REVIEW

CURRENT OPINION

Competency-based medical education in interventional pulmonology: current state and future opportunities

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Purpose of review

This chapter examines the evolution and current status of competency-based medical education (CBME) in interventional pulmonology, focusing on procedural skills assessment and training.

Recent findings

Traditionally, interventional pulmonology training has used an apprenticeship model with case logs and director attestation, leading to inconsistent outcomes due to a lack of standardized curricula. CBME, established to address these issues, relies on outcome-based assessments to ensure trainees achieve necessary competencies. The chapter reviews various assessment tools, including global rating scales, checklists, and simulation-based methods, and their effectiveness in skill acquisition and clinical evaluation. It also covers specific procedures such as EBUS-TBNA, electromagnetic navigation bronchoscopy, and rigid bronchoscopy, discussing their assessment tools and learning curves. The chapter emphasizes the need for standardized assessment tools and suggests using entrustable professional activities (EPAs) to improve competency evaluation. Future directions include integrating real-time artificial intelligence feedback, addressing high-risk low-volume procedures, and enhancing workplace-based assessments to improve interventional pulmonology training and patient care quality.

Summary

This chapter reviews the transition from traditional apprenticeship models to CBME in interventional pulmonology, highlighting advancements in procedural skills assessment, the effectiveness of various assessment tools, and future directions for improving training and patient care.

Keywords

bronchoscopy, competency based medical education, interventional pulmonary, medical education

INTRODUCTION

Interventional pulmonology training programs started in 1996, as the need for specialized education in advanced bronchoscopy and pleural techniques was recognized. Since that time, interventional pulmonology has grown to include 42 individual training programs in the United States and achieved accreditation from the Accreditation Council for Graduate Medical Education (ACGME). Traditionally, training in interventional pulmonology has been an apprenticeship model and competency deemed by surrogate measures (case logs and program director attestation). Outcomes from this model of training are varied, as there is no standardized curriculum and few standardized assessments [1▪]. In contrast, competency-based medical education (CBME) uses an outcomes approach to ensure all trainees have achieved the appropriate patient-oriented competencies prior to graduation. This approach has been embraced by the Royal College of Physicians and Surgeons of Canada [2] as well as the American Board or Surgeons [3▪,4,5]. Interventional pulmonary requires trainees to master multiple procedural skills; however, the new ACGME requirements do not stipulate procedural numbers or methods to objectively determine competency. For the field of interventional pulmonology to move towards CBME, the development of tools to directly assess competency of trainees remains a top priority.

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KEY POINTS

- Interventional pulmonology training has evolved from an apprenticeship model to a competency-based medical education (CBME) approach, focusing on standardized assessment tools.
- The use of assessment tools with evidence for validity is crucial for evaluating procedural skills and learning curves in interventional pulmonology.
- Simulation training has proven effective in accelerating competency acquisition and should be integrated into interventional pulmonology training programs.
- The development of entrustable professional activities (EPAs) could enhance competency assessment and bridge gaps in current training methods.
- Addressing high-risk, low-volume procedures through targeted training and assessment is essential for comprehensive interventional pulmonology education and patient safety.

This chapter will review the current state of CBME in interventional pulmonary, with a focus on procedural skills assessment tools with validity evidence, procedure-specific training suggestions, and explore how the use of entrustable professional activities (EPAs) may help us bridge the gap toward achieving CBME.

VALIDATED MODELS FOR PROCEDURAL TRAINING ASSESSMENT AND LEARNING THEORY

Assessing competency requires multiple tools to capture distinct realms in adult learning including cognitive assessment, skills mastery, clinical performance assessment, and ongoing education through professional review of cases [6].

The tools should provide a sound assessment of knowledge and skill and help educators monitor both trainee and program performance [7]. Before using any assessment tool, one should investigate the evidence for the validity of its interpretation. Messick's unitary framework of validity proposes that all validity is 'construct' validity gathered from different sources [8]. This method of validity assessment is frequently utilized to develop and establish evidence for the validity of assessment tools. The five sources of validity evidence are summarized in Table 1.

