World Journal of Otorhinolaryngology-Head and Neck Surgery (2018) xx, 1–5

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.keaipublishing.com/WJOHNS; www.wjent.org

Research Paper

Ex vivo ovine model for teaching open laryngotracheal surgery

Ahmed M.S. Soliman [a,*], **David C. Ianacone** [a], **Glenn C. Isaacson** [a,b]

[a] *Department of Otolaryngology – Head & Neck Surgery, Lewis Katz School of Medicine Temple University, Philadelphia, PA, 19140, USA*
[b] *Department of Pediatrics, Lewis Katz School of Medicine Temple University, Philadelphia, PA, 19140, USA*

Received 13 April 2018; accepted 17 April 2018

KEYWORDS
Airway surgery;
Laryngotracheal reconstruction;
Sheep;
Surgical simulation;
Tracheal resection

Abstract *Objective:* To develop an animal model for teaching open laryngotracheal surgical procedures.
Methods: The heads and necks from 5 pre-pubescent sheep were harvested after humane anesthesia. After 2–5 days to allow for rigor mortis to resolve, a specimen was supported with sandbags on an operating table. Operative procedures including tracheotomy, medialization laryngoplasty, anterior cartilage grafting, tracheal resection with primary anastomosis, and laryngectomy with closure of the pharynx were attempted.
Results: The ovine head and neck provided an accurate model for simulation of all attempted procedures. Ovine tissue resembled that of humans in mechanical properties and handling. Postsurgical endoscopy confirmed graft alignment.
Conclusions: The sheep head and neck provides an inexpensive, realistic, and safe model for surgical training for a variety of open laryngotracheal procedures. This is particularly relevant given the recent emphasis on surgical simulation and the relative rarity of some of these procedures in residency training.

* Corresponding author. Department of Otolaryngology – Head & Neck Surgery, Lewis Katz School of Medicine at Temple University, 3440 N. Broad Street Kresge West 300, Philadelphia, PA, 19140, USA. Fax: +215 707 7523.
E-mail address: asoliman@temple.edu (A.M.S. Soliman).
Peer review under responsibility of Chinese Medical Association.

Production and Hosting by Elsevier on behalf of KeAi

https://doi.org/10.1016/j.wjorl.2018.04.002

Please cite this article in press as: Soliman AMS, et al., *Ex vivo* ovine model for teaching open laryngotracheal surgery, World Journal of Otorhinolaryngology-Head and Neck Surgery (2018), https://doi.org/10.1016/j.wjorl.2018.04.002

Introduction

Surgical training in open laryngotracheal procedures is limited in most otolaryngology residency programs in the United States. Although, many programs provide adequate experience in tracheotomy and medialization laryngoplasty, few offer adequate training in laryngotracheal reconstruction or tracheal resection.[1] The relative rarity of these cases and the increased use of endoscopic techniques has left a void in resident education.

Simulation has gained wide acceptance in medical student and resident education — providing trainees with first-hand exposure to emergency situations and complex procedures while minimizing risk to patients. This is particularly true for surgical training, where simulation allows students to acquire mechanical skills and teachers to document technical competence in a standardized fashion.[2] Several models have been proposed for the experimental study of laryngotracheal stenosis including rodent, leporine, porcine, canine, and ovine.[3–7] There has been limited use of animal models for surgical training in the head and neck where a porcine model for microlaryngeal surgery and cricothyrotomy has been proposed.[8,9]

Our group recently described the use of a fresh, saline-perfused sheep head and neck model for surgical simulation.[10] This article explores its use for teaching open laryngotracheal procedures.

Materials & methods

Tissue was collected from pre-pubescent sheep ($n = 5$; mean age: 4 months; mean mass: 28 kg) following humane euthanasia (100 mg/kg sodium pentobarbital solution) at the end of an *in vivo*, protocol approved by the Lewis Katz School of Medicine through its Institutional Animal Care and Use Committee (IACUC). These sheep were obtained from a Temple University and United States Department of Agriculture approved supplier, tested for *Coxiella burnetii* according to Centers for Disease Control and Prevention (CDC) protocol, and accepted into the University Laboratory Animal Resource facility of Temple University after full inspection by a licensed veterinarian to assure good health. No live animals were used in this study. Post-euthanasia, the head and neck of the sheep were disarticulated 4–6 cm above the sternal notch. The tissue was stored at 5 °C for 2–5 days.

Prior to working with fresh ovine tissue, study personnel were enrolled in the Temple University's Occupational Health Program and screened for Q-Fever antibodies. They wore appropriate personal protective clothing while handling the specimen. Sheep tissues were transported in double plastic disposable bags and all carcass material was treated as biomedical waste through a commercial waste management company.

The ovine head and neck preparation was supported in the supine position with sand bags. Standard soft tissue instruments were used to perform the procedures. Expired Montgomery™ silastic thyroplasty implants (Boston Medical Products, Boston MA) were used for medializations. Polydioxanone (PDS) suture (Ethicon US LLC, Somerville NJ) was used for the tracheal anastomoses after resection. Endoscopic evaluation of the anastomoses was performed with a Karl Storz™(Tuttlingen, Germany) adolescent Parsons laryngoscope through which a 4 mm 0° Karl Storz™ rigid rod endoscope was passed. A Karl Storz™ Tele Pack X system was placed at the foot of the operating table for image visualization and recording. Closure of the pharynx after total laryngectomy was performed using a 4-0 polyglactin 910 suture on a tapered needle (Ethicon US LLC, Somerville NJ).

Results

A total of 5 procedures were readily performed on the sheep head and neck preparations: tracheotomy with flap, medialization laryngoplasty with a silastic implant, anterior laryngotracheal cartilage grafting, tracheal resection with end to end anastomosis, and total laryngectomy with pharyngeal closure (Figs. 1–8). The ovine model proved highly realistic for open laryngotracheal surgery with the size of the larynx and trachea closely approximating that of an adult human. The trachea was quite pliable allowing for resection of segments yet still allowing tension free closure. The fresh soft tissues of the sheep have similar consistency, thickness and surgical handling to that of humans. In addition, their oropharyngeal anatomy easily allowed for laryngoscopy and bronchoscopy to assess the outcome of the procedures endoscopically. The fresh sheep had relatively strong *rigor mortis* in the first 48 h after sacrifice so it is best to use the preparation after that period of time.

Discussion

Surgical simulation has become increasingly important in resident education. In fact, current Accreditation Council for Graduate Medical Education (ACGME) 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."[11] Human cadavers have been traditionally used in otolaryngology for teaching otologic surgery and bronchoscopy. Several authors have described using excised larynx models for learning

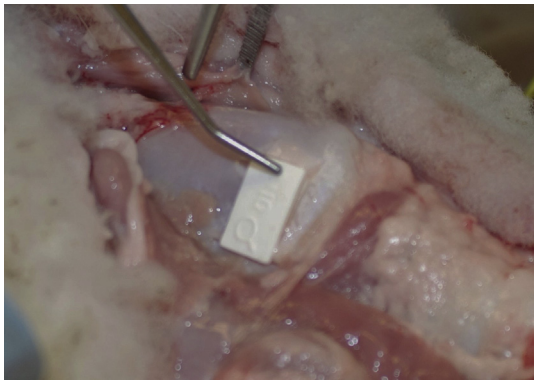

Fig. 1 Right medialization laryngoplasty with silastic implant placed.

Please cite this article in press as: Soliman AMS, et al., *Ex vivo* ovine model for teaching open laryngotracheal surgery, World Journal of Otorhinolaryngology-Head and Neck Surgery (2018), https://doi.org/10.1016/j.wjorl.2018.04.002