11 Simulation for Endoscopy Training

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Introduction

Bronchoscopy is a common procedure, with an estimated 500,000 bronchoscopies performed annually in the United States. It is mainly performed by pulmonologists, but surgeons, anesthesiologists, and intensivists also perform this procedure for a variety of diagnostic and therapeutic purposes. Acquisition and maintenance of bronchoscopy skills for both novice and advanced learners is an issue of high priority to ensure optimal delivery of health care and reduce errors and complications. Simulation presents a new option in the armamentarium of skill teaching and is positioned to play an essential role in the education of current and future physicians. In this chapter, I will review the current state of bronchoscopy training and the evolving role and data on simulation in bronchoscopy.

Current Training of Bronchoscopy

There are currently no published guidelines for bronchoscopy training. In 2003, the American College of Chest Physicians recommended the number of yearly procedures needed to establish or maintain competency in advanced bronchoscopic procedures.

Flexible bronchoscopy training for pulmonologists in the USA takes place during a 2–3-year fellowship following internal medicine residency. The Accreditation Council for Graduate Medical Education (ACGME) requires the performance of 100 bronchoscopies per pulmonary trainee in order to graduate. The current method of learning bronchoscopy relies on the traditional apprenticeship model, the so-called "see one, do one, teach one" philosophy.

In this model, the learners acquire some basic understanding of the procedure by simple observation then hone their skills by practicing on patients under faculty supervision. No prior training or assessment of the learners is usually carried out or required prior to performing the procedures on patients.

The advantage of this teaching model is the opportunity for the learner to learn directly from a skilled operator with one-on-one mentoring; however, the disadvantages are abundant including the lack of consistency in teaching methodology across training centers, subjective evaluation of skill acquisition, and unnecessary and taxing practice on individual patients.

A few surveys of pulmonary fellows' bronchoscopy training over the last decade found that most procedural training is obtained "on the job" via individualized instruction from faculty; very few training programs offered structured curriculum or hands-on experience at the onset of training.

Competency in bronchoscopy among trainees is currently established based on procedures' number and a global subjective assessment of faculty observers. Pulmonary fellowship training programs require the performance of at least 100 bronchoscopies for pulmonary trainees to achieve competency.

A number-based competency metric does not test the cognitive component of procedural learning, nor does it account for variation in the number needed for an individual learner to acquire a skill.

Emerging Tools for Bronchoscopy Education

Realizing the limitation of the apprenticeship model, educators have sought other venues to provide practical education of bronchoscopy. These include extracted and preserved animal lungs, live animals, cadavers, inanimate airway models, and airway simulation software. While the first three options

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can be effective teaching tools, they are fraught with issues such as ethics of animal and human tissue use, durability of models, infectious risks, and the burden of regulatory oversight. The use of airway models or airway simulation software, lo- or hi-fidelity simulation respectfully, eliminates these issues and represents an effective alternative for the teaching of bronchoscopy.

Simulation in Bronchoscopy Education

Simulation offers an effective method of teaching procedural skills which avoids using animals and offers a scenario-based interaction that imitates real-life situations. Other disciplines, such as the aviation industry, where errors also can have serious consequences rely heavily on simulation learning and assessment of continued competence.

Simulation technology in bronchoscopy is available in two forms: lo-fidelity inanimate mechanical airway models and hi-fidelity computer-based electronic simulation.

Lo-fidelity Simulation

Lo-fidelity models consist of molded tracheobronchial trees that offer realistic tubular-shaped airway-like structures with accurate anatomy to the first subsegmental bronchial level. Figure 11.1 shows an example of such a model, the CLA Broncho Boy (CLA, Coburg, Germany). A lo-fidelity model can be an excellent tool for novice operators to memorize airway anatomy, build muscle memory, and enhance hand-eye coordination. Lo-fidelity simulation offers a cheap alternative to the costly hi-fidelity simulation and can be effective in teaching bronchoscopic skills. The main disadvantage is the lack of interactive capability which limits situational learning and the limited ability to teach various iterations of the airways including abnormal anatomy or pathologic findings.

