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ORIGINAL ARTICLE

Novel minimally invasive transoral surgery bleeding model implemented in a nationwide otolaryngology emergencies bootcamp

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Abstract

Post-operative hemorrhage is the most concerning complication after minimally invasive transoral surgery, as can result in airway compromise. Simulation-based medical education provides trainees with structured learning in an intensive and immersive environment allowing deliberate practice of skills and behaviors in the management of real-life situations. We implemented a novel post-oropharyngeal surgery bleeding model in a nationwide otolaryngology emergencies bootcamp, to teach and evaluate technical and non-technical skills required to competently manage this clinical scenario. 28 Otolaryngology residents from 11 programs in Canada participated in the annual Otolaryngology Emergencies Bootcamp of Western University in London, Ontario. After teaching technical aspects of emergency surgical airways in models, the course culminated with a complex scenario of a post-minimally invasive transoral surgery bleeding model using a fresh cadaver. The Non-Technical Skills for Surgeons (NOTSS) rating scale was applied to video analysis and a scenario-specific Medical Expert Checklist was implemented. The model design in a cadaveric torso is described for use in a simulation of a high-volume oropharyngeal bleed after a minimally invasive approach. Participants agreed that the model evoked an elevated degree of realism and conveyed the emotion of a life-threatening event. NOTSS analysis identified a marginal score in the domains of decision-making and communication and teamwork. Critical action checklist analysis highlighted the early mobilization of available resources and time to decision for surgical airway. We present the first report of a post-minimally invasive transoral surgery bleeding model. It was successful in recreating with high fidelity such a high-stake event and to teach technical and non-technical skills.

Keywords TORS · TLM · Post-operative bleeding · Training · Bootcamp

Introduction

The rapid adoption of mini-invasive endoscopic techniques (transoral robotic surgery—TORS—and transoral laser microsurgery—TLM) among some of the main head and neck cancer centers in North America and Europe as part of deintensification strategies for resection of HPV-related oropharyngeal squamous cell carcinoma (HPVOPSCC) has increased the exposure of the patients and the treating physicians to the risks of these approaches [1–3]. Post-operative bleeding represents the most feared complication of these procedures, with rates reported from 1.5 to 13% [4], and can occur in community hospital settings after the patient discharge [5].

The risk of airway compromise and death, added to the anatomic inaccessibility to adequately control the bleeding outside the operating room, demands high degree of

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proficiency to manage this event. As the use of these techniques continues to increase, it is paramount that residents of head and neck surgery training programs acquire the surgical and non-surgical skills to manage the unfortunate event of post-operative bleeding after a minimally invasive transoral approach.

Simulation-based medical education provides trainees with structured learning in an intensive and immersive environment allowing deliberate practice of skills and behaviors in the management of real-life situations [6]. Simulation training may focus on technical skills, such as practicing different surgical techniques, and in occasions, non-technical skills which emphasize situation management, leadership, communication, and team interactions. There is a lack of literature exploring the evaluation of non-technical skills in otolaryngology [7]. We implemented a novel post-TORS bleeding model in a nationwide otolaryngology emergencies bootcamp, to evaluate and teach technical and non-technical skills to competently manage this clinical scenario.

Methods

Twenty-eight PGY1 and PGY2 otolaryngology residents across Canada participated in the Annual otolaryngology Emergencies Bootcamp of Western University in London, Ontario. Six faculties from the otolaryngology and Anesthesia Departments supervised the course. The bootcamp consisted in a full-day course in which all domains of learning (knowledge, skills, and behavior) were included. One module focused in teaching the technical aspects of an emergency surgical airway using animal and synthetic-made models. Facilitators highlighted the non-technical aspects, such as communication and decision-making, when facing an emergency airway situation.

The bootcamp concluded with simulations which included a post-operative base of tongue (BOT) bleeding after a minimally invasive transoral procedure.

Oropharyngeal bleeding model scenario

The setting was an emergency room of a community hospital in which one of the faculties played the role of an emergency physician, consulting the otolaryngology team on call for a patient with a recent onset of profuse oral bleeding after "some sort of robotic surgery performed 7 days ago". A group leader was chosen from the participant group of 3–4 residents.

