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ORIGINAL ARTICLE

Evaluation of chest compression effect on airway management with air-Q®, aura-i®, i-gel®, and Fastrack® intubating supraglottic devices by novice physicians: a randomized crossover simulation study

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Abstract
Purpose In the 2010 American Heart Association guidelines, supraglottic devices (SGDs) such as the laryngeal mask are proposed as alternatives to tracheal intubation for cardiopulmonary resuscitation. Some SGDs can also serve as a means for tracheal intubation after successful ventilation. The purpose of this study was to evaluate the effect of chest compression on airway management with four intubating SGDs, aura-i® (aura-i), air-Q® (air-Q), i-gel® (i-gel), and Fastrack® (Fastrack), during cardiopulmonary resuscitation using a manikin.
Methods Twenty novice physicians inserted the four intubating SGDs into a manikin with or without chest compression. Insertion time and successful ventilation rate were measured. For cases of successful ventilation, blind tracheal intubation via the intubating SGD was performed with chest compression and success or failure within 30 s was recorded.
Results Chest compression did not decrease the ventilation success rate of the four intubating SGDs (without chest compression (success/total): air-Q, 19/20; aura-i, 19/20; i-gel, 18/20; Fastrack, 19/20; with chest compression: air-Q, 19/20; aura-i, 19/20; i-gel, 16/20; Fastrack, 18/20). Insertion time was significantly lengthened by chest compression in the i-gel trial ($P < 0.05$), but not with the other three devices. The blind intubation success rate with chest compression was the highest in the air-Q trial (air-Q, 15/19; aura-i, 14/19; i-gel, 12/16; Fastrack, 10/18).
Conclusions This simulation study revealed the utility of intubating SGDs for airway management during chest compression.

Keywords aura-i® · air-Q® · i-gel® · Fastrack® · Chest compression · Manikin · Novice physicians

Introduction

Securing the airway during cardiopulmonary resuscitation (CPR) is technically challenging and is influenced by the location and position of the patient and skills of the rescuer. The American Heart Association (AHA) 2010 guidelines suggest supraglottic devices (SGDs), such as the laryngeal mask (LMA), as alternatives to tracheal intubation during CPR [1, 2]. A number of reports suggest that SGDs have advantages over ordinary tracheal intubation for airway management under emergency situations, such as cardiopulmonary arrest. However, tracheal intubation is preferred in situations such as transfer of the patient or mechanical ventilation after recovery of spontaneous circulation [2].

Several SGDs have unique features that render them useful for difficult or emergency airway management [3, 4]. One such SGD is the intubating SGD, which allows tracheal

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intubation via the inner lumen [5, 6]. Although several types of intubating SGDs are commercially available [7, 8], they have not been compared or evaluated for airway management during chest compression.

This study aimed to compare the performance of four intubating SGDs [air-Q® ("air-Q"; Cookgas LLC, Mercury Medical, USA), i-gel® ("i-gel"; InterSurgical, USA), Ambu aura-i ("aura-i"; Ambu, Denmark), and the single-use LMA Fastrack® ("Fastrack"; Laryngeal Mask, Prodol Meditec, Spain)] for emergency airway management during chest compression. Our primary endpoint was the evaluation of these four intubating SGDs for successful ventilation with or without chest compression, and the secondary endpoint was the evaluation of blind intubation via these intubating SGDs after successful ventilation.

Materials and methods

This study was approved by the Research Ethics Committee of Hyogo College of Medicine. Twenty-two novice physicians at Hyogo College of Medicine with less than 1 year of experience with anesthesia were targeted; 20 agreed to participate and provided written consent. We asked the doctors about their prior experience with general anesthesia and usage of the intubating SGDs.

The AirMan (Laerdal, Sentrum, Stavanger, Norway) was used as the manikin for chest compression, intubating SGD insertion, and intubation. Size 3.5 air-Q and size 4 aura-i, i-gel, and Fastrack devices were used. The necessary equipment for each simulation was placed in a box next to the manikin. Participants were given 10 min to practice with the four intubating SGDs before the trials. The manikin was placed on a hard and flat floor to simulate "on the bed" conditions (Fig. 1). According to published guidelines, the same Advanced Cardiac Life Support (ACLS) instructor performed chest compressions at a rate

