High-Fidelity Patient Simulation Mannequins to Facilitate Aerodigestive Endoscopy Training

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Objective: To evaluate the perceived value of aerodigestive endoscopy training using high-fidelity simulation.

Design: Self-reported survey.

Setting: Pediatric tertiary care hospital.

Participants: Consecutive sample of otolaryngology residents and 1 fellow during the 2006-2007 academic year.

Interventions: Foreign body aspiration and ingestion were simulated in a high-fidelity, computer-assisted infant simulation mannequin. Avoidance of complications and successful removal required teamwork and responsiveness to the mannequin's physiologic characteristics in addition to dexterity with instruments.

Main Outcome Measures: Postcourse 5-point Likert scale and subjective evaluation of perceived realism reported by participants.

Results: Participant response was generally positive. Ratings were highest for training cognitive and psychomotor endoscopy skills, preventing and managing complications, and facilitating team process. Overall realism and appropriate “feel” showed opportunity for improvement.

Conclusion: Pediatric otolaryngology trainees perceive that high-fidelity patient simulation facilitates acquisition of aerodigestive endoscopy skills, especially in training cognitive and psychomotor endoscopy skills, preventing and managing complications, and facilitating team process.

tion to the mannequin just as they would a real patient, rather than waiting for descriptive but abstract information provided by a teacher. Participants, either singly or in teams, begin with a feeling of “role-playing,” but this is quickly overcome by a sense of realism.

**METHODS**

Following institutional review board approval of the study, participants completed a self-reported survey after using high-fidelity simulation to train equipment selection, assembly, and use; patient preparation; recognition and management of complications; and team leadership skills during endoscopic evaluation and treatment of a simulated infant (SimBaby; Laerdal Medical, Stavanger, Norway) with foreign body (FB) aspiration and FB ingestion (Figure 1 and Figure 2). Postcourse participants completed an anonymous survey with a 5-point Likert scale and subjective evaluations of perceived realism. Residents were coached to achieve competence; scores reflected the learner’s assessment of the model and the exercise. The setting was a pediatric tertiary care hospital.

Study participants were a consecutive sample of 8 otolaryngology residents (1 resident in postgraduate year 2 and 1 resident in postgraduate year 4 participated at a time, rotating in 3-month blocks) and 1 pediatric otolaryngology fellow (participating during the first 3-month block of his fellowship) during the 2006-2007 academic year.

The high-fidelity, computer-assisted infant mannequin’s capabilities were demonstrated to the residents, and the primary learning objectives of the exercise, as described in the introductory paragraphs, were articulated. Foreign body aspiration was simulated in a mannequin by placing an FB in the left main bronchus (Figure 3) and programming left-lung obstruction to ventilation; poor left chest-wall motion; audible stridor; and audible, progressively decreasing pulse oximeter saturation unless supplemental oxygen and ventilation were accomplished. Airway manipulation without adequate teamwork would trigger laryngospasm (ie, the mannequin’s glottis would mechanically close, preventing both distal instrumentation and ventilation [Figure 4]). Foreign body ingestion was simulated by placing a coin in the esophageal introitus. Critical skills practiced were the selection and assembly of appropriate endoscopy equipment, coordination of airway management with the “anesthesiologist,” removal of the FBs, and leadership communication skills within a team. Simulation exercises were repeated until trained to competence. Participants worked in teams of 2 (a junior and a senior resident) or 3 (plus a fellow) and took turns performing endoscopy and role-playing the anesthesiologist and/or the nurse. The faculty member was present for the entire session and functioned as both the “content expert” providing information, instruction, and correction as needed and as the “facilitator” controlling selected mannequin actions and responses. Sessions

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**Evaluation of Endoscopy Practicum Using High-Fidelity Patient Simulation Mannequin**

Note: This evaluation form is intended to assess the value and impact of using a high-fidelity patient simulation mannequin as a component of developing pediatric endoscopy skills.

Please rate your level of agreement with each evaluation criteria, using a scale from 1 (disagree) to 5 (agree).

<table>
<thead>
<tr>
<th>Evaluation Criteria</th>
<th>Assessment</th>
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<tr>
<td>Adequate overall realism</td>
<td>1 2 3 4 5</td>
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<tr>
<td>Appropriate manual “feel” realism</td>
<td>1 2 3 4 5</td>
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<tr>
<td>Facilitated improving endoscopy skills</td>
<td>1 2 3 4 5</td>
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<tr>
<td>Facilitated understanding the prevention and management of complications</td>
<td>1 2 3 4 5</td>
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<tr>
<td>Facilitated understanding of team process</td>
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Observed strengths of the mannequin:

Observed deficiencies of the mannequin:

Suggestions for improvement in the teaching exercise:

Other comments:
generally took 1.5 to 2 hours; residents were allowed to practice as many times as they wished, and exercises were continued until competence and resident satisfaction were achieved.

