Simulators for Laryngeal and Airway Surgery

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KEYWORDS

• Simulation • Larynx • Airway • Microlaryngoscopy • Virtual reality

KEY POINTS

- Simulators for laryngeal and airway surgery have become increasingly important in residency training.
- Effective laryngeal and airway surgery simulators can be made from low-cost and easily attainable materials.
- Simulators should be able to measure a subject's performance, and feedback from trainees is an important part of developing useful laryngeal and airway surgery simulators.

INTRODUCTION

Laryngeal and airway surgery require precise technique and a significant amount of mastered skill that can be difficult to obtain during otolaryngology residency training. Traditional on-the-job training with mentor oversight has become more challenging because of time and fiscal constraints, a growing medicolegal environment, and higher patient expectations and awareness of receiving care in an academic training environment. Procedural simulators have become increasingly important in residency training (eg, temporal bone simulators, bronchoscopy simulators, cadaver dissection courses), and in new-surgeon skill acquisition (eg, transoral robotic surgery, photoangiolytic laser laryngeal surgery). Current otolaryngology residency program requirements mandate that residents "must demonstrate knowledge of anatomy through procedural skills demonstrated in cadaver dissection, temporal bone lab, and/or simulation labs." Nevertheless, in a survey by Shah and colleagues,[1] only 18.8% of US otolaryngology residents were very satisfied with their phonomicrosurgery experience

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in residency. More than 87% thought they would benefit from laboratory-based training.

Simulators are particularly useful for developing skills in laryngeal and airway surgery. These surgeries are often performed by a single operator and therefore do not lend themselves well to a more traditional mentor relationship where the teacher assists the trainee. In-office laryngeal and airway procedures present additional challenges in awake patients, whose anxiety about a procedure and strong desire for success may preclude their willingness to participate in procedural skill training. Mandates for increased patient safety and more uniform training curricula have spurred the development of physical training platforms that allow learners to emulate teaching models such as the temporal bone drilling station that has now become a mandatory part of Accreditation Council for Graduate Medical Education accreditation of Otolaryngology-Head and Neck surgery resident training programs. In these models, experts mentor trainees in a zero-risk environment where laryngeal and airway surgeries as well as office-based procedures are simulated on cadaveric animal structures, human larynges, or trainers that incorporate noncadaveric materials.

This article reviews the literature pertaining to simulators and ex vivo training methods used in teaching laryngeal and airway surgery and highlights the efficacy of these models. Descriptions of simulators reported for use in microlaryngoscopy, transcervical laryngeal injection, bronchoscopy, intubation, flexible laryngoscopy, cricothyroidotomy, and tracheotomy are presented.

PHONOSURGERY TRAINER AND ASSESSMENT OF SKILL ACQUISITION

The laryngeal dissection station originally developed by Dailey and colleagues[2] was made from cheap materials and allowed for a physical platform onto which a human or animal cadaveric larynx could be mounted (**Figs. 1–4**). Both endoscopic and open surgery could be simulated with instrumentation identical to the operating room. A focus on the preservation of tissue for maximum utility of larynges, sometimes hard to come by, was maintained. Again mirroring the temporal bone experience, dissection manuals by Johns and Klein and then by Dailey and Verma helped to provide learners with detailed step-by-step surgical directions with emphasis on clinical pearls and pitfalls of the various procedures.[3–5] Implementation of this type of training into resident training programs was demonstrated later by Verma, including cost analysis for dissemination and implementation of laryngeal training.[4] With cost always an issue, Verma then developed a low-cost version of the dissection station able to reliably be constructed with easy-to-find materials.[6] This station was termed the versatile optimally constructed aid for laryngeal surgery simulation (**Fig. 5**). Less than $100, it is now being used across the United States. With the beginnings of a more standardized training curriculum under way, additional refinements were now possible to mirror surgical precision for task-specific evaluation as seen in laparoscopic training in general surgery.

It is well known that endoscopic surgery involving tissue manipulation for so-called benign lesions of the vocal fold (eg, polyps, cysts, nodules) is extremely challenging. Surgeons must work through a small-bore laryngoscope while using long fulcrum arm instruments to maximally preserve the delicate layered structure of the lamina propria. They must preserve overlying epithelium to prevent healing by secondary intention and subsequent scar formation, all this in a setting of looking through a binocular microscope and maintaining adequate ergonomics to prevent muscle fatigue with subsequent loss of instrument stability and accuracy. This set of circumstances where mistakes can lead to poor phonatory outcomes is ideal