High-Fidelity Simulation of Lung Isolation With Double-Lumen Endotracheal Tubes and Bronchial Blockers in Anesthesiology Resident Training

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Objectives: **Demonstrate the feasibility of using the AirSim Bronchi airway simulator to teach residents how to manage lung isolation with double-lumen endotracheal tubes and bronchial blockers and evaluate their performance with a detailed checklist.**

Design: **Prospective observational study.**

Setting: **University anesthesiology residency training program.**

Participants: **Anesthesiology residents taking a cardiothoracic anesthesiology rotation.**

Interventions: **Residents were instructed in 7 tasks using the AirSim Bronchi: The use of the fiberoptic bronchoscope, methods for placing left and right double-lumen endotracheal tubes and 3 bronchial blockers (Univent, Arndt, and Cohen), and application of continuous positive airway pressure (CPAP) to the unventilated lung. Two to 3 weeks later, checklists and a detailed scoring system were used to assess performance. Residents rated the curriculum and their own confidence in performing the tasks using a 5-point Likert scale.**

Measurements and Main Results: **Thirteen residents completed the curriculum. Their median Likert scale ratings of the curriculum based on a questionnaire with 6 items ranged from 4 to 5 of 5. Resident confidence scores for each lung isolation technique improved after the simulation training, with the median gain ranging from 0.5 to 1.5 Likert levels depending on the task. The largest improvement occurred with the bronchial blockers ($p < 0.05$). The median performance score for the 7 tasks combined was 88% of the maximum possible points.**

Conclusions: **The authors used the AirSim Bronchi simulator in a novel simulation curriculum to teach lung-isolation techniques to anesthesiology residents and evaluated performance using a detailed checklist scoring system. This curriculum is a promising educational tool.**

KEY WORDS: airway management, continuous positive airway pressure, intubation, intratracheal, simulation, double-lumen endobroncial tube, single-lung ventilation, residency training program

SIMULATION IS BECOMING more important for teaching specific skills and evaluating performance during anesthesiology residency. Highly realistic simulation may enhance or even partially replace clinical experience in some circumstances. This potentially could result in safer and more efficient patient care in teaching centers and also might result in a higher level of skill and performance at the conclusion of the training program.[1–3]

This anesthesiology residency training program includes a large thoracic anesthesiology practice. Most of the thoracic cases that require single-lung ventilation are performed with left double-lumen endotracheal tubes. The cardiothoracic anesthesiology faculty and cardiothoracic surgeons have a strong preference for left double-lumen endotracheal tubes and use right double-lumen endotracheal tubes and bronchial blockers only in a few special situations. The authors have found that the residents generally have ample opportunity to place left double-lumen endotracheal tubes in the clinical setting. However, most residents have little or no experience or knowledge pertaining to right double-lumen endotracheal tubes or bronchial blockers. Therefore, the use of a simulation curriculum to teach the use of right double-lumen endotracheal tubes and bronchial blockers was attractive.

The authors used a commercially available airway simulator, the AirSim Bronchi (Trucorp, Belfast, Northern Ireland), to teach the use of left and right double-lumen endotracheal tubes and 3 types of bronchial blockers. The purpose of this study was to demonstrate the feasibility and effectiveness of this novel curriculum.

METHODS

The study was reviewed by the Institutional Review Board and was granted an exempt status. The AirSim mannequins are realistic, life-sized, plastic upper airway simulators. A version of this simulator, the AirSim Bronchi, includes a realistic model of the bronchial tree (Figs 1 and 2). The authors previously used computerized tomography scanning to show that the AirSim is one of the more realistic upper airway simulators available and that it corresponds reasonably well to normal human anatomy.[4] A video showing alignment of the right upper lobe bronchus of the AirSim Bronchi with the lumen of a right double-lumen endotracheal tube is available (Video 1).

Anesthesiology CA 2 and CA 3 residents on their 4-week-long cardiothoracic anesthesiology rotation participated in 2 simulation teaching sessions lasting approximately 1 hour each. Two of the cardiothoracic anesthesiology faculty, having substantial experience with all of the lung-isolation methods, conducted the tutorials using a standardized approach. Before the first simulation session, the residents were provided with reading materials to provide basic information about lung isolation (Appendix 1). During the first session, faculty

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Fig 1. The AirSim Bronchi. The inset shows the view of the carina through the fiberoptic bronchoscope with a Univent blocker in the left main bronchus.

guided the residents through the performance of seven tasks, including (1) use of the fiberoptic bronchoscope, (2) placement of a left double-lumen endotracheal tube (Mallinckrodt, Covidien, Mansfield, MA), (3) placement of a right double-lumen endotracheal tube (Mallinckrodt, Covidien, Mansfield, MA), (4) placement of a Univent endotracheal tube (Fuji Systems Corp, Tokyo, Japan) with built-in bronchial blocker, (5) placement of a Cook-Arndt bronchial blocker (Cook Medical, Bloomington, IN), (6) placement of a Cook-Cohen bronchial blocker (Cook Medical, Bloomington IN), and (7) application of continuous positive airway pressure (CPAP) to the unventilated lung using a left double-lumen endotracheal tube (Mallinckrodt, Covidien, Mansfield, MA). The simulator was made available for further practice after the session.