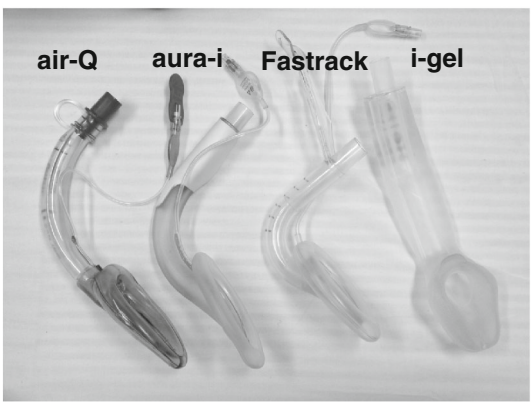

Fig. 1 Image of the four intubating supraglottic devices used in the study. *air-Q* air-Q laryngeal mask airway®, *i-gel* i-gel supraglottic airway®, *aura-i* Ambu aura-i®, *Fastrack* Fastrack single use®

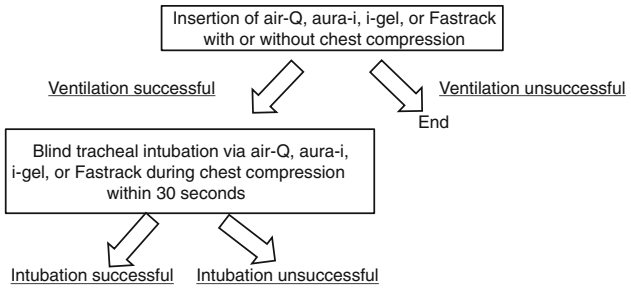

Fig. 2 Study protocol for evaluating the four intubating supraglottic devices. *air-Q* air-Q laryngeal mask airway®, *i-gel* i-gel supraglottic airway®, *aura-i* Ambu aura-i®, *Fastrack* Fastrack single use®

of 100 per minute at a depth of 5 cm according to the AHA2010 guideline [1, 9].

This study adopted a randomized crossover design to minimize learning effects. Participants inserted each of the four devices with or without chest compression. This randomization process resulted in a total of eight trials per participant, which was determined by a random numbers list. The study protocol is shown in Fig. 2. We first evaluated the utility of the four devices for ventilation with or without chest compression. Participants who achieved successful ventilation then attempted to intubate the manikin's trachea via the intubating SGD during chest compression. In the first part of the study, participants inserted each of the four intubating SGDs, inflated their cuffs with 20 ml air for the aura-i or Fastrack device, connected the devices to a bag-valve mask, and attempted to ventilate the manikin's lungs. A fixed volume of air was administered to evaluate the utility of the aura-i or Fastrack device in emergent airway management. We decided on 20 ml based on results of a preliminary study. We did not administer air during the air-Q trial based on the manufacturer's instructions. Insertion times from the startpoint to the endpoint were recorded; the startpoint was when the participant picked up the intubating SGD, and the endpoint was manual ventilation after insertion, regardless of success or failure in inflating the manikin's lungs. After successful insertion, chest compression was temporarily stopped and participants were told to perform ventilation with a 2-l bag-valve mask (Laerdal Silicone Resuscitator, Sentrum). Ventilation was considered successful when the manikin's chest visibly rose.

In the second part of the study, participants who successfully ventilated the manikin then attempted blind tracheal intubation via the intubating SGD. Continuous chest compression was performed by the same ACLS instructor. A tracheal tube with an internal diameter of 7.0 mm (Portex, USA) was used. We did not perform this trial without chest compression because our main aim is the evaluation of tracheal intubation via intubating SGD during chest compression.

In the second study, intubation started when the participant picked up the tracheal tube and ended at the point of manual ventilation with a bag-valve mask after tube insertion. Tracheal intubation via intubating SGD was performed blindly. When the tracheal tube was inserted into the esophagus or the intubating SGD was dislodged, the participant could try again as many times as needed within the time limit of 30 s. Time measurement stop was not performed in such failed cases. Success or failure of tracheal intubation (visible chest rise with bag-valve mask) within 30 s was recorded.

Results obtained from each trial were compared by two-way repeated-measures analysis of variance for insertion time. The chi-squared test was used to compare rates for successful ventilation or successful intubation during chest compression. Data are presented as mean ± SD. $P < 0.05$ was considered statistically significant.

Results of our preliminary study with 9 novice physicians showed that the time required to ventilate the lungs after successful insertion of the air-Q was approximately 10 ± 3 s. We considered 3 s as the clinically meaningful difference between the groups. Using an α error of 0.05 and β error of 0.2, we estimated that 18 participants would be required for evaluation of the effect by chest compression.

