CLINICAL TECHNIQUE

An Indigenous Suction-assisted Laryngoscopy and Airway Decontamination Simulation System

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Abstract

Background: Suction-assisted laryngoscopy and airway decontamination (SALAD) is a new modality and training manikins are quite costly. Few modifications have been described with their pluses and minuses. We describe a low-cost simulator that replicates fluid contamination of the airway at various flow rates and allows the practice of SALAD *in vitro*.

Materials and methods: We modified a standard Laerdal airway management trainer with locally available equipment to simulate varying rates of continuous vomiting or hemorrhage into the airway during intubation. The effectiveness of our SALAD simulator was tested during an advanced airway workshop of the Airway Management Foundation (AMF). The workshop had a brief common presentation on the learning objective of the SALAD technique followed by a demonstration to small groups of 5–6 participants at one time with necessary instructions. This was followed by a hands-on practical learning session on the simulator.

Results: One hundred and five learners used the simulator including 15 faculties and 90 participants (48 on ICU and 42 on ENT workstations). At the end of the session, the workshop faculty and participants were asked to rate their level of confidence in managing similar situations in real practice on a four-point Likert scale. All 15 faculty members and 70 out of 90 participants felt very confident in managing similar situations in real practice. Fifteen participants felt fairly confident and 5 felt slightly confident.

Conclusion: In resource-limited settings, our low-cost SALAD simulator is a good educational tool for training airway managers in the skills of managing continuously and rapidly soiling airways.

Keywords: Airway, Simulator, Suctioning, Suction-assisted laryngoscopy and airway decontamination.

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Highlights

This is a low-cost simulator that replicates fluid contamination of the airway at various flow rates and allows the practice of suction-assisted laryngoscopy and airway decontamination (SALAD) *in vitro*.

Introduction

Blood and vomitus in the airway can obstruct the glottic view and make emergency airway management difficult. If incriminating material is gushing continuously in the airway, the difficulty increases manifold. Securing a soiled airway with an endotracheal tube is a lifesaving, core skill at such times for airway protection, oxygenation, and ventilation.[1,2] Historically these situations have been managed by positioning the patient in head low or lateral position followed by suctioning.[3–6] Lately, a new modality named SALAD has been described that appears to be very promising for such situations.[7]

The described technique for SALAD involves patient positioning in the appropriate position for laryngoscopy and the introduction of a Yankauer suction catheter (YSC). The operator holds YSC in his right hand and inserts it into the mouth with a concave side facing up so that the curve of YSC matches the curve of the upper airway. The suctioning is switched on and YSC is used to displace the tongue to maximize space for laryngoscopy while continuing suctioning to clear the airway. The laryngoscope/video-laryngoscope blade is now introduced under continuous suctioning until the blade of the scope is optimally positioned. At this time, YSC is withdrawn and re-inserted into the mouth to the left of the scope blade and parked in the hypopharynx under direct vision to allow continuous suctioning. An endotracheal tube is now inserted under direct vision into the glottic opening. Once the tube position is confirmed, the contents inside the tube are suctioned using a soft catheter before ventilating the patient's lungs.[1,6,7]

A manikin has also been described to train the trainees in this technique.[1,6,7] We describe a low-cost simulator that replicates fluid contamination of the airway at various flow rates and allows the practice of SALAD *in vitro*.

The Making of SALAD Simulator

We used an airway management trainer (Laerdal Medical, India) to create our simulator. It has a lifelike upper torso, head, mouth, and oral cavity. The oral cavity leads into the pharynx and thereafter into the life-like laryngeal inlet and hypopharynx. The hypopharynx leads into the esophagus located behind the trachea. The distal end

