Medical Education Training Research Innovation in Clinical Care

Experience of an advanced multidisciplinary simulation course and literature review: bronchoscopy and beyond

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Keywords

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Abstract

Simulation based training has demonstrated several advantages over the apprenticeship model with provision of a safe learning environment, accelerated skill acquisition and transfer of skills to clinical domains. Specialties including cardiothoracic surgery, respiratory medicine and critical care have adopted simulation based training to teach a variety of postgraduate procedures. In the field of interventional pulmonology strong evidence exists to support the use of simulation based training to teach basic bronchoscopic skills, however there is a paucity of literature with regards to the role of simulation in training for endobronchial ultrasound and endobronchial valves. The authors describe their experience of conducting an advanced simulation based course teaching the principles of flexible and rigid bronchoscopy, endobronchial ultrasound and endobronchial valves. The one day course combines both high and low fidelity simulators; BRONCH MentorTM Simbionix and Bronchoboy Trainer used with a real flexible bronchoscope. In total 28 delegates from medicine, cardiothoracic surgery and anaesthesia, completed the course between 2014 and 2019. All delegates completed a 5-point Likert scale based questionnaire prior to and following the course to self assess confidence across the domains taught. Pre-course questionnaires demonstrated areas of least confidence as operation, preparation and performance of rigid bronchoscopy, planning an endobronchial valve and performance of endobronchial ultrasound. Post course questionnaires demonstrated a statistically significant increase in confidence scores across all four procedures ($p<0.001$). Limitations upon training due to restrictions on trainee working hours, patient safety and the COVID-19 pandemic have presented challenges to training in interventional pulmonology. Simulation based courses may have a role in mitigating these challenges and enhance postgraduate training.

Introduction

Postgraduate medical education has rapidly evolved and utilisation of simulation training has been widely accepted to teach specialist skills to higher trainees across a range of disciplines. Simulation based education has been proven to be advantageous in providing a safe learning environment with effective skill transfer into clinical practice [1]. Cardiothoracic surgery incorporates training in a broad range of techniques ranging from open to minimally invasive and endovascular techniques. The learning curve for these procedures many of which are high risk may require extensive supervised exposure and can be supported using simulation based education, which may speed up training and reduce the risks to patients [2]. In the context of teaching bronchoscopy skills traditionally the apprenticeship model has been applied, however this has received criticism due to limited trainee exposure to procedures, compounded by the restrictions imposed by working hours and the risk to patient safety [3].

Interventional pulmonary procedures are essential skills required across a variety of specialties including cardiothoracic surgery, respiratory medicine and critical care. These skills are often taught using a combination of techniques ranging from didactic lectures to advanced simulation training. The benefits of simulation training in teaching bronchoscopy skills include training within a less stressful and controlled environment with the possibility for high yield practice. Limitations upon clinical experience for trainees imposed by the European Work Time Directive, the COVID -19 pandemic and variable unit caseloads combined with a longer learning curve for more advanced procedures, demands an adaptive approach to current training methods.

The role of simulation training in teaching basic bronchoscopic skills has been widely described in the literature, however there is limited data with regards to the role of simulation in training in endobronchial ultrasound (EBUS) and endobronchial valves [1-6, 8-12, 19-21, 23, 30]. We describe in this article our experience of conducting a multidisciplinary advanced bronchoscopy course teaching the principles of rigid and flexible bronchoscopy, endobronchial ultrasound and endobronchial valves using a combination of high and low fidelity simulators. Our data supports the use of simulation based training for advanced interventional airway procedures that can benefit both the novice and expert across several disciplines.