During the second session (2-3 weeks later), each resident was asked to demonstrate 2 or 3 of the tasks; each resident could not be tested on all of the tasks because of the limited time available for simulation education in the residency training program. Residents were assigned to perform particular tasks in an informal random fashion by the faculty conducting the session; there was no formal randomization. Performance on these tasks was evaluated by the faculty using a checklist with a detailed scoring system that included 2 to 15 specific items depending on the task (Appendix 2). This checklist was validated by the cardiothoracic anesthesiology division faculty, who agreed by concensus that the checklist accurately reflected the steps required for each task. Confirmation of successful device placement was made by fiberoptic bronchoscopy performed by the faculty. Performance scores were assigned by one faculty per task.

Residents also evaluated themselves by ranking their confidence with right and left double-lumen endotracheal tubes and bronchial blockers before and after the training sessions using a 5-point Likert scale (1-5, where 5 is the best; Appendix 2).

Finally, residents completed an evaluation of the curriculum by rating the effectiveness of the curriculum in 6 areas using a 5-point Likert scale (1-5, where 5 is the best; Appendix 2).

Continuous, discrete, and categoric data were described as the median and 95% confidence interval where appropriate. The Mann-Whitney test was used for comparison of confidence self-evaluations before and after simulation training. A p value less than 0.05 was considered statistically significant. There were no multiple comparisons, and the p value was not adjusted. All statistical comparisons were performed using STATA version 11.0 (Statacorp; College Station, TX).

RESULTS

Thirteen residents completed the curriculum. The resident ratings for each of the 6 course evaluation items are shown in Table 1. The median rating was 4 or more (maximum possible score was 5) for all items. Resident ratings of self confidence improved after training, with an increase in median scores ranging from 0.5 to 1.5 Likert levels depending on the task. There were statistically significant improvements in resident confidence for the bronchial blockers (Table 2).

The scores for resident performance assigned by the two teaching faculty during the second session are shown in Table 3, along with the number of attempts and time required to complete each of the 7 tasks. The overall performance score combining the median scores for all of the tasks was 88% (57 of the 65 maximum possible points). The lowest median performance (50%) was recorded for application of CPAP to the unventilated lung. This occurred because residents frequently forgot to "inflate" the unventilated lung before

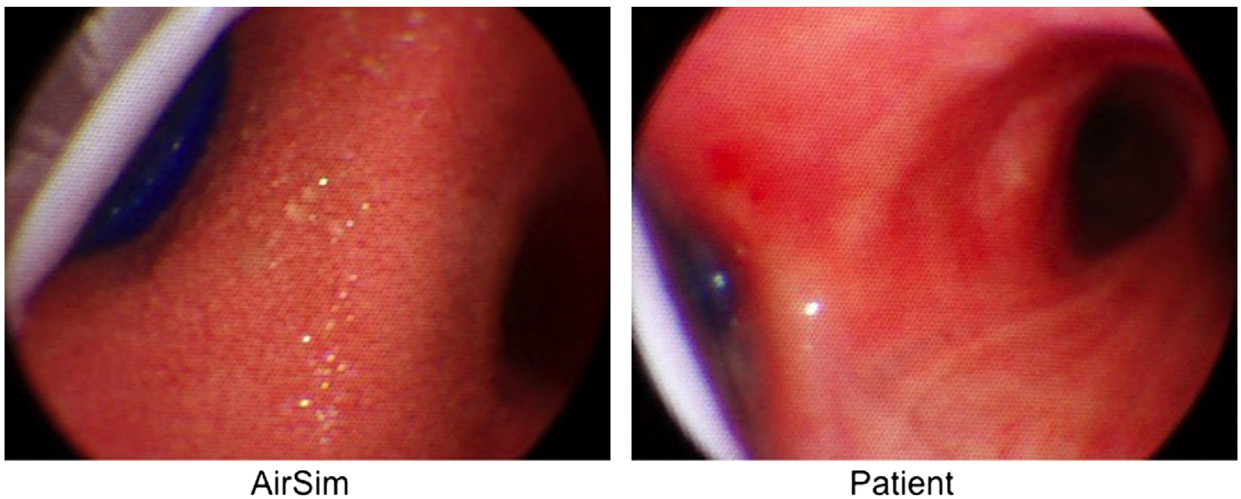

Fig 2. The bronchoscopic view of the carina and left double-lumen endotracheal tube is shown for the AirSim Bronchi (left) and an actual patient (right).