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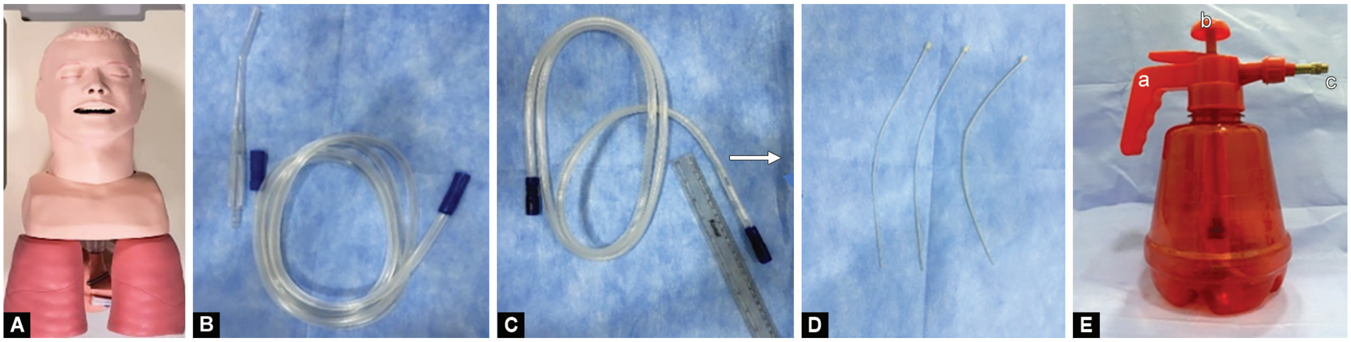

Figs 1A to E: Equipment's required (from left to right) for making of SALAD simulator, (A) Laerdal airway management trainer; (B) Yankauer suction catheter tip with first flexible tube-A; (C) Second flexible tube-B having 5–6 holes (marked by arrow) in the distal ~15 cm; (D) Zip ties; (E) Garden spray pump: (a) Piston; (b) Nozzle; (c) Lever

