

# Low-Cost Models for Simulation as a Tool for Increasing Medical Student Interest in and Understanding of Otolaryngology

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## Article Information

Received date: Sep 01, 2017

Accepted date: Nov 03, 2017

Published date: Nov 08, 2017

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**Keywords** Simulation, Education, Medical student, Airway modeling, Head and neck, Otolaryngology, Clinical anatomy

**Abbreviations** POM: Practice of medicine; ENT: Ear, Nose, and Throat; ASA: American Surgical Association; FEES: Flexible Endoscopic Examination of Swallowing; OSCE: Observed Structured Clinical Encounter; NBME: National Board of Medical Examiners

## Abstract

**Objectives:** We sought to determine the utility of a low-cost simulator and brief educational session to help students understand midline neck anatomy and increase exposure to otolaryngology with an easily reproducible model.

**Design:** Pilot study including survey with lecture and hands on instructional lesson.

**Methods:** As part of the first-year medical student curriculum at our university, the otolaryngology department offers a workshop on head and neck anatomy and related components of the physical exam. Students participated in five 20-minute stations. One was devoted to neck anatomy with models of midline structures and a tracheostomy. Students completed a survey after the head and neck station.

**Results:** 182 students responded to the survey. Over 85% of participants felt the head and neck station and models helped them understand anatomy of the neck. Eighty-five percent of students responded the models helped them visualize what a tracheostomy would look like in a patient. Before the head and neck station, 16% of students agreed or strongly agreed that they had interest in ENT, Ear Nose and Throat surgery, as a career. After the station, that increased to 73% ( $p < 0.05$ ). Sixty-nine percent of students stated the tracheostomy models specifically increased their interest in otolaryngology.

**Conclusion:** Simulation is a useful adjunct for teaching head and neck anatomy to medical students. Our workshop's head and neck station, with lecture and simulation, strongly increased participant interest in otolaryngology and solidified relevant anatomy.

## Introduction

Interest in surgery and surgical specialties has declined over the past two decades [1-6]. It is projected that by 2030, there will be a deficit of nearly 30,000 surgeons, including otolaryngologists (aka Ear, Nose, and Throat (ENT) surgeons) [1,3]. Otolaryngology has seen a decline in residency applications, which contrasts with the increased success rate of students matching into surgical residency programs [1,7].

Many studies have considered factors contributing to this decline in applications to surgical fields [1-3,6,8]. In 2004, the American Surgical Association (ASA) acknowledged medical students' declining surgical interest and put forward recommendations to address contributing factors [9]. Due to curriculum changes in medical schools throughout the U.S. and abroad, surgical clerkships have been shortened, allowing less time for students to experience surgical specialties [1-3,8,10]. The exposure to surgery prior to clinical training is even more limited, particularly regarding otolaryngology. One of the ASA 2004 recommendations was to increase involvement of surgical departments in teaching preclinical medical students [9,11].

Involvement in teaching and mentorship by surgical staff and faculty has consistently been shown to increase medical student interest in selection of surgery as a career [1,3,5,12,13]. Workshops offer excellent opportunities for preclinical students to interact with surgical staff and incorporate surgical learning that is not a standard part of the preclinical curriculum. Workshops and simulation sessions are often limited in number due to time, equipment, staff, and budget constraints [2,5,14]. This may create situations where those with interest in information on various specialties may be dissuaded due to perceive lack of available exposure. For our study, we aimed to determine the impact of a preclinical otolaryngology session for all first-year medical students.

The use of simulation and surgical workshops have emerged as opportunities for students to learn practice technical skills while eliminating some of the pressures and stressors of hands-on patient care scenarios such as assistance in the operating room [1,5,15-17]. While the use of simulation has been shown to increase medical student interest in general surgery, cardiothoracic

surgery, and vascular surgery, its use in otolaryngology has not been well demonstrated [5]. It was important to design our project with a low-cost model in order to create a reproducible model that is feasible for use outside of our institution. For our project, we evaluated the use of simulation with a low-cost model of the head and neck to increase both interest in otolaryngology and understanding of head and neck anatomy.

At the University of Texas Medical Branch, first year students participate in a course called “Practice of Medicine” (POM). This course is held throughout the entire first year and offers students the opportunity to learn physical exam maneuvers, shadow physicians in clinical settings, and gain exposure to clinical medicine during their preclinical curriculum.