RESULTS

Participant evaluations were generally positive. The mean (SD) ratings were highest for training cognitive and psychomotor endoscopy skills (4.89 [0.33]), preventing and managing complications (4.67 [0.50]), and team process (4.78 [0.44]) (Figure 5). Overall realism (3.78 [0.67]) and appropriate “feel” (4.00 [0.87]) showed room for improvement. Subjective comments suggested that this exercise facilitated instrumentation dexterity and sequencing; limitations cited were unrealistic feel and lack of penalty for injury (Table 1). The exercise seemed to provide excellent psychological fidelity.

COMMENT

Simulation is a technique, not a technology, used to replace or amplify real experiences with guided experiences that evoke or replicate substantial aspects of the real world in a fully interactive manner. Aerodigestive endoscopy requires a complex and sometimes delicate balance of cognitive, psychomotor, and teamwork skills; clinical opportunities may be unpredictable and unevenly distributed. The use of simulation in surgical education allows opportunities for practice and exploration based on the needs of the learner, exploration without direct risk to patients, immediate feedback and objective documentation, and activated adult learning.

The broad field of simulation-enhanced learning is defined by the Agency for Healthcare Research and Quality as “a strategy—not a technology—to mirror, anticipate, or amplify real situations with guided experiences in a fully interactive way” and includes a variety of physical, electronic, and animate models representing normal and abnormal anatomic and physiologic conditions, diseases, and situations (Table 2). Teachers may use a single modality or assemble multiple learning modalities in hybrid combinations to achieve specific educational objectives addressing the needs of single or transdisciplinary learners.

For very unique otolaryngology skills, otology, sinus surgery, and flexible bronchoscopy simulators are being developed both in academic and commercial settings, and ongoing studies address the validity of these devices and strategies. In this study, I used a commercially available, relatively inexpensive high-fidelity mannequin that was not specifically designed for these teaching objectives.

The mannequin was programmed to demonstrate changing physical findings correlating with evolving medical circumstances, so that the participants had to repeatedly evaluate the mannequin’s condition rather than rely on cues provided by an instructor. For example, blockage and subsequent lack of ventilation of the left lung were evidenced by the lack of chest rise only on the left side of the chest, laryngospasm was demonstrated by mechanical closure of the glottis, and oxygen desaturation was represented by standard decreasing oxygen saturation information on the monitor (ie, decreasing oxygen saturation value visible on the display, and audible decrease in the pulse oximeter tone), as well as activation of a blue light within the oral cavity. For the purposes of

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Figure 4. Demonstration of mannequin vocal folds. A, Normal position; B, mechanically closed during laryngospasm.

Figure 5. Likert scale ratings from participants’ evaluations (5 is best rating).
the learning objectives in this study, the facial and oral anatomy and jaw thrust mechanism of the mannequin are excellent; laryngeal anatomy is less accurate but remains representative, and tracheobronchial and esophageal anatomy is relatively primitive.

Better simulators, including a ready assortment of pathologic airway abnormalities, would be useful. It is likely that development of more accurate anatomic fidelity is in progress and will be incrementally improved with mannequin upgrades in the near future. The needed development of a cohort of pathologic airway abnormalities is important but more technically challenging and expensive for the manufacturers. As a specific example, managing tracheotomies is often intimidating for health care providers (physicians, nurse practitioners, and nurses), and sophisticated models are not yet available. The physical feasibility of placing a tracheotomy in the SimBaby has been demonstrated in a pilot study by the anatomically correct placement of a tracheotomy into a mannequin laryngotracheal complex (lent to me by the manufacturer) without damage to the laryngeal mechanics. One mechanism to support enhanced fidelity would be to obtain funding to develop a nonproprietary archive representing a spectrum of both normal and abnormal anatomy.

This preliminary report suggests that otolaryngology trainees are receptive to using simulation with high-fidelity mannequins to enhance their training. Study limitations include the small sample size, potential selection bias, subjective evaluation, and difficulty differentiating the contribution of high-fidelity simulation from the scenario-based exercise itself.

In conclusion, pediatric otolaryngology trainees perceive that high-fidelity patient simulation facilitates acquisition of aerodigestive endoscopy skills, especially in training cognitive and psychomotor endoscopy skills, preventing and managing complications, and facilitating the team process. The use of an “off-the-shelf” technology
allows for the replication of this exercise in other institutions.

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REFERENCES