ± 6° (95% CI = 8.0 to 31.8)
- Appropriate midline puncture rate
  - US group : 20/23 (87%)
  - Landmark group : 12/24 (50%)
  - RR = 1.74; 95% CI = 1.13 to 2.67; P = 0.006
- First-pass success rate
  - US group : 20/23 (87%)
  - Landmark group : 14/24 (58%)
  - RR = 1.49; 95% CI = 1.03 to 2.17; P = 0.028
- Procedural complications -> no significant difference

Crit Care. 2014;18(5):514.

Role of ultrasound in PDT

Intraprocedural real-time US-guided PDT without bronchoscopy

- Disadvantages of bronchoscopic PDT
  - Adds complexity to the procedure
  - Necessitates a second bronchoscopist
  - Adds cost
  - Associated with some negative physiologic consequences (de-recruitment with subsequent hypoxemia)

Role of ultrasound in PDT

Intraprocedural real-time US-guided PDT without bronchoscopy

- Non-inferior over bronchoscopic PDT
- In low-risk patients, the complication rates and success of PDT is identical
  - US-guided PDT is feasible in obese patients
  - However, small number of patients
- High risk and obese patients are more likely to benefit from bronchoscopic visualization.

J Thorac Dis. 2021;13(8):5343-61.
Crit Care. 2012;16(2):R40.

Comparison between ultrasound- and bronchoscopy-guided percutaneous dilational tracheostomy in critically ill patients: A retrospective cohort study

André Luiz Nunes Gobatto, M.D. [a,d,*], B
Paulo Fernando Guimarães Morando M
Daniel Joelsons, M.D. [c], Livia Melro, M.I

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Cadamuro, M.D. [b],
son, M.D., Ph.D. [b,d]

- US-guided PDT as an a
- Retrospective analysis,

choscopy-guided)

Table 1
General characteristics of the patients

	Bronchoscopy (n = 11)	US (n = 49)	*P* value
Male sex, n (%)	5 (46)	31 (67)	.189
Age, y	49 (18.7)	52 (19.8)	.417
Weight, kg	67 (61-72)	72 (68-76)	.122
Height, cm	168 (163-173)	169 (167-172)	.773
Body mass index, kg/m^2	23.7 (22.4-25.0)	25.0 (24.0-26.0)	.225
Pao_2/Fio_2 ratio before PDT	298 [273-460]	318 [260-396]	.677
Pao_2/Fio_2 ratio after PDT	242 [234-450]	367 [273-516]	.078
SAPS 3	66 [61-67]	59 [50-72]	.263
Diagnosis on admission, n (%)			.831
Traumatic brain injury	3 (27)	28 (51)	
Cerebrovascular disorder	4 (36)	11 (22)	
Pneumonia	2 (18)	3 (6)	
CNS neoplasm	1 (9)	3 (6)	
CNS infection	1 (9)	2 (4)	
Others	0	6 (12)	
Indication for intubation, n (%)			.631
Respiratory failure	2 (18)	6 (12)	
Inability to protect airway	9 (82)	43 (88)	
Indication for tracheostomy, n (%)			1.000
Difficult weaning	0	3 (6)	
Inability to protect airway	11 (100)	46 (94)	
Anatomical difficulties, n (%)			.191
None	9 (82)	46 (94)	
Short neck	1 (9)	3 (6)	
Limited neck extension	1 (9)	0	
MV before tracheostomy, d	15 [14-23]	13 [10-22]	.004

Table 2
Procedure data

Procedure difficulty, n (%)			
Easy			
Some difficulty			
Difficult/very difficult			
No. of tracheal punctures			
Distance between skin and trachea, cm			
Tracheal diameter, cm			
Vessels beneath the puncture site, n (%)			
Change in puncture site after US, n (%)			
Procedure length (min)	15 [15-22]	12 [8-15]	.028

	Bronchoscopy (n = 11)	US (n = 49)	*P* value
	1 (9)	6 (12)	1
	1 (9)	2 (4)	.491
%)	1 (9)	2 (4)	.462
n (%)	1 (9)	5 (10)	1
%)	0	3 (6)	1
	1 (9)	1 (2)	.336
	0	1 (2)	1
nd	48 [24-54]	48 [42-96]	.284
	20 [16-30]	20 [15.5-25]	.411
	30 [20-42]	30 [22-52]	.745
	2 (18)	14 (29)	.71
Hospital mortality, n (%)	7 (64)	21 (43)	.318

Ultrasound-guided percutaneous tracheostomy in critically ill obese patients

Pierre-Grégoire Guinot[1*], Elie Zogheib[1], Sandra Petiot[1], Jean-Pierre Marienne[2], Anne-Marie Guerin[2], Pauline Monet[3], Rody Zaatar[4] and Hervé Dupont[1,5]

CRITICAL CARE

- To evaluate the feasibility of US-guided PDT and the incidence of complications in critically ill, obese patients
- Prospective
- Obese (BM

