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ORIGINAL RESEARCH

# Cricoid-mental distance-based versus weight-based criteria for size selection of classic laryngeal mask airway in adults: a randomized controlled study

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**Abstract**
The optimal size selection of laryngeal mask airway (LMA) based on body weight is not always applicable. This study was prospectively conducted to evaluate the efficacy of cricoid-mental distance-based method versus weight-based method in optimal size selection of LMA in adults. Seventy-four patients (aged from 18 to 65) undergoing ophthalmic surgery were randomly assigned into cricoid-mental (CM) distance-based group or weight-based group to select appropriate size of LMA. The primary outcome was oropharyngeal leak pressure (OLP). Secondary outcomes included overall insertion success rate, number of insertion attempts, time to successful insertion, ease of insertion, score of fiber-optic view, peak inspiratory pressure during mechanical ventilation and postoperative pharyngolaryngeal morbidity. The OLP was significantly higher in CM distance-based group than that in weight-based group ($19.38 \pm 3.52$ vs. $17.50 \pm 3.18$, $P = 0.022$). The successful placement at the first attempt in CM distance-based group was dramatically increased as compared with weight-based group (89.2% vs. 62.2%, $P = 0.005$). The overall success rate of LMA insertion in CM distance-based group was slightly increased in comparison with the weight-based group (100% vs. 91.9%, $P = 0.240$). There were no significant differences in score of fiber-optic view and postoperative pharyngolaryngeal morbidity between both groups (all $P > 0.05$). CM distance-based criteria is an alternative choice for optimizing size selection of classic LMA in adults.

**Keywords** Laryngeal mask airway · Size · Adults · Cricoid cartilage · Mentum

## 1 Introduction

Supraglottic airway devices (SADs), especially the laryngeal mask airway (LMA), have been extensively adopted as an alternative technique to tracheal intubation or mask ventilation for airway management in short length surgery [1]. More than 50% of patients under general anesthesia in the UK are ventilated with SADs [2]. Meanwhile, administration with LMA provides more stable intraocular pressure (IOP) than tracheal intubation in patients undergoing ophthalmic surgery [3].

Selection of the appropriate size of LMA is very important for the safe and effective use of the LMA, although the manufacturers have recommended the weight-based criteria for sizing LMA [4]. In clinical practice, however, the weight-based criterion is not always applicable, especially for patients in asthenic or stout shape as there is no linear correlation between the upper airway anatomy and body weight due to the individual anatomical variation, as previous studies have demonstrated that the first attempt success rate of LMA insertion based on weight was as low as 77% to 82% [5, 6].

Many studies have been conducted to look for the appropriate size of the LMA in the adult population, previous study suggested that the optimal size of LMA selected by the regression model was better than by manufacturers'

Yanling Zhu and Weihua Shen contributed equally to this study.

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recommendations [7]. Several lines of evidences have proved that the distance between the mentum and the lower border of cricoid cartilage(cricoid-mental, CM)is highly correlated with the length of pharyngeal cavity, which may have a potential role for size selection of LMA [8, 9].

In this observational study, we evaluated CM distance-based method of sizing classic LMA for adults. The primary aim of our study was to determine whether the neck measurement of CM distance is related to more reliable ventilation efficacy. The secondary aim was to achieve a high first success rate of insertion with less morbidity of complications following the CM distance-based technique. To validate this procedure, the size of the classic LMA as determined according to the CM distance-based method was compared with the manufacturer's weight-based criteria.

## 2 Methods

### 2.1 Ethics statement

This study was conducted with ethics approval from Institutional Review Board of Zhongshan Ophthalmic Center (No. 2017KYPJ080) and was registered at Chinese Clinical Trial Registry: www.chictr.org.cn (No. ChiCTR-INR-17012689).

### 2.2 Study population

This prospective, randomized, single-center study was performed between January to April, 2018. After obtaining written informed consent, 74 adult patients (aged from 18 to 65 years old) with ASA physical status I to II undergoing elective ophthalmic surgery by general anesthesia with classic LMA were recruited. Exclusion criteria included body mass index (BMI) $\geq 30$ kg/m$^2$, a predicted difficult airway (a history of difficult airway, mouth opening $< 2$ cm, Mallampati class 4, limited neck extension or cervical spine disease), a high risk of aspiration, recent history of upper respiratory tract infection, presence of gastro-esophageal reflux.

