

A comparison of three supraglottic airway devices used by healthcare professionals during paediatric resuscitation simulation

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ABSTRACT

Objective The aim of this study was to determine the best airway device among the laryngeal mask, I-gel and the laryngeal tube used by healthcare professional groups with different levels of experience with paediatric airway management.

Method Three groups of healthcare professionals were separately provided with brief supervised training in using the three devices. Afterwards the participants were asked to place the airway device. For every participant, the positioning of each device was recorded. The success rate and timing of insertion were measured. Furthermore, each insertion was scored for the ease of insertion, clinical and fiberoptic verification of the position and successful ventilation.

Results A total of 66 healthcare providers (22 paramedics, 22 nurse anaesthetists and 22 anaesthesia residents) participated in the study. The median time of insertion of both the laryngeal mask and the tube was significantly longer than for the I-gel for all professional groups ($p < 0.001$). The success rate with the I-gel was higher than that with the laryngeal mask or tube ($p < 0.001$). Except for the laryngeal mask, there were no differences among the professional groups regarding the fiberoptic evaluation.

Conclusions In terms of both the time required for successful placement and the rate of successful placement, the I-gel is superior to the laryngeal mask and tube in paediatric resuscitation simulations by healthcare professional groups with different levels of experience with paediatric airway management.

INTRODUCTION

Although tracheal intubation remains the most secure and effective way of establishing airway control and ventilation, the European Resuscitation Council Guidelines also endorse the use of supraglottic airway devices (SADs).¹ Along with the classic laryngeal mask (LMA) and other modified devices, various types of SADs have been described and investigated in several studies.² The I-gel mask is a relatively new supraglottic gel-filled anatomical mask with a gastric drain port and a non-inflatable cuff. It has been used in adult emergency patients by healthcare professionals with a wide range of experience in airway management.³⁻⁴ The laryngeal tube (LTS) airway is a completely different SAD, consisting of a dual tube with a distal and a proximal cuff. The LTS has been shown to be effective for adult airway management by healthcare professionals with different levels of experience.⁵⁻⁶

Although numerous studies have compared various types of SADs in adult emergency

simulations, there have been no investigations comparing the use of the LMA, LTS and I-gel devices during paediatric resuscitation training. Due to the promising results on the use of the LTS and I-gel devices in adult emergency simulations, the aim of the present study was to compare the success rates for intubation and the time required to establish effective ventilation using the LMA, LTS and I-gel airway devices in preschool-age children during a paediatric resuscitation simulation course for healthcare professionals. Proper device positioning was confirmed by a fiberoptic evaluation by a single unblinded observer. Furthermore, all participants underwent a structured interview about their performance and received a maximum score of 10.⁷

METHODS

The study was designed to determine the success rates of healthcare workers with different levels of experience in paediatric airway management when placing three different SADs.

Airway devices

The laryngeal tube (LTS) (VBM Medizintechnik, Sulz a. N., Germany) is a dual-lumen tube consisting of a smaller distal and a larger proximal high volume-low pressure cuff. The ventilation tube terminates between the proximal and the distal cuffs. The tip of the device with the drain port orifice is placed into the oesophagus, and the cuffs are simultaneously inflated.

The I-gel (Intersurgical, Sankt Augustin, Germany) is a relatively new device with a gastric drain port and a non-inflatable cuff made of a soft gel-like, medical-grade, thermoplastic elastomer. The airway seal that is provided by the gel-like cuff improves as the device warms to body temperature.

The LMA-unique (LMA, Bonn, Germany) is the original single-use laryngeal mask airway. It consists of an inflatable mask and a single tube.

All devices were inserted according to the manufacturer's instructions.

Participants

Approval by the local ethics committee was obtained. The participants were paramedics from the local emergency service, nurse anaesthetists and anaesthesia residents. The study involved separate training sessions for each professional group.

Protocol

Before starting the study, a group of five expert anaesthesiologists from the department of anaesthesiology of the University Hospital of Regensburg, all

experienced in paediatric airway management, evaluated all three airway devices to determine the most appropriate size of each to be used on our M-Mega Code Junior manikin (Ambu, Bad Nauheim, Germany). This manikin model corresponds to a child of five years of age. Each specialist ranked the right size according to his best and easiest performance. In a final discussion, we chose the following sizes for the different SADs:

LMA-unique, single use, size 2

I-gel, single use, size 1.5

LTS II, reusable, size 2.5

All participants received standardised instructions from the same individual on using the LMA-unique, I-gel and LTS II devices, including advice on insertion techniques for the manikin. The LMA direct and rotational technique with a partially inflated cuff was demonstrated.^{8 9} All participants were informed of the purpose of the study and the goals of the resuscitation simulations, including the timely and correct positioning of the SADs. They were informed that we would be measuring insertion times and the number of attempts to establish efficient ventilation with each device.