Methods

A retrospective review was conducted of a full day advanced bronchoscopy course utilising simulation training. As part of the quality assessment, we collected and subsequently analysed the pre and post course questionnaires received from the participants. The course was conducted five times between March 2014 and May 2019 and participating trainees were from respiratory medicine, general internal medicine, anaesthesia, cardiothoracic surgery specialities and had different levels of training and expertise. The faculty comprised of experienced bronchoscopists including three consultant respiratory physicians and one cardiothoracic surgeon, all with specialist interests in simulation. The course covered three domains; high fidelity bronchoscopy simulation, endobronchial ultrasound and endobronchial valve insertion. An introduction was provided to allow delegates to describe their current experience in bronchoscopy and advanced bronchoscopy and to familiarise themselves with the current guidelines. The outline of the course included the use of high fidelity bronchoscopy simulation with the aim of allowing participants to become familiar with bronchial anatomy and the bronchoscopy procedure using a high fidelity simulator and to afford the opportunity to practice bronchoscopy.

During the rigid bronchoscopy session participants were taught about the rigid bronchoscopy instruments and the procedure. Subsequently delegates were given the opportunity to acquire practical skills of performing rigid bronchoscopy using a low fidelity simulator. In addition, delegates were taught the indications for endobronchial valve insertion including how to perform the procedure through the review of a video. Delegates were then given training on insertion of endobronchial valves using low fidelity simulators. At the end of the course a debrief was conducted and allowed for learning objective to be set for future training.

The course used a combination of high fidelity and low fidelity simulators. Bronchoscopy and EBUS were taught using the high fidelity virtual reality bronchoscopic simulator BRONCH

Mentor™ Simbionix (Cleveland, Ohio, USA). This simulator utilises a scope and a robotic interface connected to a 24 inch touch screen with virtual reality software allowing for tactile feedback. The virtual reality software allows for reactive vitals including breathing, coughing and complications such as bleeding, hypoxia and hypotension. The configuration enables for a lateral or posterior working position for an individual trainer or team. The scope can be used together with a model to simulate entrance via the nasal or oral route. This simulator allows for local anaesthetic to be administered and bronchoalveolar lavage to be performed through a syringe. In addition, the equipment allows for biopsies to be taken using a forceps and brushings to be performed for cytological analysis. The simulator has several modules which are based on real cases and include essential, diagnostic and emergency bronchoscopy modules and essential EBUS. The performance of trainees can be monitored through performance metrics based on self-assessment and demonstration of procedural competency. The low fidelity simulator used was the Bronchoboy Trainer (Adam Rouilly Ltd, Kent, UK) which is an inanimate model with a full face and respiratory tract composed from plastic and rubber. This simulator is a fixed model displaying the upper airways, vocal cords, larynx and bronchial tree. The model can retroflex and rotate and if excessive pressure is placed upon the upper teeth there will be an acoustic warning. This simulator was used together with a real flexible bronchoscope Olympus, BF Q290 (Olympus, Tokyo, Japan) with light source, camera and screen.

Each delegate performed three tasks using the high fidelity simulator, BRONCH mentor. The first task focused on navigation of the bronchoscope through the bronchial tree with emphasis on minimal contact with the bronchial walls, followed by navigation through a labelled bronchial tree for anatomical training purposes and finally three attempts to identify segments correctly, whilst navigating the scope. Using the low fidelity model, delegates were asked to prepare a patient for bronchoscopy. This task involved labelling the steps involved in preparation including consent, prescription and preparation of sedation (Midazolam), local anaesthetic (Lidocaine) and reversal agents. Following these, each delegate was provided with the necessary information about the patient requiring bronchoscopy i.e. case details, blood results, chest radiograph, computer tomography. Each delegate then performed three bronchoscopies using the flexible bronchoscope and Bronchoboy trainer following instructions provided as to which segment to enter. Delegates were asked to explain how they would perform diagnostic sampling and where these samples would subsequently be processed.

