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ORIGINAL RESEARCH

Developing Modules to Train Anesthesiology Residents & Medical Students in a Lung Isolation Technique

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Abstract

Background One-lung ventilation (OLV) can be accomplished by using ether a double-lumen endotracheal tube (DLT) or a bronchial blocker. Patient factors, surgical requirements and the anesthesiologist's expertise influence technique choice. Bronchial blockers are in general less traumatic, safer to place, and suitable in a wider variety of scenarios than DLTs, but require greater technical skill. We designed a study to determine whether trainees can achieve OLV using a bronchial blocker on completion of a 4-week multimodal training module.

Methods Anesthesia residents and medical students took part in didactic (lecture and video) and clinical simulation training. During simulation training, participants practiced placing a bronchial blocker under supervision until they performed the technique satisfactorily. Trainees could then practice independently as often as they wished. A skills check was performed during the supervised and after the independent practice; feedback was provided. For more advanced learners, practical clinical training was continued in the operating room. Assessments data (test scores and skills checks) were analyzed using the t-test.

Results Difference between pre-test and post-test scores (didactics) was statistically significant (p=0.02) as was the number of skills checks items satisfactorily demonstrated by the 14 participants on the first supervised attempt and the last independent practice (simulation; p<0.01). All eight who performed one-lung isolation in the operating room were technically proficient in achieving adequate OLV to the satisfaction of the supervising attending anesthesiologist.

Conclusions This multimodal standardized teaching module which incorporates didactics, simulation training, and, for more advanced trainees, practical clinical experience, improves trainees' knowledge and skills in bronchial blocker placement and OLV

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Introduction

The ability to isolate a lung is an essential skill for the anesthesiologist as one-lung ventilation (OLV) is usually required to allow for optimal surgical exposure during thoracic and minimally invasive cardiac surgery. There are two main techniques for achieving OLV, use of a double-lumen endotracheal tube (DLT) and a bronchial blocker (BB). Patient factors, surgical requirements and the anesthesiologist's level of expertise influence technique choice. While DLT is the preferred choice when differential lung ventilation is required in patients with a significant unilateral bronchocutaneuos fistula or to protect the ventilated lung from massive hemoptysis or contralateral suppurative lung disease, bronchial blockers are in general less traumatic, safer to place, and suitable in a wider variety of scenarios than DLTs, but require greater technical skill.

We designed a study to determine whether a trainee could achieve OLV using a bronchial blocker on completion of a 4-week multimodal training module.

DLTs, which can be placed quickly, can block either lung independently, and enable suctioning or intermittent inflation of the nonventilated lung, [1] are more commonly used in clinical practice to achieve OLV.[2] There are limitations to their use, however. For example, DLTs are challenging to use in a difficult airway and cannot be used in patients with a tracheostomy or stoma or in patients requiring a nasal intubation. Bronchial blockers, which allow lung collapse distal to an adequately placed device in a main stem bronchus, overcome some of these limitations for instance by eliminating the need for tracheal tube exchange in a critically ill patient who arrives in the operating with a pre-existing endotracheal tube. Tube exchange is not required in a patient who is to remain intubated after the procedure and they effectively isolate lungs in patients with tracheostomies, or stomas. If a nasal intubation is required or a single lumen tube is placed in a patient with a difficult airway, a bronchial blocker can be used to effectively isolate the lung to provide differential lung ventilation. In addition, selective lobe isolation can be achieved in critically ill patients who cannot tolerate one lung ventilation and require a specific lobe to be blocked to maintain adequate oxygenation during surgery. With the increasing complexity of the patient population, bronchial blocker use is increasing, especially as it can be used in a wide variety of thoracic operations and have been associated with a lower rate of complications during OLV. A 2015 meta-analysis of 39 trials comparing the efficacy and adverse effects of DLTs and bronchial blockers noted that bronchial blockers were associated with a lower incidence of sore throat, hoarseness and airway injury.[3] An earlier study by Knoll et al[4] reported that intubation with DLTs led to more minor vocal cord injuries such as redness, edema or hematoma than endobronchial blockers placed via standard endotracheal tubes (44% vs 17%). Although the incidence of airway rupture is rare with DLTs at <0.2%, it is associated with mortality as high as 42%.[5] In contrast, to date there have been no reports in the literature of airway rupture resulting from bronchial blockers.

