A feasibility study of jaw thrust as an indicator assessing adequate depth of anesthesia for insertion of supraglottic airway device in morbidly obese patients

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Abstract

Background: Jaw thrust has been proven as a useful test determining adequate depth of anesthesia for successful insertion of supraglottic airway device (SAD) in normal adults and children receiving intra-venous or inhalational anesthesia induction. This prospective observational study aimed to determine the feasibility and validity of this test when using as an indicator assessing adequate depth of anesthesia for successful insertion of SAD in spontaneously breathing morbidly obese patients receiving sevoflurane inhalational induction.

Methods: Thirty morbidly obese patients with a body mass index 40 to 73 kg/m^2 undergoing bariatric surgery in Beijing Friendship Hospital from October 2018 to January 2019 were included in this study. After adequate pre-oxygenation, 5% sevoflurane was inhaled and inhalational concentration of sevoflurane was increased by 1% every 2 min. After motor responses to jaw thrust disappeared, a SAD was inserted and insertion conditions were graded. The anatomic position of SAD was assessed using a fiberoptic bronchoscope.

Results: The SAD was successfully inserted at the first attempt in all patients. Insertion conditions of SAD were excellent in nine patients (30%) and good in 21 patients (70%), respectively. The fiberoptic views of SAD position were adequate in 28 patients (93%).

Conclusions: Jaw thrust test is a reliable indicator determining adequate anesthesia depth of sevoflurane inhalational induction for successful insertion of SAD in spontaneously breathing morbidly obese patients.

Clinical trial registration: ChiCTR1800016868; http://www.chictr.org.cn/showproj.aspx?proj=28646.

Keywords: Obesity; Inhalational induction; Sevoflurane; Supraglottic airway device; Jaw thrust test

Introduction

The prevalence of obesity is increasing in most countries, and there is a growing demand for surgical procedures in these patients. In obese patients, combination of anatomic and respiratory physiologic changes may increase the risk of adverse airway events such as difficult face-mask ventilation, difficult intubation, and severe hypoxemia.[1] It is reported that the risk of experiencing serious airway complications in obese patients is at least fourfold than that in normal-weight counterparts.[2,3] Thus, a robust anesthesia strategy including choice of anesthesia induction methods and airway management techniques is needed for obese patients, especially for morbidly obese patients with body mass index (BMI) ≥40 kg/m^2.[4]

The available evidence indicates that in morbidly obese patients, the supraglottic airway device (SAD) can not only maintain better oxygenation before tracheal intubation,[5] but also provide a conduit for safe tracheal intubation.[6] Thus, SAD has been recommended as a useful tool for routine or emergency airway management in obese patients.[7,8] Sevoflurane inhalational induction with spontaneous breathing is one of the recommended anesthesia methods for management of adult and pediatric difficult airways,[9] as it has a pleasant odor and a less irritation to the airway.[10] It has been shown that in obese patients, sevoflurane inhalational induction can provide the ideal conditions for successful SAD insertion,[11] and result in more stable hemodynamic changes than total intra-venous anesthesia induction.[12] Before SAD insertion, however, an important thing is to determine whether

Access this article online

Quick Response Code:

Website: www.cmj.org

DOI: 10.1097/CM9.0000000000000403

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Chinese Medical Journal 2019;132(18)

Received: 25-04-2019 **Edited by:** Peng Lyu

the depth of anesthesia is enough to suppress the adverse airways reflexes without untoward hemodynamic changes. This is especially important for morbidly obese patients who are more prone to have obstructive sleep apnea syndrome, hypertension, arrhythmia, and ischemic heart diseases.[7] The end-tidal concentration of sevoflurane (ET_{sev}) is one of the indicators commonly used to determine the proper depth of anesthesia for SAD insertion,[13] but ET_{sev} required for successful SAD insertion varies significantly between patients.[14,15] The jaw thrust is a common maneuver to prevent upper airway obstruction in anesthetized patients.[16] As jaw thrust can cause noxious stimulus, it has been proven as a useful indicator assessing appropriate depth of anesthesia for SAD insertion in normal adults and children when anesthesia is induced using sevoflurane or propofol with and without spontaneous breathing.[17-19] However, there has been no study to determine whether jaw thrust test is also a useful indicator assessing adequate depth of anesthesia for successful insertion of SAD in morbidly obese patients. Thus, this prospective observational study was designed to determine the feasibility and validity of jaw thrust test used as a clinical indicator assessing adequate depth of anesthesia for successful insertion of SAD in morbidly obese patients receiving sevoflurane inhalational induction with spontaneous breathing.