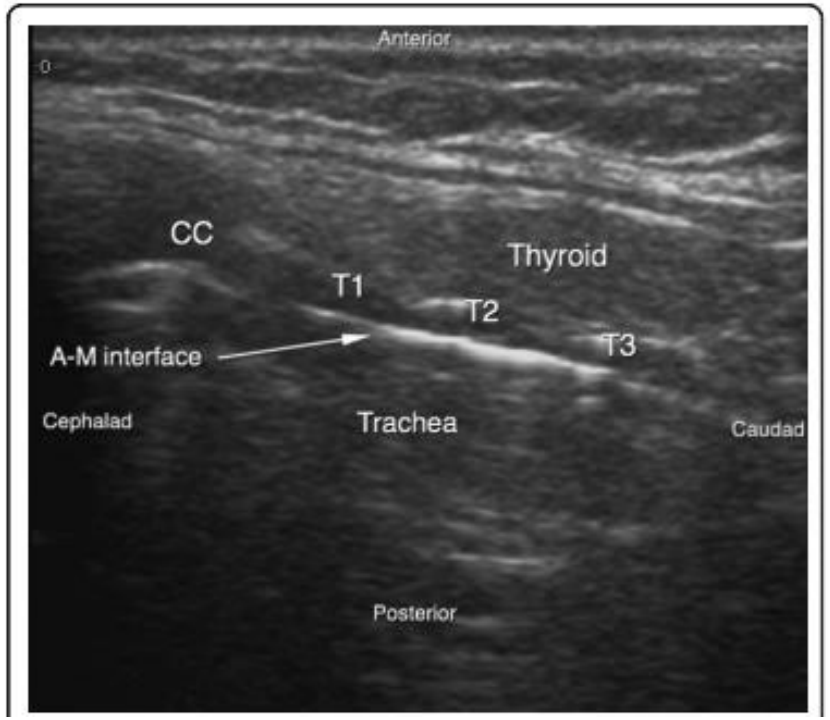
Table 4 Complications in the overall study population and in the obese and non-obese subgroups

	Global population (n = 50)	Obese (n = 26)	Non-obese (n = 24)	*P* value
No complications	33 (66%)	17 (65%)	16 (71%)	0.92
Minor complications				
Hypotension	3 (6%)	1 (4%)	2 (8%)	0.6
Desaturation: SpO_2 < 90%	3 (6%)	1 (4%)	2 (8%)	0.6
Tracheal cuff punctu				0.41
Multiple puncture				0.22
Bleeding less than 5				0.6
Fractured tracheal ri				1
Atelectasis				1
Intermediate complicatio				
Granuloma				0.5
Major complications				
Cutaneous infection	1 (2%)	0	1 (4%)	1
Surgical conversion	0	0	0	
Death	0	0	0	
No complications	17 (34%)	9 (35%)	8 (33%)	0.92

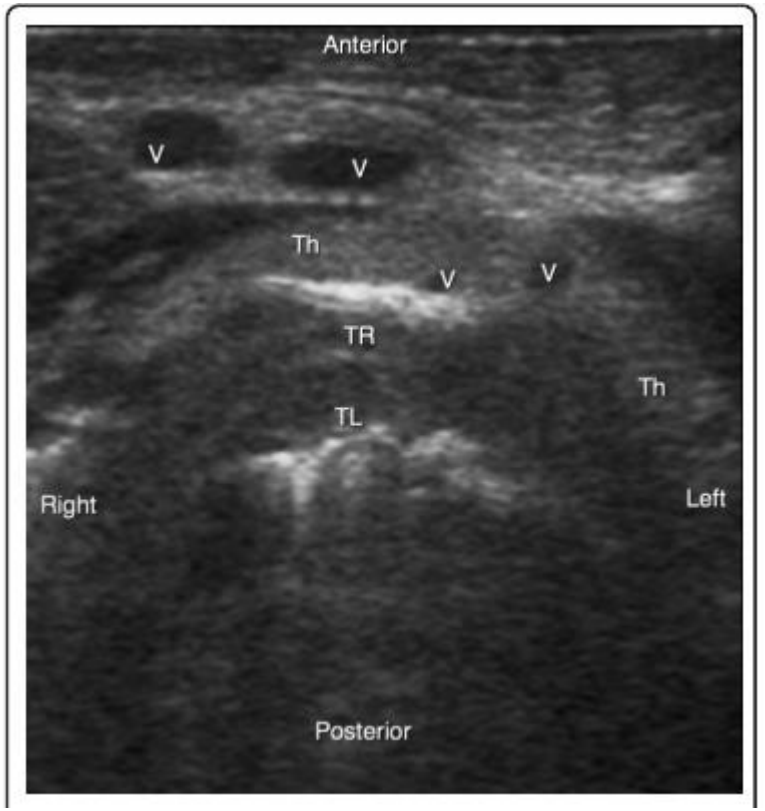
PDT can be performed in obese patients
under real-time US guidance
and with a short completion time.

Crit Care. 2012;16(2):R40.