For the past several years, the otolaryngology department has held a workshop for POM students dedicated to the complete head and neck exam. Our department has expanded the use of simulation in this workshop, incorporating rigid nasal endoscopy, flexible laryngoscopy, and Flexible Endoscopic Examination of Swallowing (FEES). These stations received high remarks by students, and the ability to perform endoscopy during the sessions has consistently rated highly among participants.

While this equipment is typically available in otolaryngology clinics, it may not be available for workshops due to significant effort to transport and maintain. Due to costs, it may not be available for use outside the direct patient care setting. Several medical schools do not have an otolaryngology department and would be unable to replicate such a workshop. We sought to evaluate the use of a low-cost simulator during the workshop to determine student perception of a less expensive alternative to endoscopic equipment and commercially-available anatomic models.

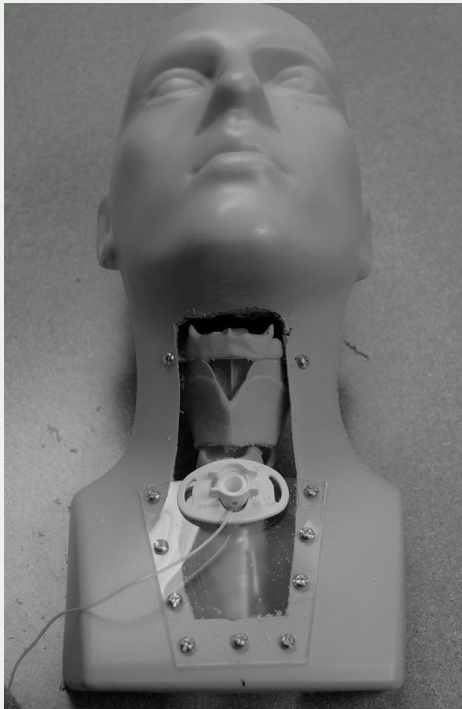


Figure 1: Model of the adult head and neck.

## Materials and Methods

This project was approved by the Institutional Review Board of the University of Texas Medical Branch.

A model of the adult head and neck was created by the lead author (L.R.) using inexpensive materials (see Figure 1). The model utilizes a hollowed out generic mannequin head and neck with a 3D printed high-fidelity model of a human larynx. A saw was used to cut the mannequin in half in the coronal plane, from the base up through the neck. Then, the two pieces were reattached using 2 double-screw hinges. An anterior chest window was made by using a Dremel cutting bit, drill, and small hacksaw. Screws were placed around the chest cavity window to allow placement of clear and opaque window coverings. After attempting many window coverings, an IV bag was used to create a clear window and thin natural rubber sheeting was used for the opaque cover. A single whole punch and a CNC laser cutter were used to create holes for screws and passage of a tracheostomy tube, respectively. The 3D larynx was printed on a 3D printer, with firm and flexible plastics, located at Makerspace at University of Texas Medical Branch at Galveston using a file created by University of Dundee and BodyParts3D (with permission). The printed trachea was secured to the chest wall and lateral aspects of the thyroid cartilage via screws. Finally, a hole was made in the anterior trachea to simulate tracheostomy windows using a dremel. The model had a viewable window at the level of the larynx to allow individuals to view the underlying structures. This area could be covered with rubber sheeting to allow individuals to palpate the underlying structures without direct visualization to simulate palpation of an adult neck.

A second model was created using a silicone baby doll toy (see Figure 2). The “squeak” mechanism was removed from the toy to allow for a connection between the mouth and chest cavity. A window was cut out of the chest and a rectangular piece of clear plastic office packaging was sewn to cover the hole. A similar window was cut in the back and sealed with Velcro to allow for easy access to the chest cavity. A trachea was created with 1” clear tubing with a small anterior hole to allow for tracheostomy placement later. Another window was made in the side of the tracheal tube and another 1” tube was inserted to simulate the carina and bronchi. A third 1” tube was glued to the “squeak” mechanism remnant and created an opening to the mouth acting as the esophagus. Esophagus and trachea were



Figure 2: Model of an infant with tracheostomy *in situ*.

zip-tied together and a green wire was passed through the mouth into the esophagus simulating an orogastric tube. A small hole was created in the doll's neck with a drill and a neonatal tracheostomy tube was inserted through the hole into the trachea via the pre-cut window. This model did not have palpable neck landmarks but had a clear neck and chest window to allow individuals to view the deep neck structures including views of a tracheostomy tube *in situ*. The estimated costs of the adult model totaled approximately \$50 while those for the pediatric model totaled approximately \$30.