Methods

Ethical approval

The protocol of this study had been approved by the Institutional Ethics Committee of Beijing Friendship Hospital, China (No. 2018-P2-079-02), and written informed consent was obtained from all patients before the initiation of the study.

Study design and patient population

This study was performed between October 2018 and January 2019. In previous study of Chang *et al*,[17] insertion success rate of the Classic laryngeal mask airway (LMA) (Intavent Orthofix Ltd., Maidenhead, UK) in normal adult patients receiving sevoflurane inhalational induction was 72%. According to the single group objective value method based on binomial distribution principle, assuming that the predicted insertion success rate of BlockBuster^{TM} SAD in this study was 95%, 26 morbidly obese patients were required to provide 90% power with a type I error of 0.05. Considering the possible dropout, 30 morbidly obese patients with a BMI ≥40 kg/m^2 and American Society of Anesthesiologists physical status classification 1 or 2, aged 18 to 60 years, and scheduled for elective bariatric surgery, were recruited. The patients with respiratory tract infection, asthma, unstable cervical, lingual thyroid or tonsillar hypertrophy, severe obstructive sleep apnea syndrome, history of gastroesophageal reflux, allergy or hypersensitive reaction to drugs used during the study were excluded from this study.

All patients did not receive any premedication and were fasted for at least 8 h before surgery. After arriving in the operating room, standard monitoring including electrocardiogram, non-invasive artery blood pressure, and pulse oxygen saturation (SpO_2) was applied in all patients. During anesthesia induction, bispectral index, end-tidal concentrations of oxygen, carbon dioxide ($ETCO_2$) and ET_{sev}, and respiratory parameters including tidal volume (TV) and respiratory rate (RR) were continuously measured. The lactate ringer's solution was infused after the intra-venous catheter was placed.

The patients were placed in the ramped position. Pre-oxygenation was conducted with a 6 L/min pure oxygen flow through a closed facemask and was regarded as qualified after the end-tidal oxygen fraction was 0.9 or above. Then, the breathing circuit was filled with 5% sevoflurane and anesthesia was induced using a TV breathing technique. The inhalational concentration of sevoflurane was increased by 1% every 2 min until no motor response to jaw thrust or inhalational concentration of sevoflurane had increased to 8%. During anesthesia induction, the jaw was lifted gently by anesthesiologist A to ensure the upper airway patency and an oropharyngeal airway was inserted if necessary. After the loss of eyelash reflex, jaw thrust test was executed by anesthesiologist A through progressively lifting the angles of the mandible vertically upward every 10 s. A negative response to jaw thrust was confirmed if no motor response happened after a vigorous jaw thrust was maintained for 5 s. Subsequently, a 4-size BlockBuster^{TM} SAD (Tuo Ren Medical Instrument Co., Ltd., Changyuan, Henan, China) lubricated with lidocaine cream was inserted into the upper airway according to the manufacturer's instructions and all SAD insertion procedures were performed by anesthesiologist A who was proficient with the use of BlockBuster^{TM} SAD before this study. The cuff of SAD was inflated with 20 to 40 mL air. The insertion conditions of SAD were graded as to the criteria designed by Bouvet *et al*[20] [Table 1]. Six variables were recorded: resistance to mouth opening, resistance to SAD insertion, swallowing, coughing and gagging, head or body movement, and laryngospasm. Each of these variables was scored as excellent or intermediate or poor. The classifications of resistances to mouth opening and SAD insertion were assessed by anesthesiologist A, and the patients responses to SAD insertion were assessed by anesthesiologists A and B. The insertion conditions of SAD were excellent if all criteria were scored as excellent, good if all criteria were scored as either excellent or intermediate, and poor if a single criterion was scored as poor. The SAD insertion was regarded as unsuccessful if one or more variables were scored as poor or effective ventilation could not be obtained. If SAD insertion was a failure, propofol 1 mg/kg based on the ideal body weight (IBW) calculated by Miller formula[21] was intra-venously administered and then SAD insertion was again attempted. A maximum of three attempts was allowed to obtain effective ventilation, but only insertion conditions at the first attempt were assessed. Effective ventilation by SAD was determined by observing chest wall movement, auscultation, and capnography. After the SAD was successfully inserted, a fiberoptic bronchoscope (FOB) with a 4-mm outer diameter (Karl Storz Endoscopy, Tuttlingen, Germany) was passed to a position closed to the distal opening of the airway tube. According to the classical scoring system established by

