Thoracic ultrasound competence for ultrasound-guided pleural procedures

David J. McCracken[1,2], Christian B. Laursen[3], Graham Barker[4], Fergus V. Gleeson[5], Kathy M. Cullen[2] and Najib M. Rahman[1,6]

Affiliations: [1]Oxford Centre for Respiratory Medicine, Oxford, UK. [2]Centre for Medical Education, Queen's University Belfast, Belfast, UK. [3]Dept of Respiratory Medicine, Odense University Hospital, Odense, Denmark. [4]Nuffield Dept of Anaesthesia, Oxford University Hospitals NHS Foundation Trust, Oxford, UK. [5]Dept of Radiology, Oxford University Hospitals NHS Foundation Trust, Oxford, UK. [6]Oxford NIHR Biomedical Research Centre, Oxford, UK.

Correspondence: David McCracken, Oxford Centre for Respiratory Medicine, Churchill Hospital, Old Road, Oxford, OX3 7LE, United Kingdom. E-mail: david.mccracken@ouh.nhs.uk

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Focused thoracic ultrasound is essential in the guidance of pleural interventions to reduce unwanted complications. It forms a crucial component of physician training. Current training standards and assessment methods vary. http://bit.ly/2me8hoU

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ABSTRACT Focused thoracic ultrasound has become essential in the guidance and direction of pleural interventions to reduce unwanted complications and as a result now forms a crucial component of physician training. Current training standards along with assessment methods vary widely, and are often not robust enough to ensure adequate competence. This review assesses the current state of training and assessment of thoracic ultrasound competence in various settings, allowing comparison with alternative competency based programmes. Future directions for training and assessment of thoracic ultrasound competence are discussed.

Epidemiology and relevance

Pleural disease is common, with an estimated annual incidence of 3000 people per million population. This translates to approximately 200 000 new cases of pleural disease yearly in the UK and this incidence continues to rise, therefore representing a significant burden on healthcare systems. There are more than 40 000 new cases of malignant pleural effusion in the UK annually, contributing to an annual incidence of approximately 300 000 cases across the USA and UK combined. Incidence rates for all cancers combined in the UK have increased by 7% over the past 10 years and are projected to rise by a further 2% between 2014 and 2035 to 742 cases per 100 000, which is likely to result in an ongoing increase in the incidence of malignant pleural effusion. In addition, there are approximately 2500 deaths per year in the UK from mesothelioma. The incidence has steadily risen over the past 50 years and is expected to peak in 2020 [1–5].

The combined UK and US population also has an estimated annual incidence of 80 000 cases of pleural infection. This frequency has doubled over the past decade and continues to rise [6, 7].

Role of ultrasound for pleural procedures

As the prevalence of pleural disease has continued to rise, so has the need for increasingly specialised interventions. This includes local anaesthetic thoracoscopy with or without pneumothorax induction, pleural biopsy and indwelling catheter insertion along with more traditional procedures such as pleural aspiration and chest drain insertion. The role of ultrasound guidance for these procedures has also increased. A

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European Respiratory Society (ERS) Monograph on thoracic ultrasound (TUS) published in 2018 states that "At this point in time, the evidence that the appropriate use of TUS reduces the risk of iatrogenic complications from pleural procedures in comparison with unguided (blind) intervention is so overwhelming that the authors would regard a failure to carry out a TUS examination prior to any intervention for suspected pleural fluid as being indefensible, except in the most exceptional circumstances" [8].

The evidence for TUS guidance prior to pleural intervention is compelling. As early as 2003, Diacon *et al.* [9] showed that ultrasound demonstrated 15% of intervention sites identified by clinical examination were unsafe. Ultrasound also identified appropriate intervention sites in 54% of cases where an appropriate site could not be identified clinically. Overall in this study, ultrasound prevented possible accidental organ puncture in 10% of cases and increased the rate of accurate site identification by 26% [9].

