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Review

Suction Assisted Laryngoscopy and Airway Decontamination (SALAD): A technique for improved emergency airway management

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A B S T R A C T

Emergency airway management is often complicated by the presence of blood, emesis or other contaminants in the airway. Traditional airway management education has lacked task-specific training focused on mitigating massive airway contamination. The Suction Assisted Laryngoscopy and Airway Decontamination (SALAD) technique was developed in order to address the problem of massive airway contamination both in simulation training and in vivo. We review the evidence describing the dangers associated with airway contamination, and describe the SALAD technique in detail.

Introduction

Rapid placement of an endotracheal tube is a lifesaving procedure performed in critically ill patients for the purposes of providing airway maintenance, airway protection, oxygenation, and ventilation. Many clinical scenarios that require emergency airway intervention may be complicated by the presence of airway contaminant, here defined as blood, emesis, or any other liquid or semi-liquid substance in the airway. Such scenarios include regurgitation of gastric contents, upper gastrointestinal bleeding, ruptured esophageal varices, thick and or dried secretions, and post-operative upper airway bleeding. Airway contaminant can significantly degrade a clinician's ability to provide adequate ventilation, perform laryngoscopy, or deliver other lifesaving airway maneuvers. The rate of adverse events increases dramatically when more than one attempt is required to successfully intubate patients in both the pre-hospital and emergency department settings.[1–3] The presence of airway contaminant has been shown to decrease first-pass success (FPS) at intubation both in simulation and in vivo regardless of whether direct or video laryngoscopy is employed.[4–10]

Airway contamination is also a significant concern in the field of

Abbreviations: SALAD, (Suction Assisted Laryngoscopy and Airway Decontamination).

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anesthesiology. Although standard pre-operative precautions such as a period of fasting decreases the risk of aspiration of gastric contents, The National Audit Project 4 Report (NAP4) published by the Royal College of Anaesthetists and the Difficult Airway Society found that aspiration of gastric contents was the most common complication causing mortality, leading to 8 deaths and 2 cases of brain damage in 184 reported major complications.[11] Estimates of pulmonary aspiration during general anesthesia cases vary from 1 in 900 to 1 in 10,000 cases.[12,13] NAP4 reported the event rate for "Can't Intubate, Can't Oxygenate" (CICO) situations at 1:50,000 cases.[11] Even though aspiration occurs more frequently, and can lead to mortality, there are fewer formal guidelines and task specific training options for this scenario than exist for CICO situations.

The traditional approach to the contaminated airway involves suctioning the airway and repositioning the patient.[13–15] Indeed, appropriate suctioning can mitigate many of the obstacles presented by a contaminated airway. Until recently, however, traditional airway management education has not included the integration of a simultaneous suctioning and airway decontamination skill set as a technique that can be deployed in the setting of large volume contamination. Clinicians frequently underestimate the importance of suction as part of airway management,[4,16] and a lack of familiarity with the setup and trouble-shooting of suction equipment can prolong an already difficult intubation.[17–19] Additionally, standard suction set-ups typically employ the Yankauer rigid catheter, which was originally designed to clear scant blood from the surgical field. The Yankauer is ill-suited for clearing the airway of copious heavy contamination of varying consistencies such as clotted blood and gastric contents.[20,21]

Suction Assisted Laryngoscopy and Airway Decontamination (SALAD) was developed to overcome the challenges of a massively contaminated airway. The technique utilizes high-fidelity manikins specially modified to regurgitate simulated contaminant from the esophagus during attempts at intubation. We present the SALAD technique here to raise awareness about the shortcomings of current airway management and training in this important area, and to share this novel training tool and skillset with the goal of enhancing knowledge translation to achieve better outcomes for patients requiring emergency airway management.

Technique

The SALAD technique is an incremental step-wise approach to the management of a massively contaminated airway. Ideally, any provider trained in the SALAD technique can rapidly and effectively deploy it during any laryngoscopy in which there is concern for potential airway contamination. The optimal patient positioning for endotracheal intubation (ETI) has been described in detail elsewhere.[22–24] After the patient has been appropriately positioned, the clinician begins the SALAD procedure of ETI with the rigid suction catheter (RSC) in their right hand, held in an over-hand fashion so that the curve of the RSC mirrors the curve of the structures of the upper airway (Fig. 1a). The RSC is inserted into the mouth and swept from side to side, continuously suctioning as it is advanced just ahead of the laryngoscope blade around the base of the tongue under direct visualization. The RSC is gripped tightly like a laryngoscope and used to displace the tongue and lower jaw in order to maximize space for laryngoscopy and subsequent tube delivery (Fig. 1b). As the RSC is advanced ahead of the laryngoscope, continuous suction clears the airway and ensures that the lens of the camera remains clean if the clinician is employing video laryngoscopy. The RSC is primarily responsible for displacing the structures of the upper airway until the blade of the laryngoscope has been optimally positioned (Fig. 1c). Once the laryngoscope is controlling the structures of the upper airway, the RSC can be used to suction the glottis and proximal trachea under direct visualization. The RSC is then withdrawn and re-inserted into the mouth to the left of the laryngoscope while maintaining constant visualization of the proximal esophagus and glottic opening. It is then advanced until the tip is sitting in the upper esophagus. This is referred to as the *SALAD Park Maneuver* (Fig. 1d). "Parking" the catheter in this position allows for the continuous suctioning of the hypopharynx even if the patient continues to actively vomit or hemorrhage and frees the operator's right hand to