Brimacombe and Berry,[22] the fiberoptic view of SAD positioning is scored as follows: grade 1, the glottis not seen; grade 2, the glottis plus anterior epiglottis seen; grade 3, the glottis plus posterior epiglottis seen; grade 4, only the glottis seen [Figure 1]. The grades 4 to 2 are regarded as good positioning, while grade 1 is considered as a poor positioning. After effective ventilation was achieved through the SAD, sulfentanil 0.4 μg/kg and rocuronium 0.6 mg/kg based on the IBW were intra-venously administered. If necessary, small-dose propofol was also given intra-venously. Then, tracheal intubation was performed with the guidance of FOB through the SAD and mechanical ventilation was initiated using a volume-controlled mode with TV of 8 mL/kg (IBW) and RR of 12 breaths per minute.

The heart rate (HR), mean artery pressure (MAP), SpO_2, $ETCO_2$, TV, RR were recorded before anesthesia induction, before and 1 min after SAD insertion. All adverse events associated with anesthesia induction and SAD insertion, such as apnea, hypoxemia, hypertension, hypotension, bradycardia, laryngospasm, aspiration, and airway injury, were recorded. If apnea time lasted more than 60 s or SpO_2 decreased to less than 92% during anesthesia induction, artificially assisted ventilation was used.

Statistical analysis

The SPSS statistical software (version 17.0, SPSS Inc., Chicago, IL, USA) was used to analyze these data. The hemodynamic and respiratory parameters of patients in different time points were presented as mean ± standard deviation (normal distribution of data was checked by Kolmogorov-Smirnov test) and analyzed using one-way analysis of variance. A P value <0.05 was considered significant.

Results

A total of 33 morbidly obese patients were assessed for eligibility. Among them, three patients with severe obstructive sleep apnea syndrome were excluded from the study and 30 patients were recruited into the study. The demographic data of patients were shown in Table 2.

The SAD was successfully inserted at the first attempt in all patients. Insertion conditions were excellent in nine patients (30%) and good in 21 patients (70%), respectively. Twenty patients (66.7%) presented an intermediate resistance to mouth opening and 18 patients (60%) presented an intermediate resistance to SAD insertion. Only one (3.3%) patient had slight swallowing and gagging during the SAD insertion. Coughing, head and body movement, and laryngospasm were not observed in any patient [Figure 2]. All patients obtained effective ventilation with spontaneous breathing after SAD insertion.

The mean ET_{sev} at loss of eyelash reflex and no motor response to jaw thrust were 2.2% ± 0.2% and 4.7% ± 0.5%, respectively. The mean times required for loss of eyelash reflex and no motor response to jaw thrust were

Table 1: Scoring system for insertion conditions of the supraglottic airway device.[20]

Variables	Insertion conditions		
	Excellent	Intermediate	Poor
Resistance to			
Mouth opening	No	Significant	Undue force required
Device insertion	No	Significant	Undue force required
Patients response			
Swallowing	Nil	Slight	Gross
Coughing and gagging	Nil	Slight	Gross
Head and body movements	Nil	Slight	Gross
Laryngospasm	Nil	Partial	Total

No: No any resistance during manipulation; Significant: obvious resistance but is able to complete the manipulation; Nil: no any adverse reactions occurred during SAD insertion; Slight: no and mild affect on SAD insertion. Gross: severe enough to result in a failed SAD insertion; Partial: incomplete laryngospasm, imperfect ventilation; Total: complete laryngospasm, no ventilation.