Real-time US-guided PDT

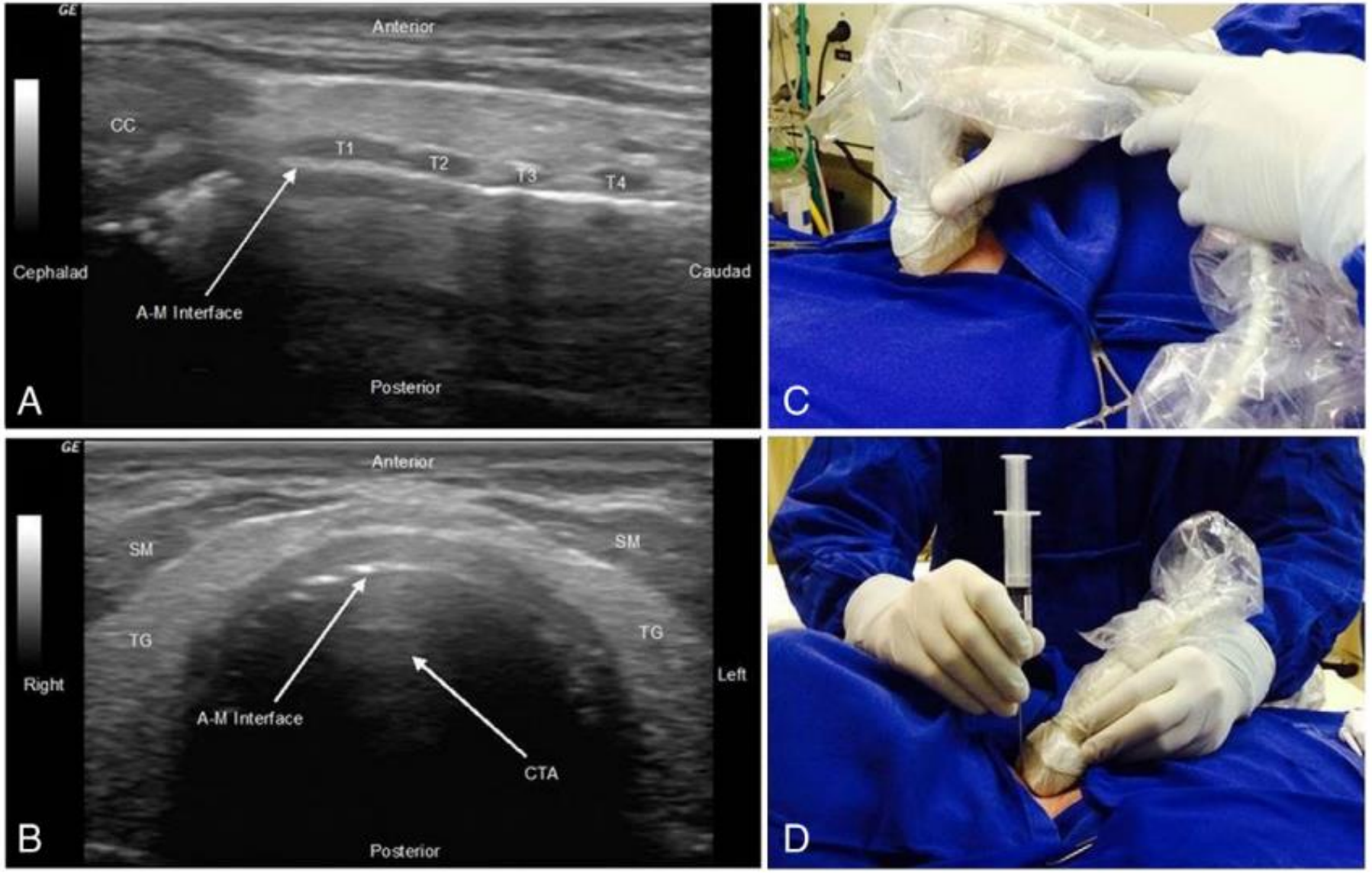


Ultrasound sagittal view of the neck
A-M interface : air-mucosa interface
CC : cricoid cartilage
T1-3 : tracheal rings



Ultrasound transverse view of the neck
Th: thyroid gland
TL : trachea lumen
TR : tracheal ring
V : vessel

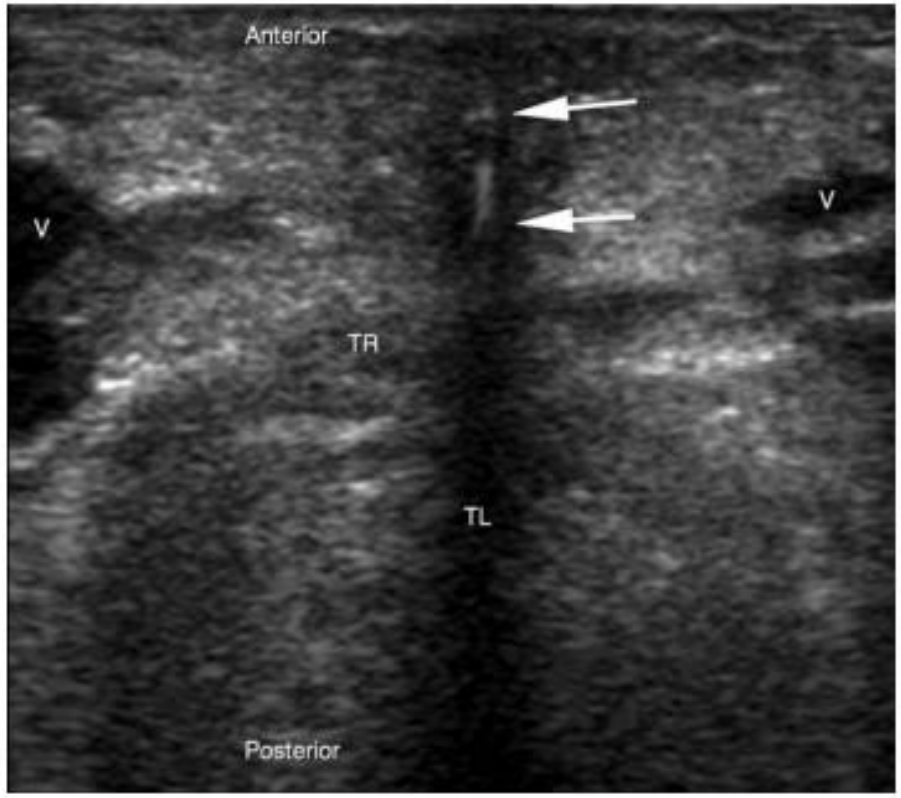
Crit Care. 2012;16(2):R40.



Journal of Critical Care. 2015;30(1):220. e13-. e17.

Real-time US-guided PDT

Progression of the needle is determined by a distinct acoustic shadow (arrow)



The dilator is determined by a hyperechoic signal centered by a distinct acoustic shadow (arrows)

Crit Care. 2012;16(2):R40.

Others

- Ultrasound-guided central venous catheter insertion
  - Internal jugular vein catheter insertion : C-line, ECMO return cannula
  - Femoral vein catheter insertion : CRRT line, ECMO drainage cannula

- Recommendations for clinical practice
  - 1) Identify anatomy of the insertion site and localization of the vein
  - 2) Confirm patency of the vein
  - 3) Use real-time US guidance for puncture of the vein
  - 4) Confirm needle position in the vein
  - 5) Confirm wire position in the vein
  - 6) Confirm catheter position in the vein

Crit Care. 2017;21(1):331.

