Advanced Pediatric Airway Simulation

Charles M. Myer IV, MD[a,*], Noel Jabbour, MD, MS[b]

KEYWORDS

• Pediatric airway • Airway foreign body • Bronchoscopy • Simulation • Education

KEY POINTS

- Pediatric airway surgery is an ideal target for simulation given the limited case exposure, unique instrumentation, and shared airway.
- The use of a high-fidelity simulator for pediatric airway endoscopy scenarios allows for integration of procedural technical competency training with interdisciplinary crisis resource management.
- Limited simulation models exist for practice of more complex endoscopic airway procedures and open surgical techniques. Further development of validated simulators and integration of assessment tools will allow for improved surgical training.
- The use of simulation, including in situ sessions inside the operating room, is ideal for refining care delivery algorithms, especially in high-risk low-frequency events, such as pediatric aerodigestive foreign body ingestion.

INTRODUCTION

Pediatric airway cases often involve the shared management of the airway with anesthesia personnel, frequently without endotracheal intubation and using intermittent ventilation on airways undergoing surgical manipulation. Complex equipment must be assembled and handled by operating room (OR) nurses and surgical technicians. Achieving a successful outcome relies not only on the technical skill of the surgeon, but also on the interaction between this group of professionals through teamwork and effective communication.

There are several unique aspects of the care of the infant and pediatric airway that differ from adult airway management: the small size of airway, the significantly shorter

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[a] Division of Pediatric Otolaryngology, Department of Otolaryngology–Head and Neck Surgery, Cincinnati Children's Hospital Medical Center, University of Cincinnati College of Medicine, 3333 Burnet Avenue, MLC 2018, Cincinnati, OH 45229-3026, USA; [b] Department of Otolaryngology, Children's Hospital of Pittsburgh of UPMC, University of Pittsburgh, 4401 Penn Avenue, Faculty Pavilion, 7th Floor, Pittsburgh, PA 15224, USA
* Corresponding author.
E-mail address: charlie.myer@cchmc.org

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time of apnea that is tolerated by children given lower pulmonary reserve, and the types of airway pathology seen in infants and children. These features coalesce to create a high-stakes environment, and when coupled with the low-frequency of pediatric airway cases, these events are prime targets for surgical education using simulation. This can apply to residents in training and practicing otolaryngologists. Foreign body aspiration is one such case.

The Centers for Disease Control and Prevention categorizes foreign body aspiration under the umbrella of "suffocation." There has been an increase in the rate of death by suffocation between 2000 and 2009. It is the leading cause of death by unintentional injury in children younger than 1 year of age. In this age group, it increased from 526 to 907 deaths per year from 2000 to 2009. Suffocation deaths are less common in the 1-to-4-year-old range, with 151 deaths in 2000 and 125 deaths in 2009.[1]

Before the introduction of instrumentation for airway endoscopy and foreign body removal in the early 1900s, aspirations were commonly fatal. Now, largely because of these advances, such aspiration events are nearly universally survivable with proper care. Endoscopy for foreign body removal is a potentially life-saving procedure, but it is a complex, multistep procedure, with instrumentation that is used exclusively for this procedure, making skill acquisition and retention of acquired competency difficult.

Despite the frequency of these events, given the temporal and geographic distribution, the exposure to pediatric aerodigestive foreign body cases in otolaryngology residency is variable, and has been estimated at 1.3 cases per resident per year.[2] There is therefore a need to shift the learning outside of the OR for such cases. Over the past 10 years, simulation has played a significant role in the training of otolaryngology residents in these procedures.

But simulation for pediatric airway management is not a novel concept. Chevalier Jackson used rag dolls, such as his "Michelle the Choking Doll," to demonstrate his technique for foreign body removal and for emergency tracheostomy.[3] From foreign body removals to tracheostomy to complex airway reconstruction, simulated surgery of the pediatric airway can play a key role in the training of otolaryngologists for high-stakes, low-frequency airway emergencies and for more routine endoscopic and open airway procedures.

Recent advances in the quality of simulators and the ability to assess trainee performance broadens the application for simulation in otolaryngology surgical education. This article covers the use of simulation for pediatric aerodigestive foreign body management and other pediatric airway procedures. The final section covers recent technological advances in airway simulation and discusses the potential application of these advances for the future of pediatric airway simulation.

SIMULATION FOR AIRWAY ENDOSCOPY AND AERODIGESTIVE FOREIGN BODIES

Endoscopic and laparoscopic surgical techniques lend themselves to simulation because of the complex psychomotor tasks necessary to manipulate unique instrumentation. The primary goal of simulation, that of deliberate practice to achieve or maintain proficiency, is especially relevant in endoscopic management of an airway foreign body in a child (a true high-acuity, low-frequency event). A learner who is "primed" through prior exposure to the concepts, equipment, and surgical steps before being involved in a live patient encounter may be able to better function inside the OR and achieve greater educational gains. This concept of a pretrained novice is especially important in these cases, where there is less opportunity to allow for the more traditional surgical educational apprenticeship model of increasing responsibility.[4]