Model design

A fresh-frozen cadaver torso was placed in dorsal decubitus, connected to a vital sign monitor that could be manually set by a faculty outside the room. A speaker was placed in the room-simulating sounds of the patient. A 14-gauge Abbocath was inserted transcervically to the surface of the base of the tongue of the cadaveric model and its tip was cut. It was connected to a saline bag with artificial blood in it and covered. A pressure bag kept the flow continuously pressurized to mimic a severe oropharyngeal bleeding. As soon as the group stepped in the scenario, they encountered a faculty playing the role of an agitated ER doctor who described the situation, along with a nearly unresponsive "patient" with a profuse oropharyngeal hemorrhage. A difficult intubation cart with a Glidescope® laryngoscope, suction catheters, and a tracheostomy tray (if requested) were provided to the participants. The vital signs were altered to mimic a progressive emergency airway situation. Residents were instructed to initially attempt orotracheal intubation and then proceed as they thought appropriate. The scenario culminated after 5 min or earlier by either the intubation or tracheostomy of the patient. All simulations were recorded for evaluation and learning. All provided their written consent to be filmed.

Assessment

The Non-Technical Skills for Surgeons (NOTSS) [8] rating scale was applied to objective video analysis of the scenario. The NOTSS scale represents a classification system based on observed skills in an operative setting which encompasses four main categories: situation awareness, decision-making, communication and teamwork, and leadership. Each of these categories comprises three sub-categories, resulting in a total of 16 assigned scores, with scores from one (poor) to four (good). Three independent surgical experts rated the residents. Mean scores from the three raters of the four NOTSS main categories and sub-elements were calculated. In addition, a Medical Expert Checklist specifically created for this scenario was implemented, which evaluated with scores from one to four times to mobilize available resources, assess the need to establish an airway, time until an airway was obtained, number of intubation attempts (they were encouraged to attempt oral intubation as a first step), and time to request a surgical airway. Cohen's Kappa inter-rater reliability was calculated using SPSS (Version 17.5, SPSS, Chicago).

Qualitative assessments were provided within the comment section for the NOTSS elements, and from the post-scenario debriefing, led by faculty with simulation debriefing expertise. Participants were surveyed about the scenario experience. This permitted analysis of scenario fidelity and realism. Achievements and failures were discussed in a non-judgemental manner, and participants provided their feedback (Fig. 1).

This educational study was approved by Western University REB 107915.

Fig. 1 Three main modules of the boot camp: **a** synthetic and animal made models to teach technical aspects of emergency airway. **b** Recording of bleeding model scenario for posterior NOTSS assessment. **c** Debriefing leaded by faculty