Ultimately, validity is a property of the interpretation of the tool and not of the tool itself. This is well stated by Downing, 'Validity requires an evidentiary chain which clearly links the interpretation of …scores…to a network of theory, hypothesis, and logic which are presented to support or refute the reasonableness of the desired interpretations') [9]. As an example, the evidence must show that the test scores of an assessment tool correlate to a proposed outcome such as competency or patient safety and should ideally be able to distinguish levels of expertise.

In procedural teaching, there are two broad approaches to skills assessment and include global rating scales (GRS) and checklists. GRS are subjective but widely applicable and can be modified to assess different procedures. Checklists are a structured format in which a trainee must appropriately identify sequential steps to performing a procedure correctly and can be used as guidance in longer complex procedures [6]. GRS are useful, as they typically have high average inter-item and inter-station reliability and may be better at detecting nuanced elements in developing expertise. Both checklists and GRS have high inter-rater reliability [10]. Pairing GRS and checklists is often employed to develop actionable assessments.

Standard setting in medical education has been described in several articles, which are often done through one of the methods for setting performance standards described in Table 2 [11,12].

The standard setting methods described in Table 2 are useful to set passing scores and develop and gather evidence for validity of an assessment tool. In clinical/procedural training, an emphasis can be placed on the patient safety method, and subsequently contrasting groups methods when evaluating for competency and subsequently expertise. These tools can also be used to develop learning curves to assess and reassess performance over time.

Table 1. Sources of validity evidence [1▪]

Sources of validity evidence				
Content	**Response process**	**Internal structure**	**Relationship to other variables**	**Consequences**
Blueprint of questions, checklist, who designed the tool.	Instructions for students, rater training.	Measure of internal consistency/reliability of a test such as Cronbach's α.	Comparison of two groups such as score difference between novice and experts.	Identification of pass/fail scores. Or effects of administering the tool.

Table 2. Standard setting methods

Method	Description	Key features	References
Angoff method	Used to develop performance standards for pass-fail systems by having content experts make judgments about item difficulty. Allows setting of cutpoints without direct observation of individuals.	Subjective assessments; no direct observation; focuses on expert judgment.	Ben-David 2000 Yudkowski 2020
Ebel method	Experts assess the difficulty and relevance of each test item, correlating it to a point matrix. Pass mark is based on the combination of probabilities that a borderline candidate will answer correctly. Unlike Angoff, it uses an absolute standard rather than relative performance	Combines difficulty and relevance; absolute standard; frequently used in high-stakes examinations	Downing 2006, Yudkowski 2020
Hofstee method	Considers examination characteristics when identifying cut scores. Experts determine minimum/maximum passing scores and acceptable failure rates.	Considers examination characteristics; focuses on passing score limits and acceptable failure rates.	Downing 2006, Yudkowski 2020
Contrasting groups	Identifies cut points by comparing two contrasting groups (e.g., experts versus novices) based on checklist scores and global ratings by experts. The cut point is set to distinguish these groups and reduce false positives.	Examines performance across categories; frequently used in procedural assessments and learning curves.	Livingston 1982 Downing 2006
Borderline group	Experts observe examinees directly and calculate the median score of borderline performers to determine the pass/fail cut point. Often used for standardized patient encounters.	Direct observation; median score of borderline performers used as cut point.	Downing 2006
Patient safety method	Focuses on patient-centered outcomes by assigning higher importance to critical components impacting patient safety. Passing scores are based on essential and nonessential items, with essential items being crucial for passing.	Prioritizes critical components for patient safety; passing score dependent on essential items.	Yudkowsky 2014

Learning curves are a form of measurement used to associate the learning effort, via number of procedures performed, and the subsequent learning outcome. Learning curves can then be created for individual trainees to assess when competency in a procedure has been achieved based on assessment tools with published validity evidence for their use in training/simulation. Key defining factors for learning curves depends upon the assessment method; some assessments may be checklist based (i.e. does a trainee know basic steps to performs procedure) vs. clinical outcomes (i.e. is the desired outcome achieved such as diagnostic yield) [13].