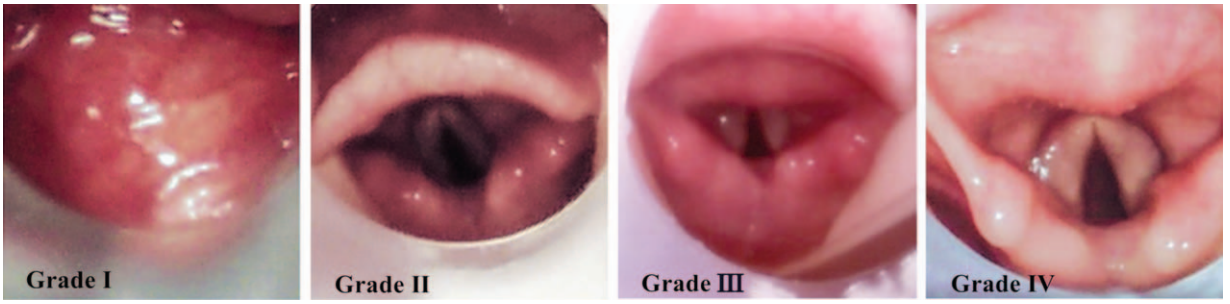

Figure 1: The classical fiberoptic views of supraglottic airway device positioning according to a scoring system established by Brimacombe and Berry.[22]

96.0 ± 16.2 s and 346.1 ± 47.7 s, respectively. The fiberoptic view of SAD positioning was grades 2 to 4 in 28 patients (93.3%). Two patients (6.7%) had a grade 1 fiberoptic view of SAD positioning, but adequate ventilation was obtained and the fiberoptic view of SAD positioning was significantly improved by the up-down maneuver. During mechanical ventilation *via* the SAD, TV was adequate and peak airway pressure was maintained between 22 and 30 cmH_2O (1 cmH_2O = 0.098 kPa) in all patients. Moreover, the FOB-guided intubation through the SAD was successfully completed at the first attempt in all patients.

Before SAD insertion, both HR and RR were significantly increased compared with their baselines, but MAP, TV, and $ETCO_2$ were significantly decreased compared with their baselines. As compared with the values before SAD insertion, HR and RR at 1 min after SAD insertion were significantly decreased, and $ETCO_2$ at 1 min after SAD insertion was significantly increased [Table 3]. During sevoflurane inhalational induction, apnea occurred in five patients (16.7%), but spontaneous breathing resumed in all five patients after placement of an oropharyngeal airway. No hypertension, hypotension, bradycardia, laryngospasm, aspiration, and airway injury were noted throughout the observation. Furthermore, no complication associated with jaw thrust maneuver was found.

Table 2: Patients' characteristics of the study ($n = 30$).

Parameters	Value
Age (years)	29.2 ± 5.0
Gender; female	22 (73.3)
Body mass index (kg/m^2)	46.9 ± 8.5
Inter-incisor distance (cm)	6.3 ± 0.7
Thyromental distance (cm)	7.9 ± 1.0
Neck circumference (cm)	46.9 ± 5.0
Mallampati classifications	
I	1 (3.3)
II	17 (56.7)
III	9 (30.0)
IV	3 (10.0)
Hypertension	8 (26.7)
Diabetes mellitus	10 (33.3)
Hyperlipemia	13 (43.3)

Values are expressed as mean ± standard deviation or numbers (%)

