J Anesth (2012) 26:357–361
DOI 10.1007/s00540-011-1322-1

ORIGINAL ARTICLE

Initial experience of the i-gel supraglottic airway by the residents in pediatric patients

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Received: 9 July 2011 / Accepted: 26 December 2011 / Published online: 7 February 2012

Abstract
Purpose Insertion of a laryngeal mask airway (LMA) is occasionally difficult in children because of their anatomical features and variations. A new single-use supraglottic airway device, the i-gel airway, was recently introduced. The objective of this study was to show the initial experience of the i-gel airway device by the residents for pediatric patients.
Methods With approval from the local ethics committee and parental informed consent, 70 children undergoing minor surgery in the supine position, ASA score I–II, were investigated. Exclusion included patients having thoracic, neurosurgical, spine, and otolaryngological procedures. Patients were divided into three groups: group 1 was airway size 1.5 for patients weighing 5–12 kg, group 2 was size 2 for 10–25 kg, and group 3 was size 2.5 for those weighing 25–35 kg. The following seven characteristics were evaluated: (1) ease of the i-gel and gastric tube insertion; (2) leak pressure; (3) tidal volume/body weight at leak pressure point; (4) fiberscope score; (5) insertion time; (6) hypoxia rate (laryngospasm); and (7) coughing and trace of bleeding.
Results The overall insertion success rate and the success rate at first attempt were 99% and 94%, respectively. Gastric tube insertions were easy in all patients. The overall leak pressure was 23 ± 5 cmH_2O. The tidal volume per body weight was 24 ± 10 ml/kg. A good view of the fiberscope was achieved in 79%. In group 1 (size 1.5), one failed insertion, two dislocations, and one dysphonia were observed. Hypoxia rate was 1%. There was no case with coughing and trace of bleeding.
Conclusion These results show that the i-gel airway is a safe and effective device for use by residents who do not have experience with insertion of a pediatric LMA. However, using size 1.5, special caution should be taken to protect the infant airway, similar to what has been previously reported for other airway devices.

Keywords i-gel · Airway device · Laryngeal mask · Pediatric general anesthesia

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Introduction

Since the early 1990s, pediatric anesthetic practice has been significantly advanced by using the laryngeal mask airway (LMA). Several smart devices have been developed. However, sometimes we are still faced with difficulties associated with device insertion in pediatric patients. Important considerations of using an LMA in pediatric patients are a high larynx in the neck (C2–C3), larynx angled more over glottis, cone-shaped larynx, long epiglottis, and hypertrophy of the adenoid. The Pro-Seal LMA (PLMA) was a ground-breaking invention that enabled drainage of the gastric contents. However, in some cases, use of PLMA required the device rotation method, gum elastic bougie (GEB)-guided insertion technique, and digital technique [1–3]. Other issues associated with PLMA were difficult stomach tube insertion and obtaining appropriate sealing pressure [4, 5].

A new single-use supraglottic airway device, the i-gel airway, was introduced to the Asian market recently. The

i-gel is an airway with a noninflatable cuff that is made from a soft gel-like material (Fig. 1). The objective of this study was to show initial experience of the i-gel airway use by residents for pediatric patients and to assess the bronchoscopic view of the glottis to determine the appropriate positioning.

Methods

With approval from the local ethical committee and parental oral and written informed consent, patients of ASA score I–II were included in this prospective observational study (Table 1). Inclusion criteria were selection by the attending anesthesiologist of general anesthesia through the i-gel in the supine position. Exclusion included patients having thoracic, neurosurgical, spine,and otolaryngological procedures. We excluded the patients who underwent operation in the prone or lateral position. A patient with previous history of upper respiratory infection (URI) within 2 weeks was excluded. All patients underwent preoperative fasting. The operation time was estimated to be less than 3 h.

The size of the i-gel airway was selected according to patient's body weight following the manufacturer's recommendations. Group 1: size 1.5 was used in patients weighing between 5 and 12 kg; group 2: size 2 was used in patients weighing between 10 and 25 kg; and group 3: size 2.5 was used in patients weighing between 25 and 35 kg.

