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Simulation of Pediatric Endoscopic Cricoid Reduction and Expansion

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Abstract

Endoscopic cricoid expansion and reduction are newer approaches to the management of pediatric bilateral vocal fold immobility and postlaryngotracheal reconstruction glottic insufficiency, respectively. These procedures offer a less invasive, endoscopic alternative to procedures that typically required open management with a more prolonged recovery. These technically demanding procedures are currently performed only in select centers, and there is no currently described training model for practicing them. We present a modification to a laryngeal dissection station that allows for simulation of endoscopic cricoid reduction and expansion with excised larynges. The model allows trainees to practice endoscopic posterior cricoid exposure, incision of the cricoid cartilage, placement of a simulated costal cartilage graft for expansion, and endoscopic suturing for reduction. Development of simulators for procedures that are infrequently performed have the potential to help trainees reach surgical competency faster and more safely.

Keywords

endoscopic cricoid reduction, endoscopic cricoid expansion, laryngeal dissection station, surgical simulation, bilateral vocal fold paralysis, laryngotracheal reconstruction

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Endoscopic cricoid expansion and reduction are difficult procedures performed exclusively in the quaternary care setting. Endoscopic cricoid expansion—introduced by Inglis et al in 2003 as an alternative treatment of posterior glottic/subglottic stenosis or bilateral vocal fold paralysis[1-3]—has been shown to be effective with limited morbidity.[4,5] Endoscopic cricoid reduction is performed to address dysphonia related to glottic insufficiency following prior prolonged intubation or laryngotracheal reconstruction.[6-8]

Cases with these procedures are relatively rare, resulting in trainees receiving less exposure; however, optimal outcomes still depend on regular practice.[9] Simulations provide regular practice and have been shown to improve trainees' abilities.[10] Studies show that students with simulation training have fewer errors than those without.[11,12] Simulation training has also been linked to improved patient outcomes. Correspondingly, the American Residency Review Committee for Surgery and the American Surgical Association recommend simulation training.[13,14]

We describe a modification to an aforementioned dissection station[15] that can be used to simulate endoscopic cricoid reduction and expansion. No other endoscopic simulations are available for pediatric cricoid grafting.

Methods

Simulation Apparatus

This study was exempt from review by the Institutional Animal Care and Use Committee of the University of Wisconsin–Madison. Three larynges were excised from beagles sacrificed for purposes unrelated to this research. Internal cricoid dimensions for specimens were 10 × 15 mm, 12 × 17 mm, and 13 × 17 mm.

The station was modified from that developed by Verma et al.[6] Main alterations were the addition of an infant Lindholm laryngoscope (length, 9.5 cm; proximal opening, 2.6 × 1.7 cm) and an aluminum platform for the posterior support required to sustain applied forces. The laryngoscope is attached to a support arm with mobility in all planes. The aluminum platform is designed to provide support and positioning to simulate the intraoperative view. Pins stabilize

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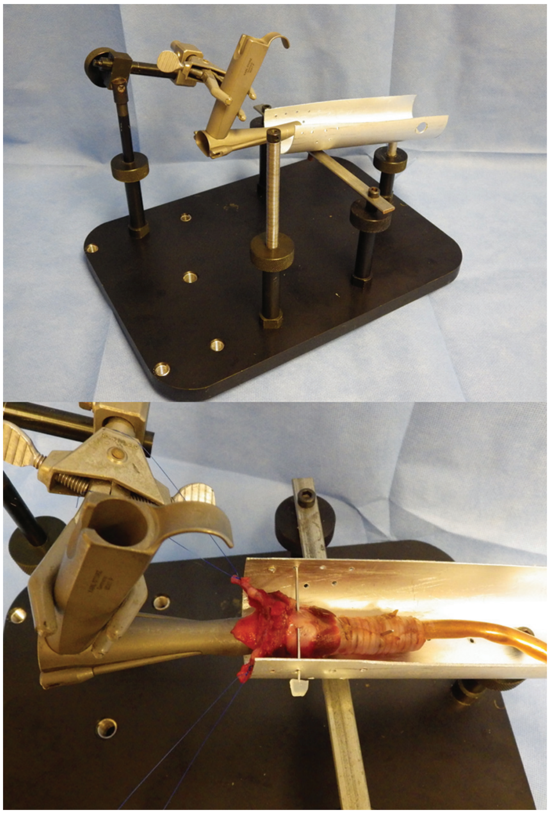

Figure 1. Top: full dissection station. Bottom: dissection station with larynx mounted.