Methods

Study Design

This multimodal simulation training study was conducted at an academic medical center (Augusta University Health, Augusta, GA) in 2016 and was approved by the university's Institutional Review Board Office. The purpose of the study was to test whether didactic learning followed by hands-on simulation training with assessments (written tests and skills checks) effectively train junior practitioners in the use of bronchial blocker to achieve one-lung isolation in a 4-week period. After obtaining consent, anesthesia residents at the beginning of their first clinical anesthesia year of training and fourth-year medical students with an interest in anesthesia who lacked experience in one-lung isolation techniques were enrolled in the study. Participants completed a multiple-choice pre-test to establish baseline knowledge. They then viewed 1) a 30-minute online lecture which explained the purpose of lung isolation, provided an overview of relevant anatomy and physiology, described various lung isolation techniques, and explained how to manage hypoxemia on OLV and 2) a 4-minute online video which showed learners how to assemble, insert, and, with the aid of a fiberoptic bronchoscope, seat the bronchial blocker to achieve one-lung isolation. The online format allowed trainees to view the lecture and video as often as needed, and facilitated anytime, anywhere learning. Participants took a multiple-choice post-test to ensure adequate knowledge of anatomy and technique.

In the simulation laboratory, anesthesiology faculty demonstrated the technique on a bronchoscopy mannequin (NAKHOSTEEN Bronchoscopy model "SCOPIN", D-96450, CLA, Coburg, Germany) using a 9Fr/65cm Uniblocker (Fuji Systems Corporation, Tokyo, Japan) and provided direct supervision and immediate feedback as the trainees attempted the technique. Participants were to have hands-on practice under supervision as many times as were needed to satisfactorily perform the technique, after which trainees were encouraged to practice independently as often as they wished. A standardized assessment form was used at the beginning of supervised training and end of independent training to note whether the trainee could demonstrate each of 10 skills check items: how the patient should be positioned, how the bronchial blocker is checked and assembled and proper use of the bronchoscope; identify the carina, left and right bronchus, and unique features of the bronchial anatomy; place the bronchial blocker; discuss how to management hypoxemia; troubleshoot wrong placement of the bronchial blocker; demonstrate how to resume two-lung ventilation.

Any residents deemed to have demonstrated proper technique in the simulation lab were paired with a faculty member for a day in the thoracic operating room to perform the technique during cases appropriate to the participant's ability. Participants received immediate feedback in the operating room using the assessment form.

At points in the training that an assessment was completed (i.e., post-test, assessment during after simulation training, assessment after clinical training), if a participant was deemed not to have performed adequately, he or she would have been recommended for remediation (Figure 1).

Data Analysis

For the didactic portion of the study, pre-test and post-test scores were compared using a two-sample t-test. For the hands-on portion, the number of supervised attempts at OLV, number of independent attempts at OLV, and number of items a participant could perform (out of 10) were reviewed. Statistical analyses were performed using MedCalc for Windows, version 17 (MedCalc Software, Ostend, Belgium).