All delegates completed a pre- and post- course questionnaire to self-assess confidence in the four interventional pulmonary techniques taught in the course; rigid and flexible bronchoscopy, EBUS and endobronchial valves. The questions included understanding of the indications, operation, preparation and ability to perform rigid bronchoscopy. The questions for endobronchial valves covered confidence in understanding the indications of the valves, how they work and ability to plan a valve. For EBUS delegates were asked to rate their confidence in understanding the indications, knowledge of mediastinal anatomy and ability to perform the procedure. The delegates ticked responses ranging from strongly agree to strongly disagree in accordance with the 5-point Likert scale. Quantitative analysis of the delegates responses was performed using the paired t-test. Ethical approval was not required for this course as it describes the authors experience and a standardised evaluation form was utilised.

Results

In between 2014 and 2019 there were 5 courses conducted and a total of 28 delegates attended. The delegates were from various specialities including respiratory medicine, cardiothoracic surgery and intensive care medicine. The experience of the delegates ranged from surgical care practitioners and junior doctors to more senior trainees. Pre-course questionnaires revealed four areas delegates self-assessed as having the least confidence; operation and preparation of the rigid bronchoscope, placement of endobronchial valves and performance of EBUS. The area of greatest confidence prior to the course was an understanding of the indications for flexible bronchoscopy. Post course questionnaires demonstrated a statistically significant improvement ($P<0.001$) in confidence scores across all domains of rigid and flexible bronchoscopy [table 1], endobronchial valves and endobronchial ultrasound compared with pre-course scores. Comments from the post course questionnaire included “very good time dedicated to practicals,” “good delegate to faculty ratio” and “excellent course”.

Discussion

Simulation training has been demonstrated as a complementary tool to traditional teaching methods. Currently there are limitations upon training including those imposed by the COVID-19 pandemic and subsequently training in interventional pulmonary procedures is challenging due to the aerosol generating nature of these techniques. Simulation courses as described by the authors may play an important role in overcoming the reduction in training opportunities. Our data demonstrates that the use simulation based courses resulted in improved theoretical knowledge and practical skills in relation to bronchoscopic techniques.

Rigid and flexible bronchoscopy

There is now over 20 years of evidence to support simulation training for flexible bronchoscopy [4]. In fact, a number of national and international organisations including the American Board of Internal Medicine and American Thoracic Society recommend simulation-based training as part of procedural training [5]. The American Association of Bronchology and Interventional Pulmonology (AABIP) has adopted a simulation-based approach utilising boot camps for interventional pulmonology fellows to improve training. In order to standardise teaching in procedural tasks the AABIP also conduct hands-on simulation procedure based training. In addition to training delegates in specific skills, simulation has also been shown to improve time management skills [5]. Moreover, tools have been introduced to allow for the assessment of competency such as the Bronchoscopy Skills and Tasks Assessment Tool (BSTAT) and Bronchoscopy Step-by-Step Evaluation Tool 6. These tools have been validated and have shown to be able to differentiate between experts and more novice bronchoscopists. Limitations of these tools include the poor discriminative ability in distinguishing between intermediate levels of competency compared with more experienced bronchoscopists.

An important component of achieving competency is task volume. In thoracic surgery high volume intensive observership training has been suggested to improve VATS (video assisted thoracoscopic surgery) proficiency in a shorter time frame [7]. Kastelik et al., summarised the 12 studies using virtual reality simulation bronchoscopy which offer supporting evidence of improvement in technical skills and reduction in the length of the learning curve [8]. Gopal et al., have demonstrated statistically significant improvements in knowledge of bronchial anatomy and navigational bronchoscopy skills in the first study, specifically investigating the use of virtual reality simulation for medical students [9]. This study used the EndoVR endoscopy simulator, a high fidelity simulator with haptic feedback to train 47 medical students up to 8 sessions per participant [9]. Evaluation was conducted using a modified version of the validated Bronchoscopy Skills and Tasks Assessment Tool (BSTAT) evaluation tool [9]. Studies have set out to identify predictors of performance in bronchoscopy simulation [10]. An observation cohort study involving 53 internal medicine residents in Saudi Arabia using the Simbionix bronchoscopy simulator observed gender difference among residents with regards to basic scope manipulation9. The study observed male residents achieved higher scores in basic scope manipulation, time spent at mid lumen during scope manipulation was significantly higher in males (P=0.003) and males had statistically significantly less time in contact with the walls of the airways [10]. The observational nature of this study offers limitations, and the authors describe potential unconscious bias of specific gender candidates receiving more intraprocedural assistance [10].