Standard monitoring such as noninvasive blood pressure monitoring, electrocardiography, pulse oximetry, capnography (Compact airway modules E-CAiOV; GE Healthcare, NJ, USA), and bispectral index was applied. All patients did not receive premedication in the ward. Patients who had an intravenous (IV) line in place before surgery received midazolam (0.2 mg/kg) in the preparation unit with their parents. Otherwise, the patients were taken to the operation room with their parents and received inhalation anesthesia through the mask. General anesthesia was induced by inhalation of 8% sevoflurane in 66% nitrous oxide with oxygen and an injection of 2 μg/kg fentanyl. Anesthesia induction was not standardized but left to the discretion of the experienced pediatric anesthesiologists, using either propofol or sevoflurane induction. After entering the operation room and monitoring, the level of anesthesia was deepened by an injection of fentanyl (2 μg/kg) followed by

Fig. 1 The i-gel is supplied in a protective cradle (*left picture*). The whole shape of the i-gel (*middle picture*). The right hole is the gastric cannel (*right picture*)

Table 1 Patient characteristics

	Size 1.5 ($n = 13$)	Size 2.0 ($n = 43$)	Size 2.5 ($n = 14$)
Sex (M/F)	9/4	29/14	3/11
Age (months)	13 ± 5	55 ± 23	120 ± 31
Weight (kg)	9 ± 1	16 ± 3	28 ± 3
Height (cm)	73 ± 7	102 ± 11	134 ± 7
Induction inhalation/propofol, number (%)	2/11 (15/85)	17/26 (40/60)	3/11 (21/79)
Anesthesia time (min)	123 ± 36	111 ± 36	88 ± 23
Operation time (min)	68 ± 33	58 ± 28	37 ± 17

Data are expressed as mean ± standard deviation (SD) or number (%)

propofol (2–3 mg/kg). The i-gel airway was inserted when sufficient depth of anesthesia was determined by absence of eyelash reflex, mandibular relaxation, and absence of limb movement. The i-gel airway was inserted by residents under constant supervision of two experienced pediatric anesthesiologists. Ease of insertion of the i-gel device and nasogastric tubes was evaluated on the same scale by the residents (1 = easy, 2 = moderate, 3 = difficult). After three failures of i-gel insertion, endotracheal intubation was used. General anesthesia was maintained with 2–3% sevoflurane with 35% oxygen with air. No neuromuscular blocking drugs were used. All patients were ventilated with pressure-controlled ventilation, and respiration was monitored by airway pressure and expiratory tidal volume measurement with an Aisys care station (GE Healthcare, Madison, WI, USA). Normocapnia (end-tidal CO_2, 35–45 mmHg) was maintained by adjustment of respiratory rate. Once the proper position was judged by adequate chest movement, square wave of the capnograph trace, and inaudibility of stridor, leak pressure was measured. Fresh gas flow was set at 3 ml/min, and the pressure adjustment valve was set to 70 cmH_2O. Leak pressure was recorded when residents detected leakage by a stethoscope at the patient's neck. When the leak pressure reached 30 cmH_2O, the expiration valve was opened. A fiberscope (diameter, 3.1 mm: Olympus LP-TP; 2.8 mm: Karl-Storz, Tuttlingen, Germany) was passed to a position just 1 cm inside the soft non-inflatable cuff. The fiberscope score was recorded in a natural position and the score following the Inagawa grading: grade 1, the aperture view was covered with anterior epiglottis completely, but the airway stayed open; grade 2, anterior epiglottis seen for more than two-thirds of the aperture view in the diameter; grade 3, anterior epiglottis seen for more than one-third, but less than two-thirds, of the aperture view in diameter; and grade 4, anterior epiglottis seen for less than one-third of the aperture view in diameter [6]. When the operation had been completed, we stopped the inhalation anesthesia. After patients began spontaneous breathing, we checked the tidal volume. If there was adequate tidal volume (more than 6 ml/kg), we removed the i-gel airway.

The following seven characteristics were evaluated: (1) ease of the i-gel and gastric tube insertion; (2) leak pressure; (3) tidal volume divided by body weight at leak pressure point; (4) fiberscope score; (5) insertion time; (6) hypoxia rate; and (7) incidence of severe coughing, dysphonia, and trace of bleeding on the i-gel after removal.