In 2009, Duncan *et al.* [10] demonstrated that post-procedural pneumothorax rate decreased from 8.6% to 1.1% ($p=0.0034$) following the introduction of ultrasound, although ultrasound was included as one of multiple quality improvement interventions, including formal training and structured competency standards. Mercaldi *et al.* [11] performed an observational cohort study of more than 61 000 patients undergoing thoracocentesis and found that ultrasound reduced the complication rate of pneumothorax by 19%, which had subsequent impacts on cost and length of stay. A meta-analysis found that ultrasound reduced the risk of pneumothorax with an odds ratio of 0.3 [12]. Furthermore, a retrospective analysis of almost 20 000 patients published by Patel *et al.* [13] in 2012 demonstrated a reduction in pneumothorax of 16.3% ($p=0.014$) and a reduction in post-procedural bleeding of 38.7% ($p=0.071$).

Significantly, these figures represent improvements with either bedside ultrasound or real-time ultrasound guidance. The practice of a patient undergoing departmental ultrasound in radiology and marking an appropriate site for intervention before having an intervention performed elsewhere, such as the ward or a procedure room, has been proven to be no better than interventions performed without ultrasound [14, 15].

As previously noted, TUS may also be used to guide more advanced pleural interventions, such as pleural biopsies or medical thoracoscopy. It has been demonstrated that this provides similar safety benefits by reducing the incidence of haemorrhage, pneumothorax and visceral injury, while also facilitating a high diagnostic yield of >90% [16–21].

Training and curriculum requirements

This evidence has resulted in ultrasound becoming a crucial component in the direction of pleural interventions. Due to requirements for bedside performance of ultrasound, the technique predominantly utilised by radiologists has been adopted as a key skill within physician and respiratory practice to facilitate ongoing patient safety. Specialist training curricula have evolved to reflect this development in practice. Within the UK, it is a mandatory requirement for specialist respiratory trainees to have achieved level one focused TUS competence prior to completion of training. The curriculum states that in order to be deemed competent, trainees must "be safe, efficient and competent at performing focused pleural ultrasound, be able to interpret focused pleural ultrasound and know the role of focused pleural ultrasound in the diagnostic evaluation of patients with pleural disease" [22]. The acute internal medicine curriculum states that trainees within the acute medicine programme must be fully competent to insert a chest drain using ultrasound guidance in order to complete training, although no formal assessment is defined [23].

Therefore, the demand for ultrasound training has increased exponentially as the increasing burden of pleural disease has resulted in a high demand for safe, effective pleural intervention. The ERS provides up to six ultrasound courses per annum. Candidate slots for ultrasound skills courses often fill up months in advance of the course taking place, and an upcoming course was filled to capacity within 10 days of being advertised. At times, these courses have even been oversubscribed by almost 400%. This demand for TUS training is only likely to increase further. A recent UK expert consensus paper has made the recommendation that staffing in each hospital around the UK should include the provision of one staff member who is adequately trained to insert a chest drain in an emergency situation, including under ultrasound guidance, 24 h a day [24]. With particular reference to remote district general hospitals and those with general staffing and rota issues, the limitations associated with providing constant respiratory cover are clear. This is likely to result in a further increase in the need for TUS training in other specialties, including acute and general medicine. The introduction of this highly specialised skill to a broader group and into non-specialist areas subsequently results in the need for high quality training, assessment and accreditation in order to safeguard quality and standards in practice.

Current training standards

At present, multiple agencies provide guidelines on assessing competence in TUS. In the UK, the Royal College of Radiologists first published ultrasound training recommendations in 2005 with subsequent updates in 2012 and 2017. A further recommendation document was also produced outlining the training requirements for undertaking focused ultrasound-guided procedures [25, 26].