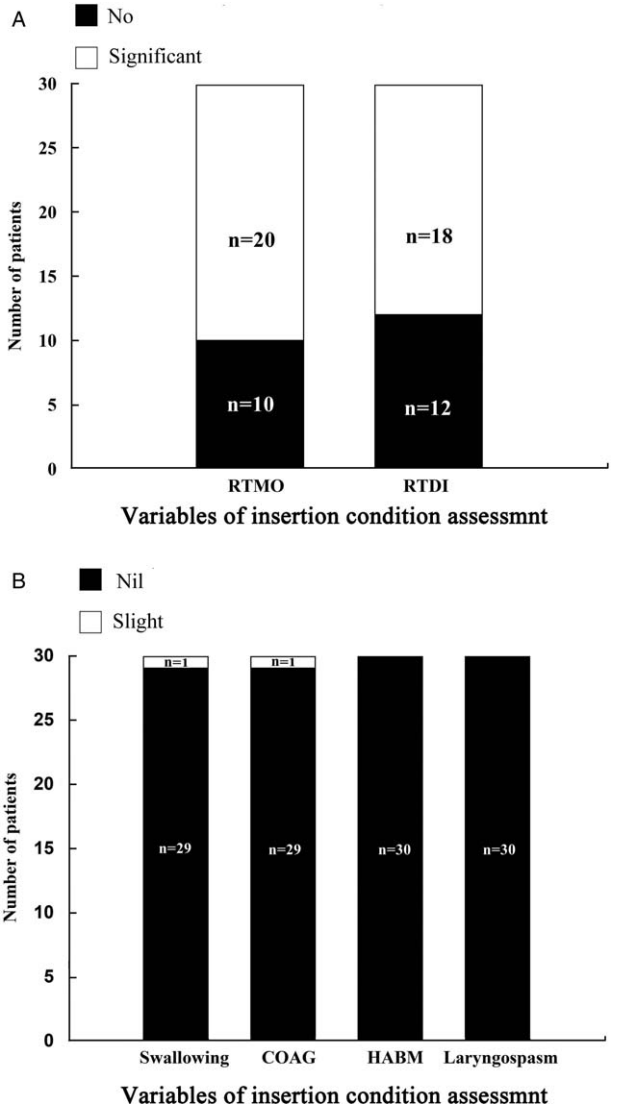

Figure 2: Number of patients who responded to Blockbuster™ supraglottic airway device insertion. Categories of all six variables are shown. (A) RTMO and RTDI; (B) COAG; HABM; and laryngospasm. No and Nil represent excellent insertion condition. Significant and Slight represent intermediate insertion conditions. COAG: Swallowing, coughing, and gagging; HABM: Head and body movement; RTDI: Resistance to device insertion; RTMO: Resistance to mouth opening.

Table 3: Changes in hemodynamic and respiratory parameters before and after SAD insertion ($n = 30$).

Parameters	Baseline	Before SAD insertion	1 min after SAD insertion	*F* values
Heart rate (beats per min)	81.5 ± 10.4	98.1 ± 8.3*	90.0 ± 10.0*,†	22.42
MAP (mmHg)	103.5 ± 8.8	92.5 ± 10.5*	90.8 ± 9.6*	15.50
Tidal volume (mL)	676.7 ± 139.0	449.3 ± 102.7*	422.3 ± 84.2*	47.52
Respiratory rate (breaths per min)	15.4 ± 2.9	28.0 ± 5.0*	23.0 ± 5.4*,†	58.91
$ETCO_2$ (mmHg)	39.5 ± 1.8	31.2 ± 4.6*	41.0 ± 2.6†	79.92

Values are expressed as mean ± standard deviation. $^*P < 0.001$, compared with baselines; $^\dagger P < 0.001$, compared with values before SAD insertion. 1 mmHg = 0.133 kPa. SAD: Supraglottic airway device; MAP: Mean artery pressure; $ETCO_2$: End-tidal concentrations of oxygen, carbon dioxide.

Discussion

The current study showed that jaw thrust test could reliably determine adequate depth of anesthesia for successful insertion of SAD in spontaneously breathing morbidly obese patients receiving sevoflurane inhalational induction, that is, no motor response to jaw thrust test indicated excellent or good SAD insertion conditions in all patients.

Intra-venous anesthesia induction with propofol without the use of muscle relaxants is commonly used for SAD insertion in adult patients, but it can result in a higher incidence of respiratory depression than sevoflurane inhalational induction.[23-25] This means that in patients with difficult airways, the use of intra-venous anesthesia induction with propofol may increase the risk of a sudden loss of airway control, making patients fall into the "cannot intubate cannot ventilate" situation.[26] In contrast, the depth of anesthesia can be gradually increased with sevoflurane inhalational induction while maintaining spontaneous breathing. In this situation, adequacy of facemask ventilation during spontaneous breathing can be reliably assessed at various anesthetic levels. If airway obstruction occurs during anesthesia induction and cannot be relieved by routine airway maneuvers, sevoflurane is turned off and then the patient is woken up.[27] Given that morbidly obese patients have an increased risk of difficult airways,[6] sevoflurane inhalational induction with spontaneous breathing is selected in this study as to our routine practice.