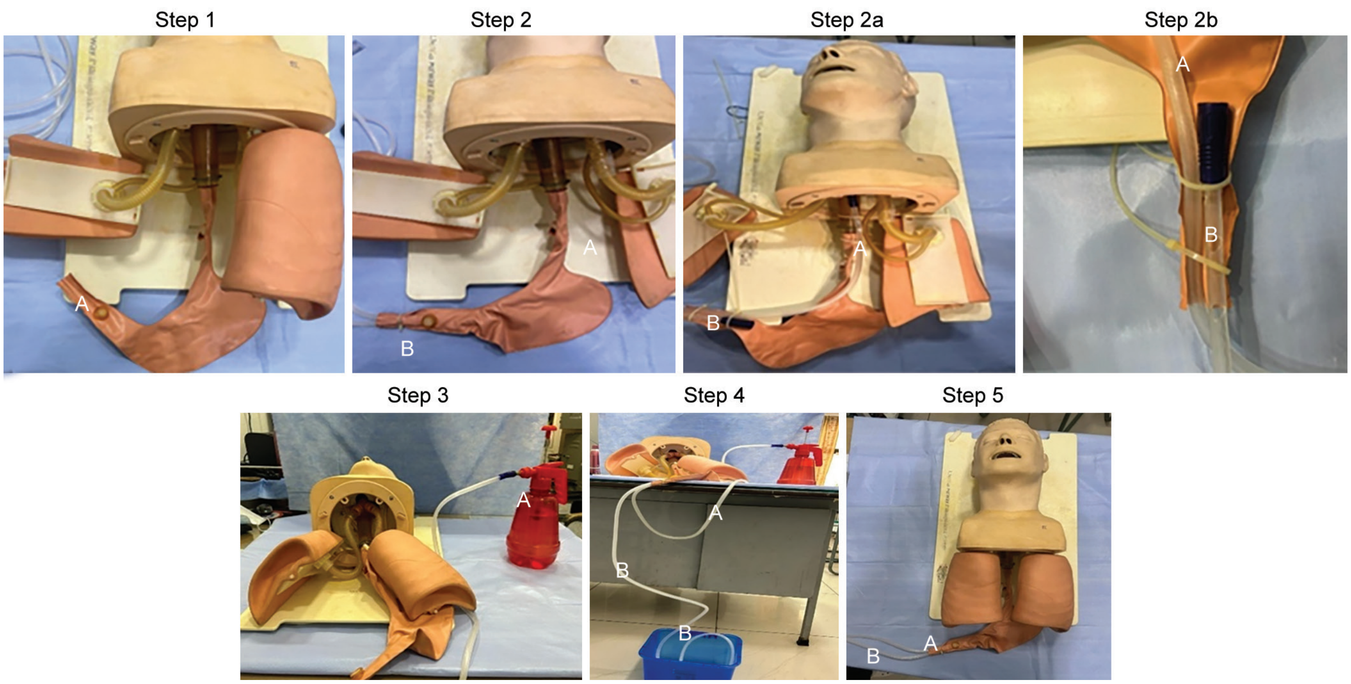

Fig. 2: The Making of SALAD simulator, Step 1: The lungs of the manikin are removed and clip at the distal end of the stomach (A) of a Laerdal airway management traineris removed; Step 2: One end of the first flexible tube-A is inserted through distal end of the stomach and pushed up until it reaches the upper end of esophagus. One end of tube-B (having 5–6 holes in the distal ~15 cm) is also pushed into the distal end of the stomach alongside the tube-A just enough to ensure that all the holes are inside the stomach. Two zip ties are then applied to distal end of the stomach to secure the two tubes (A and B) and prevent leakage of fluid from the stomach during the procedure. (Step 2a and 2b show the final positions of the two tubes by placing these over the stomach and esophagus); Step 3: The other end of the tube-A, which is outside the manikin, is connected to the brass nozzle of the two-liter hand-held garden-spray pump; Step 4: The other end of the tube-B, which is outside the manikin, is left open into a drainage container to drain the excess simulated airway contaminant (SAC); Step 5: The lungs of the manikin are placed back in their position

of the esophagus opens into the proximal end of the stomach and the distal end of the stomach is closed with a clip.

The distal end of the stomach is opened by removing the clip (See Fig. 2; Step 1). Two 2-meter-long clear flexible kink-resistant medical grade 6.0/8.5 internal diameter/outer diameter polyvinyl chloride (PVC) tubes are taken (Figs 1A to C). These tubes are available with a YSC pack. One end of the first tube (Tube-A) is inserted through the distal end of the stomach up to the upper end of the esophagus (Fig. 2; Step 2 and 2a). The other end of this tube is connected to the brass nozzle of a two-liter hand-held garden spray pump and the nozzle is adjusted to supply a continuous jet when actuated (Fig. 2; Step 3). The garden spray pump has a piston to build desired pressure inside the container and a pressure release trigger or lever to release liquid from the nozzle (Figs 1D and E).

The second flexible tube (Tube-B) is taken and five to six holes are created by cutting on the alternate side of the initial 15 cm of one end of the tube (Fig. 1B). It is then inserted into the stomach alongside of the first tube up to 15 cm or till all holes are inserted into the stomach (Fig. 2, Steps 2 and 2b). This tube acts as a drainage tube of the stomach and collects fluid in the bucket connected to the other end of this tube (Fig. 2, Steps 4 and 5). The zip ties are then applied to the distal end of the stomach to prevent leakage of fluid from the stomach during the procedure. Simulated airway contaminant (SAC) is created by mixing food color (10 gm), either red or green, in two liters of water to simulate either blood or vomitus.

Using Modified Simulator

The simulator is placed in the appropriate position for intubation and suctioning. A standard portable suction machine with appropriate PVC tubing and wide bore Yankauer suction tip is placed alongside. The garden spray pump connected to one of the PVC tubes (the one reaching the upper end of the esophagus) is filled with SAC and is pressurized by repeated pumping of the piston. The nozzle is adjusted to deliver a continuous jet (rather than a sprinkle) of liquid when actuated. As the operator holds the YSC in his hand a continuous stream of SAC is delivered into the hypopharynx and mouth of the manikin. The operator now has to perform the procedure of SALAD, consisting of continuous suctioning, placement, and re-placement of the Yankauer suction tip, and endotracheal intubation.

Outcome

We tested the efficacy of our simulator at the airway workshop of the AMF having 105 participants. The participants consisted of anesthesia and intensive care junior and senior residents, practicing anesthesiologists, and faculty from various institutions. The SALAD workstation was part of two advanced specialty workshops; one on airway skills unique to ENT surgeries and the other on airway skills unique to ICU. The faculty members running the SALAD workstation practiced the procedure before the hands-on session began. The other faculty members at these two workshops practiced the procedure next. Once the workshop began the participants, had a brief common presentation on the learning objective of each workstation, including the SALAD workstation. Thereafter, the technique of SALAD using our simulator was demonstrated to small groups of 5–6 participants at one time with the necessary instructions. This was followed by a hands-on practical learning session on the simulator. At the end of the session, the workshop faculty and participants were asked to rate their level of confidence in managing similar situations in real practice on a four-point Likert scale (4 = very confident, 3 = fairly confident, 2 = slightly confident and 1 = not confident at all). All 15 faculty members felt very confident, and 70 out of 90 participants (48 in ICU and 42 in ENT surgery workstations) felt very confident, 15 were fairly confident and 5 were only slightly confident in managing similar situations in real practice.