Results

The average clinical experience of the participants with anesthesia was 3.2 ± 1.6 months. None of the participants had used any of the four intubating SGDs before this study.

Number of successful ventilations

Table 1 shows the number of successful ventilations. Chest compression did not decrease the insertion success rate of the four intubating SGDs [without chest compression (success/total): air-Q, 19/20; aura-i, 19/20; i-gel, 18/20; Fastrack, 19/20; with chest compression: air-Q, 19/20; aura-i, 19/20; i-gel, 16/20; Fastrack, 18/20].

Table 1 Number of successful ventilation trials with or without chest compression

	air-Q	aura-i	i-gel	Fastrack
Without chest compression	19/20	19/20	18/20	19/20
During chest compression	19/20	19/20	16/20	18/20

Success number/total number

air-Q air-Q laryngeal mask airway®, *i-gel* i-gel supraglottic airway®, *aura-i* Ambu aura-i®, *Fastrack* Fastrack single use®

Table 2 Ventilation time with or without chest compression

	air-Q	aura-i	i-gel	Fastrack
Without chest compression	6.7 ± 1.8	6.6 ± 1.7	6.2 ± 2.1	7.3 ± 1.7
During chest compression	7.6 ± 2.5	7.7 ± 2.2	10.2 ± 1.9*	9.5 ± 2.3

air-Q air-Q laryngeal mask airway®, *i-gel* i-gel supraglottic airway®, *aura-i* Ambu aura-i®, *Fastrack* Fastrack single use®

* $p < 0.05$ compared to without chest compression

* $p < 0.05$

Table 3 Number of successful blind intubations during chest compression

	air-Q	aura-i	i-gel	Fastrack
During chest compression	15/19	14/19	12/16	10/18

Success number/total number

air-Q air-Q laryngeal mask airway®, *i-gel* i-gel supraglottic airway®, *aura-i* Ambu aura-i®, *Fastrack* Fastrack single use®

Insertion times

Table 2 shows insertion times for the four intubating SGDs with or without chest compression. Insertion time was significantly lengthened by chest compression in the i-gel trial ($P < 0.05$), but not with the other three intubating SGDs (air-Q: 6.7 ± 1.8 s without chest compression vs. 7.6 ± 2.5 s with chest compression; aura-i: 6.6 ± 1.7 s without chest compression vs. 7.7 ± 2.2 s with chest compression; i-gel: 6.2 ± 2.1 s without chest compression vs. 10.2 ± 1.9 s with chest compression; Fastrack: 7.3 ± 1.7 s without chest compression vs. 9.5 ± 2.3 s with chest compression).

Number of successful blind intubations with chest compression

Table 3 shows the blind intubation success rate with the four intubating SGDs during chest compression. The intubation success rate with chest compression was the highest in the air-Q trial (air-Q, 15/19; aura-i, 14/19; i-gel, 12/16; Fastrack, 10/18).

Discussion

SGDs are recommended by professionals for rescue ventilation in cases of failed intubation [10]. The utility of conventional LMAs, such as the LMA-Classic®, LMA-ProSeal®, and Soft Seal® LMA, for rescue ventilation has been previously reported. New SGDs have been developed to improve on conventional LMAs. Anatomically curved

SGDs, such as LMA-Supreme®, air-Q, and aura-i allow for easy insertion [11, 12]. Non-cuff-type SGDs, such as the i-gel, also exist [13]. As improved versions of SGDs, intubating SGDs that can serve as a conduit for tracheal intubation have also been developed. The utility of intubating SGDs for the management of difficult airways has been reported in several clinical situations [14, 15].

SGDs are suited for difficult airway management, especially in a "cannot intubate, cannot ventilate" situation [16]. The concept of "difficult airway management" includes physical difficulties associated with the patient, such as a small jaw and restricted opening of the mouth; it also includes several situations that make airway management more difficult [17]. Airway management during CPR is often performed under restricted situations resulting from severe head and neck trauma and victim position. Thus, SGDs are not only useful for physically difficult airways but also for such situation-specific difficult airways.

Airway management is considered as an essential element of both in-hospital and out-of-hospital CPR. Tracheal intubation is the most widely used method for airway management, but it is considered difficult for those who do not routinely perform this technique [18]. The AHA-ACLS guidelines emphasize avoiding interruptions of chest compression as much as possible, even for airway management [1, 2].