US-guided central venous catheterization

1) Identify anatomy of the insertion site and localization of the vein

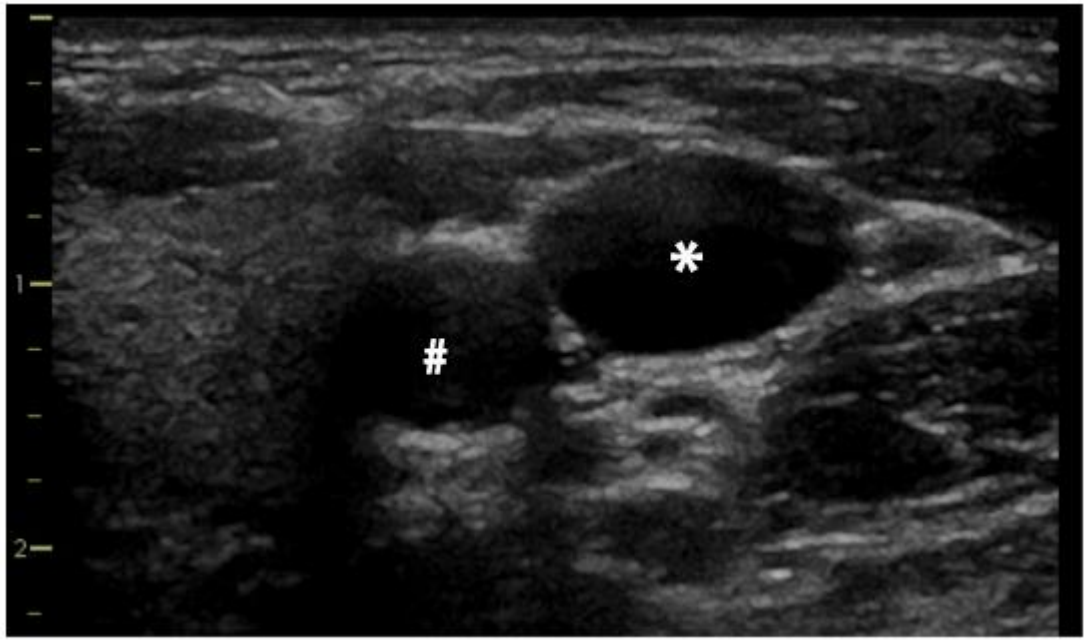
Normal position

(*) Internal jugular vein
(#) Carotid artery

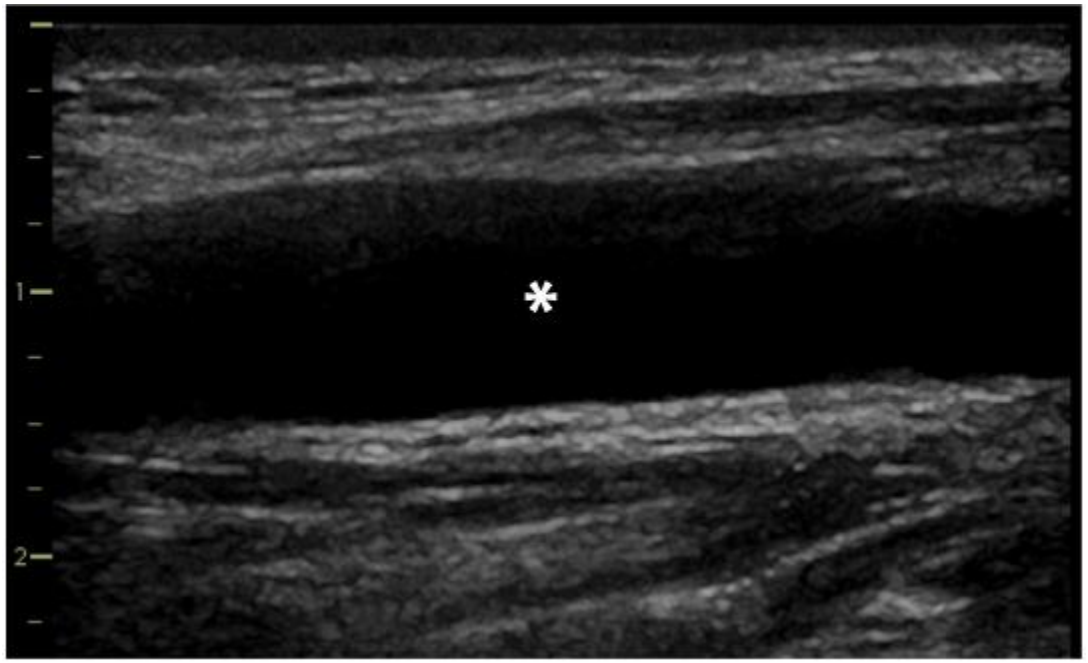
Non-optimal position ; IJV(*) directly over the carotid artery (#)

US-guided central venous catheterization

1) Identify anatomy of the insertion site and localization of the vein



Short-axis (transverse) view
(*) Rt. Internal jugular vein
(#) Carotid artery



Long-axis (longitudinal view)

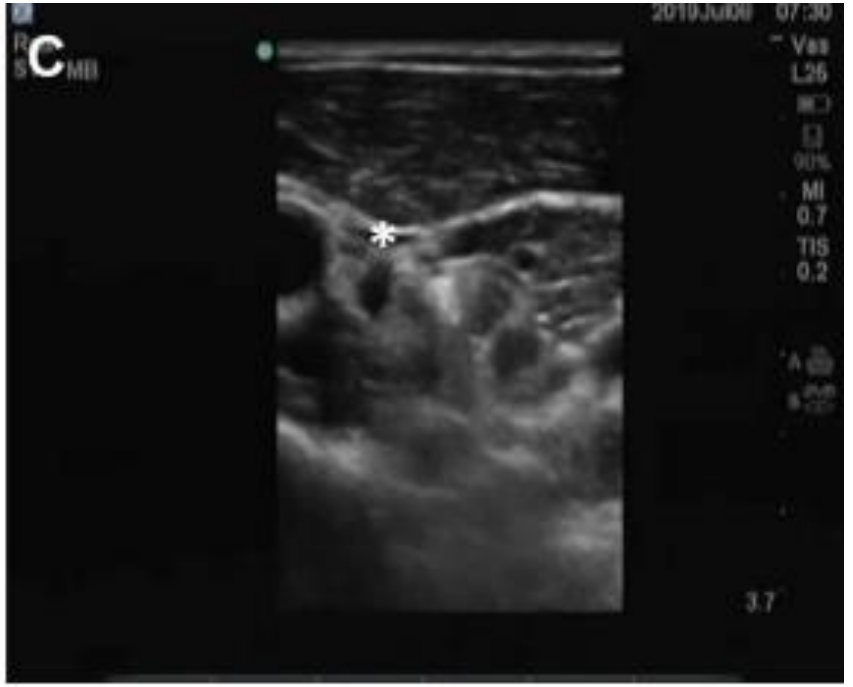
Crit Care. 2017;21(1):331.