### 2.3 Randomization

The enrolled individuals were randomly allocated into two groups: weight-based group and CM distance-based group. The CM distance was defined as the distance between the mentum (lower midline border of mandible in jaw occlusion) and the lower border of cricoid cartilage (Fig. 1). In weight-based group, the size was chosen according to the manufacturer's instructions as follows: size 3 for weight $< 50$ kg, size 4 for weight 50 to 70 kg, and size 5 for weight $\geq 70$ kg. In CM distance based group, the optimal size was selected following our pilot study: size 3 for CM distance $< 8.92$ cm, size 4 for CM distance between 8.92 to 11.25 cm, and size 5 for CM distance $\geq 11.25$ cm. The randomization was performed via a random number generator program by Statistical Analysis System (SAS Institute Inc., US). All preoperative assessments and group allocation were carried out by a trained nurse who did not involve in anesthesia management and data analysis.

### 2.4 Management of anesthesia

All the patients were evaluated the day before the surgery. Patients fasted for at least 8 h for solids and 4 h for water-deprivation and received no medications before anesthesia induction. Patients were in supine position with the head resting on a ring-shaped pillow in operation room, and then being continuously monitored by electrocardiography, noninvasive blood pressure, pulse oximetry, and capnography. Before induction of anesthesia, the CM distance was measured with an electronic vernier caliper in head extension position [10] (Fig. 1) (Range 0–200 mm, Error value: $\pm 0.02$ mm, Resolution: 0.01 mm; 150 T, Meinaite, Shanghai, China).

Patients were anesthetized with 2.5 mg/kg propofol and 2 μg/kg fentanyl as well as 0.2 mg/kg cisatracurium. After loss of consciousness, patient was manually ventilated through a face mask with high flow (5–6 L/min) oxygen. Once the conditions were sufficiently satisfied for

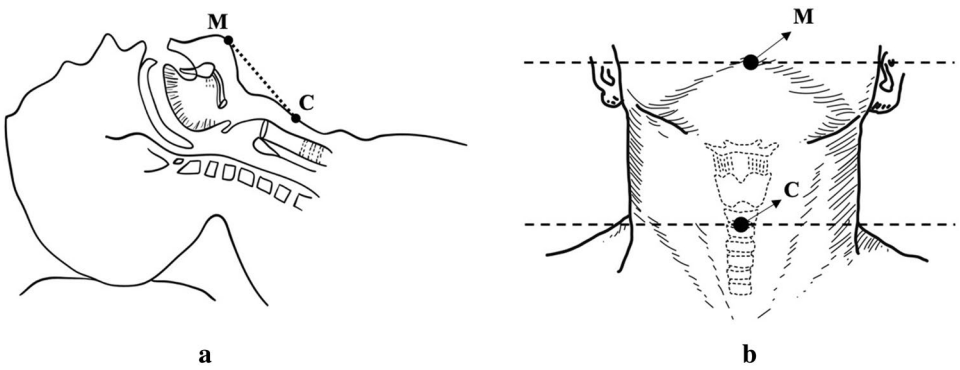


**Fig. 1** The cricoid-mental distance (CM distance) is defined as the linear distance between the lower midline border of mandible in jaw occlusion (point M) and the lower border of cricoid cartilage (point C). **a** The measurement is conducted with head extension position, which requires the patients fully extend their head and neck. **b** Head in full face view

insertion (loss of eyelash reflex, jaw relaxation or absence of movement), an assigned, partially inflated classic LMA (TUORen, Xinxiang, China) was inserted by Dr. Hongbin Chen who was qualified and had performed LMA insertions more than 1000 times. The insertion was conducted by single-handed rotational technique. The cuff of airway was inflated with air to obtain an intra-cuff pressure of 60 $cmH_2O$ by using a handle aneroid manometer (54-04-000, VBM Medizintechnik, Sulk, Germany). The head was returned to neutral position. Effective airway establishment was confirmed by thoracic movement and continuous square end-tidal capnograph traces during manual ventilation. If ventilation was inadequate (high peak inspiratory pressure, serious air leakage or an improper capnograph trace), operator was allowed to perform the following adjustments: adjusting head/neck position, modifying the depth of airway tube, applying jaw-thrust or repositioning the airway cuff. A maximum of three attempts was permitted before insertion was considered a failure, then the airway was secured with other type of SADs or endotracheal intubation, and the patient was excluded from the study analysis.