Securing definite ventilation during resuscitation is the effective oxygenation of the lungs and brain, leading to the recovery of spontaneous circulation [1]. From this point of view, application of intubating SGDs is effective because these devices are easy to insert even with chest compression. After ventilation is confirmed, rescuers can perform tracheal intubation via the inner lumen of intubating SGDs [19].

In comparison of the four intubating SGDs, only the i-gel showed a lower success number compared to the other three devices. Furthermore, i-gel showed significant increase of insertion time by chest compression. One probable reason for this is the other three intubating SGDs have an anatomically shaped curve but the i-gel does not. For tracheal intubation through intubating SGDs, several participants failed to achieve blind tracheal intubation within 30 s. There are reports about the utility of fiberoptic bronchoscopy for definite tracheal intubation through intubating SGDs [14, 20]. Thus, intubation utilizing fiberoptic bronchoscopy may be appropriate after recovery of spontaneous circulation.

Another advantage of SGDs is their ease of use by novice operators. In emergency situations, airway management is often performed by less experienced physicians. There are reports that SGDs require less professional skill and are suited for the novice and occasional operators [21, 22]. In this study, although participants had no previous experience using the four intubating SGDs, success of ventilation during chest compression was more than 80 %. Thus, a short training period with these intubating SGDs may help improve emergent airway management among novice physicians.

This study has several limitations. First, use of the intubating SGDs may be difficult for patients with severely restricted mouth openings, as well as those with foreign bodies or tumors in the mouth. Second, we used a manikin rather than real patients. Simulations with a manikin cannot mimic certain factors encountered in the clinical setting, such as blood, vomit, or sputum in the oropharynx [22, 23]. Third, the time required for airway intervention in a manikin is generally shorter than that required in actual patients [24]. Fourth, in clinical situations, the homogeneity of CPR techniques cannot be assured. Accumulation of data on the clinical use of intubating SGDs in emergency airway management during resuscitation is needed.

Our simulation study demonstrated that intubating SGDs are useful for airway management during chest compression. Insertion success rate did not significantly decrease by chest compression in all four intubating SGDs. Insertion times of air-Q, aura-i, and Fastrack did not significantly lengthen by chest compression but that of i-gel did.

Conflict of interest The authors have no affiliation with any manufacturer of any device described in the manuscript and declare no financial interest in relationship to the material described here. Financial support for the study was provided by our institution and department.

References

1. Hazinski MF, Nolan JP, Billi JE, Böttiger BW, Bossaert L, de Caen AR, Deakin CD, Drajer S, Eigel B, Hickey RW, Jacobs I, Kleinman ME, Kloeck W, Koster RW, Lim SH, Mancini ME, Montgomery WH, Morley PT, Morrison LJ, Nadkarni VM, O'Connor RE, Okada K, Perlman JM, Sayre MR, Shuster M, Soar J, Sunde K, Travers AH, Wyllie J, Zideman D. Part 1: Executive summary: 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations. Circulation. 2010;122:S250–75.
2. Neumar RW, Otto CW, Link MS, Kronick SL, Shuster M, Callaway CW, Kudenchuk PJ, Ornato JP, McNally B, Silvers SM, Passman RS, White RD, Hess EP, Tang W, Davis D, Sinz E, Morrison LJ. Part 8: Adult advanced cardiovascular life support: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2010;122:S729–67.
3. Asai T, Murao K, Shingu K. Efficacy of the ProSeal laryngeal mask airway during manual in-line stabilisation of the neck. Anaesthesia. 2001;57:918–20.
4. Reinhart DJ, Simmons G. Comparison of placement of the laryngeal mask airway with endotracheal tube by paramedics and respiratory therapists. Ann Emerg Med. 1994;24:260–3.