A workshop for the POM students was held over a 3-day period in early falls. The event was promoted as a mandatory portion of the POM curriculum, but attendance was based on the honor system creating a voluntary atmosphere. First year medical students rotated through the following 5 stations: ear, nose and throat, larynx, neck, and cranial nerves. Students were randomly assigned to different starting stations and rotated through in a specified order to complete all 5 stations in the allotted workshop time. Students had 20 minutes to spend at each station, with individual session instructors able to use the time as they wished. Each station had an otolaryngology resident or faculty present with some stations having non-first year medical students present as well. The student volunteers were members of the Otolaryngology Interest Group. The lead author (L.R.) was present for and instructed all sessions of the neck station. A PowerPoint presentation was used for portions of this station to ensure continuity from one group of students to the next.

At each station, students were given a checklist of physical exam maneuvers related to the station that they would be expected to perform during Observed Structured Clinical Encounters (OSCEs). These OSCE maneuvers are taught at many institutions across the country in preparation for both general medical practice as well as performance on the standardized National Board of Medical Examiners (NBME) Step 2 Clinical Skills examination.

During the neck station, students were taught the proper examination of the neck including palpation of cervical lymph nodes and thyroid gland. A brief presentation on anatomy of the neck as well as clinical correlations including specific details relevant for both general practice and otolaryngology was given by the lead author (L.R.) and assistants. The presentation included discussion of tracheostomies. During the presentation, both volunteer individuals and the models were used to demonstrate neck anatomy and proper

physical examination technique. Following the presentation, all participants were asked to practice the OSCE maneuvers on other group members or the models. Students were also allowed to utilize the models to practice manipulation of a tracheostomy tube. They were given ample time for practice and to ask any questions of the instructors.

At the end of the neck station, participants were asked to complete a voluntary, anonymous 9-question survey. Questions were single-answer Likert-type responses (Table 1). This survey was specific to the neck station, and students were not asked to complete surveys regarding any other stations. Participants were asked to fill out a general survey regarding their experience with the workshop as a whole, but the results of this voluntary survey are beyond the scope of this paper.

Survey responses were evaluated using Microsoft Excel v. 2016®. Mean responses and percent distribution were calculated for all Likert-type responses. The Student's t test was used to compare overall interest in ENT before and after the intervention (survey questions 8 and 9). Chi-square testing was used to compare those who responded with agreement (response 4 or 5) regarding interest in surgery before and after the intervention (survey questions 8 and 9).

**Results**

This was the third year the lead author (L.R.) instructed stations at the ENT POM workshop, but it was her first year instructing the neck station. This was the first time a model was used at the neck station. It was also the first time a survey was used to assess an individual station.

Throughout the workshop, participants expressed a strong interest in learning relevant exam maneuvers. They also asked many questions in each session, ranging from those regarding specific physical exam maneuvers to career options and information on otolaryngology as a field.

In total, 182 students completed the neck station survey. The percentage of participants completing the survey could not be determined as attendance was not recorded. However, based on observation, instructors noted a very high survey participation rate. All individual questions had at least 180 responses (98.9% complete response rate; Table 2). 94% of students felt the workshop's neck station helped them understand the anatomy of the neck. 88% of

**Table 1:** Neck Session Survey Questions.

Question	Statement Text
1	Before this workshop, I knew what a tracheotomy or tracheostomy was
2	Before this workshop, I knew tracheostomies were common procedures done by ENT surgeons
3	This workshop helped me understand the anatomy of the neck
4	The adult tracheostomy model helped me understand the midline anatomy of the neck
5	The adult and pediatric tracheostomy models helped me visualize what a tracheostomy would look like in a real person
6	This workshop increased my interest in ENT
7	The tracheostomy models increased my interest in ENT
8	Before today, I had some interest in ENT as my possible career
9	After this workshop, I have some interest in ENT as my possible career

Instructions to Participants: Please rate your agreement with the following statements on a scale of 1-5 (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree).