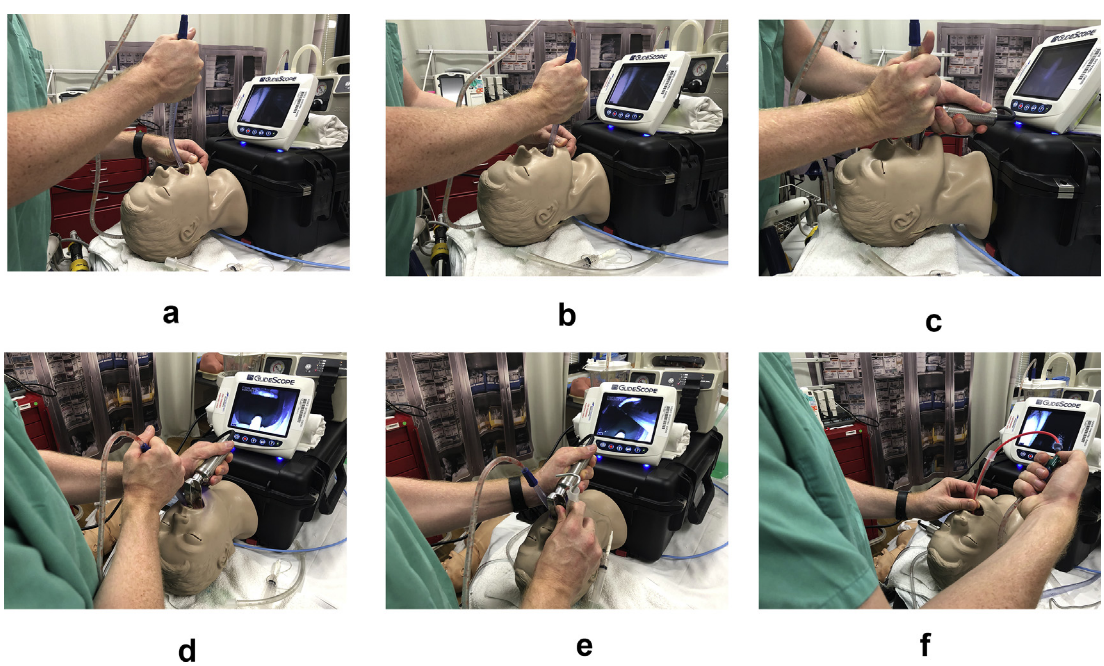

Fig. 1. 1a) The rigid suction catheter (RSC) is gripped overhand. 1b) The RSC displaces the structures of the upper airway. 1c) The airway is continuously suctioned as the laryngoscope blade is positioned. 1d) The RSC is withdrawn and repositioned to the left of the laryngoscope blade and seated in the hypopharynx in order to provide continuous suction. 1e) The endotracheal tube is delivered through the vocal cords. 1f) The endotracheal tube is suctioned prior to ventilation.

deliver the endotracheal tube. Next, the endotracheal tube is delivered with a constant awareness of optimizing the space and maintaining good visualization (Fig. 1e). Once positioned between the vocal cords, the lumen of the endotracheal tube is suctioned with a soft catheter to clear any residual contaminant prior to ventilation via the tube (Fig. 1f).

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The SALAD technique can also be adapted to incorporate the use of a bougie to aid in tube delivery. The bougie acts as a narrow-bore, directable introducer that can be passed through the vocal cords when visualization of the entire glottic opening is suboptimal or impossible. A recent trial by Driver et al. demonstrated that use of a bougie increased first pass success from 82% to 96% in patients with a characteristic of a difficult airway (defined as "body fluids obscuring the laryngeal view, airway obstruction or edema, obesity, short neck, small mandible, large tongue, facial trauma, or the need for cervical spine immobilization").[25] A simulation study of novice physicians intubating contaminated airways showed that the use of a bougie significantly reduced the time to intubation compared to intubation without a bougie.[5]

Discussion

At present, there have been no large, randomized controlled trials of SALAD versus conventional emergency airway management strategies in vivo. The very nature of unanticipated massive airway contamination during an intubation attempt would make a randomized control study of SALAD versus conventional techniques infeasible. However as knowledge of the technique has spread, there is a growing body of evidence evaluating the technique in simulation and assessing its benefit to learners.