PROCEDURE-SPECIFIC COMPETENCY-BASED TRAINING

General training concepts

The most studied procedure assessment outside of direct patient care is simulation whether that is low-fidelity models through plastic models or high-fidelity simulators/cadavers. One systematic review and meta-analysis showed increased benefits toward skills, behavior, and time to completion when compared to standard training [14] Importantly, it was noted in the same study that structured authentic clinical context added increased validity to the simulation training. This same meta-analysis also showed that low-fidelity simulation training performed slightly better than high fidelity simulation training making simulation more easily accessible and readily available compared to expensive simulators [14]. Additionally, simulation training has been shown to decrease time to achieve competency in basic bronchoscopy [15]. The importance of simulation is highlighted by the fact that there are increased procedural complications when trainees are the primary bronchoscopist [16]. Overall, the body of evidence supports simulation training as a preceding factor to patient care and will form the basis of low-stakes evaluation of clinical skills.

Inspection bronchoscopy

Inspection bronchoscopy is an essential skill set in interventional pulmonology. In order to assess baseline competency, the Bronchoscopy Skills and Tasks Assessment Tool (BSTAT) and Bronchoscopy Step by Step Evaluation Tool (BSET) were developed using virtual reality simulation training [17]. This tool has been used subsequently in the clinical context and has been able to differentiate between learners at different levels [15]. Konge *et al.* [18] developed a novel bronchoscopy assessment tool that could be used after the fact and was done with recorded bronchoscopies. This tool was able to distinguish between different learner levels and had the advantage of eliminating bias that can occur as a result of the human relationship between the rater and ratee [18]. Both the BSTAT and tool developed by Konge *et al.* [18] focused mainly on the technical aspects of the procedure. A group out of Ontario subsequently developed the Ontario Bronchoscopy Assessment Tool (OBAT) to provide assessment of all aspects of the basic bronchoscopy procedure including pre-procedural and post procedural aspects. This novel 12-point tool is based on an entrustability scale and was developed to be used clinically [19]. The OBAT was tested with novice and advanced fellows and was able to accurately distinguish between the groups. When used longitudinally, it also showed significant variation in learning curves before competency was achieved [20]. This highlights the importance of using assessment tools to determine competency rather than a global 'minimum number.' Recently, an interesting study on training in inspection bronchoscopy demonstrated that simulation training was superior to the traditional model of teaching with apprenticeship [21]. Siow *et al.* [21] demonstrated that structured simulation training led to improved cognitive and technical skills performance compared to the control group highlighting the central role that simulation training deserves in bronchoscopy education.

EBUS-TBNA: EBUS-STAT

Endobronchial ultrasound-guided transbronchial needle aspiration (EBUS-TBNA) typically represents the first step up in skill from basic diagnostic bronchoscopy where learners must integrate 2D imaging with a knowledge base of airway anatomy, mediastinal anatomy, and radiology. Importantly, when teaching the anatomy acquisition of EBUS, emphasis should be placed on consistency in procedural planning and evaluation to avoid procedural errors in mediastinal diagnosis and staging. One approach is the six landmarks approach utilized by the European respiratory society (ERS) described in Table 3 [22].

Table 3. Six landmarks approach to EBUS anatomy from the European respiratory society [2]

Six landmarks approach to EBUS	
Landmark 1	Station 4 L: cranial to carina, between the aortic arch and the left pulmonary artery.
Landmark 2	Station 7: place the scope in the right or left main bronchus with the scope facing medially between the right pulmonary artery and the left atrium below the carina.
Landmark 3	Station 10 l left main bronchus cranial to the left upper lobe. The upper border of the left pulmonary artery separate station 4 and 10 L.
Landmark 4	Station 10 R: lateral wall of the right main bronchus inferior to the azygous vein.
Landmark 5	The azygous vein which can be seen draining into the superior vena cava.
Landmark 6	Station 4R superior to the azygous vein

References: data from [22,50].

To evaluate procedural competence in EBUS, the endobronchial ultrasound skills and task assessment tool (EBUS-STAT) was developed. This 10-section check-list based assessment has published outcomes of the tool with respect to content, internal structure, and relationship to other variables. It has been used as an objective measure of competency for EBUS [23]. Similarly, the EBUS Assessment tool (EBUSAT) is a 12-item assessment tool developed by experts and has demonstrated high internal consistency, high discrimination ability, and assigned a pass/fail standard utilizing the contrasting groups methods [24]. Subsequent studies show these tools can guide learners through multiple high or low fidelity simulation models [25], with simulation again appearing to be more effective in the initial learning curve phase compared to apprenticeship training [24].