After successful insertion, the airway device was taped on cheeks. Volume-controlled mode (Fabius Plus XL, Drager, Germany) was applied with a tidal volume of 8 ml/kg and an inspiratory/expiratory ratio of 1:2. Respiratory rate was adjusted to maintain the end-tidal carbon dioxide ($EtCO_2$) in the range of 35 to 40 mmHg. Peak inspiratory pressure was recorded. Time to successful insertion defined as the interval began with picking up the airway device and ended when a successful airway was established was recorded. Ease of insertion was graded from 1 to 4 (1 for no resistance, 2 for mild resistance, 3 for moderate resistance, 4 for unable to placement) and scored by the operator who performed the insertion [6]. Oropharyngeal leak pressure (OLP) was measured as follow: setting the expiratory valve to 30 $cmH_2O$ at a fixed gas flow rate of 3 L/min, recording the maximum inflation pressure when a noise of gas leakage was heard in the oropharynx via a stethoscope [11]. A video flexible laryngoscope (TIC-SD-II, UE Medical Corp., Taizhou, China) was used to score the anatomical position by passing through a self-sealing catheter mount to a point 1 cm proximal to the mask aperture bars as follows: 4—only vocal cords visible; 3—vocal cords and posterior part of epiglottis visible; 2—vocal cords and anterior epiglottis visible; 1—vocal cords invisible [12]. Anesthesia was maintained with total intravenous anesthesia (propofol and remifentanil).

At the end of the surgery, the airway device was removed in confirmation of adequate recovery of spontaneous respiration and consciousness (being able to respond to verbal commands). The patients were then transferred to the post-anesthesia care unit (PACU) for further monitoring. Postoperative pharyngolaryngeal complications including blood staining on the device, dry throat, sore throat, dysphagia, hoarse were recorded by a blinded research nurse in PACU.

### 2.5 Statistical analysis

The primary outcome was oropharyngeal leak pressure (OLP). A previous study showed mean ± SD of OLP in classic laryngeal mask airway selected in body weight was 17.9 ± 3.85 $cmH_2O$ [13]. We considered giving an estimated difference of 2 $cmH_2O$ between two groups in our study [6]. Assuming a type I error of 0.05 and a power of 0.8, a sample size of 33 patients per group was required. Finally, a total of 74 patients were designed to include in our study with allowing a dropout rate of approximately 10%.

The distribution of the data was determined using the Kolmogorov–Smirnov analysis. Statistical differences between two groups were analyzed by Student's *t* test for continuous variables, Chi square test for categorical variables and Mann–Whitney *U* test for variables on ordinal scale. $P < 0.05$ was considered statistically significant. Data analysis was performed using Statistical Package for the Social Sciences version 22.0 (SPSS Inc., Chicago, IL).

## 3 Results

After screening, 74 patients consented to our study were randomly allocated into two groups and 71 of patients finally completed the study protocol (Fig. 2). There were no significant differences in demographics characteristics and duration of anesthesia in two groups (all $P > 0.05$, Table 1).

The OLP in CM distance-based group was significantly higher in comparison with the weight-based group (19.38 ± 3.52 vs. 17.50 ± 3.18, $P = 0.022$). As shown in Table 2, the overall insertion success rate in CM distance-based group was slightly higher than that in the weight-based group without statistical significance (100% vs. 91.9%, $P = 0.240$). The successful placement at the first attempt in CM distance-based group was significantly increased than that in weight-based group ($n = 33$ vs. $n = 23$, $P = 0.005$). Further, there were three failures using initial size of LMA in weight-based group whereas none of patients were unable to be ventilated in CM distance-based group. Time to successful insertion and ease of insertion were comparable between both groups ($P = 0.205$ and $P = 0.280$, respectively). The scores of fiber-optic view in CM distance-based group were not significant compared with the weight-based group ($P = 0.899$).

Peak inspiratory pressure during mechanical ventilation was similar between both groups ($P = 0.344$, Table 3).