The TUS document specifies the requirements deemed necessary to obtain competence in general TUS and creates three discreet tiers of competence based on a hierarchy proposed by the European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB) and supported by the British Medical Ultrasound Society. The defining characteristics of the three tiers or levels are displayed in table 1. This guideline also suggests that training should consist of both theoretical and practical components. Theoretical introductory courses are offered by many organisations, including the British Thoracic Society and provide a platform for trainees from which to begin their training. Stipulations also include the requirement for a named mentor or supervisor and the EFSUMB document suggests that a minimum number of scans and procedures for each anatomical region should be determined. In the case of TUS, this has been translated in the Royal College of Radiologists guidelines as one session per week for no fewer than 3 months, with approximately five scans per session, although it is recognised that variation amongst trainees will affect the rate at which skills are required. It is therefore suggested that a final assessment or sign-off should be conducted but the specifics of this are not defined. The guidance for focused, ultrasound-guided pleural drainage suggests observing 20 ultrasounds, performing 20 normal and 20 abnormal ultrasounds and performing 20 procedures [25–27].

The delineations within the levels of competence, along with the recommended minimum ultrasound experience and procedural requirements needed to attain these levels are based purely on expert consensus, with no evidence supporting the minimum experience criteria. Additionally, none of the recommendations include any statements regarding the use of technical skills training on models or simulators and competency assessment prior to performing the procedures on patients.

Competence

Competence is complex and multifaceted. A suggested definition from Epstein and Hundert [28] is of the habitual and judicious use of communication, knowledge, technical skills, clinical reasoning, emotions, values and reflection in daily practice. Pyramid of competence, first described by Miller [29] in 1990, defined the conceptual levels of competence and how these may be individually assessed. Competence progresses from “knows” to “knows how” to “shows how” and finally to “does” [28, 29].

Although many current individual assessment methods have proven reliable in that they consistently measure what they are designed to measure, they fail to adequately assess crucial domains that contribute to a definition of competence, such as the integration of knowledge and skills within a professional environment, thus reducing their validity. Multimodal assessment is therefore required to assess each facet of competence and meet each level of Miller pyramid, while compensating for the limitations recognised with individual assessment formats, as described by Epstein *et al.* [30] and displayed in table 2. It is also

TABLE 1 Minimum training requirements for the practice of medical ultrasound in Europe

Level 1: practice at this level would usually require the following abilities
To perform common examinations safely and accurately
To recognise and differentiate normal anatomy and pathology
To diagnose common abnormalities within certain organ systems
To recognise when referral for a second opinion is indicated
Level 2: practice at this level would usually require the following abilities
To accept and manage referrals from Level 1 practitioners
To recognise and correctly diagnose almost all pathology within the relevant organ system
To perform basic, non-complex ultrasound-guided invasive procedures
To teach ultrasound to trainees and to Level 1 practitioners
To conduct some research in ultrasound
Level 3: this is an advanced level of practice, which involves the following abilities
To accept tertiary referrals from Level 1 and 2 practitioners
To perform specialised ultrasound examinations
To perform advanced ultrasound-guided invasive procedures
To conduct substantial research in ultrasound
To teach ultrasound at all levels
To be aware of and to pursue developments in ultrasound

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TABLE 2 Commonly used methods of assessment