US-guided central venous catheterization

2) Confirm patency of the vein

- Compression -> exclude venous thrombosis

(*) Internal jugular vein
(#) Carotid artery

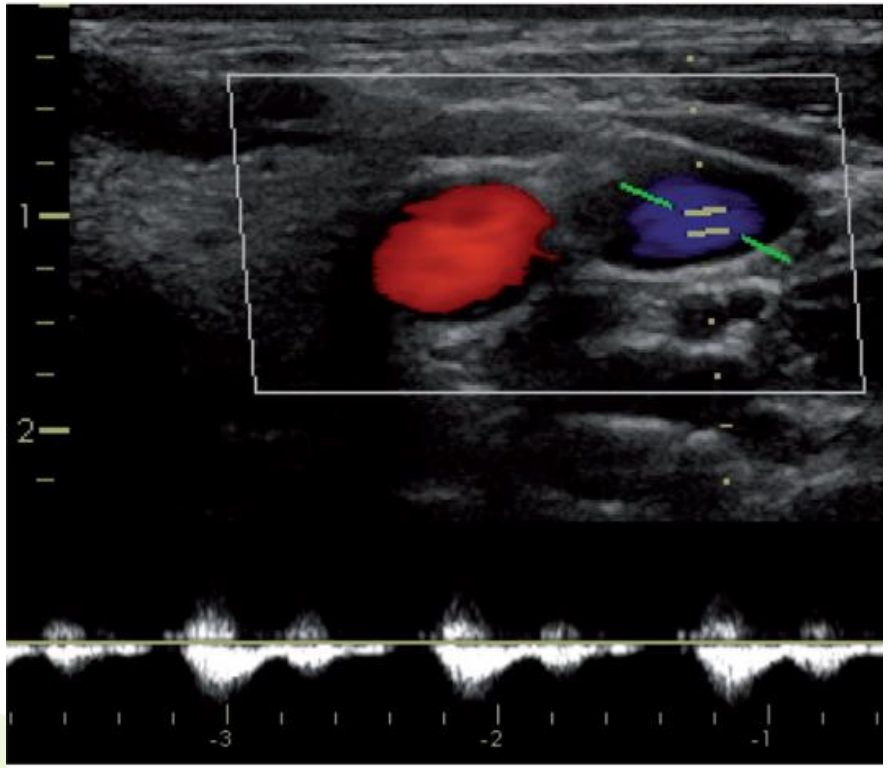


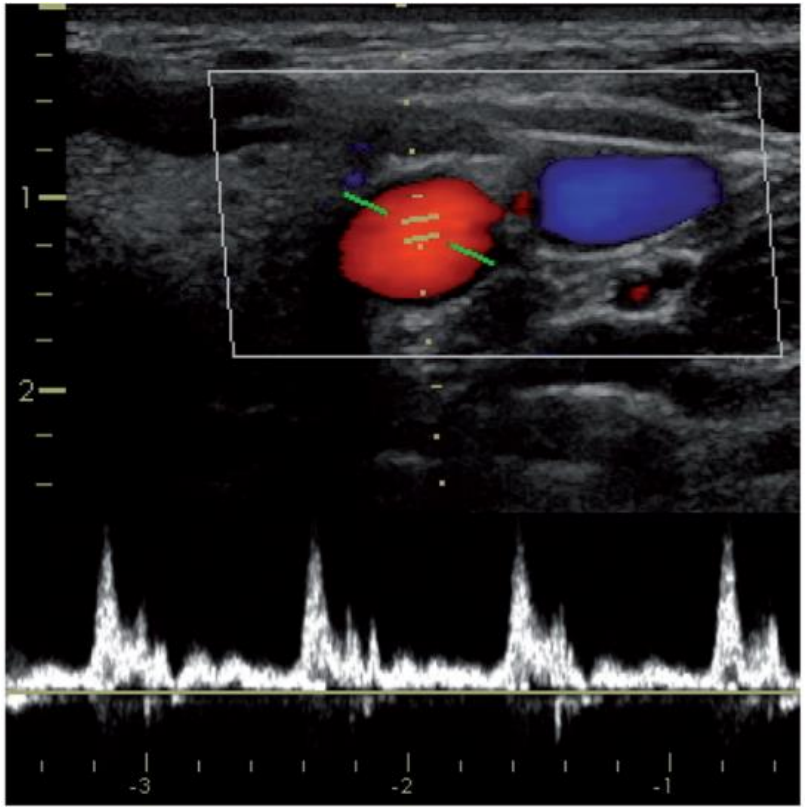
Compression of the IJV

US-guided central venous catheterization

2) Confirm patency of the vein

- Color Doppler imaging, Doppler flow measurements -> to quantify venous and arterial blood flow