Amongst the variety of simulators available, further studies are required to directly compare high and low fidelity simulators and subsequently bodies such as the Skills Based Working Group of the American Thoracic Society Education Committee are unable to make recommendations about which system to use [11]. A recent systematic review of simulation in upper airway endoscopy by Nilsson and authors reviewed literature describing how to structure bronchoscopy training [12]. The four studies included two randomised studies, one cohort study and one pre- and post- test of novices compared with experienced bronchoscopists [12]. These articles reinforce the role of simulation training in training procedural accuracy with less wall contact and fewer missed segments post training [12]. Bjerrum et al., found no difference in performance between dyad and individual practice nor between performance after a one day practice compared with weekly distributed practice [12].

Endobronchial ultrasound

EBUS TBNA (transbronchial needle aspiration) combines the principles of bronchoscopy and ultrasound to allow simultaneous airway visualisation with real time sampling of mediastinal, hilar and parabronchial tissue [13]. This technique has high sensitivity and specificity for identifying malignancy in mediastinal and hilar lymph nodes in patients with lung cancer [14]. The interventional procedure has an established role as a valuable alternative to surgical staging of mediastinal lymphadenopathy as part of the investigation for lung cancer [15]. Several bodies including the European Society of Gastrointestinal Endoscopy, European Respiratory Society and the European Society of Thoracic Surgeons recommend EBUS TBNA in preference to surgical staging of mediastinal lymph nodes in patients with suspected or proven non small cell lung cancer [15]. In patients with suspected or proven non small cell lung cancer without evidence of mediastinal involvement on computer tomography (CT) or positron emission tomography (PET-CT), EBUS TBNA is recommended prior to commencement of therapy, if one or more of the following conditions is present; enlarged or FDG-PET avid ipsilateral hilar nodes, primary tumour without FDG uptake and/or tumour size ≥3cm [15]. The advent of such guidelines has resulted in an expansion of EBUS services and has placed an increased demand on training to enable specialists to develop the competencies and skills required to safely undertake the procedure. EBUS may be performed by a thoracic surgeon or respiratory physician [16]. It has been postulated by Gilbert at al., that the operative experience of thoracic surgeons may allow for a favourable position to understand the anatomic relationships displayed during EBUS [17]. It has been suggested that the number of procedures required to gain competency in EBUS may be lower for thoracic surgeons who frequently perform bronchoscopy and mediastinal procedures [17]. EBUS is often performed by respiratory physicians and major societies recommend at least 40-50 supervised procedures to establish basic EBUS competency and then to maintain proficiency to perform approximately 50 procedures each year [17, 18]. Stather et al., conducted a prospective study to evaluate the learning curve of endobronchial ultrasound skills following simulation compared with clinical training, concluding that simulation led to a more rapid acquisition of skill [19]. The study demonstrated significantly shorter procedural time and greater success in correct lymph node identification in the cohort trained with simulation compared with those that undertook 15-25 cases on patients [19]. A systematic review on simulation-based training in flexible bronchoscopy and EBUS TBNA by Naur and authors focused on 7 studies on EBUS [6]. These studies all used virtual reality with participant numbers ranging from 8 to 22 with the majority comparing training methods [6]. The authors emphasize the importance of high quality minimally invasive procedures in order to improve the diagnostic yield and support the role of simulation in helping trainees to achieve this while ensuring patient safety [6]. In order to assess both the knowledge gained and skills acquired through simulation training in EBUS the EBUS-STAT can be applied and is a tool which has been validated. This may aid in ensuring trainees are on track with their learning, which is of importance due to the greater learning curve with EBUS and can be applied to novice learners [20].