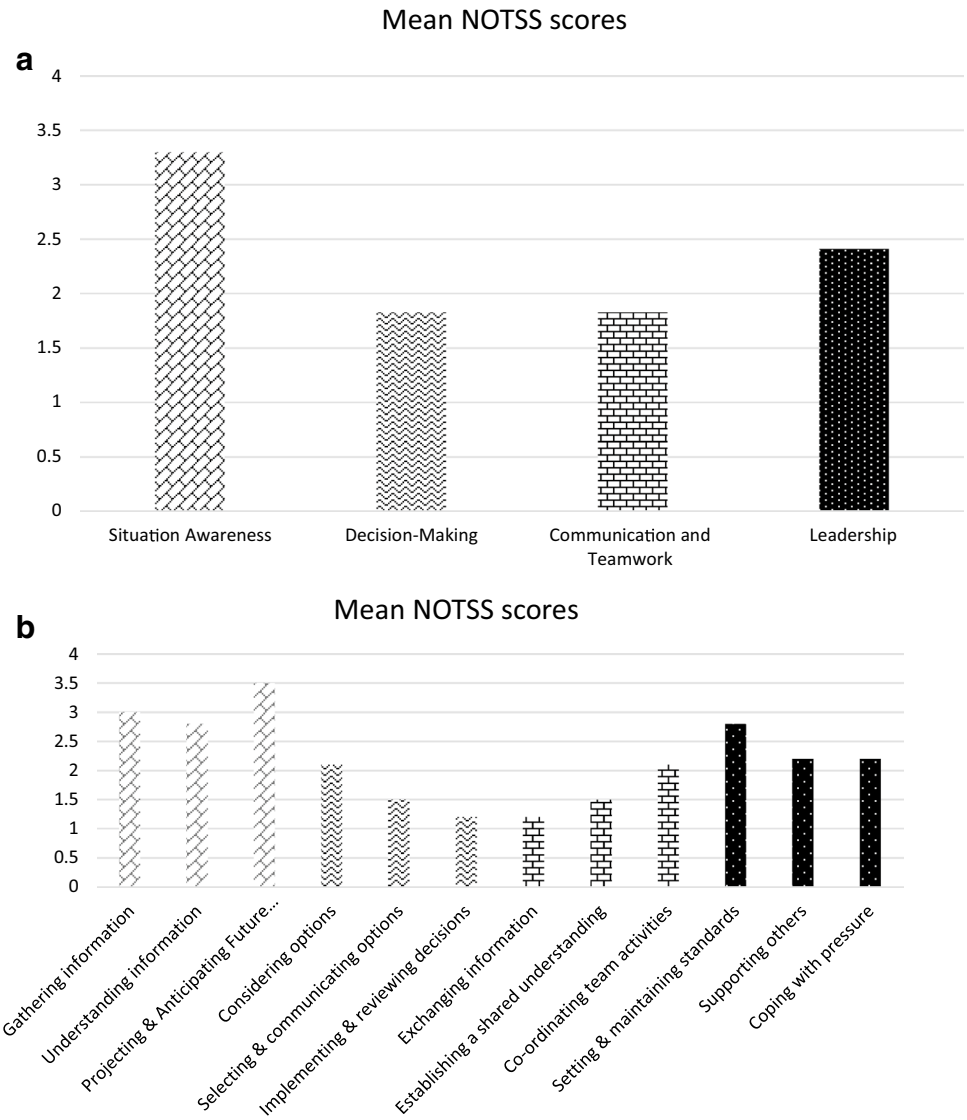

Fig. 2 **a** NOTSS score for each category. **b** NOTSS score for each sub-category

Results

Quantitative NOTSS scores

Average scores of the NOTSS scale were 3.3 for situation awareness, 1.83 for decision-making, 1.83 for communication and teamwork, and 2.41 for leadership. Scores for each category and sub-category are depicted in Fig. 2a, b. The Medical Expert Checklist showed superior scores in earlier mobilization of available resources and the need to establish an airway, while number of intubation attempts, time to ask for a surgical airway, and time until an airway was obtained had lower scores (Fig. 3). Inter-rater reliability score was 0.71 showing substantial agreement between the surgical experts.

In the immediate post-simulation surveys, residents emphasized the scenario realism and agreed that the model evoked the elevated emotion of a life-threatening event.

Qualitative analysis

Qualitative data were obtained from the debriefing and from the scenario video analysis from three surgical experts. Using the constructivist grounded theory approach, the following themes were identified. For situational awareness, participants obtained relevant information efficiently, promptly established the presence of intravenous lines, and determined the availability of blood in the setting of a severe bleeding with low blood pressure values. They also projected and anticipated future state by considering the necessity of establishing a surgical airway in two groups. All four groups grasped the sense of urgency of the clinical scenario.

Comments on leadership highlighted the fact that, in two groups, leaders remained calm despite the challenges presented by confederates, and that a stepwise treatment plan was presented to the rest of the team. However, none of the leaders made full use of team members to assist; all demonstrated some hesitation, lack of clarity in asking for equipment, and some lack of role clarity. All participating leaders showed drastic fluctuations in their series of commands, often asking for several tasks or items simultaneously.

Decision-making, communication, and teamwork had the lowest scores. Prolonged time to recognition that a surgical airway was required and hesitation related to ensuing technical steps were the most notable observations about decision-making. Communication and teamwork demonstrated that there were long silences, and interactions predominant open-loop communication with unacknowledged requests and unanswered questions. Little information on the result and findings during the intubation attempts were shared among the group members.

Discussion

The epidemic of HPVOSCC has shifted the patient archetype from an elderly individual with a life-long history of tobacco and alcohol consumption, among other comorbidities, and poor survival rates towards younger, more fit patients without prolonged carcinogenic exposure, and an increased overall survival after treatment [9, 10]. Therefore, consideration of functional outcomes has been recently the overarching point of research in the head and neck oncology community, with tailored deintensification strategies emerging from the historical non-surgical approaches which consisted in high doses of radiotherapy or chemoradiotherapy. Endoscopic