Discussion

The patients who need emergency intubation often have blood or vomitus in the airway, which may impair visualization during intubation and reduce intubation success rate.[1,2] The traditional approach to manage such patients is a head-down position with suctioning the airway with a large bore suction catheter. Unfortunately, this approach does not work in case of massive regurgitation or when incriminating material is gushing continuously in the airway. This increases the risk of intubation failure and complications manifold.[3–6]

The resident doctors who generally manage such patients in emergency and ICU are trained in airway management skills on standard airway manikins or in the operation theatre. It is difficult or impossible to simulate real-life airway emergencies like active regurgitation or bleeding in these manikins, which in turn limits the learner's ability to practice managing grossly contaminated and continuously contaminating airways. Naturally, the trainees feel under-confident and lost when faced with similar challenging real-life situations.

It has been shown that skill acquisition and retention are better when trainees are trained on simulation manikins as compared to non-simulation manikins.[8,9] Training in the SALAD technique classically requires high-fidelity manikins specially modified to regurgitate simulated contaminants from the esophagus during attempts at intubation. But these simulators are very costly.[7] Considering such a high cost, attempts have been made to modify existing airway manikins.[10]

Our modification is minimalistic, inexpensive, and easy to install. The only requirements other than a Laerdal airway management trainer are being two flexible kink-resistant medical grade PVC tubes, a garden spray pump, a few zip ties, and a food coloring agent. We did not remove the lungs and stomach from the airway manikin which gives a more natural look to the manikin and it can be used for airway management training other than SALAD also.

Ko S et al. reported in their study that the DuCanto suction catheter was more effective than the YSC in clearing the SAC from the oral cavity of the manikin. DuCanto suction catheter does not have a thumb port which allows continuous suctioning from the oral cavity.[11] In our study we used a YSC which has a thumb port. The operator has to apply continuous thumb pressure at the thumb port for rapidly re-accumulating vomitus or blood in the oropharynx. This problem was resolved by permanently obliterating the thumb port of the YSC with tape. This allowed continuous suctioning without having to continuously place the thumb over the side port.

To simulate either vomit or blood, xanthan gum powder or chicken noodle soup has been used in various studies.[1,7,12] Xanthan gum powder is a food additive that increases the consistency of the solution when added to the water. Vinegar or BARFume puke smell spray has also been used to add an olfactory component to the vomit.[1,7,12] In our study SAC was created by mixing food color in two liters of water which can be easily prepared without any risk of bacterial contamination. Vinegar or puke smell spray spreads smell and makes the whole environment uncomfortable for the operator. We feel that adding more thickness to the vomitus and adding vinegar or puke smell spray will not add value to the clinical skill imparted with the SALAD technique. Moreover, xanthan gum powder or chicken noodle soup may increase the chances of bacterial growth in the simulated contaminant.

Our SALAD simulator adds value to traditional airway teaching by providing learners unlimited opportunities to master one of the most challenging skills of life-saving airway decontamination, suctioning, and intubation. It also allows for monitoring of learners' progress and skill acquisition which can be easily measured and documented. As documented during our workshop, it is easy to learn and easy to teach on our simulator.

Limitations

Our simulator is best suited for regurgitates of low viscosity. Increasing the consistency of SAC can block the nozzle of the garden spray pump. Moreover, it is difficult to provide a similar flow of regurgitation (SAC) to all the participants. This variability might make the experience of participant's variable as well. However, we feel that both these limitations are clinically not significant because the main learning objective of this station is to learn to deal with a continuously soiling oropharynx and oral cavity which can be better learned with fast-flowing liquid of low viscosity. Secondly, in real-life situations, the flow of regurgitation will vary from patient to patient. We do not know whether the subjective feeling of increased confidence in dealing with similar situations after the workshop will translate into improved outcomes in real clinical practice or not; in terms of better success of first-pass intubation and/or reduced time to intubation in a continually vomiting patient. Further studies are needed to evaluate that.

Conclusion

In resource-limited settings, our low-cost simulator is a good educational tool for training airway managers in the skills of managing continuously and rapidly soiling airways.

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