



Experiential learning in simulated parapharyngeal abscess in breathing cadavers

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Abstract

Purpose Education in airway management is a fundamental component of anesthesiology training programs. There has been a shift towards the use of simulation models of higher fidelity for education in airway management. The goal of this study was to create a novel cadaveric model of a simulated parapharyngeal abscess with features of a difficult airway such as distorted anatomy and narrow airway passages presenting as stridor. The model was further assessed for its suitability for enhanced experiential learning in the management of difficult airways.

Methods Cadaver heads were modified surgically to simulate parapharyngeal abscess. Airtight torso of the cadaver was connected to an Oxylog ventilator to simulate respiratory movements—the opening and closing of air channels with breaths in a patient with parapharyngeal abscess. Advanced airway workshop facilitators conducted directed one-to-one learning, and provided feedback to participants. A paper-based feedback was obtained from 72 participants on their confidence level, and the realism, attractiveness, beneficial, and difficulty levels of the simulated cadaveric models.

Results The modified cadavers were reliable in simulating difficult airways. The majority of participants (91%) reported an increase in confidence level for management of the difficult airway after the experience with the modified cadavers and found the models realistic (93%), attractive (92%), beneficial (93%), and difficult (85%).

Conclusions Surgical modifications of cadavers to simulate difficult airways such as parapharyngeal abscess with edema and stridor can be incorporated into advanced airway management courses to enhance experiential learning in airway management by awake fiberoptic intubation, and promote patient safety.

Keywords Cadavers · Difficult airway · Intubation · Learning · Parapharyngeal abscess · Simulation

Introduction

The widespread availability of antibiotics has led to a reduction in incidence of deep neck infections. However, deep neck infections remain a serious health concern due to their potentially life-threatening complications [1]. The incidences of complications such as airway obstruction, mediastinitis and jugular vein thrombosis have been reported to range from 10 to 20% [1, 2], and the mortality of patients with deep neck infections ranges from 0.3 to 1.6% [2, 3]. Airway compromise has been reported to be the most common cause of mortality in such patients with deep neck abscesses [4].

Deep neck infections are most commonly caused by dental abscesses and tonsillitis and lead to parapharyngeal, peritonsillar, and retropharyngeal abscesses [5]. Although rare, foreign bodies in the parapharyngeal space can sometimes

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be a causative factor [4]. Deep neck infections are commonly polymicrobial—with prevalent causative organisms inclusive of *Klebsiella pneumoniae*, *Streptococcus* Group, anaerobic bacteria and *Staphylococcus aureus* [6]. Parapharyngeal abscess and peritonsillar abscess are the common types of deep neck infections [7]. The parapharyngeal space is easily affected as communication of the peritonsillar, submandibular, masticatory, and parotid spaces with the parapharyngeal space serves as a conduit and a reservoir [8].

Airway management is challenging in patients presenting with parapharyngeal abscess. First, medial bulging of the pharyngeal wall due to deep space pathology and edema from soft tissue inflammation distorts airway anatomy [9], modifies tissue planes [4], decreases tissue mobility [10], and impairs visualization and localization of the glottis [6]. Second, trismus, decreased interdental gap, and narrowing of the oropharyngeal isthmus [4] limit accessibility for intubation and subsequent administration of general anesthesia might conversely trigger airway closure and prevent intubation [11, 12]. Lastly, rupture of the parapharyngeal abscess might induce aspiration of the material, intra-oral hemorrhage, and laryngospasm [13, 14].

In these highly complicated cases where visualization of the airway is almost impossible due to varied causes, awake fibreoptic intubation is considered the best option by anesthesiologists [15]. The most significant advantage of fibreoptic intubation is the preservation of spontaneous respiration and perhaps avoidance of CICO (Cannot Intubate Cannot Oxygenate) situation. In edematous airways, awake fibreoptic intubation makes use of pharyngeal and laryngeal ‘air spaces’ to allow gas exchange and facilitate viewing of the larynx as they open up and close during patient breaths. These air spaces are maintained by muscle tone and reflexes of the upper airways and tongue, thus also preventing aspiration, which could be potentially lethal in case of a ruptured abscess [16, 17]. However, such difficult cases are rare and mostly dealt with by senior anesthesiologists due to their difficult and potentially life-threatening nature.