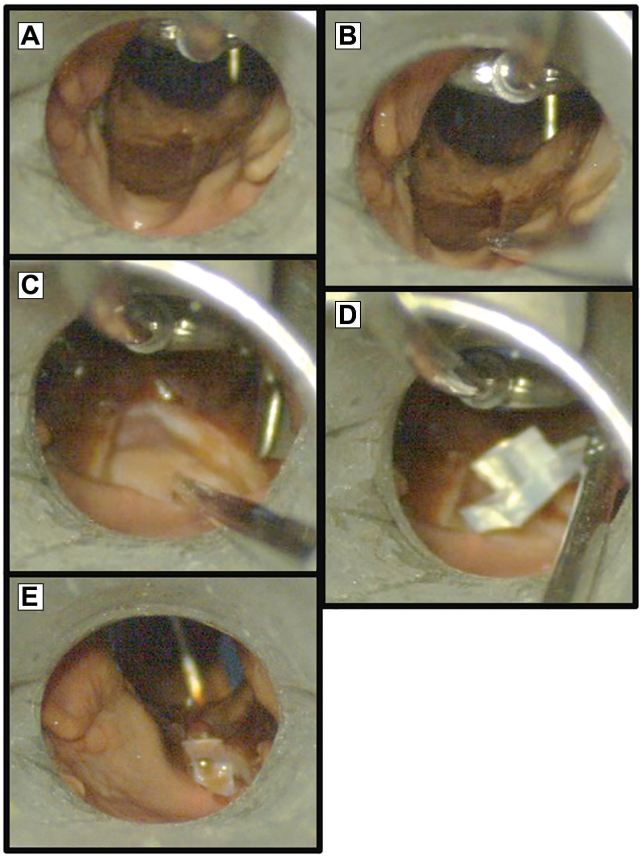

Figure 2. (A) Posterior glottic spreader exposes the cricoid cartilage. (B) Vertical incision made at the posterior midline of the cricoid cartilage. (C) Cricoid cartilage separated along the midline. (D) Silastic block inserted into the cricoid. (E) Expanded posterior glottis.

the larynx in the sagittal and coronal planes. Sutures are passed around the hyoid for superior tension.

Endoscopic Cricoid Expansion

The larynx is mounted as described here and as shown in **Figure 1**. An operating microscope (Leica) is used. A posterior glottic spreader is used to expose the posterior cricoid cartilage (**Figure 2**). A vertical incision is made along the posterior midline of the cricoid. Blunt dissection is performed with a microlaryngeal spatula to separate the 2 edges of the cartilage. A carved silastic block is used to simulate a costal cartilage graft, which is inserted between the edges of the cricoid cartilage with alligator forceps, thus expanding the cricoid diameter.

Endoscopic Cricoid Reduction

The same simulation setup and preparation of the larynx are performed. Dissection is taken down to the posterior perichondrium. A vertically oriented portion of the cricoid is removed. An endoscopic needle driver is used to pass two 4-0 polydiaxone sutures on an RB1 needle (or P3 for smaller larynges) to approximate the edges of the cricoid cartilage, thus reducing the cricoid diameter (**Figure 3**).

Laser Adaptation

Laser usage is optional for this simulation. If used, the cold steel instruments for incisions described here are replaced by a laser. The AccuBlade carbon dioxide laser is attached to the microscope. For endoscopic cricoid expansion, it is set to 4 to 6 W in superpulse mode to incise the posterior cricoid. For reduction, it is set to use a large spot diameter of 1.0 to 1.8 mm at 10 to 16 W and 3-mm depth to ablate a vertically oriented portion of the cricoid.

Results

Canine larynges simulated the size of pediatric human larynges. The posterior subglottis could be visualized through the laryngoscope. The posterior glottic spreader was successfully inserted to apply tension, allowing for the incision to be made along the posterior cricoid. Silastic blocks were inserted to simulate expansion and removal of a portion of the cricoid, followed by endoscopic suturing–simulated reduction. Exposure, expansion, and reduction were completed on all larynges.