5. Häske D, Schempf B, Gaier G, Niederberger C. Performance of the i-gel™ during pre-hospital cardiopulmonary resuscitation. Resuscitation. 2013;84:1229–32.
6. Asai T. Intubating laryngeal mask airway after failed insertion of a classic laryngeal mask. Anaesthesia. 2006;61:303.
7. Komasawa N, Ueki R, Yamamoto N, Atagi K, Nishi S, Kaminoh Y, Tashiro C. Comparison of air-Q® and Soft Seal® laryngeal mask for airway management by novice doctors during infant chest compression: a manikin study. Resuscitation. 2012;83:365–8.
8. Reinhart DJ, Simmons G. Comparison of placement of the laryngeal mask airway with endotracheal tube by paramedics and respiratory therapists. Ann Emerg Med. 1994;24:260–3.
9. Komasawa N, Ueki R, Nomura H, Itani M, Kaminoh Y. Comparison of tracheal intubation by Macintosh laryngoscope and Pentax-AWS (Airway Scope) during chest compression: a manikin study. J Anesth. 2010;24:306–8.
10. Combes X, Le Roux B, Suen P, Dumerat M, Motamed C, Sauvat S, Duvaldestin P, Dhonneur G. Unanticipated difficult airway in anesthetized patients: prospective validation of a management algorithm. Anesthesiology. 2004;100:1146–50.
11. Kohama H, Komasawa N, Ueki R, Samma A, Nakagawa M, Nishi S, Kaminoh Y. Comparison of Supreme® and Soft Seal® laryngeal masks for airway management during cardiopulmonary resuscitation in novice doctors: a manikin study. J Anesth. 2011;25:98–103.
12. Vaida SJ, Yodfat UA. Angulation of the airway tube in the AMBU laryngeal mask could be responsible for improved insertion success. Anesth Analg. 2006;103:264.
13. Theiler LG, Kleine-Brueggeney M, Kaiser D, Urwyler N, Luyet C, Vogt A, Greif R, Unibe MM. Crossover comparison of the laryngeal mask supreme and the i-gel in simulated difficult airway scenario in anesthetized patients. Anesthesiology. 2009;111:55–62.
14. Asai T, Eguchi Y, Murao K, Niitsu T, Shingu K. Intubating laryngeal mask for fibreoptic intubation—particularly useful during neck stabilization. Can J Anaesth. 2000;47:843–8.
15. Frappier J, Guenoun T, Journois D, Philippe H, Aka E, Cadi P, Silleran-Chassany J, Safran D. Airway management using the intubating laryngeal mask airway for the morbidly obese patient. Anesth Analg. 2003;96:1510–5.
16. Timmermann A. Supraglottic airways in difficult airway management: successes, failures, use and misuse. Anaesthesia. 2011;66(suppl 2):45–56.
17. Apfelbaum JL, Hagberg CA, Caplan RA, Blitt CD, Connis RT, Nickinovich DG, Hagberg CA, Caplan RA, Benumof JL, Berry FA, Blitt CD, Bode RH, Cheney FW, Connis RT, Guidry OF, Nickinovich DG, Ovassapian A; American Society of Anesthesiologists Task Force on Management of the Difficult Airway. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. Anesthesiology 2013;118:251–270.
18. Wang HE, Simeone SJ, Weaver MD, Callaway CW. Interruptions in cardiopulmonary resuscitation from paramedic endotracheal intubation. Ann Emerg Med. 2009;54:645–52.
19. Fukutome T, Amaha K, Nakazawa K, Kawamura T, Noguchi H. Tracheal intubation through the intubating laryngeal mask airway (LMA-Fastrach) in patients with difficult airways. Anaesth Intensive Care. 1998;26:387–91.
20. Galgon RE, Schroeder KM, Schmidt CS, Matioc AA, Han S, Andrei AC, Joffe AM. Fiberoptic-guided tracheal tube placement through the air-Q® Intubating Laryngeal Airway: a performance study in a manikin. J Anesth. 2011;25:721–6.
21. Alexander R, Hodgson P, Lomax D, Bullen C. A comparison of the laryngeal mask airway and Guedel airway, bag and face mask for manual ventilation following formal training. Anaesthesia. 1993;48:231–4.
22. Komasawa N, Ueki R, Itani M, Nishi S, Kaminoh Y. Validation of the Pentax-AWS Airway Scope utility as an intubation device during cardiopulmonary resuscitation on the ground. J Anesth. 2010;24:582–6.
23. Jordan GM, Silsby J, Bayley G, Cook TM, Difficult Airway Society. Evaluation of four manikins as simulators for teaching airway management procedures specified in the Difficult Airway Society guidelines, and other advanced airway skills. Anaesthesia. 2007;62:708–12.
24. Gatward JJ, Thomas JC, Nolan JP, Cook TM. Effect of chest compressions on the time taken to insert airway devices in a manikin. Br J Anaesth. 2008;100:351–6.