Method	Domain	Type of use	Limitations	Strengths
Written exercises				
Multiple-choice questions in either single-best-answer or extended matching format	Knowledge, ability to solve problems	Summative assessments within courses or clerkships; national in-service, licensing, and certification examinations	Difficult to write, especially in certain content areas; can result in cueing; can seem artificial and removed from real situations	Can assess many content areas in relatively little time, have high reliability, can be graded by computer
Key-feature and script-concordance questions	Clinical reasoning, problem-solving ability, ability to apply knowledge	National licensing and certification examinations	Not yet proven to transfer to real-life situations that require clinical reasoning	Assess clinical problem-solving ability, avoid cueing, can be graded by computer
Short-answer questions	Ability to interpret diagnostic tests, problem-solving ability, clinical reasoning skills	Summative and formative assessments in courses and clerkships	Reliability dependent on training of graders	Avoid cueing, assess interpretation and problem-solving ability
Structured essays	Synthesis of information, interpretation of medical literature	Preclinical courses, limited use in clerkships	Time-consuming to grade, must work to establish interrater reliability, long testing time required to encompass a variety of domains	Avoid cueing, use higher order cognitive processes
Assessments by supervising clinicians				
Global ratings with comments at end of rotation	Clinical skills, communication, teamwork, presentation skills, organisation, work habits	Global summative and sometimes formative assessments in clinical rotations	Often based on second-hand reports and case presentations rather than on direct observation, subjective	Use of multiple independent raters can overcome some variability due to subjectivity
Structured direct observation with checklists for ratings (*e.g.* mini-clinical-evaluation exercise or video review)	Communication skills, clinical skills	Limited use in clerkships and residencies, a few board-certification examinations	Selective rather than habitual behaviors observed, relatively time-consuming	Feedback provided by credible experts
Oral examinations	Knowledge, clinical reasoning	Limited use in clerkships and comprehensive medical school assessments, some board-certification examinations	Subjective, sex and race bias has been reported, time-consuming, require training of examiners, summative assessments need two or more examiners	Feedback provided by credible experts
Clinical simulations				
Standardised patients and objective structured clinical examinations	Some clinical skills, interpersonal behaviour, communication skills	Formative and summative assessments in courses, clerkships. Medical schools, national licensure examinations, board certification in Canada	Timing and setting may seem artificial, require suspension of disbelief, checklists may penalise examinees who use shortcuts, expensive	Tailored to educational goals; reliable, consistent case presentation and ratings; can be observed by faculty or standardised patients; realistic
Incognito standardised patients	Actual practice habits	Primarily used in research; some courses, clerkships, and residencies use for formative feedback	Requires prior consent, logistically challenging, expensive	Very realistic, most accurate way of assessing clinician's behavior
High-technology simulations	Procedural skills, teamwork, simulated clinical dilemmas	Formative and some summative assessment	Timing and setting may seem artificial, require suspension of disbelief, checklists may penalise examinees who use shortcuts, expensive	Tailored to educational goals, can be observed by faculty, often realistic and credible

Continued

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TABLE 2 Continued

Method	Domain	Type of use	Limitations	Strengths
Multisource ("360-degree") assessments				
Peer assessments	Professional demeanour, work habits, interpersonal behaviour, teamwork	Formative feedback in courses and comprehensive medical school assessments, formative assessment for board recertification	Confidentiality, anonymity, and trainee buy-in essential	Ratings encompass habitual behaviours, credible source, correlates with future academic and clinical performance
Patient assessments	Ability to gain patients' trust; patient satisfaction, communication skills	Formative and summative, board recertification, use by insurers to determine bonuses	Provide global impressions rather than analysis of specific behaviours, ratings generally high with little variability	Credible source of assessment
Self-assessments	Knowledge, skills, attitudes, beliefs, behaviours	Formative	Do not accurately describe actual behaviour unless training and feedback provided	Foster reflection and development of learning plans
Portfolios	All aspects of competence, especially appropriate for practice-based learning and improvement and systems-based practice	Formative and summative uses across curriculum and with-in clerkships and residency programmes, used by some U.K. medical schools and specialty boards	Learner selects best case material, time-consuming to prepare and review	Display projects for review, foster reflection and development of learning plans

crucial that any assessment is standardised to ensure consistency or reliability across time or geographical location [31, 32].

A log book may be a useful tool in assessing the highest level of competence as defined by Miller [29], but in isolation is inadequate to fully prove competence. Although some surgical studies have suggested a correlation between logbook recorded operative caseload involvement and the development of technical skills along with an encouragement to actively pursue learning opportunities, it has been suggested that logbooks do not deliver sufficient reliability or validity to allow for their use in accreditation purposes, and several studies have shown that they do not correlate with educational outcomes [33–38].

Several studies have also demonstrated significant variance within learning curve trajectories, questioning the validity and reliability of deeming competency following completion of a minimum number of procedures. Within a respiratory ultrasound setting, this includes significant variation in the attainment of competence in endobronchial ultrasound [39].