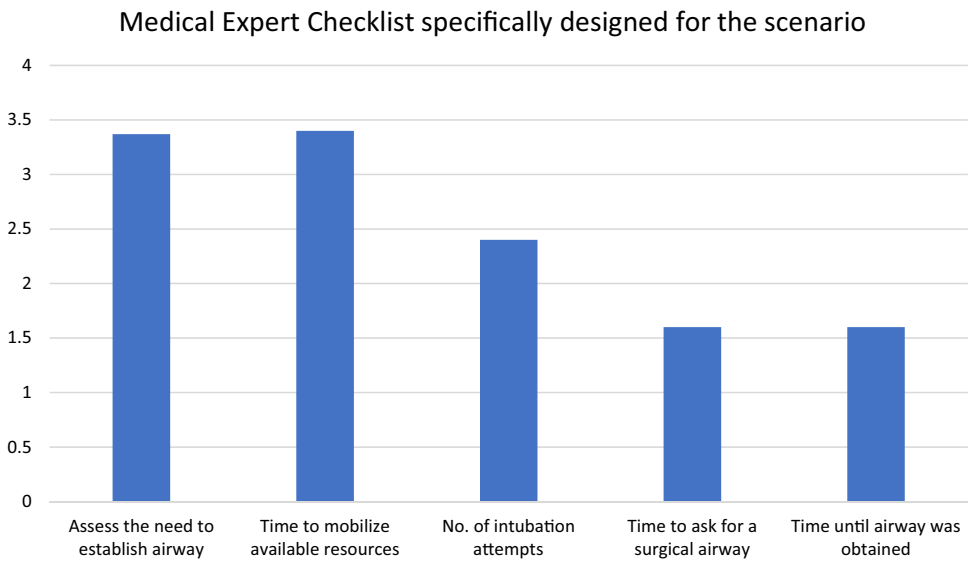

Fig. 3 Medical Expert Checklist scores

procedures such as TORS and TLM demonstrated similar oncologic results and low long-term functional deficits [11] in comparison with the traditional approaches, with ongoing randomized-controlled trials to elucidate which option carries within less functional morbidity [12]. This resulted in a rapid adoption of these minimally invasive techniques throughout the high-volume head and neck cancer centers in North America and Europe [3, 5]. Post-operative bleeding represents the most significant complication, with high mortality rates in cases of severe episodes. Some measures have been adopted to prevent death from this event such as a prophylactic temporary tracheostomy and external carotid artery ligation, with some favorable results, especially in reducing the incidence of major bleeding [4]. Residents or Emergency physicians may be the early responders to these emergency situations and it is expected that they are able to adequately manage life-threatening clinical situations. With the rising epidemic of HPVOPSCC and popularity of minimally invasive methods, the likelihood of residents facing a post-operative bleeding after TORS or TLM approaches is high.

Limited duty hours, restricted intraoperative autonomy, and medico-legal and patient safety issues along with the increasing pressure on physicians' productivity represent some of the main challenges for surgical training [13]. Simulation in surgical specialties has emerged as a tool to overcome these aspects and provide the trainees a safe learning environment with intensive teaching and feedback from the trained physicians. A recent systematic review of simulation models in otolaryngology reported the various simulation and training models [14]. We present the first reported oropharyngeal bleeding model, endeavoring to train otolaryngology residents to manage this event that can result in devastating outcomes. This simple and inexpensive model can assist to teach the trainees in how to proceed with a post-minimally invasive transoral surgery bleeding event. Facing this scenario, we noted that residents exhibited some degree of improvisation and focused in trying to tamponade the hemorrhage with the laryngoscope and simultaneously suctioning the oropharynx in an attempt to get a clear view of the glottis, which seemed appropriate maneuvers. Evaluation with this type of model can also encourage innovation in devices to control or treat these events in the future.

We implemented a custom-made medical expert checklist, with specific items for this acute airway emergency scenario. We focused on decision-making, as we consider that the elements of the scale are within the domain of executive decisions. Faculty identified that the number of intubation attempts, time to ask for a surgical airway, and time until airway were obtained, corresponded to success in managing an emergency airway.

Global surgical competency encompasses both technical and non-technical skills [15], and thus, our simulation was designed to each and assesses both aspects. There is a scarcity of reports in analyzing the non-technical skills in the otolaryngology literature. Key aspects to efficiently manage emergency situations are effective communication and team management [7], key non-technical skills which are assessed with the NOTSS scale. In our study, lower scores were ascribed to communication and decision-making, representing the areas of future teaching focus. These areas were discussed with the residents during the debriefing. The fact that the situation awareness scores were higher and that the four groups prematurely grasped the severity of the situation infers that the model recreated with high fidelity a real-life scenario. This is in concordance with the results of immediate post survey. However, residents who participated in this bootcamp were the first- and second-year residents, so it is expected that results are far from the higher scores that would be acquired with more experience. Teaching and deliberately practicing non-technical skills during the early stages of residency seem highly advantageous, as junior residents are often early responders in these emergency situations.

Future directions will include an interdisciplinary approach to scenario training with Emergency Medicine residents and faculty. This model may also be useful in skill maintenance and faculty development.

Conclusion

We present the first minimally invasive transoral surgery hemorrhage model. It was implemented in an otolaryngology emergencies bootcamp, obtaining high degree of fidelity. Technical and non-technical skills in competently managing this clinical scenario were assessed. We believe that, in the rapidly changing environment of surgical training, simulation-based training should also evolve and non-technical skills should be incorporated with models that reproduce with high fidelity the complications of emerging surgical approaches.