Postoperative pharyngolaryngeal morbidity was described in Table 4. Only one patient in each group was seen blood staining on airway device ($P = 0.952$). The incidences of dry

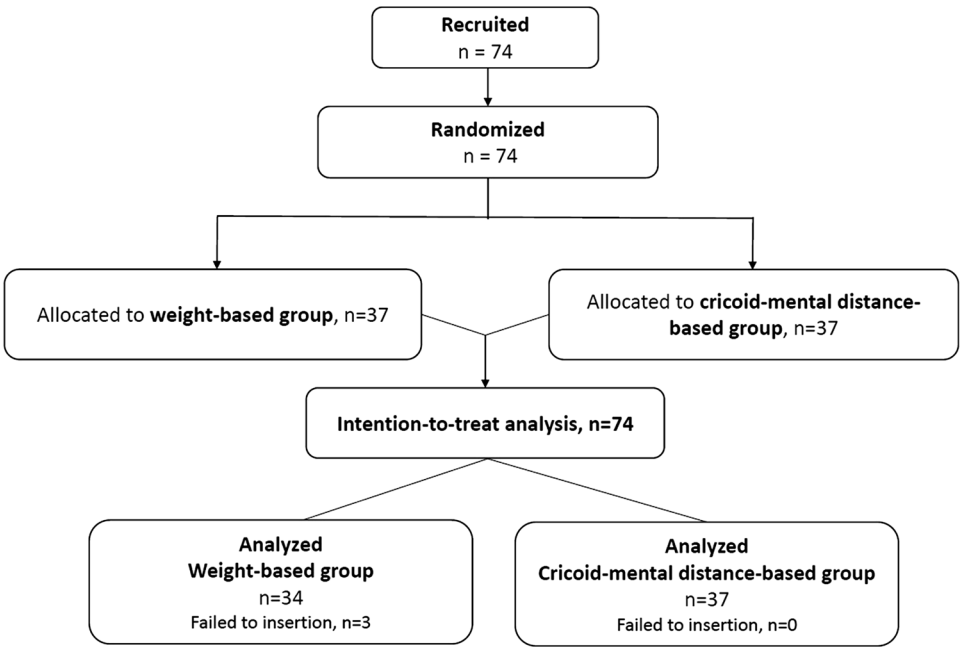


**Fig. 2** Seventy-four patients consented to our study were recruited and randomly enrolled into two groups: weight-based group (n = 37) and cricoid-mental distance-based group (n = 37). Intention-to-treat analysis was used in comparison with the demographics characteristics in two groups. Three of patients in weight-based group were failed to insert the classic laryngeal mask airway and were excluded from the study. Finally, 34 patients in weight-based group and 37 patients in cricoid-mental distance-based group completed the study protocol and were analyzed

**Table 1** Demographic characteristics of patients in two groups

| Parameters | Cricoid-mental distance-based group | Weight-based group | *P* value |
|---|---|---|---|
| Number | 37 | 37 | N/A |
| Age (year) | 34.1 ± 13.3 | 33.5 ± 11.4 | 0.845 |
| Gender (male/female) | 21/16 | 21/16 | N/A |
| Height (cm) | 166.7 ± 8.0 | 165.2 ± 7.7 | 0.400 |
| Weight (kg) | 63.6 ± 10.8 | 61.9 ± 10.0 | 0.478 |
| BMI ($kg/m^{2)}$ | 22.8 ± 2.8 | 22.6 ± 2.6 | 0.748 |
| ASA PS (I/II) | 30/7 | 27/10 | 0.410 |
| Cricoid-mental distance (cm) | 10.87 ± 1.06 | 10.67 ± 0.90 | 0.358 |
| Mallampati class (1/2/3) | 18/19/0 | 20/17/0 | 0.644 |
| Duration of anesthesia (min) | 55.4 ± 18.7 | 59.4 ± 20.3 | 0.384 |

Data are shown as mean ± standard deviation or numbers

*N/A* not access

or sore throat were similar between the groups (37.8% vs. 52.9, P = 0.201; 13.5% vs. 17.6, P = 0.631, respectively). None of patients displayed dysphagia and hoarse in both groups.

## 4 Discussion

In the present study, we found that optimal size selection for classic laryngeal mask airway based on CM distance provided higher OLP as well as first success rate of insertion as compared with the weight-based group. Further, there were no significant differences in the postoperative pharyngolaryngeal morbidity between the groups. The findings from the present study suggested that CM distance-based method should be an alternative criterion for optimal size selection of classic laryngeal mask airway in adults.