Bias may be introduced due to the limitations associated with logbooks such as subjectivity and the need for close scrutiny. Supervision or mentorship help to avoid this bias in assessment, but adequate prior assessment of the more basic levels of competence are required using formal structured methods.

Current UK TUS competence assessment is undoubtedly open to bias. No objective measurement of the more basic parameters of competence is undertaken and supervision of logbook-based assessment is also lacking. A survey of respiratory trainees demonstrated that 59% of respondents rarely or never received direct supervision, with only 42% receiving real-time review of images in cases where there was uncertainty [40].

The adequate definition and measurement of TUS competence is therefore challenging. It would appear that standard setting of a minimum number of procedures as the sole method of assessment is not appropriate due to different learning styles, variance of individual learning curves, subjectivity and the possibility of bias. Formal, structured, multimodal assessment tools are required in order to more adequately assess competence. Applying Miller's pyramid to TUS competence of any defined level would suggest that written assessments may best examine "knows" or "knows how". Objective structured clinical examinations provide satisfactory reliability to assess "shows how," while current methods such as logbooks may strengthen the validity associated with measuring "does" if applied and used robustly [33, 41].

Alternatives to current UK practice in TUS

Australasian practice

In 2017, the Thoracic Society of Australia and New Zealand published a position paper on recognition of TUS competence. This was produced by an expert panel and consists of completion of an introductory course, a logbook of at least 40 scans, two formative assessments after five to 10 scans and again after 20 scans, followed by a barrier assessment after 40 scans carried out by an independent assessor, with a minimum pass mark of 90% [42].

Formative and summative assessments in this pathway are all undertaken using the ultrasound-guided thoracentesis skills and tasks assessment test (UG-STAT). This tool assesses 100 points over 11 domains related to the British Thoracic Society guidelines, including familiarity with basic ultrasound parameters, recognition of ultrasound images illustrative of common pleural effusion appearances, as well as the ability to perform a TUS using a model or mannequin and to subsequently mark an appropriate site for pleural drainage. It has been validated to discriminate between novice, intermediate and advanced users [43].

This pathway would certainly appear more robust than current UK practice, and addresses each aspect of Miller's pyramid, but a number of limitations remain. The Thoracic Society of Australia and New Zealand recognise the inadequacy of using the number of scans to define competence; however, still concluded that a minimum of 40 scans was desirable based on expert consensus and comparison with other accepted pathways. The timing and necessity of formative assessment in this context was not investigated but it should be noted that assigned mentors may identify areas of deficiency in trainees in order that they may be addressed prior to formal assessment. One of the most significant areas of limitation appears to be in the definition of a pass mark. The original validation study demonstrated mean scores of 49.3 in the novice group, 73.0 in the intermediate group, and 91.5 for advanced practitioners. To obtain recognition of competence by the Thoracic Society of Australia and New Zealand, a score of 90% is required. This may not be achievable for some users, may not reflect the minimum standard required to safely undertake a procedure and fails to recognise the gradations of skill or competence between basic and advanced practitioners [42, 43].

European practice

No specific European TUS training programme exists at present, although the ERS does provide TUS training courses that conform to EFSUMB recommendations. They consist of pre-course online learning with assessment, followed by a 2-day course, including lectures and practical supervised ultrasound experience. The course culminates with a 15–30 min assessment consisting of a supervised ultrasound scan. The method used for this assessment is unclear, as is the subsequent definition of competence and the minimum requirements to achieve it.

Within European practice, however, a Danish group have developed a similar assessment tool to the UG-STAT, although this encompasses a much broader curriculum than pleural intervention guidance and includes diagnostic lung ultrasound, such as the identification of the interstitial syndrome. A comprehensive assessment such as this has its advantages but is less likely to be applicable at all levels, principally the most basic level which augments procedural competence. Although validation included assessment of novice, intermediate and expert groups, the clinical application in defining competence was not addressed in the development of this tool [44].