A systematic review of simulation-based studies revealed overall that simulation is an effective method for initial training and assessment of competency in EBUS-TBNA [26]. Studies of learning curves for EBUS demonstrate that competency is achieved somewhere between 55 and 60 procedures [27]. This learning curve may be shortened if a trainee completes a minimum of 30 standard bronchoscopies prior to EBUS training. The new learning curve in this setting was an average of 13 procedures [28]. It is important to note however that the expertise required of interventional pulmonology physicians is likely higher, as expert level was not attained until an average of 164 procedures and efficiency continued to improve even up to 200 cases [29].

Electromagnetic navigation bronchoscopy: LEAP

Electromagnetic navigational bronchoscopy (ENB) is a method for sampling peripheral lung nodules. A published tool to assess skill in simulation for ENB is the learning electromagnetic navigational bronchoscopy (LEAP), which assesses procedural planning, equipment set up, navigation, and biopsy outcomes [30] This tool was then used to develop learning curve for ENB competence in a multicenter study [31]. Competency was thought to be able to be achieved by all learners after 15 procedures. A limitation of this study was that no second slope was found on the learning curve indicating that these learners had not yet achieved mastery.

Although the steps of ENB may be learned quickly, obtaining consistent clinical outcomes may take longer, as Toennesen *et al.* [32] demonstrated an average of 40–50 cases to consistently obtain a diagnostic yield from the procedure.

Rigid bronchoscopy: RIGID-TASC

The Rigid Bronchoscopy tool for assessment of Skills and Competence (RIGID-TASC) tool is a 23-point checklist evaluation that demonstrated a high degree of discrimination between learners [33]. Initial learning curves demonstrated competency of trainees between 5 and 24 rigid bronchoscopies with an average of 15 [34]. Limitations of this tool include a probable ceiling effect, as assessment beyond the basics of rigid bronchoscopy (intubation and navigation) are not factored into the assessment.

Thoracoscopy, ultrasound, and pleural procedures

The Ultrasound-Guided Thoracentesis Skills and Task Assessment Test (UGSTAT) is an 11-domain 100-point combined check list and global rating scale to use ultrasound guidance for pleural procedures [35]. Validity evidence for its use consists of its ability to stratify novice, intermediate, and advanced learners for skill assessment of bedside ultrasound to identify the appropriate location to perform a thoracentesis.

Chest tube placement: TUBE-iCOMPT

Salamonsen *et al.* [36] developed and validated a five-domain 100-point assessment tool entitled Chest Tube Insertion Competency Test (TUBE-iCOMPT). This tool can be utilized for either Seldinger or blunt dissection chest tube placements. The five domains are scored via a checklist with an additional subjective global rating. The assessment tool demonstrated excellent stratification of learners as well as high reliability. Potentially, with some modifications, the TUBE-iCOMPT could be modified to assess competency in placement of tunneled indwelling pleural catheters.

Local anesthetic thoracoscopy

The Local Anesthetic Thoracoscopy Assessment Tool (LATAT) was developed by pulmonary and education experts utilizing Messick's framework of validity with the final assessment tool being composed of eight-item checklist of procedural categories and a global rating scale. Utilizing the contrasting groups method, they developed a pass-fail standard with excellent validity outcomes to be utilized as a formal assessment tool [37].

Teaching new thoracoscopy skills in a 2-day postgraduate course has also been showed to be effective and feasible using pre and post testing for knowledge and skills assessment [38]. Use of assessment tools to demonstrate efficacy of postgraduate education in these advanced skills is recommended.

Percutaneous tracheostomy

Percutaneous tracheostomy is another common procedure in interventional pulmonary. De la Fuente *et al.* [39] developed a check list of important steps through a Delphi process, which could be used as a checklist toward a validated assessment tool. In the surgical literature, the Objective Surgical Assessment of Tracheostomy skills (OSTS) tool has validity evidence for assessing surgical tracheostomy [40]. Studies have demonstrated that simulation training is important when learning this procedure, as it increased skills, timing, and feelings of safety [41]. A combination of the checklist by De la Fuente *et al.* [39] and OSTS could form the basis to develop and validate an assessment tool specifically for bronchoscopic-guided percutaneous tracheostomy.