Domenico et al. were able to build a real-scale anatomically accurate bronchoscopy model that cost less than $30 by utilizing iron wires, newspaper sheets, and glazier putty. Goldberg and colleagues built a hybrid model, connecting a plastic tongue and larynx to a porcine trachea and main-stem bronchi as a teaching tool for transbronchial needle aspiration (TBNA) for <$200; the model was viewed, by novice and experienced learners, as realistic and helpful in improving TBNA skills.

In the only study that compared lo- and hi-fidelity simulator as teaching tool in bronchoscopy, the author of this chapter and his colleagues performed a prospective randomized crossover design to train study participants in three methods of conventional TBNA using lo- and hi-fidelity models. Learners felt the models were equally enjoyable and enthusiasm generating but preferred lo-fidelity models in terms of realism and ease of learning. Instructors shared this sentiment with the students and regarded the lo-fidelity model as a more effective teaching instrument for TBNA. This preference for lo-fidelity simulation in this study is not generalizable to all aspects of bronchoscopy learning, but it highlights the effectiveness of lo-fidelity models in procedures that require some tactile feedback such as TBNA (needle insertion through tissue).

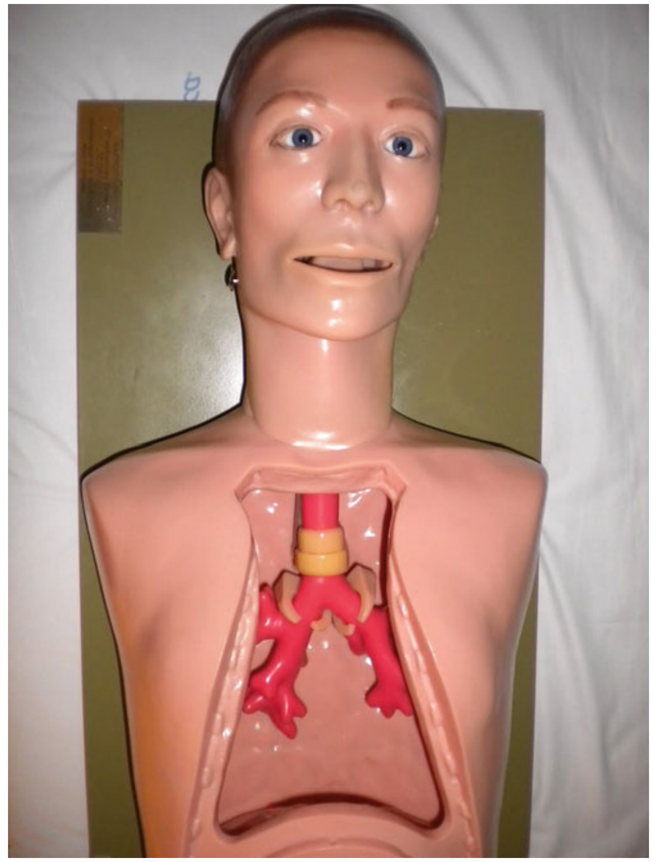

Fig. 11.1 A lo-fidelity mechanical airway model for bronchoscopy teaching

Hi-fidelity Simulation

Hi-fidelity simulators are computer-based and rely on the same technology as video games. The bronchoscopy simulator consists of a proxy bronchoscope, a robotic interface device, and a personal computer with a monitor (Fig. 11.2). The proxy bronchoscope is inserted into a plastic face and is maneuvered on the computer screen into a 3-D image recreation of the airways (Fig. 11.3). The robotic interface device tracks the motions of the bronchoscope and reproduces the force felt during an actual bronchoscopy. The “virtual” patient on the screen breathes and coughs, and the vital signs

Fig. 11.2 A hi-fidelity computer-based simulator for bronchoscopy teaching (Pictures taken using Simbionix' BRONCH Mentor simulator)

are monitored in real time. Various standardized scenarios are offered, and the learner can choose to examine normal airways, intubate difficult airways, perform brushing or biopsy on an endobronchial tumor, or sample an enlarged lymph node via TBNA (Fig. 11.4). The bronchoscopy simulator also offers anatomic labels on the airway branches and the structures adjacent to the airways to help the learner to become skilled at recognizing anatomy of normal structures; this feature can be turned on or off based on the learner's level of knowledge and educational needs.