Endobronchial ultrasound

Endobronchial ultrasound (EBUS) represents another area in respiratory medicine in which the introduction of ultrasound has revolutionised practice. This is due to a similar diagnostic yield and reduced side-effect profile in comparison with mediastinoscopy. There is also an increased diagnostic yield when compared with conventional transbronchial biopsy, along with a reduced risk of inadvertent sampling of the myocardium, oesophagus or great vessels [45].

Issues surrounding the achievement and assessment of competence have become apparent and are similar to those evident in the assessment of TUS competence. One systematic review of 27 studies suggested that to achieve an accuracy of 80%, trainees should undertake a minimum of between 37 and 44 procedures. Although the definition of competence was somewhat unclear, the number of procedures required to achieve "competence" varied between 10 and 529; however, using a cumulative sum analysis this varied between 10 and 100. This serves to prove previous data that minimum numbers of procedures when taken in isolation are unreliable as a marker of competence, although expert consensus continues to differ [46–48].

In this field, a three-step approach has therefore been suggested comprising of theoretical learning followed by simulator-based learning prior to supervised practice involving patients. The first stage is based on the intuitive premise that theoretical knowledge is required before practical application. The second step has been applied because the EBUS assessment tool (EBUSAT) study demonstrated that training using a simulator produced higher scores using an objective scoring system when compared with those who undertook traditional apprenticeship style training. Finally, supervised practice on genuine patients is required to improve validity. This study resulted in the development of an objective EBUS assessment tool called the EBUSAT and subsequently a further assessment tool has been developed in the USA called the EBUS-STAT. These tools have been proven to be reliable and valid in their ability to discriminate between novice and expert operators [49, 50].

Therefore, the current ERS training programme has been developed to reflect this and contains a well-defined curriculum. It incorporates the three-stage approach of theoretical learning, which is assessed using multiple choice questions, a second stage of structured simulation training, followed by a portfolio of 20 cases, of which three must be submitted by video for assessment using the EBUSAT tool, although the justification for using 20 cases as a minimum requirement is unclear [51].

Echocardiography

Traditional assessment of competence in echocardiography is similarly based on recording a minimum number of scans presented in a logbook. Recently, this has developed somewhat further to incorporate other formal objective measurements. The European Association of Cardiovascular Imaging is part of the European Society of Cardiology and provides accreditation in transthoracic echocardiography. Requirements include an intensive theory examination followed by completion of a logbook of at least 250 cases. The British Society of Echocardiography accreditation has the same requirements; however, it is possible to achieve the more basic level one accreditation following completion of a logbook with 75 cases over a 12-month period, followed by an assessment, including review of the logbook, a live assessed scan and interpretation of video clips. Accreditation information on transthoracic echocardiography can be accessed from the society websites (www.escardio.org and www.bsecho.org). Similar problems have been identified with regard to the use of a logbook alone to define competence in this cardiology context. Conflicting evidence has been published, although overall it would appear that logbooks in isolation are insufficient, as has already been suggested. This has resulted in the development of alternative methods such as objective structured assessments, including the use of simulators. Despite the development of such assessments, they have yet to be widely adopted [52–54].

Focused intensive care echocardiography training has been developed to facilitate more widespread integration of echocardiography in a critical care context. The current pathway requires engagement with an initial teaching day, including both didactic and practical sessions followed by completion of a logbook including 10 directly observed scans, 40 further scans and a final observed assessment. The rationale for setting a total of 50 scans as an acceptable benchmark is based on a solitary study that demonstrated an acceptable level of performance from six trainees who completed an average of 33 scans each. The study therefore postulates that 30 scans may be a reasonable number to achieve competence, as performance was improved when compared with a previous pilot study with a mean number of 15 scans. It is not clear whether attributing these improvements to increasing experience represents a true causal relationship or whether curriculum modification and improved initial teaching with the inclusion of interactive clinical cases acted as a confounding factor. No direct measurement of competence with increasing scan volume was undertaken. As a result of these findings, the Intensive Care Society recommends a minimum of 50 scans to allow for differing levels of skill acquisition [55, 56].