**Table 2:** Neck Session Survey Responses.

Question	1-Strongly disagree n (%)	2-Disagree n (%)	3-Neutral n (%)	4-Agree n (%)	5-Strongly agree n (%)
1	10 (5.5)	17 (9.3)	29 (15.9)	59 (32.4)	67 (36.8)
2	25 (13.8)	49 (27.1)	42 (23.2)	39 (21.5)	26 (14.4)
3	1 (0.5)	0 (0)	14 (7.7)	67 (36.8)	100 (54.9)
4	0 (0)	5 (2.8)	17 (9.4)	69 (38.1)	90 (49.7)
5	0 (0)	2 (1.1)	30 (16.6)	57 (31.2)	92 (50.8)
6	1 (0.6)	3 (1.7)	17 (9.4)	75 (41.4)	85 (47.0)
7	2 (1.1)	11 (6.1)	43 (23.9)	75 (41.7)	49 (27.2)
8	38 (20.9)	49 (26.9)	65 (35.7)	19 (10.4)	11 (6.0)
9	1 (0.5)	7 (3.8)	42 (23.1)	87 (47.8)	45 (24.7)

students reported the adult head and neck model helped them understand the anatomy of the neck.

The neck station increased students' overall interest in otolaryngology as a potential career. The mean response to questions regarding interest in ENT increased from 2.5 to 3.9 ( $P < 0.0001$ ). The percentage of students who reported they agreed or strongly agreed in having an interest in ENT increased from 16% to 73% ( $P < 0.0001$ ).

## Discussion

The decline in applicants to surgical careers is startling. Decreased exposure to surgery and surgical specialties in preclinical curricula is frequently cited as a contributing factor [1-3,8-10]. This is particularly relevant, as many students decide upon their final medical career prior to their clinical medical education [2,13,18,19]. A survey of medical students in England and Wales found 23% of students had chosen their medical specialty prior to entering medical school [13]. Kozar found 59% of students selected their career choice prior to the 3rd year (beginning of clinical training), and only 33% of 1st year students reported general surgery or a surgical specialty as their anticipated career [19]. These findings correlate with our students' reported low interest in otolaryngology prior to the workshop.

Limited exposure to surgical training is particularly problematic for otolaryngology. While few students are exposed to surgical training in preclinical years, many students experience little, if any, otolaryngology at all in medical school [1,10,12,13,20,21]. Less than 1% of medical school curricula in the UK incorporate ENT topics, and 1/3 of medical schools do not offer ENT placement [12]. 39% of medical students in England and Wales had no clinical exposure to ENT, and another 43% had less than 2 weeks exposure [13]. A survey of over 100 medical schools in the United States found over 90% of schools did not require otolaryngology clerkships, nearly 90% of those offered were less than 4 weeks long, and only 9% of students participated in these rotations [21]. In addition to limited exposure to otolaryngology, students' understanding of what the field encompasses is very limited. Ranta found that 1/3 of third year students starting their 1-week ENT rotation did not know head and neck surgery was part of the specialty [20].

Our workshop offers a simple method of exposing students early in their medical training to otolaryngology. Our increase in interest in ENT after completion of the workshop's neck station corresponds well with results from similar programs [8,10,22]. An early interest

in and exposure to surgery correlates with matching into a surgical residency [1,5,11]. A study out of the UK found those interested in ENT as a career had near universal exposure to ENT in medical school or during postgraduate medical training, but options for exposure were greatly limited [12].

While only a small percentage of medical students will choose otolaryngology as a profession, it is important for all providers to be knowledgeable about commonly seen ENT illnesses. When asked to rank how well they needed to know certain surgically-related topics for their practice, primary care practitioners in New Mexico ranked acute otitis media, sinusitis, reflux, and pharyngitis as the four most important for their practice [23]. Other surveys of primary care practitioners found otolaryngology among the top 3 surgical specialties relevant to their practice [23,24].