The software tracks performance metrics such as time of procedure, amount of used lidocaine, incidence of wall collision, percentage of segments entered, and success in obtaining a sample from a targeted lymph node.

There are two commercially available hi-fidelity systems in the USA: the Endoscopy VR simulator (CAE Healthcare, Montreal, Quebec, Canada) and the GI-BRONCH Mentor (Simbionix Ltd, Israel).

Hi-fidelity simulation offers numerous advantages including repetitive practice, training in a safe stress-free environment, exposure to rare or difficult scenarios, and receiving immediate feedback on performance.

The data for hi-fidelity simulation in the learning of various medical and surgical procedures are abundant; there have been numerous publications showing the efficacy, cost-effectiveness, and increase in patients' comfort and safety when simulation-based training is undertaken by trainees.

The first reports of the efficacy of the bronchoscopy hi-fidelity simulator were published in 2001. Colt and colleagues reported the outcomes of five novice bronchoscopists who received 4 h of training on a bronchoscopy simulator and then spent 4 h practicing on their own without supervision; bronchoscopy skill sets obtained by the novices (dexterity, speed, and accuracy) reached those of a control group of skilled bronchoscopists (who had performed at least 200 bronchoscopies) after only 8 h of training. Ost et al. validated the bronchoscopy simulator as an assessment tool and demonstrated its ability to discriminate among bronchoscopists with varying levels of bronchoscopy skills; the study found that expert bronchoscopists (>500 bronchoscopies) performed better than intermediates (25–500) who in turn performed better than novices.

Most recently, the author of this chapter reported the first prospective multicenter study of performance-based metrics and educational interventions in the learning of bronchoscopy among starting pulmonary fellows. In this study, two successive cohorts of starting pulmonary training were enrolled in the study.

At prespecified milestones, validated tools were used to test their bronchoscopy skill and knowledge: the Bronchoscopy Skills and Tasks Assessment Tool (BSTAT), an objective validated evaluation of bronchoscopy skills with scores ranging from 0 to 24, and written multiple-choice question examinations.

The first cohort of fellows received training in bronchoscopy as per the standards set by each institution, while the second cohort received training in simulation bronchoscopy and was provided an online bronchoscopy curriculum. There was significant variation among study participants in bronchoscopy skills at their 50th bronchoscopy, the number previously set to achieve competency in bronchoscopy. An educational intervention of incorporating simulation bronchoscopy enhanced the acquisition of bronchoscopy skills, as shown by the statistically significant improvement in mean BSTAT scores for seven of the eight milestone bronchoscopies ($p < 0.05$). The online curriculum did not improve the performance on the written tests; however, compliance of the learners with the curriculum was low.