Standard airway training manikins are unable to simulate active regurgitation, which limits the learner's ability to practice managing a contaminated airway. Educators and airway enthusiasts from a variety of disciplines have constructed their own SALAD simulators by modifying commercially-available airway manikins to simulate regurgitation using hand-powered or electrical pumps.[26] Commercially made SALAD simulators are also available. Utilizing a SALAD simulator allows the learner to engage in deliberate practice with the technical skills of intubation and suctioning to develop the confidence necessary to manage contaminated airways.

In a simulation study by DuCanto et al., practice with a SALAD simulator by 40 learners of various backgrounds led to increased clinician confidence in the management of contaminated airways and the application of suction during airway management (pre-training mean Likert score: 3.10 ± 0.49, post-session: 4.13 ± 0.22).[27] Della Vella et al. also found that SALAD simulation training increased the confidence of 22 learners of various backgrounds in managing contaminated airways and using suction devices from 2.73 to 4.00 on a 5 point Likert scale after use of the simulator.[28] Pilbery et al., using a SALAD simulator, found that paramedics were able to successfully intubate a contaminated airway on their first attempt significantly more often after learning the SALAD technique (90.2% vs. 53.7%, $p < 0.001$). The paramedics were also able to intubate the contaminated airway more rapidly after learning the SALAD technique (difference of 11.71 s, 95% CI 1.95–21.47 s, $p = 0.02$).[29] Lin et al. trained a group of 41 Taiwanese paramedics with a SALAD simulator and found that the subjects were able to intubate a contaminated airway an average of 10.2 s faster after undergoing training in the SALAD technique (26.9 versus 37.1 s, IQR = 20.5–59.8, $P = 0.031$). The percentage of participants able to successfully intubate a contaminated airway 3 times also increased from 36.6% to 80.5% following the SALAD training.[30] Ko et al., conducted a crossover simulation study to evaluate the airway management abilities of 30 physicians working in emergency medicine in Hong Kong. They found that the SALAD technique had a higher success rate than the conventional method (100% vs 90%, $p = 0.043$), lower mean volume of aspirate in the bronchi (23.2 ml vs 40.4 ml, $p = 0.027$), and comparable time to intubation (43.7 vs 47.4 s, $p = 0.850$). Jensen et al. conducted two studies after incorporating SALAD training into the quarterly training for a cohort of flight nurses and flight paramedics in a critical care transport program. Their initial study found that the time needed to intubate a contaminated airway improved significantly from 68.28 s to 49.76 s (95% confidence interval [CI], −34.976 to −2.064; $P = 0.0282$).[31] Three months later, the effect of the training was preserved and when 20 of the original 25 participants were reevaluated, the median time to intubate the contaminated airway had continued to decrease from 43.0 s post-training (IQR = 38.0–57.5); to 29.5 s at three month follow-up (IQR = 24.5–39.0) from a baseline pre-training median of 60.5 s (interquartile range [IQR] = 44.0–84.0).[32] Fiore et al., conducted a simulation study and found that SALAD was comparable to conventional airway management techniques and deliberate esophageal intubation. They tested a cohort of 21 senior residents in anesthesiology and 10 senior residents in emergency medicine. They found that the SALAD technique and deliberate esophageal intubation collected a higher mean volume of aspirate in the lower airway (traditional 72 (45) ml; IEI 100 (45) ml; SALAD 83 (42) ml), but the differences did not reach statistical significance ($p = 0.392$). The time to successful intubation was also similar between the groups (traditional 1.69 (1.31) minutes; IEI 1.74 (1.09) minutes; SALAD 1.74 (0.93) minutes; $p = 0.805$). Subjects reported increased confidence in airway management and suction skills after the training, although the junior residents reported the training was more useful than the senior residents on a 5 point scale (PGY-2 5.0 [4.0–5.0]; PGY-3 5.0 [4.0–5.0]; PGY-4 4.0 [3.5–4.0]; $p = 0.018$).[33]

There are potential disadvantages to the SALAD technique which should be investigated in future studies. Actively suctioning for the entirety of an attempt at intubation may cause oxygenated air to be removed from the oropharynx putting the patient at risk for hypoxemia. It is also possible that the SALAD technique may take more time than the conventional approach to laryngoscopy and intubation, which could unnecessarily prolong the time to endotracheal tube placement in patients with straightforward uncontaminated airways. However, in the setting of a massively contaminated airway, the alternative of only suctioning intermittently may be more harmful to a patient in that it may cause suboptimal visualization of the airway structures, prolonged intubation attempts and an increased incidence of inadvertent esophageal intubation.

Conclusion

Emergency airway management presents unique challenges and requires a skill set distinct from that used in routine airway management. Airway contamination presents a significant and frequent barrier to successful intubation. The SALAD technique improves the ability and confidence of clinicians managing contaminated airways and has the potential to minimize adverse events associated with multiple intubation attempts.

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Declaration of competing interest

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