Results

Patient characteristics are shown in Table 1. The average anesthesia was 108 ± 35 min, and average operating time was 55 ± 29 min. Anesthetic inductions were performed under propofol anesthesia (70%) and sevoflurane anesthesia (30%). There was no difference between groups of intravenous induction ($n = 49$) and inhalation ($n = 21$) regarding peak leak pressure. The overall insertion success rate was 99%. A 9-month-old patient (body weight, 9.9 kg) received i-gel. We could not ventilate through the i-gel, but we were able to ventilate through the mask. After three failures of i-gel insertion, an endotracheal tube was used. Insertion was scored 'easy' in 54 cases (78%), 'moderate' in 14 cases (20%), and 'difficult' in one case (2%). The first attempt insertion success rate was 94%. Insertion of gastric tube was achieved in all cases (Table 2). The overall leak pressure was 23 ± 5 cmH_2O (size 1.5 vs. 2.0 vs. 2.5: 21 ± 4, 24 ± 5, 20 ± 3). The overall tidal volume divided by body weight at the leak pressure was 24 ± 10 ml/kg (size 1.5 vs. 2.0 vs. 2.5: 17 ± 6, 27 ± 10, 22 ± 10). Vocal cord visibility was 67% for size 1.5, 75% for size 2.0, and 100% for size 2.5 (Table 3). Even if only the epiglottis was visible, it was not associated with a reduction of tidal volume. The time from holding the device to pop-up of CO_2 exhalation was 24 ± 9 s (size 1.5 vs. 2.0 vs. 2.5: 23 ± 8 vs. 24 ± 10 vs. 23 ± 9 s). Only one patient had a brief episode of hypoxia (1.4%). One patient, a 9-month-old boy (body weight, 9.4 kg) received a size 1.5 i-gel. Leak pressure was 25 cmH_2O and tidal volume was 99 ml. Just before the operation started, airway obstruction was observed. The i-gel was immediately extubated, and the patient was ventilated via face mask and a tracheal tube was safely intubated. The other patient, a 10-month-old boy (body weight, 8.4 kg), received a size 1.5 i-gel. Leak pressure was 16 cmH_2O and tidal volume was 80 ml. After patient position was changed from supine to lateral, we could not ventilate through the i-gel. We diagnosed the dislocation and gave 100% oxygen. The patient was changed to the supine position. We were able to ventilate via the i-gel in the supine position. However, we decided to intubate the tracheal tube. A dysphonia was observed in one patient in group 1. After we removed the i-gel airway, this patient could respire well but her voice was changed. We asked her mother about her voice at the recovery room; we observed the patient in the recovery room, and her voice recovered within 10 min with no treatment. There was no blood on the device upon removal in any patient and no case of fleeting coughs (Table 3).

Discussion

This is the first report describing the initial experience of using small-size i-gel airways (size 1.5–2.5) by residents. We have shown that the overall insertion success rate was as high as 99%. Pediatric LMA using the i-gel airway was

Table 2 Insertion of the i-gel device and parameter of the airway

	Size 1.5 ($n = 13$)	Size 2.0 ($n = 43$)	Size2.5 ($n = 14$)
Success at first attempt	12 (92)	41 (95)	13 (93)
Overall success	12 (92)	43 (100)	14 (100)
Successful supraglottic airway	Size 1.5 ($n = 12$)	Size 2.0 ($n = 43$)	Size 2.5 ($n = 14$)
Ease of inserting the i-gel			
Very easy	12 (100)	33 (77)	9 (64)
Easy	0	9 (21)	5 (36)
Difficult	0	1 (2)	0
Parameters of the airway			
Leak pressure (cmH_2O)	21 ± 4	24 ± 5	20 ± 3
Insertion time (s)	23 ± 8	24 ± 10	23 ± 9
Tidal volume/BW (ml/kg)	17 ± 6	27 ± 10	22 ± 10
Fiberscope score			
4: epiglottis covered less than 1/3	5 (42)	19 (46)	13 (93)
3: epiglottis covered more than 1/3, but less than 2/3	3 (25)	12 (29)	1 (7)
2: epiglottis covered more than 2/3	3 (25)	8 (20)	0 (0)
1: epiglottis covered completely, but the airway stays open	1 (8)	2 (5)	0 (0)
Missing data	0	2	0
Insertion of gastric tube	12 (100)	43 (100)	14 (100)

Data are expressed as mean ± standard deviation (SD) or number (%)

Table 3 Complication rate

Complications	Size 1.5 ($n = 13$)	Size 2.0 ($n = 43$)	Size 2.5 ($n = 14$)
Overall	4 (31)	0	0
Displacement	2 (15)	0	0
Hypoxia	1 (8)	0	0
Changed voice	1 (8)	0	0

Data are expressed as number (%)

relatively easy for inexperienced residents under supervision. Furthermore, insertion of the gastric tube was easily achieved in all cases.