Standardised training in small groups of three participants each was performed for 10 min with each of the three SADs and included guidance and supervision by the observer. Additional equipment used included silicone lubricant and a standard bag-valve mask. After training, each participant was given one attempt with each device and inserted all three devices in random order blindly, without a laryngoscope.

Measurements

A single unblinded observer recorded the number of attempts required to successfully intubate the manikin and the time that was required from picking up the LMA-unique, I-gel or LTS II to achieving confirmation of correct device placement, based on inflation of the lungs (IT=inflation time). Successful ventilation was defined as a rise of 3 cm bilaterally in the chest, as this response corresponded to the manikin's tidal volume of 90–120 ml.

The number of insertion attempts was not limited unless the participant took longer than our cut-off time of more than 120 s to establish sufficient inflation of the chest. A failure of insertion was characterised by an insertion time exceeding 120 s or an incomplete insertion.

Once the devices were inserted, the anatomical position of the devices was fiberoptically assessed by the same single unblinded observer using the following scoring system: visualisation of the vocal cords (score 2), visualisation of the laryngeal structures only (score 1) or no visualisation of the laryngeal structures (score 0).¹⁰

Additionally, all participants were required to score the ease of device insertion (2=easy, 1=difficult, 0=not possible) and clinical position (2=SAD remaining in mid-position, 1=mask rising out). The participants were also asked to report whether the simulations were lifelike (2=lifelike, 1=not lifelike).

Table 1 Median inflation time of the three devices

	LTS	I-gel	LMA
Anaesthesia residents*	16.62 (9.25–81.81)	6.39 (4.53–10.62)	18.70 (8.31–82.52)
Nurse anaesthetists*	17.14 (8.47–88.40)	5.98 (3.63–9.97)	16.47 (10.19–80.80)
Paramedics***	14.55 (10.5–42.15)	5.83 (4.28–13.19)	45.18 (13.00–105.40)

Median (range); *p<0.001 I-gel versus LMA or LTS; ***p<0.001 LTS versus LMA.

Finally, the participants' scores, the fiberoptic score for placement and the ventilation score (2=good ventilation, 1=poor ventilation, 0=ventilation not possible) were added together, to yield a maximum possible score of 10. A score of <7 was considered to be a poor score.⁷

Data analysis

Continuous variables (time to insertion) were analysed using the Kruskal-Wallis rank sum test. A post hoc comparison was performed using the Dunn procedure. Categorical data are presented as numbers. The analysis of categorical data (success rate, scoring system) was performed with the χ^2 test. Values were considered significant when the type I error (p) was less than 0.05. Statistical analyses were performed separately for each professional group.

RESULTS

A total of 66 healthcare providers (22 paramedics, 22 nurse anaesthetists and 22 anaesthesia residents) participated in the study. Each participant performed one insertion with each SAD, in random order, on the manikin.

The median inflation times for both the LTS and the LMA were significantly longer than for the I-gel in all professional groups (p<0.001). In the group of paramedics, the median inflation time of the LTS was 14.55 s (10.50–42.15) compared with 45.18 s (13.00–105.40) for the LMA (p<0.001) (table 1). All participants inserted the I-gel successfully on the first attempt, eight participants in the group of the anaesthesia residents required more than one attempt with the LTS, and five required more than one attempt with the LMA. In the group of nurse anaesthetists, nine participants required more than one attempt with the LTS, and four required more than one attempt with the LMA. Two paramedics required more than one attempt to insert the LTS, and five could not successfully insert the LMA (table 2).

The fiberoptic evaluation of the inserted I-gel and LTS devices allowed for visualisation of the vocal cords or laryngeal structures in all professional groups. In the group of paramedics, it was not possible to identify the laryngeal structures following insertion of the LMA in four cases (p<0.05) (table 3).

In all but one instance, the anaesthesia residents' and nurse anaesthetists' SAD performance scores ranged between 7 to 10 points. Amongst the paramedics, five trials with the LMA

Table 2 Success rate of the three devices

Attempts	LTS			I-gel			LMA		
	1st	>1	Failure	1st	>1	Failure	1st	>1	Failure
Anaesthesia residents***	14 (64)	8 (36)		22 (100)			17 (77)	5 (23)	
Nurse anaesthetists*	13 (59)	9 (41)		22 (100)			18 (82)	4 (18)	
Paramedics****	20 (91)	2 (9)		22 (100)			10 (45)	7 (32)	5 (23)

Number (per cent); * p<0.05 I-gel versus LTS; **p<0.05 I-gel versus LMA; ***p<0.05 LTS versus LMA.

Table 3 Fiberoptic evaluation following insertion of the three devices

	LTS			I-gel			LMA		
	Vocal cords	Laryngeal structures	No laryngeal structures	Vocal cords	Laryngeal structures	No laryngeal structures	Vocal cords	Laryngeal structures	No laryngeal structures
Anaesthesia residents	19	3		22			16	6	
Nurse anaesthetists	21	1		21	1		20	2	
Paramedics*	18	4		21	1		15	3	4

Number; *p<0.05 LMA versus I-gel.

received a score of <7 points, which was considered a poor ventilation score (table 4).