Discussion

Surgical simulations provide opportunities to practice uncommon and technically difficult procedures. Due to their rarity and difficulty, cricoid expansion and reduction are ideal candidates for simulation. Treatment cannot be simultaneously

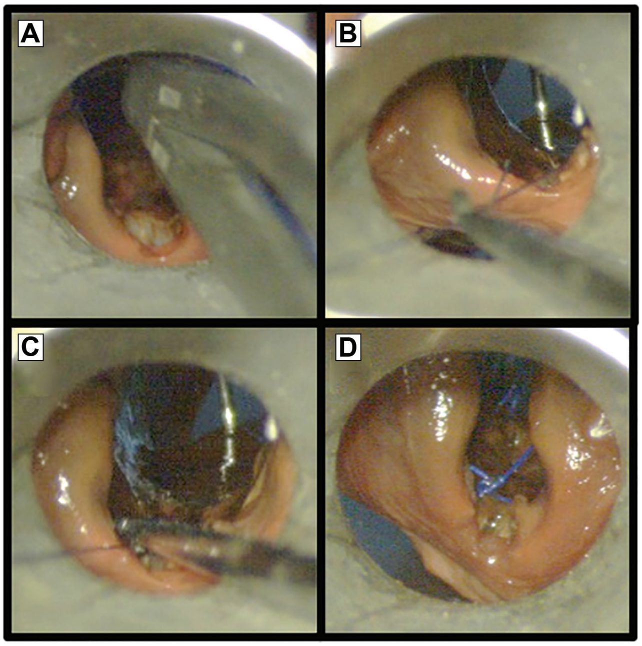

Figure 3. (A) Suture passed through exposed sides of the cricoid. (B) Endoscopic sutures placed to approximate the cricoid. (C) Endoscopic knot pusher used to place sutures. (D) The cricoid has been reduced and secured with 2 simple interrupted sutures.

performed by attending and trainee, thus reducing exposure for trainees. Endoscopic suturing and laser ablation are especially challenging due to limited working space and required precision. It is important to be efficient in all aspects of airway surgery, as excess manipulation can induce edema and stenosis.

Beagle larynges were used in this study. Beagles are commonly used for animal research and are generally available at academic institutions. Size varies across specimens. For trainees wishing to focus on endoscopic cricoid expansion, smaller larynges may be preferable to simulate the infant larynx. Larger larynges are more appropriate for endoscopic cricoid reduction, which is typically performed in older children or adolescents. Pigs and rabbits have been used in other models for pediatric airway reconstruction.[16,17] Rabbits are good models for neonatal airway surgery but too small for simulating endoscopic cricoid reduction. Pig thyroid cartilage has a longer superoinferior extent, with posterior angulation near its superior border, making adequate endoscopic exposure difficult. Beagles represent a good balance of accessibility, variability, and comparability to human larynx morphology, though the same setup can be used with larynges from other species.

This model assists trainees with equipment setup, laryngoscope/microscope positioning, and surgical tasks (incising, dissecting, implant shaping/placement, and suturing). A key limitation of this model is the lack of oral cavity and pharynx for practicing all aspects of laryngoscope placement. Future studies based on this model are needed to formally evaluate performance and assess trainee confidence and comfort. Trainee performance outcomes include visualization of the cricoid, proper instrument handling, and appropriate laser safety precautions when applicable.

Author Contributions

Austin J. Scholp, study conception, setup design, and construction; acquisition of data; primary author on manuscript; final approval of manuscript; **Matthew R. Hoffman**, study conception, setup design, image collection; acquisition of data; secondary author on manuscript; final approval of manuscript; **Alessandro De Alarcon**, study conception, analysis of setup; critical revision of manuscript; final approval of manuscript; **Mark E. Gerber**, study conception, analysis of setup; critical revision of manuscript; final approval of manuscript; **Jack J. Jiang**, study conception, analysis of setup; critical revision of manuscript; final approval of manuscript; **James Scott McMurray**, study conception, setup design, analysis of setup; final approval of manuscript.

Disclosures

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