Results

Nineteen participants enrolled in the study but five left the study after signing the consent. For the didactic portion of the study, the 14 remaining trainees (nine anesthesia residents and five medical students) scored higher on the post-test (87%) than the pre-test (71%); $p=0.02$ (Figure 2). During the simulation training portion of the study, participants attempted OLV 1-5 times under supervision and 1-2 times independently. The number of skills checks items satisfactorily achieved after the first supervised attempt compared to the last independent practice showed an improvement ($p<0.01$). When we grouped participants by the number of supervised attempts required to perform OLV satisfactorily in the simulation lab (1, 2-3, and 4-5 attempts), we found that those who required only one supervised OLV attempt appeared to able to perform more skills check items satisfactorily at the end of the training module than those who required 4-5 attempts (Figure 3). The number of independent attempts was not different among the three groups. On the first attempt, only two trainees were able to correctly assemble the blocker parts, perform successful fiberoptic bronchoscopy, identify the carina, and safely maneuver the bronchial blocker. After completing the training module, the numbers increased to 10, 7, and 5, respectively. Three items – management of hypoxemia, troubleshooting equipment, and resuming two-lung ventilation – were not evaluated during this study. All eight residents who were selected to perform one-lung isolation in the operating room achieved adequate OLV.

Discussion

The Accreditation Council for Graduate Medical Education (ACGME) requires that anesthesiology residents be able to "competently perform all medical, diagnostic, and surgical procedures considered essential for the area of practice" and specifically references lung isolation techniques as one of those essential procedures.[6]

Campos et al reported that 36%-39% of anesthesiologists who did not regularly perform OLV failed to properly place the lung isolation device[7] and that anesthesiologists with limited thoracic experience have a high incidence of malposition (38%) while placing DLTs or bronchial blockers.[8] Unfamiliarity with the tracheobronchial anatomy contributes to unsuccessful placement of these devices. Familiarity with use of the flexible fiberscope and competence in manipulating the bronchial blocker device are essential to adequately achieve OLV. In two studies, [9.10] a higher rate of malposition was found with the use of a bronchial blocker compared with a DLT. This increased incidence of malposition is reflected by a generous learning curve for trainees unfamiliar with placing bronchial blocker devices; as more experience is acquired, the incidence of this complication is reduced. In general, intraoperative malpositions are easy to correct, once identified. However, residents becoming familiar with these devices need to be aware of the catastrophic consequences of dislodgement and occlusion of the tracheal lumen or the endotracheal tube itself, which may result in cardiorespiratory arrest if not identified in a timely manner. For specific patient populations, such as patients with airway abnormalities, those with an endotracheal tube in-situ, and those with prior lobectomy requiring selective lobar blockade, a bronchial blocker is preferred for one-lung ventilation.[11,12,13] Bronchial blockade is always an option when a DLT cannot be placed, but the airway is accessible to an endotracheal tube. Examples include patients with very limited mouth opening or in whom only nasotracheal intubation is possible. As OLV becomes one of the most commonly used anesthesia techniques in thoracic surgery, training programs should make an effort to train residents in bronchial blocker placement. Although we used only one type of bronchial blocker in our training module, other types are available including Arndt, EZ Blocker, and Cohen bronchial blockers. The principle of successful lung separation with bronchial blocker devices relies on knowledge of the tracheobronchial anatomy, familiarity and skill with the flexible fiberoptic bronchoscope and expertise with the particular bronchial blocker device.

An important feature of our teaching curriculum was the use of multiple modalities to teach and demonstrate the same concept. This provided opportunities for frequent feedback and immediate remediation as the trainees learned an essential skill for practicing anesthesiologists.

The statistically significant change in test scores for the group as a whole indicates the didactic training was effective ($p=0.02$), although test scores of the residents alone did not show a significant change (Figure 2). During the simulation training, those who required fewer supervised OLV attempts were able to subsequently demonstrate more skills checks items at the end of the training module. It is interesting that those who needed to attempt the technique more often under supervision did not take advantage of the opportunity to spend more time practicing independently to improve mastery of the technique. This may indicate the trainees' overconfidence in their abilities or inadequate feedback from the faculty. Faculty could suggest to those requiring 3 or more supervised attempts that they make at least 5 independent attempts. Depending on the skills checks items that are missed, especially if related to knowledge, a return to didactic training may also be advisable.