High-volume low-risk vs. low-volume high-risk procedural training

An area for potential improvement in interventional pulmonology education is to develop training methods for high-risk low-volume procedures. Given their rarity, these procedures are not focused on however, deeming graduates as competent without the ability to independently manage elevated risk scenarios could be deleterious to patients. One study in the training of critical care fellows has shown that there is little if any formal training in the low-volume high-risk procedures. Comparatively, trainees are well trained with simulation and hands on experience when it comes to high-volume low-risk procedures [42].

Examples of high-risk low-volume procedures in the interventional pulmonology arena could include, massive hemoptysis, tracheoinnominate fistulas, and surgical chest tubes. There has been recent innovation to create massive hemoptysis simulations and curriculums [43■■,44■■].

CONTINUING MEDICAL EDUCATION IN INTERVENTIONAL PULMONOLOGY

Consideration should be made to the potential of skill decay during time away from clinical training (such as research years) or practicing physician who infrequently performs a procedure. Per our review, there have not been any studies evaluating skill decay in bronchoscopy specifically, but a scoping review found five perception-based studies in general surgery residents with trainees feeling their skills had deteriorated during time away from clinic work (e.g. research years) [45]. In one laparoscopic simulation study, general surgery residents passed an initial simulation examination looking at seven technical skills required for laparoscopic surgery. Retesting after 6 months revealed that a sizable portion of trainees were unable to pass some parts of the initial examination [46].

Furthermore, spaced competency assessment in generating learning curves may be beneficial in multiple ways, including, identify areas of weakness near end of training, but prior to completion, provide CME for those taking time away from training for research years, and provide opportunities for those who are in practice that would benefit from skill refresher courses.

FUTURE DIRECTIONS

It is an exciting time for the field of interventional pulmonology due to its rapid growth as a field and the advent on modern technologies such as electromagnetic navigation, robotics, and ablation. Interventional pulmonology is now ACGME accredited, and a standardized curriculum for programs has been published. In this study, we reviewed current assessment tools, their evidence for validity, and where learning curves have been demonstrated. This body of work is commendable; however, there is still work to be done. Some studies reviewed herein did not demonstrate a second slope in the learning curves. This indicates the learners achieved basic competency; however, this does not always translate to clinically relevant diagnostic yield, or achieving mastery of a procedure. How do we move toward workplace-based assessments that can be used during daily clinical activities and include metrics like diagnostic accuracy, procedure time, and patient outcomes to help determine mastery [47■■]?

One way to potentially bridge this gap is utilizing EPAs. EPAs are observed behaviors (or a unit of work) that physicians do (such as managing a patient with a specific medical condition). This is different than a competency, which is instead a broad domain of ability such as medical knowledge. This has been studied in other medical fields and has served to operationalize competency evaluation and related entrustment decisions in patient care. Developing EPA's specific to the practice of interventional pulmonology are needed and would enhance skill assessment and be an aid to determining graduates' ability to practice independently.

Another strong area for growth in the field is the use of artificial intelligence real-time feedback in simulation and potentially clinical cases combining ergonomic, motion analysis, and diagnostic yield [48■■,49].

Finally, competency-based training on high-risk low-volume procedures: management of massive hemoptysis, emergency airway management in central airway obstruction, or tracheoinnominate fistula should be further explored.

CONCLUSION

Interventional pulmonary training is entering a new era with the formal accreditation by the ACGME. This move will continue to improve programs through standardization of curriculum and transparency of training. Competency-based education is an important part of this change. Embracing CBME will provide direct observations on frequent evaluations of performance to drive both feedback and learning. There are currently many excellent assessment tools that have been developed in the field of interventional pulmonology and should be used to establish basic competency for trainees. Future directions involve moving these assessments into the workplace, which may be best done through the development of interventional pulmonology specific EPAs.

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Conflicts of interest

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■ of special interest
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