Author contributions AS: data collection, analysis and manuscript preparation. DEE, IB, UD, SDM, AN, JY, KF, KR: manuscript preparation. All authors read and approved the final manuscript.

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Compliance with ethical standards

Conflict of interest Authors AS, DE, IB, UD, SDM, AN, JY, KF, and KR declare they have no conflicts of interest.

Research involving human participants or animals This article does not contain any studies with human or animal subjects performed by any of the authors.

References

1. Chen MM, Roman SA, Kraus DH, Sosa JA, Judson BL (2014) Transoral robotic surgery: a population-level analysis. Otolaryngol Head Neck Surg 150(6):968–975. https://doi.org/10.1177/0194599814525747
2. Lörincz BB, Möckelmann N, Busch C-J, Knecht R (2015) Functional outcomes, feasibility, and safety of resection of transoral robotic surgery: single-institution series of 35 consecutive cases of transoral robotic surgery for oropharyngeal squamous cell carcinoma. Head Neck 37(11):1618–1624. https://doi.org/10.1002/hed.23809
3. Lörincz BB, Jowett N, Knecht R (2016) Decision management in transoral robotic surgery: Indications, individual patient selection, and role in the multidisciplinary treatment for head and neck cancer from a European perspective. Head Neck 38(Suppl 1):E2190–E2196. https://doi.org/10.1002/hed.24059
4. Gleysteen J, Troob S, Light T et al (2017) The impact of prophylactic external carotid artery ligation on postoperative bleeding after transoral robotic surgery (TORS) for oropharyngeal squamous cell carcinoma. Oral Oncol 70:1–6. https://doi.org/10.1016/j.oraloncology.2017.04.014
5. Mandal R, Duvvuri U, Ferris RL, Kaffenberger TM, Choby GW, Kim S (2016) Analysis of post-transoral robotic-assisted surgery hemorrhage: frequency, outcomes, and prevention. Head Neck 38(Suppl 1):E776–E782. https://doi.org/10.1002/hed.24101
6. Yeh DH, Fung K, Malekzadeh S (2017) Boot camps: preparing for residency. Otolaryngol Clin N Am 50(5):1003–1013. https://doi.org/10.1016/j.otc.2017.05.010
7. Wu KY, Kim S, Fung K, Roth K (2018) Assessing nontechnical skills in otolaryngology emergencies through simulation-based training. Laryngoscope. https://doi.org/10.1002/lary.27174
8. Yule S, Paterson-Brown S (2012) Surgeons' non-technical skills. Surg Clin N Am 92(1):37–50. https://doi.org/10.1016/j.suc.2011.11.004
9. Chaturvedi AK, Anderson WF, Lortet-Tieulent J et al (2013) Worldwide trends in incidence rates for oral cavity and oropharyngeal cancers. J Clin Oncol 31(36):4550–4559. https://doi.org/10.1200/JCO.2013.50.3870
10. Panwar A, Batra R, Lydiatt WM, Ganti AK (2014) Human papilloma virus positive oropharyngeal squamous cell carcinoma: a growing epidemic. Cancer Treat Rev 40(2):215–219. https://doi.org/10.1016/j.ctrv.2013.09.006
11. de Almeida JR, Byrd JK, Wu R et al (2014) A systematic review of transoral robotic surgery and radiotherapy for early oropharynx cancer: a systematic review. Laryngoscope 124(9):2096–2102. https://doi.org/10.1002/lary.24712
12. Nichols AC, Yoo J, Hammond JA et al. (2013) Early-stage squamous cell carcinoma of the oropharynx: Radiotherapy vs. Trans-oral robotic surgery (ORATOR)—study protocol for a randomized phase II trial. 13(1):133. https://doi.org/10.1186/1471-2407-13-133
13. Bhatti NI (2017) Assessment of surgical skills and competency. Otolaryngol Clin N Am 50(5):959–965. https://doi.org/10.1016/j.otc.2017.05.007
14. Musbahi O, Aydin A, Al Omran Y, Skilbeck CJ, Ahmed K. Current status of simulation in otolaryngology: a systematic review. J Surg Educ 74(2):203–215. https://doi.org/10.1016/j.jsurg.2016.09.007
15. Ponton-Carss A, Kortbeek JB, Ma IWY (2016) Assessment of technical and nontechnical skills in surgical residents. Am J Surg 212(5):1011–1019. https://doi.org/10.1016/j.amjsurg.2016.03.005