There are several limitations to our study. First, the number of participants in our study was small and we did use the same mannequin for multiple attempts by trainees at placing a bronchial blocker. Second, because of faculty availability, different faculty directly supervised the trainees, resulting in some variability in the training and assessment of trainees. Standardizing training of the trainers would reduce this issue. Third, because the training period was only one month, we did not have the opportunity to evaluate the trainee's ability to perform OLV in patients with difficult or challenging airways. We recognize that a trainee may be competent in placing a bronchial blocker in a patient with a normal airway and still fail to successfully place a blocker in a patient with abnormal or distorted airway anatomy. Fourth, we used only one type of bronchial blocker in the study as it was the only device available at our institution. However, we believe that this provides many layers of appropriate teaching and feedback that allows adequate assessment of a trainee's performance. Expanding the study to include different types of lung isolation devices including DLTs would be of benefit to residents. In the future, increasing the number of available bronchial blocking devices will enhance the trainees' educational experience and allow us to compare outcomes for the different devices. Despite these limitations, however, the outcome data from our small study can nevertheless be used to set a guide for a future class of residents which will be of similar size and undergoing a similar training module. In addition, we may consider recording the simulator sessions to improve feedback given to the trainees.

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Figure 1 Lung isolation training algorithm indicating didactic, simulation training and clinical training portions of the training module as well as points of assessment and, if needed, remediation. For example, trainees with an unsatisfactory score on the post-test would be asked to review the lecture and video before retaking the post-test and going on to simulation training.

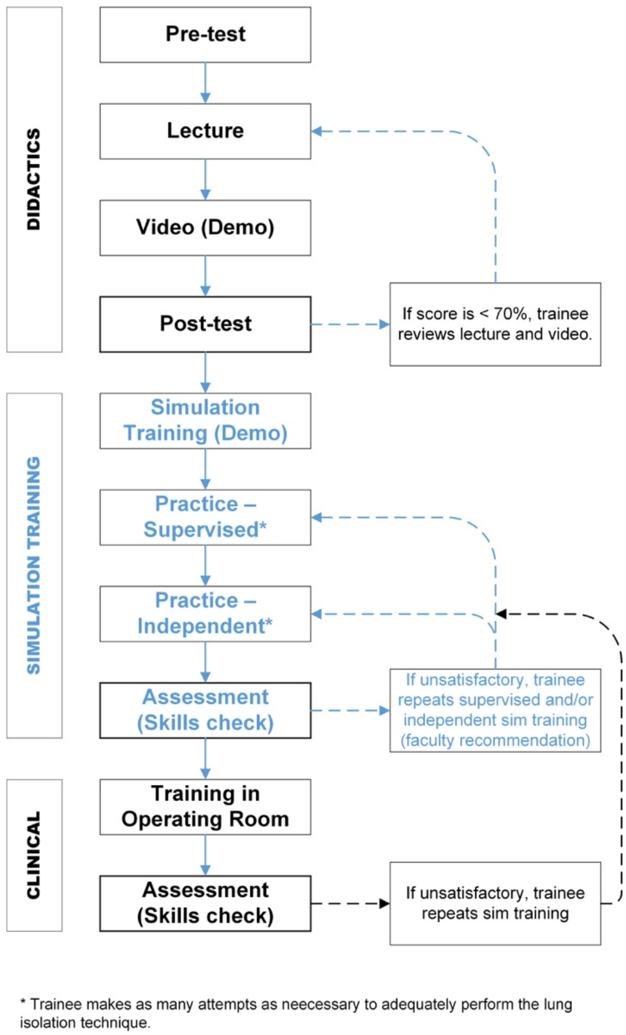


Figure 2 Mean pre-test and post-test scores of anesthesia residents, medical students, and all trainees as a whole. P-values are as noted.