High quality simulation training delivered by experts in their field, perhaps with a specialist interest in simulation, may play an important role in enabling trainees to achieve the learning outcomes. Ong and colleagues have reported there was no statistical difference in diagnostic yield from EBUS TBNA between trainees that underwent conventional training and those that underwent 2 days of simulation training [21]. This may be accounted for by the different learning curves of individual trainees and the authors also noted a higher minor complication rate amongst trainees having undertaken simulation training, namely minor hemorrhage, despite a lower major complication rate [21]. The authors postulate this may be due to differences in definition of complication [21]. Another observational study has focused on the utilization of a biosimulator made of porcine material connected to an artificial intubation training model with the aim of improving sample acquisition during EBUS TBNA [22]. Nakajima et al.. reported 47.4% of subjects obtained better quality passes on the second pass with 7 out of 19 doctors showing improvement in both quantity and quality of cytological material sampled [22]. The results from the study were limited due to a small sample size and lack of control group, however there is support for the potential use of biosimulators to train in specimen acquisition [22].

A further systematic review of training and proficiency in EBUS TBNA highlighted the variety amongst authors in terms of numbers of procedures required to overcome the initial learning curve [23]. Upon review of the evidence, the authors proposed 37 to 44 procedures may be required to attain an accuracy level of 80% and that training should be conducted in centers performing a minimum of 150 EBUS TBNA procedures per annum [23].

Endobronchial valves

Lung volume reduction surgery (LVRS) has been utilised as a therapeutic modality for selected patients with predominately upper lobe emphysema. The benefits of LVRS were demonstrated in The National Emphysema Treatment Trial, where improvements in quality of life and exercise tolerance in this cohort of patients was shown [24]. However, there are patients which are deemed unsuitable for LVRS and subsequently bronchoscopic lung volume reduction techniques have been developed. One technique is bronchoscopic endobronchial valves, a novel treatment modality for emphysematous patients [25]. The technique first described in the early 2000s, can be applied to a broader population with lower morbidity and mortality compared with surgical treatment [26]. Bronchoscopic lung volume reduction utilises insertion of multiple one-way valves which enable air to escape reducing gas trapping and hyperinflation [26]. Abia-Trujillo et al., have summarised the 8 randomised clinical trials of endo bronchial valves between 2010 and 2019 [26]. These trials provide evidence for the use of these valves demonstrating statistical and clinically significant improvements in FEV1(Forced Expiratory volume in 1 second), 6-minute walk test and quality of life [26]. The benefits of endobronchial valves has also been evaluated in patients with homogenous emphysema without collateral ventilation through the IMPACT (Improving Patient Outcomes by Selective Implantation of the Zephyr EBV) study [27]. The valves have resulted in improved lung function, quality of life and exercise tolerance [27]. Endobronchial valves have also been considered as a treatment option in patients with persistent air leaks considered to be high risk for surgical intervention [28]. Prolonged air leak is a common clinical problem with significant morbidity and mortality [28]. Benefits of endobronchial valves in this context also include the ability to be removed with minimal invasion and they allow for clearance of distal bronchial secretions [28]. Simulation training has been demonstrated as a complementary tool to traditional teaching methods. Currently there are limitations upon training including those imposed by the COVID-19 pandemic and subsequently training in interventional pulmonary procedures is challenging due to the aerosol generating nature of these techniques. Simulation courses as described by the authors may play an important role in overcoming the reduction in training opportunities. A structured portfolio of ten simulation-based cardiothoracic training courses mapped to the Royal College of Surgeons cardiothoracic curriculum was developed and implemented by Moorjani et al., with significant improvement in post self confidence scores and perceived self-competency scores for all courses [29]. Moorjani et al., state that simulation-based learning is an important part of delivery of education within Cardiothoracic surgery [29]. In Canada, Schieman et al., describe an intensive simulation based surgical skills bootcamp delivered over 3.5 days for thoracic surgery residents [30]. The bootcamp combined lecture-based teaching with hands on simulation to cover advanced endoscopy and bronchoscopy, lung cancer staging, minimally invasive thoracic surgery and benign oesophageal disorders [30]. The bootcamp was designed to offer a national centralised simulation based skills workshop covering key thoracic procedures and exposure to important but not necessarily universally available procedures, namely advanced endoscopy [30]. The authors propose the utilisation of simulation to train clinicians in both basic and advanced interventional pulmonary techniques [30]. In the era of rapid technological advancements and changes in the traditional role of thoracic surgeons, current trainees may be best served by keeping abreast of the latest interventional pulmonology procedures. There is a large body of literature in support of simulation training with a focus on flexible and rigid bronchoscopy. However, there is a paucity of literature on the extension of simulation to train candidates to perform bronchoscopic endobronchial valve insertion. This study has demonstrated self-assessed improvements across numerous domains related to these more advanced procedures with all delegates responding with self-assessed improvements in their level of confidence with regards to key aspects of these procedures. Conducting simulation training of skills that are required across disciplines may also reduce the high costs often involved with high fidelity equipment and may be a more efficient use of limited resources. Courses and training such as that described by the authors may also foster multi-disciplinary relationships and provide a venue for professional networking.