The classic LMA, made up with an inflatable cuff and an airway tube (Fig. 3), is designed to seal the hypopharyngeal cavity and the distal portion of the cuff is connected to the esophagus opening (upper esophageal sphincter muscle) [14]. As demonstrated by Mark et al., cricoid cartilage can be used to reflect the position of the hypopharynx, meanwhile, Ilona et al. proposed that cricoid cartilage is reliable

**Table 2** Insertion characteristics in two groups

| Parameters | Cricoid-mental distance-based group N = 37 | Weight-based group N = 34 | *P* value |
|---|---|---|---|
| Supraglottic airway size (3/4/5) | 1/24/12 | 3/23/8 | 0.264 |
| Overall insertion success rate, n (%) | 37 (100%) | 34 (91.9%) | 0.240 |
| Performance of insertion | | | |
| Number of insertion attempts (1/2/3/Failed) | 33/4/0/0 | 23/10/1/3 | 0.005† |
| Time to successful insertion (second) | 54 [49–68 (39–119)] | 58 [52–79 (41–154)] | 0.205 |
| Ease of insertion (1/2/3/4) | 30/7/0/0 | 24/9/1/0 | 0.280 |
| Score of fiber-optic view (1/2/3/4) | 1/15/12/9 | 4/11/7/12 | 0.899 |

Data are shown as median [IQR (range)] or numbers

Ease of insertion was graded from 1 to 4: 1 = no resistance, 2 = mild resistance, 3 = moderate resistance, 4 = unable to placement; Fiber-optic view was scored as: 4 = only vocal cords visible, 3 = vocal cords and posterior part of epiglottis visible, 2 = vocal cords and anterior epiglottis visible, 1 = vocal cords invisible

†P < 0.05

**Table 3** Sealing and ventilation characteristics of both groups in patients with successful supraglottic airways insertion

| Parameters | Cricoid-mental distance-based group N = 37 | Weight-based group N = 34 | *P* value |
|---|---|---|---|
| OLP ($cmH_2O$) | 19.38 ± 3.52 | 17.50 ± 3.18 | 0.022† |
| Peak inspiratory pressure ($cmH_2O$) | 13 [11–14 (9–19)] | 13 [12–15 (9–19)] | 0.344 |

Data are shown as mean ± standard deviation or median [IQR (range)]

*OLP* oropharyngeal leak pressure

†P < 0.05

**Table 4** Postoperative pharyngolaryngeal morbidity of the groups

| Airway morbidity | Cricoid-mental distance-based Group N = 37 | Weight-based group N = 34 | *P* value |
|---|---|---|---|
| Blood staining on supraglottic Airway device | 1 (2.7) | 1 (2.9) | 0.952 |
| Dry throat | 14 (37.8) | 18 (52.9) | 0.201 |
| Sore throat | 5 (13.5) | 6 (17.6) | 0.631 |
| Dysphagia | 0 (0) | 0 (0) | N/A |
| Hoarse | 0 (0) | 0 (0) | N/A |

Data are shown as numbers (%)

*N/A* not access

to reflect the position of esophageal opening as the esophageal opening lies beneath the inferior margin of cricoid cartilage [8, 9]. Generally, the length of pharynx cavity (from the incisors to the opening of esophagus) remains stable throughout the period of adulthood. Hence, we used the

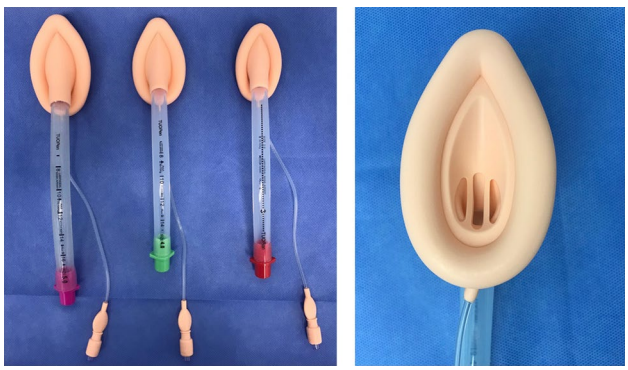

**Fig. 3** Classic laryngeal mask airway is made up with an inflatable cuff and an airway tube, and there is a bar in the middle of the conduit to prevent the epiglottis obstructing the airway tube

incisors and the lower border of cricoid cartilage to assess and select the optimal size of the LMA. The incisors were replaced by the mentum with head extension position in order to make the measurement easily. Consequently, distance between the mentum (lower midline border of mandible in jaw occlusion) and the lower border of cricoid cartilage, known as CM distance, was applied as the criteria for classic LMA size selection in our study.