Simulation of parapharyngeal abscesses by conventional means (manikins, simulators or cadavers in anesthesiology training) has not been described in the literature. The absence of simulated difficult airways with specific airway pathologies such as parapharyngeal abscess presents an important challenge in the training of junior doctors in anesthesiology. Currently, trainees lack opportunities to learn airway management techniques essential in the management of difficult airway scenarios such as that posed by a patient with parapharyngeal abscess.

As such, experiential learning through simulated cadaveric models plays an important role in teaching trainees and helps to update airway management skills in trained anesthesiologists. The models may lead to increased use of invasive airway techniques, including the application of fibreoptic

intubation in the management of difficult airways. They also serve as a more affordable method for the training of junior anesthesiologists as compared with the use of expensive manikins and simulators [18].

The use of awake fibreoptic intubation is widely accepted as a gold standard for the management of patients with difficult airways [19]; however, training in fibreoptic intubation may be lacking in different workplace settings due to various reasons. Johnson and Roberts revealed that a minimum of ten fibreoptic intubations were required to achieve basic competence [20], and McNarry et al. reported that 45 fibreoptic intubations were needed to gain true expertise [21]. However, an audit of training opportunities in a teaching hospital in the United Kingdom revealed that only 11% of fibreoptic intubations were done primarily for the purposes of training [22].

There have been significant advances in the use of simulation in anesthesiology over the past two decades, with a shift toward the use of simulation models with higher fidelity [23]. Today, education in airway management is conveyed via a broad range of simulation models—consisting of simple bench models, simple manikins, human cadavers, virtual reality simulators, and high-fidelity full-scale simulators [24]. As simulation training has been deemed effective in teaching psychomotor skills such as airway management, it is essential to explore approaches to optimize the use of simulations to further enhance airway management training [23].

The objectives of this study were to create a novel cadaveric model with features of a difficult airway due to parapharyngeal abscess, and to simulate the features of a difficult airway—edema and stridor. The changes in the anatomy of airway with breaths were simulated to create a near-exact replica of a patient with parapharyngeal abscess. The model was further assessed for its suitability for enhanced experiential learning of the management of difficult airways.

Methods

Ethics consideration

The research study protocol was submitted to the SingHealth Centralized Institutional Review Board (CIRB Reference Number: 2017/2960) and was exempted from review based on the nature of the study. The research study was conducted over two sessions of the Cadaveric Advanced Airway Workshop in Changi General Hospital, Singapore.

Cadaver models

Cadaver models cut at the mid-thorax level, and included the head, neck, and upper thorax were procured for

surgical modifications. They were certified to be negative for Hepatitis B, Hepatitis C, and Human Immunodeficiency Virus 1 and 2 based on serology testing. Maxillofacial and otorhinolaryngology specialists carried out the surgical procedure on the cadaver heads to simulate parapharyngeal abscess, as shown in the video clip (Online Resource 1).

The parapharyngeal space was accessed via a transcervical approach made with a skin crease incision two fingerbreadths inferior to the lower border of the mandible. The submandibular gland was retracted anteriorly and the sternocleidomastoid muscle was retracted posteriorly. The parapharyngeal space was then entered by dissecting superior and medial to the posterior belly of the digastric muscle along the medial surface of the ramus of the mandible. The retropharyngeal space was entered after retracting the strap muscles medially and the carotid sheath laterally below the level of the carotid bifurcation. Surgical gauze was used to pack the parapharyngeal and retropharyngeal space to create narrowing of the upper airway (Fig. 1, Online Resource 1).