Although SAD insertion is generally believed to require a lighter depth of anesthesia compared with tracheal intubation, the depth of anesthesia should be sufficient to inhibit adverse airway reflexes and circulatory responses by SAD insertion. Before SAD insertion, thus, the most important thing is how to determine whether the depth of anesthesia is adequate. An ideal test assessing appropriate depth of anesthesia for successful insertion of SAD should be easy to practice and no injurious to patients, with an ability to provide a reliable assessment.[28] The jaw thrust is a common maneuver to prevent upper airway obstruction in anesthetized patients.[16] As jaw thrust maneuver is a noxious stimulus that can cause significant motor reactions, the depth of anesthesia required for no motor reaction to jaw thrust may be sufficient for successful SAD insertion in morbidly obese patients receiving sevoflurane inhalational induction.

It has been shown that the jaw thrust test is a useful indicator assessing adequate depth of anesthesia for successful insertion of SAD in the normal adult patients. Drage *et al*[19] reported that in normal BMI adult patients receiving intra-venous anesthesia induction with propofol, a lack of response to jaw thrust could reliably predict the optimal insertion conditions of ProSeal LMA (Laryngeal Mask Company, Henley-on-Thames, UK) in 115 of 137 patients (84%), and the accuracy, sensitivity, and specificity of prediction were 0.82, 0.95, and 0.44, respectively. Chang *et al*[17] demonstrated that in normal adult patients receiving sevoflurane inhalational induction with spontaneous breathing, no motor response to jaw thrust could provide adequate conditions for successful insertion of Classic LMA at the first attempt in 36 of 50 patients (72%). The insertion success rate of SAD in our study is comparable with the findings of Drage *et al's*[19] study, but higher than that in Chang *et al's* study.[17] Furthermore, the proportion of excellent insertion conditions is significantly higher in Drage *et al's* study (87%) than in our study (30%). These various results may have resulted from significant differences in the objects and methods among studies. For example, our study objects are morbidly obese patients while the subjects in the other studies are normal adult patients. In the study of Drage *et al*,[19] anesthesia is induced with intra-venous propofol and fentanyl until loss of eyelash reflex and the occurrence of apnea in normal adult patients. Compared with anesthesia induction with intra-venous propofol, sevoflurane inhalational induction needs a longer time to achieve jaw relaxation.[23] In the above studies, moreover, the angles of the mandible were gently lifted vertically upward. In our study; however, a vigorous jaw thrust was performed to achieve a depth of anesthesia that could effectively reduce the incidences of adverse responses to SAD insertion such as body movement and coughing, which occurred in the above studies. As expected, in our study, no body movement and coughing responses to SAD insertion happened in any patients except extremely slight swallowing and gagging occurred in one case. In addition, our study used a BlockBuster^{TM} SAD, rather than the Classic or ProSeal LMA in other studies. The BlockBuster SAD is a new second-generation SAD. Its inflatable cuff is made of silica gel material with high biocompatibility and the double-cuff structure can provide a good airway sealing, with a sealing pressure up to 30 cmH_2O. As the BlockBuster SAD has the drainage tube and secretion collection designs, it can reduce the risk of reflux and aspiration of gastric contents and airway secretions.

The ET_{sev}, loss of eyelash reflex and jaw relaxation have also been attempted as the indicators assessing anesthesia level of sevoflurane inhalational induction for successful insertion of SAD, but they are sub-optimal. In the adult patients with a normal BMI, Zaballos *et al*[15] found that when Supreme LMA was inserted after ET_{sev} was as high as 2.5% and maintained for 10 min, 8 of 31 patients (26%) had gross body movement and coughing. In the obese patients, Wang *et al*[11] showed that after ET_{sev} was as high as 2.5% and maintained for 5 min, the insertion success rate of the BlockBuster^{TM} SAD was only 50%. When the eyelash reflex disappeared and a certain degree jaw relaxation was reached in normal adult patients receiving sevoflurane inhalational induction, moreover, Siddik-Sayyid *et al*[23] demonstrated that insertion success rate of the Classic LMA at the first attempt was only 46% (12 of 26 patients) and Sivalingam *et al*[29] found that 9 of 25 patients (36%) had gross body movement, coughing, gagging and laryngospasm during insertion of Classic LMA. In contrast, our and other studies confirm that jaw thrust test is a reliable clinical indicator assessing adequate depth of anesthesia for successful insertion of SAD in normal and obese patients.