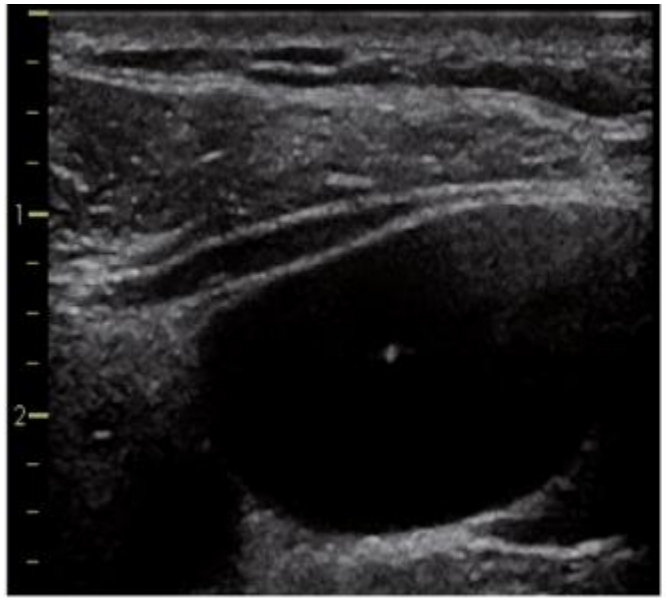


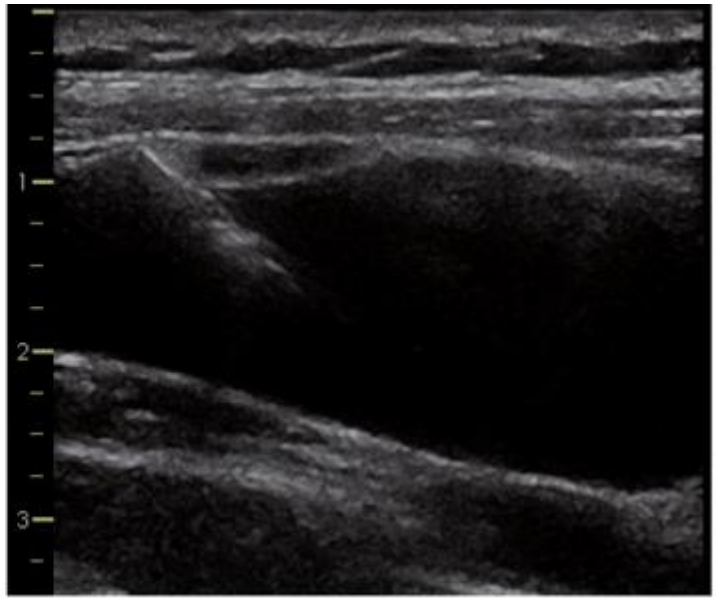
US-guided central venous catheterization