Cadaver heads were surgically modified to simulate parapharyngeal abscess. The thoracic cage was sealed completely using cling filament plastic wraps to create an airtight compartment. A breathing circuit was introduced to the thoracic cavity and connected to an Oxylog portable ventilator 3000 (Dräger, Lübeck, Germany) to simulate “reverse ventilation strategy” (Fig. 2). Ventilation of the thoracic cavity with the use of the ventilator simulated respiratory movements of thorax and movement of air through the airways. This simulated opening up/closing of the distorted and edematous airways mimicked the

opening up of air channels in a patient with parapharyngeal abscess as shown in Online Resource 1.

Participant experience

During the advanced airway workshop, tutors facilitated a one-to-one learning by way of direct feedback to participants.

Assessment by participants

The models were assessed by participants who consented before the commencement of the workshop. All participants were required to wear personal protective equipment as a precautionary measure. Participants were asked to provide information about their seniority (consultant or non-consultant), years of anesthesiology experience, and prior attempts with bronchoscope- or fibreoptic scope-assisted intubations. They were requested to rate their level of confidence in managing a patient with parapharyngeal abscess with stridor before and after training with the modified cadavers. An improvement in confidence level by at least one point on the Likert scale in higher than 75% (arbitrarily defined) of the participant population was considered clinically significant.

Feedback was also obtained on the levels of difficulty, realism, attractiveness, and benefits of the cadaver models for use in enhanced experiential learning in the management of difficult airways. The performance indicators were assessed using a seven-point Likert scale (Table 1). These simulated parapharyngeal abscesses in breathing cadaver models were evaluated by 72 participants. Achievement of Likert scores of 5, 6 or 7 in higher than 75% (arbitrarily