This study is limited by the small size with regards to delegate numbers. In addition, the Likert scale is a subjective measure of improvement and the knowledge of the trainees was not objectively evaluated. However, the results of this study offer a basis for advanced simulation training and could form the foundation for future large scale courses or even delivery of aspects of the national training programmes, conducted over several days or even weeks to meet learning objectives. A longer training session(s) would allow for assessment of skill retention and competency and could aid in training to a level of proficiency with zero risk of harm to patients. A rate limiting factor in conducting large scale simulation training is often the high start-up expenses involved in high fidelity simulation models. Centralisation of simulation with cross speciality teaching could allow for high quality training with highly experienced faculty members and may reduce demand on resources and costs. In addition, this study also utilises low fidelity simulation models which are considered less costly than the high-fidelity equipment which may allow for use in a larger number of centres. Ultimately, simulation training is an adjunct to traditional teaching methods and is supported by a wide base of literature [2]. Throughout the course of future training, regardless of the speciality, there will be new limitations to standard training methods. Simulation is a valuable teaching and assessment modality in the training armamentarium.

Competing interests

The authors declare that they have no competing interests.

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Table 1: Pre and post-course scores for rigid bronchoscopy, flexible bronchoscopy, endobronchial valves and endobronchial ultrasound

Questions	*Mean pre-course score (SD)*	*Mean post-course score (SD)*	*p value*
Indications for rigid bronchoscopy	3 ± 0.92	5 ± 0.51	p<0.001
Operation of rigid bronchoscope	2 ± 1.1	4 ± 0.75	p<0.001
Performance of rigid bronchoscopy	2 ± 1.0	4 ± 0.80	p<0.001
Indications for flexible bronchoscopy	4 ± 0.98	5 ± 0.50	p<0.001
Anatomy of the bronchial tree	3 ± 1.01	4 ± 0.78	p<0.001
Performance of flexible bronchoscopy	3 ± 1.09	4 ± 0.78	p<0.001
Indications for endobronchial valves	3 ± 1.1	4 ± 0.64	P=0.00001
How endobronchial valves work	3 ± 1.1	4 ± 0.80	P=0.000009
Placement of endobronchial valves	2 ± 0.98	4 ± 1.09	P=0.00000009
Indications for endobronchial ultrasound	3 ± 0.97	4 ± 0.74	P=0.000129
Knowledge of mediastinal anatomy	3 ± 1.0	4 ± 0.88	P=0.000116
Performance of endobronchial ultrasound	2 ± 0.84	3 ± 1.07	P=0.00001