Indeed, an improved sealing function was confirmed by higher OLP in use of CM distance-based method for size selection as compared with the weight-based method (19.38 ± 3.52 $cmH_2O$ vs. 17.50 ± 3.18 $cmH_2O$). Our finding is in line with a previous study displayed a similar outcome of OLP (17.90 ± 3.85 $cmH_2O$) in weight-based method, indicating the consistence of the pharynx cavity of patient in same race of Asian population. In the previous study, a novel method based on tongue width for selecting the size of classic LMA has been advocated, however, this method did not result in improved sealing function. Overweight patients are more inclined to have short neck, narrow oral cavity as well

as tongue body hypertrophy, which may contribute to bigger size of LMA selection than the real size used in such patients [15]. The results together with our findings suggested that CM distance-based method should be an alternative method for the appropriate size selection of LMA.

We also found that the success rate of insertion at first attempt in CM distance-based group was approximate to 90% whereas only 62% in weight-based group. Further, the LMA insertion was failed in three of patients in weight-based group. The results further indicated that weight-based method for size selection of LMA is not always reliable although the patients recruited were all in standard body mass index in current study. CM distance-based method, an individualized airway evaluation which can be quickly assessed, is applicable to increase the successful insertion. To note that, recent studies have proposed that LMA can successfully apply to emergency airway management for the reason that it can provide reliable first-time placement, high sealing pressure as well as separation of gastrointestinal and respiratory tracts [16, 17]. Therefore, an efficient and rapid insertion of LMA is crucial for airway establishment in rescue.

Pharyngolaryngeal morbidity including sore throat as well as blood staining are the common complications after using LMA, and the complications are associated with the improper size of selected SADs [18]. In the current study, we found that there were no significant differences in the occurrence of blood staining on device, dry throat, sore throat, dysphagia and hoarse between both groups. The high rate of dry throat was probably attributed to too long for fasting or the usage of anticholinergic agents. The incidences of sore throat in both groups were relatively high as sore throat may be associated with malposition of the cuff.

Currently, airway anatomy has been investigated to reflect SADs and their size selections as previous research indicated that there is relevance between sizing of LMA and external neck landmarks (ENLs) [19]. In fact, the manufacturer's sized method for LMA recommended on weight is not always available [20, 21]. In present study, we regarded CM distance as an important ENL which reflected the length of laryngeal cavity in normal adults, and our results demonstrated that CM distance criterion was associated with better OLP and successful insertion than body weight. Cattano et al. compared several important ENLs (thyromental distance, hyoid to cricoid cartilage distance, thyroid width, etc.) with body features (height and weight) and found significant correlations of them [22]. Therefore, other ENLs based on individualized estimation of airway anatomy should be validated in our further study, in order to provide more reference evidences for LMA size selection.

Although the benefits by CM distance-based method can be achieved, our study had several limitations. Firstly, we only investigated classic LMA, we cannot guarantee our results are applicable to other types of LMA, such as proseal LMA, supreme LMA, flexible LMA, etc., as they have different structures. Secondly, we enrolled only adults with normal body mass index, and our results may not be applied to obese or malnourished patient. In addition, in case of female or patients with short neck, the neck landmark identification of cricoid cartilage may not be obvious which may increase the potential bias of measurement. Thirdly, some cases in our study with good fiber-optic scope view did not relate to good LMA ventilation, visualization techniques like ultrasound may contribute to further assessment as evidence to illustrate how fitful between LMA and pharyngeal tissue.

In conclusion, the size selection of classic laryngeal mask airway based on cricoid-mental distance provided a better airway seal and higher successful rate of the first insertion, and this method can be a good choice for classic laryngeal mask airway size selection in adults.

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## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** All procedures conducted in our study involving human participants were in accordance with the ethical standards of the institutional review board and with the 1964 Helsinki declaration and its later amendments.

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