DISCUSSION

The goal of this investigation was to compare the rates and timing of successful insertions of the three SAD devices (laryngeal tube, I-gel and laryngeal mask) by different healthcare professionals. However, it must be noted that the first-line method of attaining airway control in children is bag-mask ventilation because successful airway management in children requires a high level of skill and regular training.^{1 11 12} Nevertheless, SADs, such as the LMA, LTS and I-gel, are recognised as possible alternatives to achieve airway control in a paediatric emergency. While investigations involving adult emergencies have demonstrated a high success rate with the LTS and I-gel devices, data for paediatric emergencies are lacking.^{4 6}

In contrast to the clear impact that skill and experience have on the success rate of paediatric tracheal intubation, the importance of skill and experience to the successful use of SADs is still unclear.^{13 14} Although the definition of experience is vague, previous studies in adults have demonstrated that the ability to secure a patent airway with a SAD is independent of one's level of educational attainment.⁶

The main finding of the present study was that the success rate of I-gel insertion on the first attempt was 100% for all professional groups. Neither the LMA nor the LTS were as easy to use. Furthermore, sufficient ventilation was achieved faster with the I-gel (table 1). Interestingly, in an adult manikin study comparing the use of seven airway devices by paramedics, the success rates and insertion times with the LMA, LTS and I-gel were comparable.¹⁴

In contrast with the findings in the present study, Bortone *et al* demonstrated that the LTS is less effective than the LMA in achieving adequate ventilation in children. However, the clinical study by Bortone *et al* only observed paediatric SAD insertion performed by paediatric anaesthesiologists, and they found a 100% success rate with the LMA.¹⁵ The present study demonstrated that successful insertion with the LMA is dependent on the professional group. Cook *et al* reported that the most frequent reason for suboptimal ventilation with the LMA was an imperfect seal.¹⁶ Because successful insertion of the LMA varied by professional group in the present study, the

optimal insertion in our study of the LMA seems to be experience-dependent; however, there are two relevant studies by Rechner *et al* and Blevin *et al* that showed good success rates for the use of the LMA by inexperienced healthcare workers in children when the LMA and facemask ventilation were compared.^{11 12} Furthermore, the variability of the success rate in the use of the LMA in our groups could be explained by the different techniques for LMA insertion which were not limited in the present study.^{8 9}

While the LTS is recommended as an alternative airway device for use in adult emergencies, studies with paediatric patients could not confirm rapid and effective airway control with the LTS.^{4 15} In concordance with the study by Bortone *et al*, the present investigation demonstrated frequent inadequate positioning of the LTS, according to fiberoptic evaluation. Owing to differences in the structural anatomy of adults and children, the laryngeal tube with the two cuffs adjusts more easily to and fits better with the adult anatomy. A disadvantage of the laryngeal tube is its stiffness and the angle of the device, which can cause difficulties during insertion and does not adapt well to paediatric anatomy.

Previous studies with adult patients have demonstrated that the I-gel is easy to insert and provides an effective airway.^{4 17} In concordance with the findings of Beringer *et al*, the present study has shown that a clear laryngeal view is easily achieved with the I-gel, as verified by fiberoptic assessment¹⁸ (table 3). The non-inflatable cuff of the I-gel saves time and is easy for inexperienced providers to use. Because the material of this cuff is composed of a soft material, downfolding of the epiglottis is avoided.

In contrast to the findings regarding the use of the LMA, the healthcare provider's level of education or experience did not affect the frequency of successful insertion with either the LTS or the I-gel. Therefore, the I-gel seems to be the best device, overall, for use by relatively inexperienced providers during paediatric airway emergencies.

The present study has several limitations. First, simulation with manikins may not be directly applicable to or representative of clinical situations. Simulation does not account for the reality of several clinical factors, including emergency complications (bleeding, aspiration or laryngospasm) and variations in human anatomy (difficult airways). Nevertheless, previous studies have demonstrated that manikin-based simulations are as effective as training with live patients.¹⁹ Second, because the manikins that are used for paediatric simulation vary in their design, our findings could be specific to the manikin model used. However, five experienced anaesthesiologists chose the manikin that was used in our study precisely because it was deemed to have the most realistic airway available. Nonetheless, the present findings need to be confirmed through clinical evaluation in real patients.

In conclusion, this study demonstrated a higher success rate and shorter insertion time with the I-gel device compared to

Table 4 Score for insertion and ventilation success (7)

	LTS		I-gel		LMA	
	0–6	7–10	0–6	7–10	0–6	7–10
Anaesthesia residents	0	22	0	22	1	21
Nurse anaesthetists	0	22	0	22	0	22
Paramedics**	0	22	0	22	5	17

Number; *p<0.05 I-gel versus LMA, **p<0.05 LTS versus LMA.

the LMA or LTS devices in a paediatric resuscitation simulation by healthcare professional groups with different levels of experience.

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