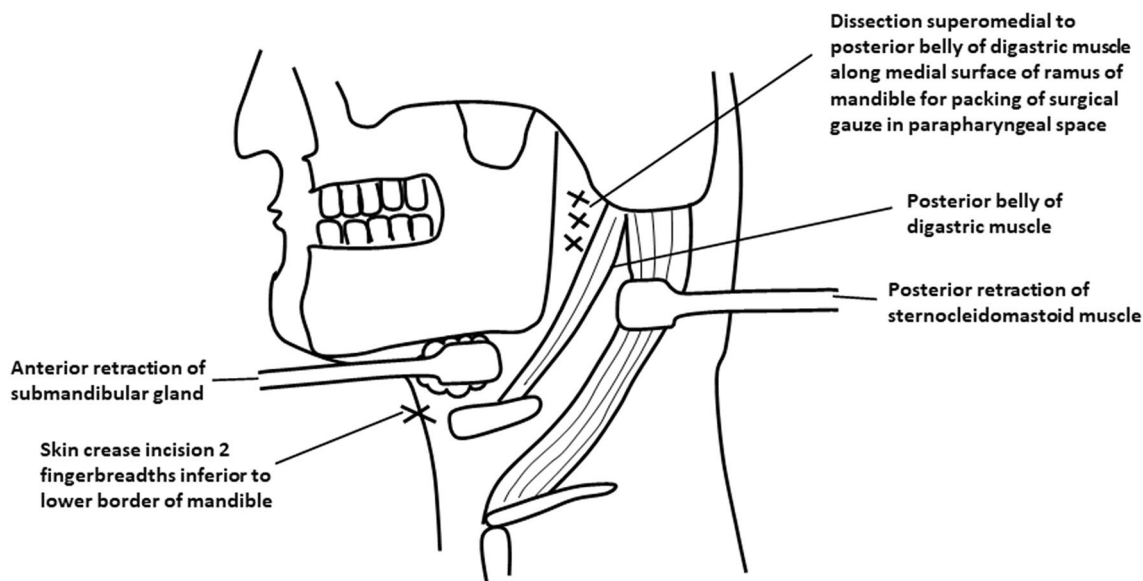


Fig. 1 Modification of cadaver head to simulate parapharyngeal abscess

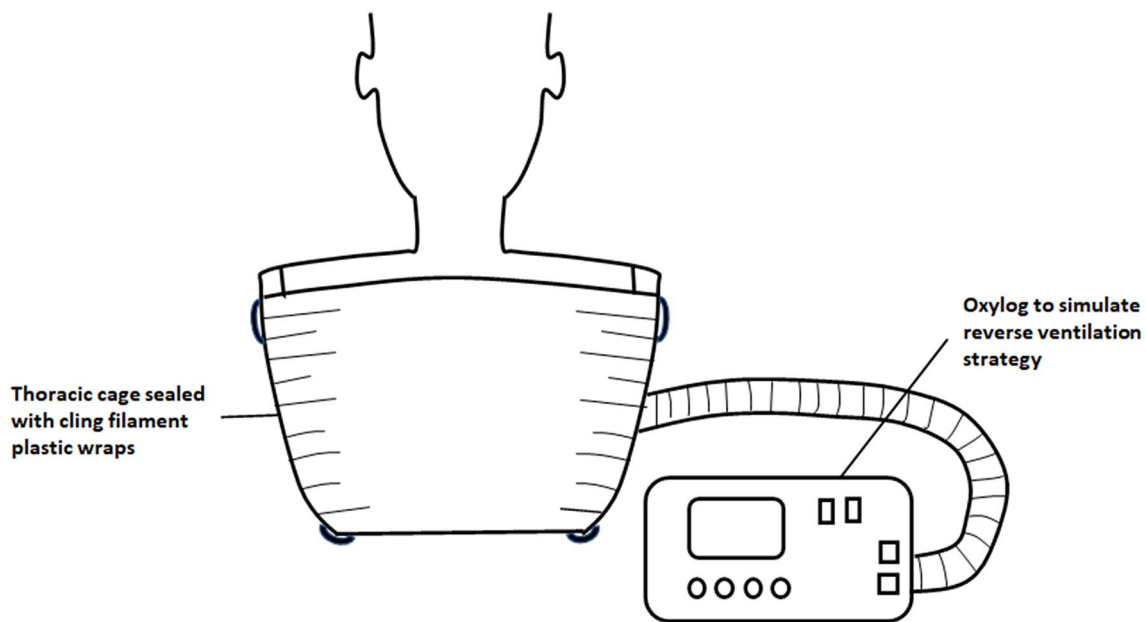


Fig. 2 Modification of cadaver thorax to simulate opening and closing of air channels with patient breaths

Table 1 Likert scale

Likert scale	Difficulty	Realism	Attractiveness	Benefits
1	Very easy	Absolutely unrealistic	Absolutely unattractive	Absolutely non-beneficial
2	Moderately easy	Unrealistic	Unattractive	Non-beneficial
3	Slightly easy	Slightly unrealistic	Slightly unattractive	Slightly non-beneficial
4	Neutral	Neutral	Neutral	Neutral
5	Slightly difficult	Slightly realistic	Slightly attractive	Slightly beneficial
6	Moderately difficult	Realistic	Attractive	Beneficial
7	Very difficult	Absolutely realistic	Absolutely attractive	Absolutely beneficial

defined) of the participant population was considered clinically significant in the assessment of difficulty, realism, attractiveness and benefits for skill training.

Statistical analysis

Categorical data were presented as frequency and percentage. Numerical data were presented in median and interquartile range. Pre- and post-confidence levels of participants in managing patients with parapharyngeal abscess with stridor were compared using the Wilcoxon Signed Rank test. Associations between seniority, years of anesthesiology experience, and prior attempts with bronchoscope- or fibreoptic scope-assisted intubations with outcomes were examined using Fisher’s Exact Test. A one-sided binomial test was used to test the models’ difficulty, realism, attractiveness and benefits (based on the Likert scale of 5, 6 or 7) with the thresholds of 75%. All comparisons, unless otherwise stated, were two sided, and