Studies of urgent care and primary care clinics have shown a consistently high rate of ENT-related illnesses [15,21]. Sinusitis is the 4<sup>th</sup> leading diagnosis for outpatient visits in the United States, and acute otitis media is the most common pediatric bacterial infection [21]. Despite the clear need for exposure to otolaryngology, medical students are severely limited in this regard as detailed above. This lack of exposure carries into residency training and formal practice. Glicksman found the majority of family medicine residents surveyed were uncomfortable diagnosing and managing common otologic conditions [25]. Others found that while 62% of medical students received instruction on head and neck anatomy, only 36% received instruction on physical diagnoses of the head and neck [21]. Our head and neck station offers an excellent opportunity for not only exposing medical students to the field of otolaryngology but also ensuring all students will feel more comfortable with examination and diagnosis of common head and neck complaints.

The use of simulators in our workshop is not unique to surgical preclinical workshops. Many authors have described workshops and training sessions utilizing simulation [1,2,11,14,15,17,22,26]. Cadaver and animal laboratories are frequently shown to improve interest in surgery and comfort with surgical skills [4,16]. Unfortunately, these laboratories are often limited to small group settings due to associated costs. A porcine lab for medical students at Ohio State University was rated as highly educational, but it was limited to 69 students at a cost of nearly \$10,000, and expansion to the entire medical school class would total nearly \$30,000 [14]. Various simulators, including those that incorporate 3D technology or other virtual anatomy have been developed to help mitigate this barrier to education [2,15-17,27].

Our workshop utilized both advanced technology (flexible laryngoscopy) and low-cost advanced simulation (the head and neck model) to instruct first year students on an array of physical exam maneuvers while incorporating clinical diagnoses and exposure to otolaryngology. While we did not directly compare the various stations of simulators used throughout the workshop, the survey results from the head and neck station demonstrate nearly all students learned useful physical exam techniques working with the low-cost model. Future studies to compare low-tech and high-tech simulators as part of an ENT workshop would offer greater insight into ways to expose medical students to broadly applicable physical exam techniques and patient pathology while minimizing costs to allow such sessions to become more readily widespread.

The use of resident and faculty otolaryngology instructors is a particular strength of our workshop. As discussed previously, mentorship and instruction by staff surgeons strongly increases students' interest in surgery and surgical specialties. In a survey from the University of South Florida, 78% of otolaryngology applicants reported exposure to current ENT residents as the main factor influencing their career decision [7]. Residents also benefit, as those who actively participate in teaching have greater job satisfaction and knowledge acquisition [28].

This project has the limitations inherent to any pilot study including lack of a comparison group. We were unable to compare data from the surveys to prior workshops as this was the first year introducing a survey on the neck station. For future evaluation of the neck model and workshop we hope to continue utilizing the post-session survey to track progress from year to year. While the reported increase in interest in ENT before and after the session is quite encouraging, we recognize the recall bias present in asking information regarding pre- and post-session beliefs after the station itself concluded. While a separate survey given immediately prior to and following the neck station would decrease recall bias, the authors felt the addition of a second survey would create too great a time strain on the already brief session. In addition, students completed the neck station at various points throughout the overall workshop. It is possible that other stations added to the increased interest in otolaryngology, but this fact was unable to be fully identified or captured in our data, as surveys did not identify whether students completed other stations in order to anonymize the results. We attempted to minimize the bias possible from the order of stations completed by asking questions specific to the neck station.

While our specific sessions may not be replicable for all medical schools due to class structure, size, or time and financial constraints, several components are widely applicable including use of physical exam maneuvers that have become standard via examinations such as the NBME clinical skills examination.

## Conclusion

Despite the decline in interest among surgical specialties including otolaryngology, a great need exists to train all medical students in proper physical exam techniques prior to residency training and expose medical students early to otolaryngology. A short workshop on head and neck anatomy with clinical correlates offers students an opportunity to practice exam maneuvers in a low-pressure scenario with no risk to patient safety. Our study showed a brief workshop using a low-cost simulator of the head and neck is useful for teaching

the anatomy and physical examination of the head and neck and significantly increases participants' interest in otolaryngology.

## Acknowledgment

The authors have no competing interests to declare. The authors wish to acknowledge the medical student volunteers who offered their assistance performing various tasks, both organizational and didactic, for the workshop. Thank you to Andrew Maxwell-Parish for his assistance in creation of the tracheostomy model. The files for the 3D model of the larynx portion of the head and neck model were provided by the University of Dundee and Body Parts 3D, The Database Center for Life Science with permission. This study was presented at the Triological Society during the Combined Otolaryngology Spring Meeting in San Diego, CA, USA on April 29, 2017.

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