Future directions for TUS competence

It is clear that ultrasound has become a crucial component of thoracic medicine by improving the safety profile of frequently undertaken interventions, as well as providing a valuable diagnostic tool. Its uptake continues to increase both within this context and also in other specialist areas. Assessment of competence is, therefore, critical to ensure patients receive high-quality, effective and safe care; however, current methods allow for significant bias and do not appear to be robust enough to provide adequate rigour.

Current medical education thinking would suggest that competence requires knowledge, technical and nontechnical skills, as well as clinical reasoning and its application into individual scenarios. An international multispecialty group has suggested that when this is applied to ultrasound competence, the criteria required to demonstrate competence include recognition of the indication for the examination, applied knowledge of equipment, an ability to obtain and optimise an image and performance of a systematic examination, as well as appropriate interpretation and documentation of the images, leading to sound medical decision making. This has led to the formulation of a generic objective structured assessment of technical skills [57]. In the simplest terms this would suggest that assessment should ensure the ability to produce a good image with appropriate interpretation of that image leading to a correct clinical decision.

Although attempts have been made to improve assessment methods in TUS, at present UG-STAT and the Danish assessment tool based on objective structured assessment of technical skills provide the only current validated assessment tools; however, each of these are associated with a number of limitations. One significant limitation with UG-STAT is that the pass mark has been validated to correspond with advanced practice and as such, fails to recognise the gradations of competence present in clinical practice and ignores that a more basic standard may be satisfactory for practice in certain straightforward scenarios [43]. The Danish tool encompasses a much wider definition of TUS consistent with the prevailing European perspective and, in particular, integrates the role of TUS as a diagnostic tool in the assessment of a wide range of intrathoracic pathologies, including pneumothorax or the interstitial syndrome, as well as pleural effusion and pleural procedural guidance. This may not be necessary for those undertaking basic TUS training but may be suitable for incorporation within the more advanced levels [44, 57].

To practically apply the EFSUMB and British Medical Ultrasound Society recommendations for tiers or levels of competence to TUS, we would suggest that level one corresponds to the ability to produce an adequate image, identify a large simple effusion and make the correct decision to proceed to intervention. This level may be more appropriate and achievable for those whose pleural experience is more limited, such as junior respiratory trainees or trainees from other specialties such as acute internal medicine. Level two may correspond to the ability to identify and intervene in smaller, more complex effusions and is likely to represent a level achievable by more senior respiratory trainees. Subsequently, level three would then represent those with a subspecialist interest in pleural disease who can undertake more advanced procedures, such as the use of live in-line ultrasound guidance, motion mode or perform image-guided pleural biopsies of pleural thickening. The inverse should also be considered, such that in level one, the identification of a more complex effusion or pathology not previously seen should result in no procedure being undertaken but instead input sought from a level two or three practitioner. This hypothesis for a new definition in the gradations in competence is not dissimilar to a suggested definition provided by the recent UK expert consensus presented in table 3. Although the standards of practice described could be