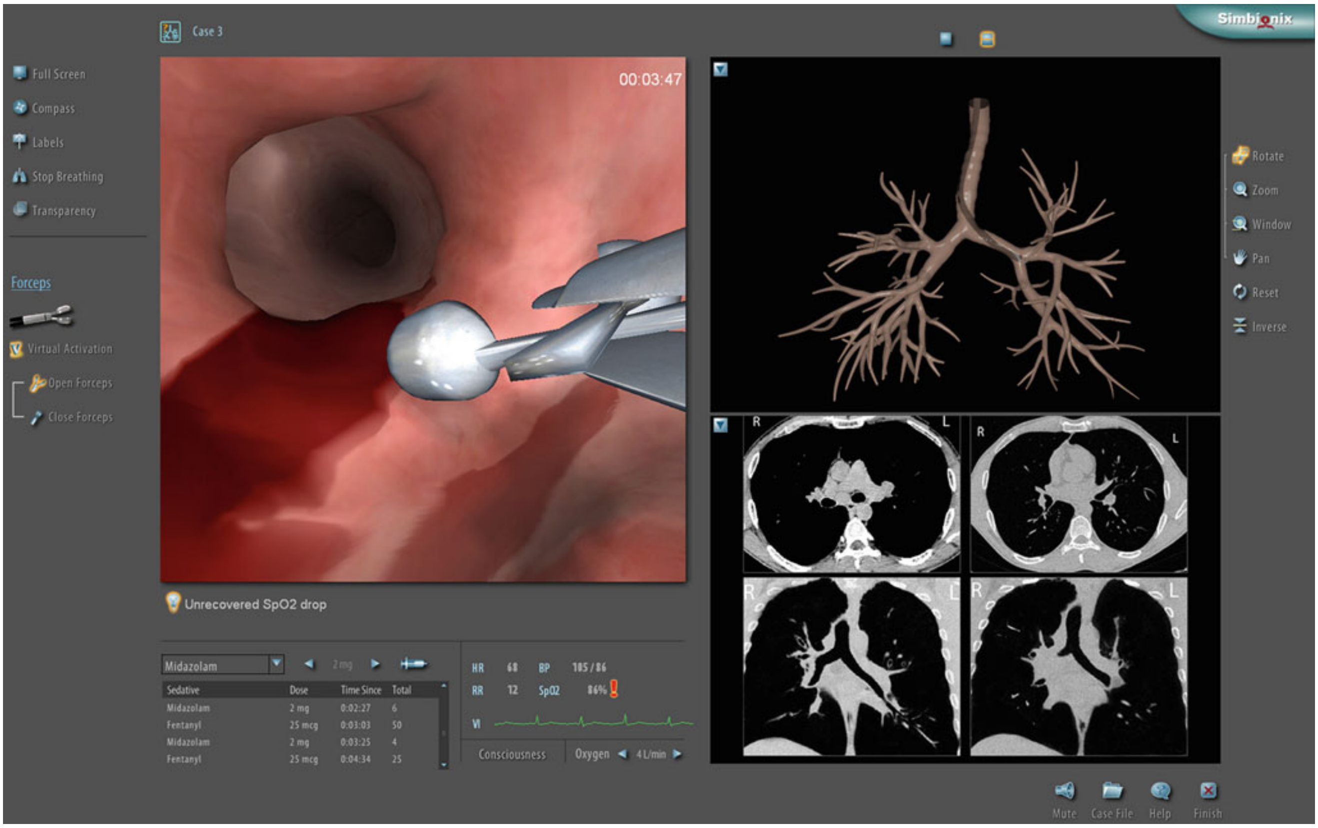

Fig. 11.3 The monitor screen of a hi-fidelity simulator showing a 3-D virtual image of the airways (Pictures taken using Simbionix' BRONCH Mentor simulator)

Fig. 11.4 A learner practices her bronchoscopy skills on a hi-fidelity computer-based simulator (Pictures taken using Simbionix' BRONCH Mentor simulator)