Table 2 Percentage of participants whose confidence level improved by at least one point of the Likert scale

Confidence level improved by at least one level of scale	
All	91% (63/69), 95% CI 82–96%
Experience	
Non-consultant	98% (47/48)
Consultant	76% (16/21)
<i>p</i> value	0.009
Years of anesthesiology experience	
< 10	98% (57/58)
≥ 10	60% (6/10)
<i>p</i> value	<0.001
Years of experience of bronchoscope/fibreoptic intubations	
< 10	100% (50/50)
≥ 10	68% (13/19)
<i>p</i> value	<0.001

Table 3 Assessment of levels of difficulty, realism, attractiveness, and benefits of models using a Likert scale

	Difficulty	Realism	Attractiveness	Benefits
All	85% (60/71)	93% (67/72)	92% (66/72)	93% (67/72)
95% CI	74–92%	85–98%	83–97%	85–98%
Experience				
Non-consultant	86% (42/49)	96% (47/49)	94% (46/49)	96% (47/49)
Consultant	81% (17/21)	86% (19/22)	86% (19/22)	86% (19/22)
<i>p</i> value	0.723	0.169	0.365	0.169
Years of anesthesiology experience				
< 10	83% (50/60)	93% (56/60)	92% (55/60)	95% (57/60)
≥ 10	90% (9/10)	91% (10/11)	91% (10/11)	82% (9/11)
<i>p</i> value	> 0.999	0.581	> 0.999	0.169
Years of experience of bronchoscope/fibreoptic intubations				
< 10	84% (43/51)	94% (49/52)	90% (47/52)	94% (49/52)
≥ 10	85% (17/20)	90% (18/20)	95% (19/20)	90% (18/20)
<i>p</i> value	> 0.999	0.613	> 0.999	0.613

a *p* value of < 0.05 was considered statistically significant. Analyses were performed with SPSS statistical software, version 19.0 (IBM Corp. Armonk, NY).

Results

Participant characteristics

Among the participants who enrolled for the advanced airway workshops, 68% (49/72) were non-specialists, and 31% (22/72) were specialists. Further, 83% (60/72) of the participants had < 10 years of anesthesiology experience, and 15% (11/72) had ≥ 10 years of experience. Additionally, 69% (50/72) of the participants had performed < 10 bronchoscope/fibreoptic intubations, while 31% (22/72) had performed ≥ 10 intubations.

Level of confidence

The percentage of participants who were confident in managing a patient with parapharyngeal abscess with stridor increased from 10% (7/69) to 59% (41/69). The difference in the proportion of participants who were confident before and after the training was statistically significant (*p* < 0.001). The median level of confidence went up from 2.0 (interquartile range (IQR) 1.0–4.0) before the training to 5.0 (IQR 4.0–5.0) after the training.

The level of confidence improved by at least one point on the Likert scale in 91% (95% confidence interval (CI) 82–96%) of participants using the modified cadavers. The percentage of participants with such improvement was significantly different between non-consultant [98% (47/48)] and consultant anesthesiologists [76% (16/21)] (*p* = 0.009); between participants with < 10 years of anesthesiology experience [98% (57/58)] to those with ≥ 10 years of experience [60% (6/10)] (*p* < 0.001) and between participants who had done < 10 [100% (50/50)] to those who had done ≥ 10 bronchoscope- or fibreoptic scope-assisted intubations [68% (13/19)] (*p* < 0.001) (Table 2).

Feedback on difficulty, realism, attractiveness and benefits of models

The majority of participants found the surgically modified cadaver models difficult (85%, 95% CI 74–92%), realistic (93%; 95% CI 85–98%), attractive (92%; 95% CI 83–97%), and beneficial (93%; 95% CI 85–98%) in simulating a difficult airway. There was no significant difference in levels of difficulty, realism, attractiveness, and benefits between ranks of seniority and levels of experience of participants (Table 3). All participants who responded expressed their

desire for more of such stations in training workshops, and found cadaver simulations to be an innovative interface for learning; the response rate was 92% (66/72). Among the 64 participants who responded, 58 (91%; 95% CI 81–97%; $p=0.001$) indicated that they were immersed in the scenario.