TABLE 3 Thoracic ultrasound (TUS) competency levels

Emergency-level TUS operator	Completed an introductory TUS session and has a basic understanding of ultrasound machines and examinations Logbook of five normal TUS and live large pleural effusions of >5 cm depth Satisfactory summative DOPS to identify thoracic and abdominal cavity structures (diaphragm, lung, heart, rib, liver, spleen and kidney) Satisfactory summative DOPS to identify a large pleural effusion >5 cm depth and to guide intervention
Basic-level TUS operator	Completed a structured TUS course and has a basic understanding of ultrasound physics, modes of ultrasound, anatomy of thoracic cavity and simulated experience Ability to identify small pleural effusions and complex/septated pleural effusions Ability to identify gross malignant pleural nodularity; for example, diaphragmatic nodularity Ability to identify consolidated and atelectatic lung Ability to assess lung sliding 2x satisfactory summative DOPS in a "challenging USS case". Examples of this include: small pleural effusion on CXR, consolidation *versus* collapse *versus* effusion on CXR and loculated effusion on CXR/CT Logbook of procedures including >60 ultrasound procedures including normal scans, pleural effusions and identification of sites for intervention The logbook should include minimum of 10 thoracic ultrasounds of small effusions <5 cm, complex/septated effusions, pleural nodularity or consolidated/atelectatic lung
Intermediate-level TUS operator	Minimum of 2 years' experience as a basic-level TUS operator Ability to detect A-lines and B-lines in lung ultrasound Ability to identify and assess pleural thickening Ability to assess diaphragm function on ultrasound Ability to perform real-time pleural aspiration and chest drain insertion when required Ability to use ultrasound help guide site for indwelling pleural catheter insertion (scanning patients in lateral decubitus position) Annual review and appraisal of practice including standardised outcome measures
Advanced-level TUS operator	Advanced TUS practitioners who performs minimum of 100 TUS per year Ability to perform real-time image-guided pleural biopsy Ability to use M-Mode, colour and Doppler in appropriate setting Annual review and appraisal of practice including standardised outcome measures

CXR: chest radiograph; CT: computed tomography; DOPS: direct observation of procedural skills.

directly adopted, assessment methods would need to be adapted further as definition of these competency levels is primarily based on minimum number of scans and logbooks. Directly observed assessments have been added to provide a measure of objectivity but are unlikely to be as objective or robust as a bespoke multimodal assessment tool [24, 26, 27].

Therefore, the currently available validated assessment tools do not appear to be sensitive or specific enough to apply to this context of pleural procedural guidance, nor does their current clinical application adequately discriminate between gradations of competence.

Assessment for these new levels of competence must be multimodal. A written component is likely the best method to assess the most basic level of Miller's pyramid's to "know". Multiple choice questions or extended matching questions appear to produce the best reliability. It could be suggested that this need only be tested at the basic level one as this provides the foundation from which other skills are developed. The "knows how" and "shows how" categories are most likely best assessed using objective structured clinical examinations; however, in contrast, this is likely to require repeat assessment as each level progresses. The requirement for real patients with genuine findings may be the most valid assessment medium, although this is unlikely to be practical on the large scale required. High-fidelity simulators have been proven to be valid and reliable in a number of examination settings, including ultrasound and in particular, a validated TUS simulator test has been recently developed. The final assessment of "does" is likely best measured using either portfolios with ongoing summative and formative assessments or logbooks with supervision; however, minimum numbers of procedures or scans not only remain undefined but may not be a valuable metric given the uncertainty around the validity and the variations in learning curves [31, 33, 39, 41, 43, 54, 58].

As a result, further work is required in a number of areas. A valid and reliable assessment tool is required, and this could either take the form of a solitary tool that discriminates between levels one and three or a number of separate assessment tools instead separately validated for each individual level. It may also be possible to measure the mean number of ultrasound scans associated with the achievement of competence at each level; however, any studies are likely to be difficult to accurately interpret given the wide variations in individual learning styles as well as other factors such as the degree of supervision or complexity of cases encountered. Therefore, it would seem most prudent that future research should primarily concentrate on the development of valid and reliable assessment tools that define and adequately discriminate between the various gradations of competence. It may also be necessary to undertake a similar approach toward the development of a separate assessment tool to independently address procedural competence of the invasive pleural procedure, such as thoracocentesis. Following the introduction of UG-STAT into clinical practice, the same Australian group has already developed one such example [59].

Conclusions

Pleural disease continues to increase in prevalence and intervention is commonly required. The value of ultrasound and the requirement in directing interventions to ensure safety is undisputed. This already crucial skill appears only to be increasing in importance and in popularity including amongst nonradiological or nonrespiratory specialties. Current assessment methods, such as logbooks requiring minimum numbers of procedures, do not appear to be adequately rigorous or robust due to their unsatisfactory validity and reliability. Subsequently, we suggest that further research should primarily be focused upon the development of valid and reliable assessment methods that also adequately reflect the variation of competence required in clinical practice.

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