Simulation for Advanced Bronchoscopic Procedures

There has been a rapid expansion in the available technology in pulmonary medicine over the last two decades. Although effective application of most of these technologies requires advanced training and therefore utilization by interventional pulmonologists, some have started to make their ways into general pulmonary practice due to their practical indication and relative ease of use. A prime example is endobronchial ultrasound (EBUS), a technology that allows the real-time guidance of mediastinal lymph node sampling with an average sensitivity and specificity of 93% and 100%, respectively. As the benefit of EBUS-guided TBNA over conventional TBNA in many patients has become clearer, the demand for training, both in fellowship programs and for established clinicians, has continued to increase. Beyond bronchoscopy skills and core knowledge of airway and mediastinal anatomy, working with an EBUS bronchoscope requires the acquisition of specific skills, including driving the scope with reduced optics and an oblique angle of view, acquiring and interpreting the ultrasound images, understanding how to operate the equipment and the needle, and performing the TBNA. A virtual reality simulator with a view mimicking the EBUS bronchoscope would be successful in teaching novice operators to handle the scope effectively and learn the anatomical relationship between airways and surrounding vessels and nodes. Recently, an EBUS capability was added to one of the available bronch simulators (CAE Healthcare, Montreal, Quebec, Canada). Though it has not yet been validated, it holds promise in providing clinicians with a realistic training experience. Alternatively, a lo-fidelity inanimate airway model could serve a similar purpose if simulators are not available. One available airway model (Olympus Inc., Center Valley, Pennsylvania, USA) has a tubular structure with surrounding silicone balls, simulating lymph nodes and allowing a realistic tactile feeling of how the EBUS scope and needle operate. Interpretation of ultrasound images could be learned using computer-based tutorials based on an atlas of CT and ultrasound images. Learning to obtain clear ultrasound images presents additional challenges, as simulators may be unable to mimic real-life challenges of an actual procedure.

An additional essential step for the success in bringing EBUS technology to an institution is adequate training of the staff in the bronchoscopy suite to learn the operation of this new equipment. After they have gained competence in individual skills required to fulfill their role in the procedure, a simulation-based team training exercise should ideally take place in order to optimize teamwork performance and to integrate the dynamic atmosphere of the bronchoscopy suite.

In summary, lo- and hi-fidelity simulation can play an essential role in the learning of new skills among trainees and established physicians before performing procedures in a patient-care setting.

Simulation for Maintenance and Acquisition of Skills for Practicing Chest Physicians

Most of the studies done on simulation and bronchoscopy relate to the teaching for novice learners. However, practicing physicians often encounter important training issues relating to the need to obtain hospital credentialing, maintain learned skills on an annual basis, and learn new procedures.

The ultimate goals of a credentialing process are proper procedure utilization and the delivery of high-quality patient care. This process is currently the responsibility of each health-care facility in the United States; professional societies usually issue consensus-based general recommendations that aid hospitals in this process. An example is the privileging and credentialing criteria for endoscopy and colonoscopy issued by the gastroenterology and surgical societies. In 2003, the American College of Chest Physicians (ACCP) published guidelines for minimal numbers for interventional pulmonary procedures. For example, 25 procedures were needed to establish competency in TBNA, and 10 annual procedures were recommended to maintain competency. These guidelines are based on experts' opinions and not on scientific data evaluating variations in individual performance or patients' outcomes.

A more challenging issue is the learning of a new medical procedure once out of training. The last decade has seen a rapid expansion in procedures available to chest physicians from percutaneous tracheostomy to endobronchial ultrasound and navigation bronchoscopy. The venues for learning such new skills are limited and challenging. Physicians can acquire basic skills through focused courses with didactic and hands-on sessions that can provide the foundation of knowledge and basic skills for such a new procedure. Afterward, physicians can further enhance their skills by taking short sabbaticals in centers performing a high volume of the procedure, seeking proctorship from physicians who perform the procedure or a variation of it (gastroenterologists who perform esophageal ultrasound), or inviting experienced operators to supervise their performance. Clearly, none of these choices are easy to pursue, and there are numerous legal and administrative obstacles that prevent physicians from pursing supervised training in other medical institutions.

Simulation can play a valuable role in the education of practicing physicians. New skills can be learned on the simulator to speed up the learning curve and avoid practice on patients. Performance on existing procedures can be evaluated and corrected on a periodic basis to maintain certification. Before this becomes a reality in our medical practice, more studies are needed to validate the effectiveness of simulation technology in establishing performance metrics and aiding in the certification process, particularly for more complex procedures.

Current Issues with Simulation

Despite the abundance of evidence of the effectiveness of simulation in medical training, the adoption of such as tool in the medical community has been slow.

The first barrier is cost; the currently available hi-fidelity simulators for bronchoscopy are priced over $100,000. This makes the investment in such an educational tool an institutional decision and is subject to budgetary restrictions. It is hoped that the price of this technology will go down with time and increasing competition. Lo-fidelity simulation can offer a cheaper advantage but lacks interaction and feedback capabilities as summarized above.