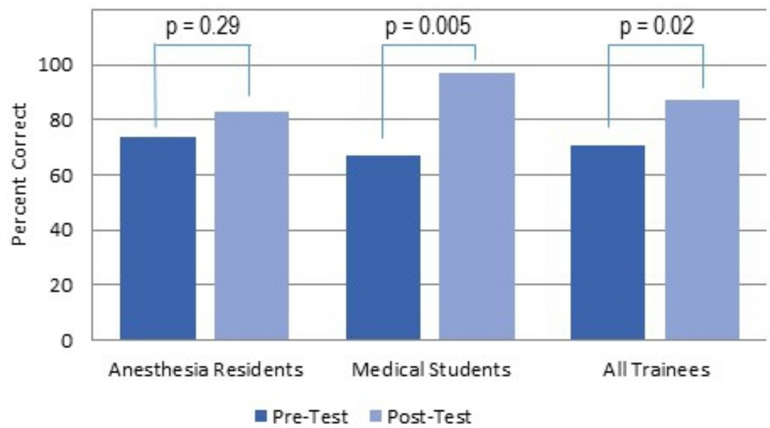
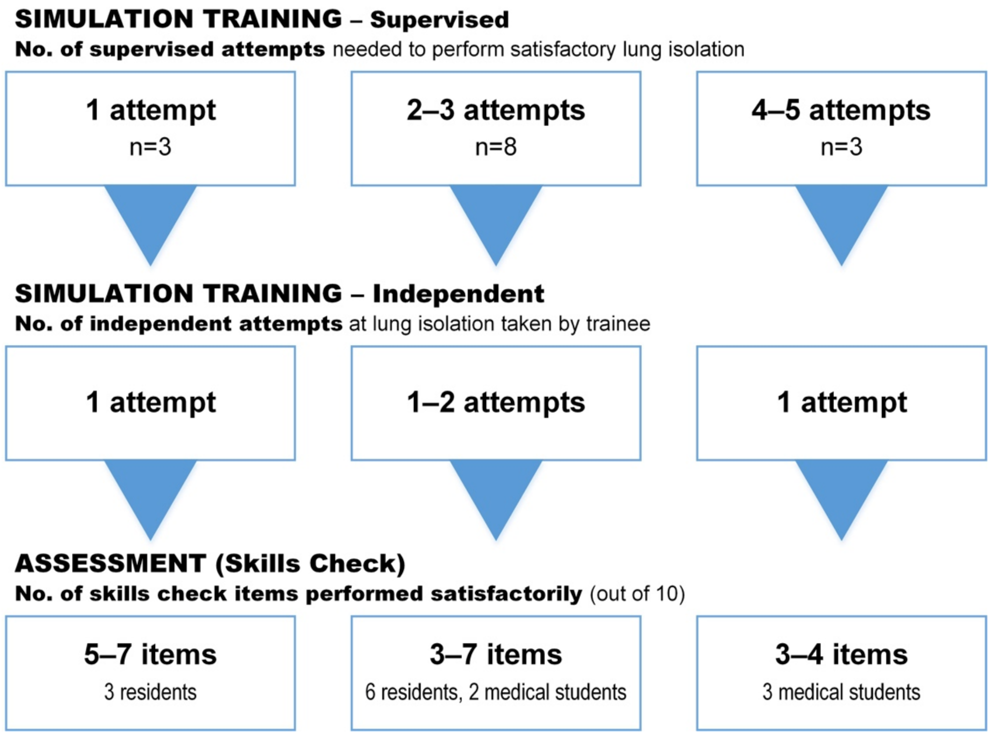


Figure 3 A comparison of trainees grouped by the number of supervised lung isolation attempts required in the simulation lab (1, 2-3, and 4-5). The number of attempts made independently was the same in all groups. The number of skills checks items performed correctly after simulation training differed by group.


SIMULATION TRAINING – Supervised
No. of supervised attempts needed to perform satisfactory lung isolation
1 attempt
n=3
2–3 attempts
n=8
4–5 attempts
n=3
SIMULATION TRAINING – Independent
No. of independent attempts at lung isolation taken by trainee
1 attempt
1–2 attempts
1 attempt
ASSESSMENT (Skills Check)
No. of skills check items performed satisfactorily (out of 10)
5–7 items
3 residents
3–7 items
6 residents, 2 medical students
3–4 items
3 medical students