This article also describes for the first time the assessment of the bronchoscopic view of glottis through the i-gel airway in pediatric patients to determine the appropriate positioning. The positions of the i-gel airway were examined by a fiberscope after insertion in all except two patients. Our results show that it was difficult to visualize the vocal cord because of epiglottis downfolding when a small-size airway (size 1.5) was used (epiglottis covered completely, 8%; epiglottis covered more than 2/3, 25%). Clinically, all patients had unobstructed airways. Von Ungern-Sternberg [7] showed that complete downfolding of the epiglottis over the laryngeal inlet occurred in 11% and partial downfolding in 32% of patients using a size 1.5 LMA. It appears that the use of the size 1.5 i-gel airway should be handled especially carefully because this size covers a wide body weight range, from 5 to 12 kg, which coincides with 6-month-old to 2-year-old children. Kelly showed a first attempt success rate of 100%, median leak pressure of 23 cmH_2O, an airway obstruction rate of 10%, and a laryngospasm rate of 5% with PLMA size 1.5 [8]. In our results, first attempt success rate was 92% (12/13), median leak pressure was 21 cmH_2O, airway displacement rate was 15% (2/13), short period episodes of change in voice was 8% (1/12), and laryngospasm was observed in 8% (1/12). It appears that the incidence of laryngospasm with the i-gel airway is relatively high. However, it is known that laryngospasm is significantly more common in young patients, one reason being that it is more common for children to have a URI before the operation rather than adults. Bagshaw [9] showed that complications with a size 1.5 LMA were as high as 42%.

The results of size 2.0 and 2.5 i-gel airways are comparable to other studies using PLMA size 2.0 and 2.5 regarding first insertion success rate, peak leak pressure, and tidal volume divided by body weight [4, 5, 10, 11]. Beylacq et al. [12] first reported the use of size 3 i-gel airways in pediatric patients. Only six minor complications in 50 patients were reported; however, the fiberscope score was not reported.

The small-size PLMA has a high first attempt success rate (90–96%) compared to the small-size CLMA or adult PLMA (84%) [8, 13]. However, use of the PLMA requires device rotation, GEB-guided insertion technique, or digital

technique [1–3]. The i-gel device insertion was easily performed without requiring any special technique, even by residents under supervision. Although in some studies using PLMA no gastric tube was inserted, this study shows that gastric tube insertion was performed easily in conjunction with the i-gel airway in pediatric patients. Recently, Theiler et al. [14] demonstrated that performance of the pediatric-sized i-gel and Ambu AuraOnce were suitable for ventilation of anesthetized children with a high rate of success. They concluded that the advantage for the i-gel might be easy gastric access. Using 3 devices of size 1.5, 38 of size 2.0, and 34 of size 2.5, their overall success rate was 93%, leak pressure was 22 ± 5, laryngospasm was 4%, and blood on device was 1%. Our overall success rate was 99%, leak pressure was 23 ± 5, laryngospasm was 1%, and there was no occurrence of blood on a device. Those results were similar to our results.

One limitation of this study is the small number of patients in each group. Furthermore, a comparison with other supraglottic devices was not carried out. Nonetheless, our results provide preliminary insights of safety and efficacy in pediatric patients.

In summary, this study showed that the i-gel airway has advantages in terms of easy insertion, capability of adequate ventilation, and easy gastric tube insertion by residents in pediatric patients. However, when using a size 1.5, special caution is required, as has also been reported for other airway devices.

Acknowledgments We are grateful to Nihon Kohden (Japan) for providing free samples of devices. This study was supported in part by the internal university clinical research budget.

Conflict of interest The i-gel devices used in this study were provided by the manufacturer. None of the authors or their institutions has received any other financial or material support from the manufacturer.

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