3) Use real-time US guidance for puncture of the vein

US-guided central venous catheterization

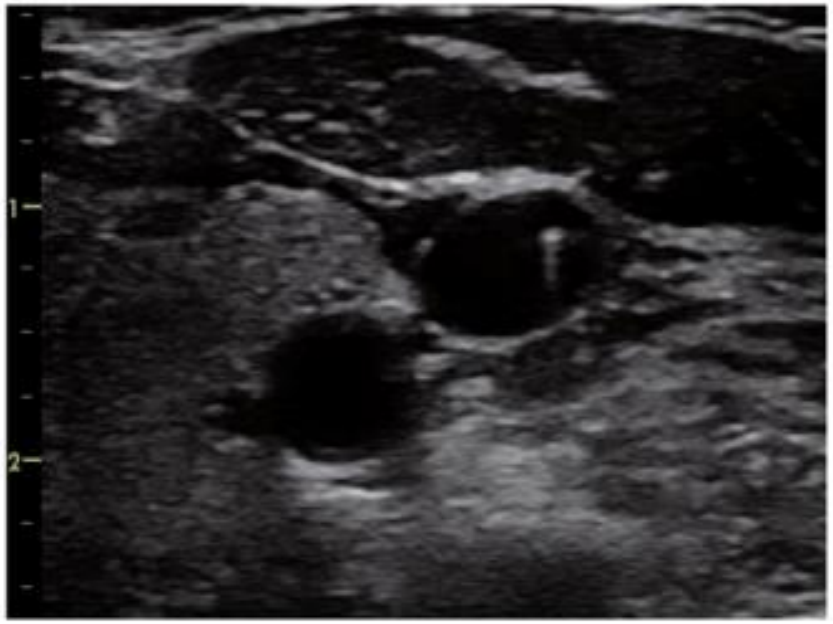
4) Confirm needle position in the vein

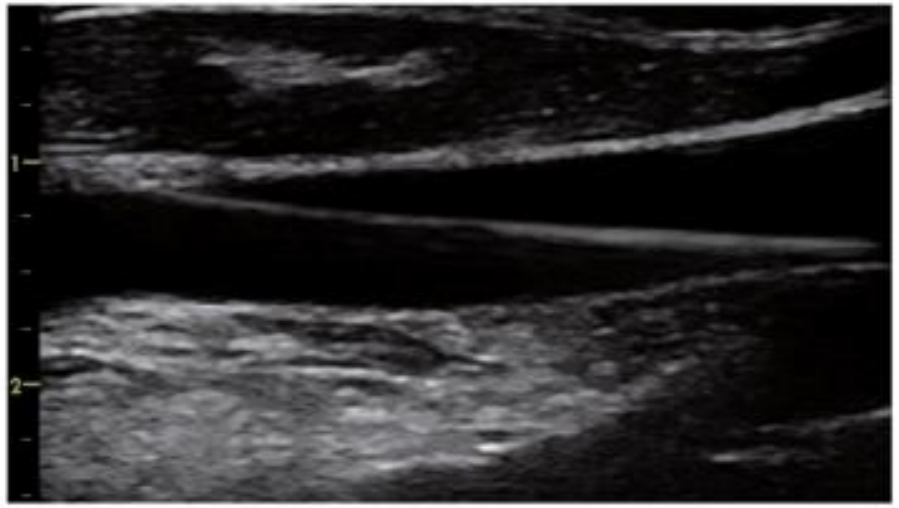




US-guided central venous catheterization

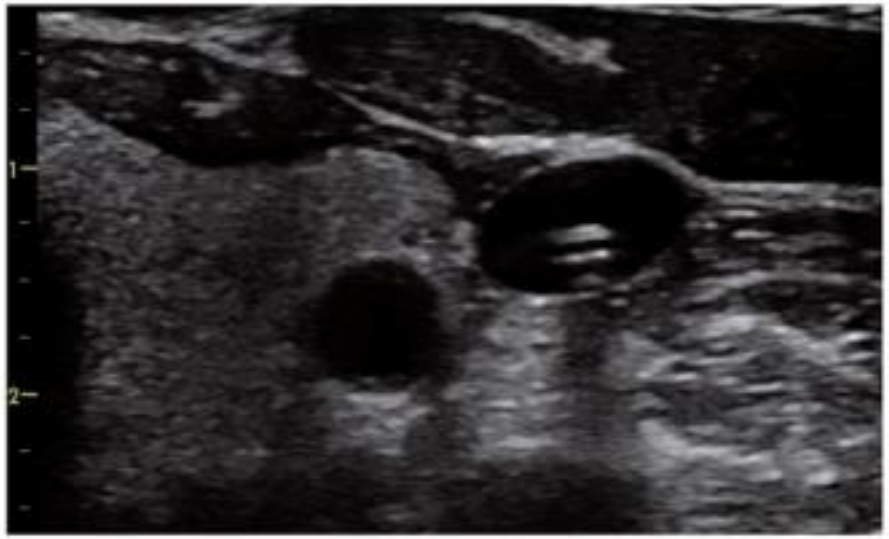
5) Confirm wire position in the vein

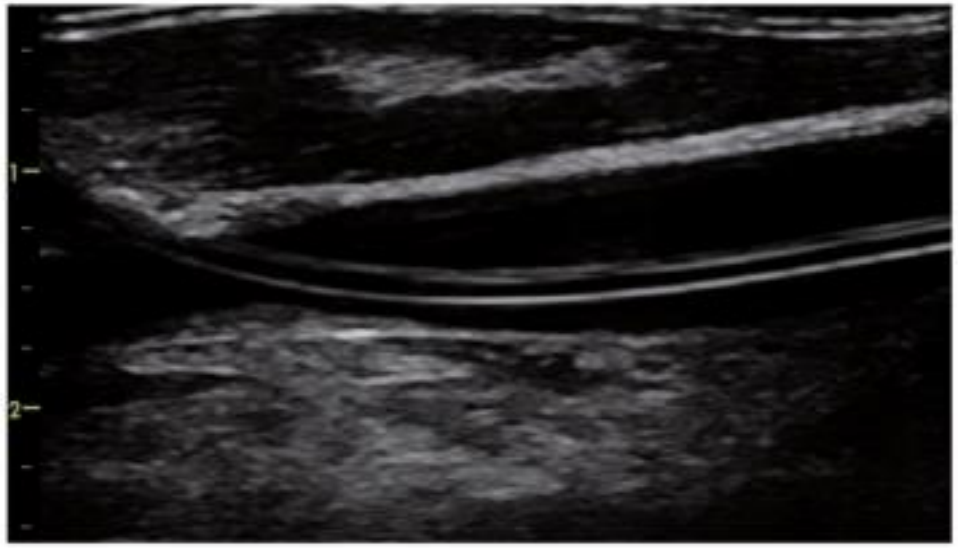




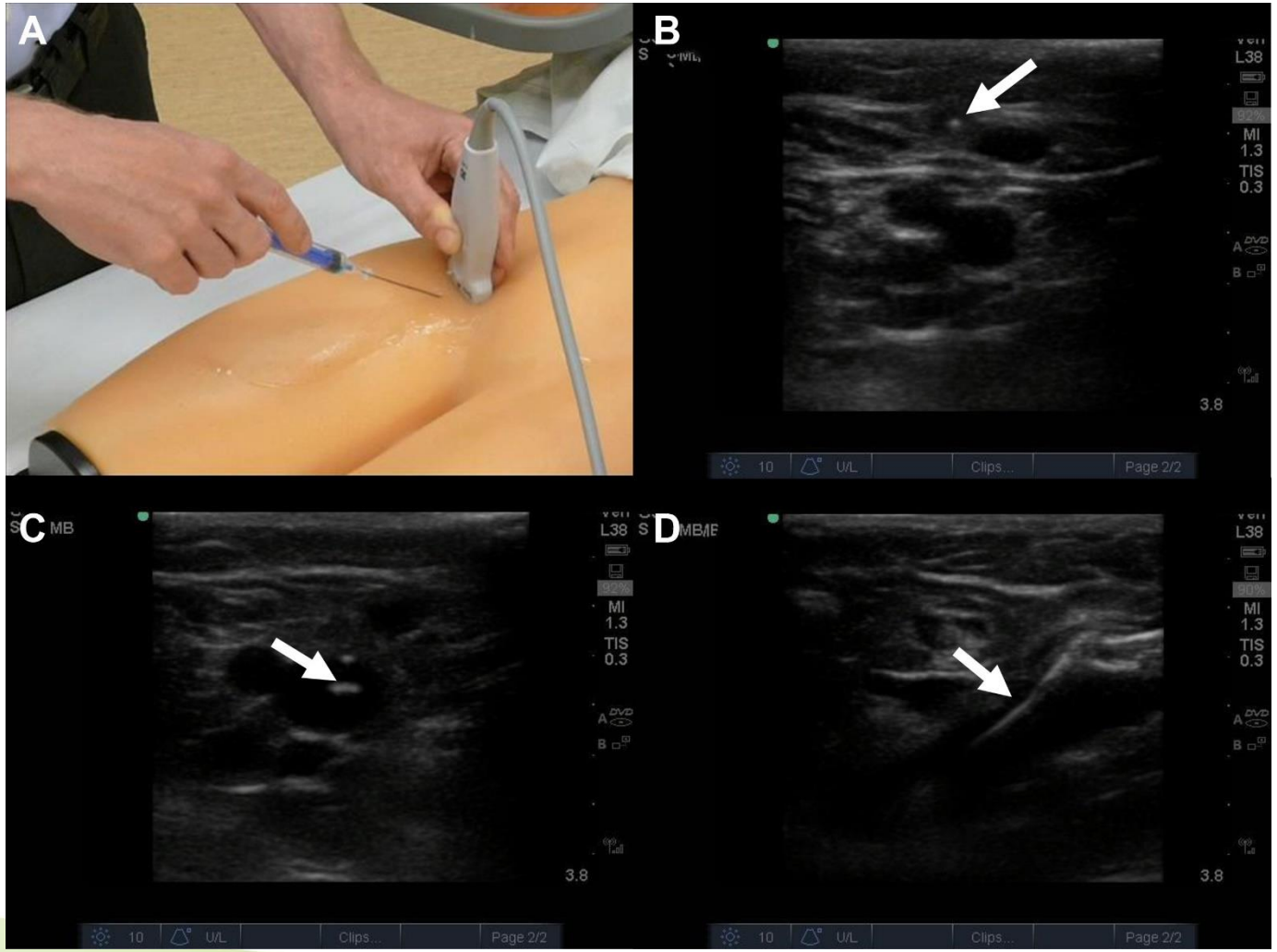
US-guided central venous catheterization