The second barrier is the lack of research on the effectiveness of bronchoscopy simulation in transferring skills to the bedside and having an impact on patient's outcome. The study by Wahidi et al. in 2010 showed that simulation enhanced the speed of bronchoscopy skill acquisition performed by trainees on patients; however, the impact on patient's outcome was not studied. Further studies are needed to establish this virtue of medical simulation in bronchoscopy.

The third barrier is the attitude among educators and physicians regarding simulation as a teaching tool. There is still some attachment to the apprenticeship model and doubts about the benefit of simulation. Further research and education about the benefits of simulation will continue to erode into these beliefs and help make simulation an integral part of bronchoscopy education.

Summary

Bronchoscopy is a procedure central to the chest physician's armamentarium to diagnose and treat respiratory diseases. The apprenticeship model remains the major teaching method for bronchoscopy. Though clearly individual interaction with faculty represents a valuable experience in bronchoscopy and procedural education in general, innovative methods are necessary to ensure clinical competency for trainees and delivery of high-quality medical care. There is a mounting body of evidence that simulation-based training can enhance the speed of acquisition of bronchoscopy skills and provide a safe environment for structured training that is acquired away from patients and transferred to the bedside. Not only can simulation help medial trainees but can also play a vital role in the continued education of practicing chest physicians as it relates to maintenance of learned skills and acquisition of new skills in technology that can tremendously improve their patient care.

Suggested Readings

1. Ernst A, Silvestri GA, Johnstone D. Interventional pulmonary procedures: guidelines from the American College of Chest Physicians. Chest. 2003;123:1693–717.
2. Haponik EF, Russell GB, Beamis Jr JF, et al. Bronchoscopy training: current fellows' experiences and some concerns for the future. Chest. 2000;118:625–30.
3. Di Domenico S, Simonassi C, Chessa L. Inexpensive anatomical trainer for bronchoscopy. Interact Cardiovasc Thorac Surg. 2007;6:567–9.
4. Lucarelli MR, Lucey CR, Mastronarde JG. Survey of current practices in fellowship orientation. Respiration. 2007;74:382–6.
5. Davoudi M, Wahidi MM, Zamanian Rohani N, et al. Comparative effectiveness of low- and high-fidelity bronchoscopy simulation for training in conventional transbronchial needle aspiration and user preferences. Respiration. 2010;80:327–34.
6. Davoudi M, Colt HG. Bronchoscopy simulation: a brief review. Adv Health Sci Educ Theory Pract. 2009;14:287–96.
7. Colt HG, Crawford SW, Galbraith 3rd O. Virtual reality bronchoscopy simulation: a revolution in procedural training. Chest. 2001;120:1333–9.
8. Ost D, DeRosiers A, Britt EJ, et al. Assessment of a bronchoscopy simulator. Am J Respir Crit Care Med. 2001;164:2248–55.
9. Wahidi MM, Silvestri GA, Coakley RD, et al. A prospective multicenter study of competency metrics and educational interventions in the learning of bronchoscopy among new pulmonary fellows. Chest. 2010;137:1040–9.
10. Gu P, Zhao YZ, Jiang LY, et al. Endobronchial ultrasound-guided transbronchial needle aspiration for staging of lung cancer: a systematic review and meta-analysis. Eur J Cancer. 2009;45:1389–96.
11. Unroe MA, Shofer SL, Wahidi MM. Training for endobronchial ultrasound: methods for proper training in new bronchoscopic techniques. Curr Opin Pulm Med. 2010;16:295–300.
12. Ost D, Eapen GA, Jimenez CA, et al. Improving procedural training and certification in pulmonary medicine. Chest. 2010;137:6–8.
13. Wexner SD, Eisen GM, Simmang C. Principles of privileging and credentialing for endoscopy and colonoscopy. Surg Endosc. 2002;16:367–9.