Discussion

Airway management training is an essential component of the anesthesiology curriculum, but the conventional teaching of anesthesiology falls short of exposing trainees to the broad spectrum of difficult airways potentially encountered in clinical practice [25]. Our study revealed a statistically significant increase in the level of confidence amongst participants from 10 to 59%. In our opinion, the confidence level is representative of the overall comfort level of physicians for performing difficult interventions, hence is reflective of their level of knowledge, skill sets, experience, and training. Therefore, the increase in confidence level likely plays an important role in the improvement of patient safety. Kashat et al. also utilized a pre- and post-course self-assessment tool to rate participants' comfort level with airway management skills in a multidisciplinary boot camp simulation course [26]. Our study revealed a significantly higher increase in confidence levels in non-consultants, participants with < 10 years of experience, and participants who had done < 10 bronchoscope- or fibreoptic scope-assisted intubations. This observation could be well associated with experiential learning offered by simulated cadavers to less experienced clinicians as compared to clinicians who have experienced intubations of such difficult situations before.

The cadaver modifications made in our study to simulate parapharyngeal abscess are unique. There have been no reported studies of simulations of parapharyngeal abscess with distorted airway anatomy. Such pathologies have not been simulated on manikins as well. Participants found the cadaver modifications difficult, realistic, attractive, and beneficial.

We recognize that simulation via cadaveric modifications might not be feasible for regular airway training courses due to the limited supply of cadavers, high storage costs, and high costs of procuring the cadavers. Other factors that might deter the use of cadaveric models in such courses include long surgical preparation times, difficult replication of surgical modifications, lack of surgeons to make the necessary modifications, and the limited number of fibreoptic intubation attempts permitted before technical problems are encountered or further cadaveric modification is required. However, practising on more sophisticated modalities is essential to hone airway management skills beyond the level of proficiency required for routine anesthesiology practice [27], which will, in turn, improve patient safety [28]. As

such, our cadaveric modifications can provide immense benefits in learning which is almost unmatched with other conventional methods of simulations in advanced airway training courses.

Cadaver modifications promote experiential learning through the four stages of Kolb's Experiential Learning Cycle—concrete experience, reflective observation, abstract conceptualization, and active experimentation [29]. Experiential learning is amongst the key methods for effective teaching as it promotes active involvement and repeated practice amongst learners [30]. In our opinion, a learner's encounter of each stage of the cycle can be enhanced by increasing realism of the simulation model. This study has shown that we can indeed simulate difficult pathologies with a high degree of realism for experiential learning. Further studies are needed to explore the usage of such simulated models in clinical research and training.

There are some limitations associated with the study. First, the ease of tracheal intubation was not evaluated on the participants in the clinical setting post-training. This follow-up was not feasible as many were overseas participants, and interactions with them were largely confined to the duration of the workshop. Second, the outcome measures, such as confidence level and perceptions of the models, were subjective indicators. The translation of a higher confidence score to an actual clinical improvement is an assumption, based on a similar approach used in a previous study [26].

In conclusion, parapharyngeal abscess presents as a difficult airway due to edema and stridor. In edematous airways, awake fibreoptic intubation promotes gas exchange by making use of the 'air spaces' which open up and close with breaths. However, such difficult airway cases are rare and less experienced anesthesiologists are often unable to practice fibreoptic intubation on real patients in such life-threatening circumstances. Hence, experiential learning through simulated parapharyngeal abscess in breathing cadavers is a novel method that plays a key role in training anesthesiologists in advanced airway management workshops and enhancing patient safety.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s00540-021-02904-0>.

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Compliance with ethical standards

Conflict of interest The authors declared that they have no conflict of interest.

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