6) Confirm catheter position in the vein





Femoral vein catheterization



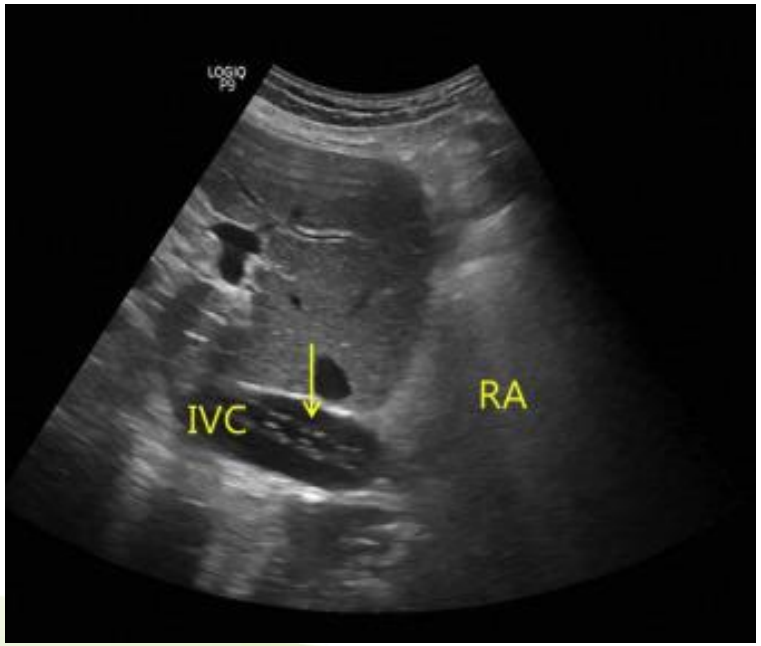
The hyperechoic needle tip (arrow) seen on ultrasound heading toward the femoral vein.

The hyperechoic needle tip (arrow) in the femoral vein.

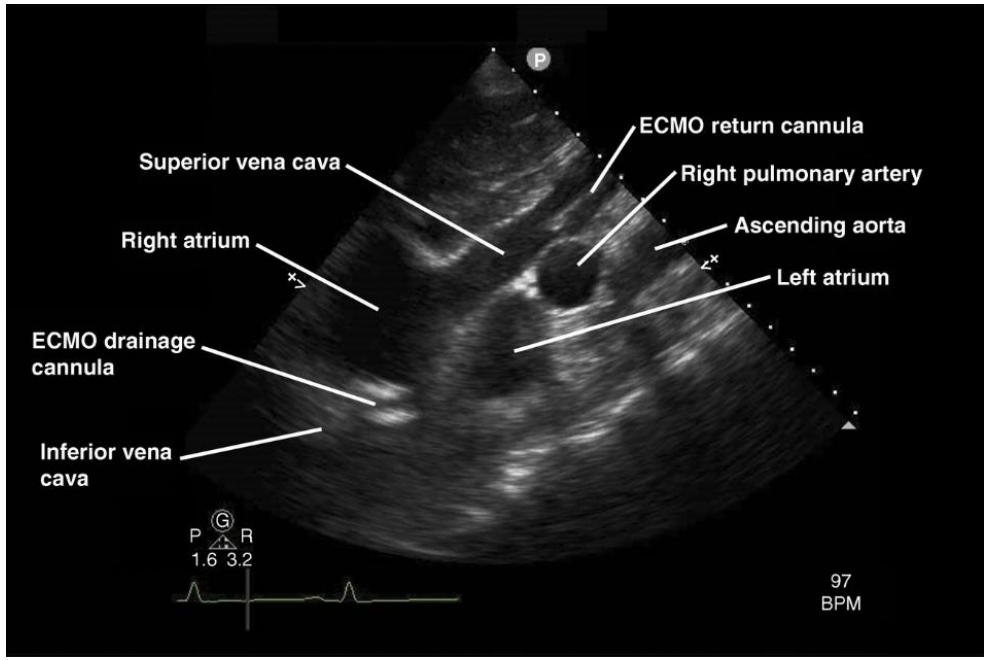
Ultrasound confirmation of the wire (arrow) in the long-axis approach prior to dilatation.

ECMO cannulation

- US-guided cannulation :
  - Transthoracic echocardiography (TTE) : subcostal view
  - Transesophageal echocardiograpy(TEE)
- Assessment of cannula position – adjust if it is not located at optimal position



Drainage catheter at RA-IVC junction



Return catheter at SVC

Am J Respir Crit Care Med. 2019;199(10):e39-e40.
J Emerg Med. 2018;54(4):507-13.

Thank you for your listening!