Although an adequate fiberoptic view of SAD positioning does not represent proper functioning of a SAD, an

optimal fiberoptic view can facilitate subsequent blind or FOB-guided tracheal intubation via the SAD.[30] The incidence of poor fiberoptic view of the SAD positioning in our study was 6.7%. This is with an agreement with the findings of some previous studies.[31] In the morbidly obese patients, Shiraishi[31] reported that the incidence of poor fiberoptic view of air-Q™ intubating LMA (Mercury Medical, Clearwater, Florida, USA) positioning was 5%. In the obese patients, Wang *et al*[11] reported that the incidence of poor fiberoptic view of BlockBuster™ SAD positioning was 10%. In the morbidly obese patients; however, Keller *et al*[32] reported that the incidence of poor fiberoptic view of ProSeal LMA positioning was as high as 25%. The reasons for a higher incidence of poor fibreoptic view in Keller *et al's* study[32] may be that patients are placed in the supine position, rather than the ramped position, which is often a position commonly recommended for anesthesia induction and airway management in the morbidly obese patients.[4]

It must be pointed out that our design has several limitations. First, a main limitation is observational character of this study without control design. Thus, an issue that was not answered in this study is whether jaw thrust test is superior to other methods when assessing adequate depth of anesthesia for insertion of SAG in morbidly obese patients. Second, a size 4 BlockBuster™ SAD was used for all morbidly obese patients. Perhaps, the use of thyropalatal distance and IBW to guide the selection of optimal SAD size is more appropriate.[33] In the morbidly obese patients; however, excess adipose tissue deposition in the pharyngeal space may lead to a decreased upper airway space. In our previous studies,[11,34] all obese patients obtained adequate ventilation via a size 4 BlockBuster SAD. Third, the force strength to perform jaw thrust may differ among patients and cannot be reliably quantified. Thus, we emphasize that repeated practices and experiences are needed before one attempts to use the jaw thrust test to assess adequate depth of anesthesia for successful insertion of SAD. Fourth, female patients account for a high proportion (22/30, 73.3%) in our study. It has been shown that morbidly obese males have more difficult intubation conditions than morbidly obese females.[35] Thus, different results may be obtained when our plans are repeated in another study where male-female ratio is symmetrical or males are predominant. Fifth, the ages of the morbidly obese patients enrolled in our study are 18 to 37 years. As age can significantly influence the pharmacodynamics of inhalational anesthetics,[36] our results may also not extrapolated to morbidly obese patients of other ages. Finally, the results of this study may not be applicable to morbidly obese patients receiving with spontaneous breathing loss under sevoflurane inhalational induction. In conclusion, the present study demonstrates that jaw thrust test is a reliable clinical indicator assessing adequate depth of anesthesia for successful insertion of SAD in spontaneous breathing morbidly obese patients receiving sevoflurane inhalational induction.

Conflicts of interest

None.

References

1. Murphy C, Wong DT. Airway management and oxygenation in obese patients. Can J Anaesth 2013;60:929–945. doi: 10.1007/s12630-013-9991-x.
2. Cook TM, Woodall N, Frerk C. Fourth National Audit Project. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 1: anaesthesia. Br J Anaesth 2011;106:617–631. doi: 10.1093/bja/aer058.
3. Cook TM, Woodall N, Harper J, Benger J. Fourth National Audit Project. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 2: intensive care and emergency departments. Br J Anaesth 2011;106:632–642. doi: 10.1093/bja/aer059.
4. Hodgson E. Airway management of the morbidly obese patient. J Perioper Pract 2016;26:196–200. doi: 10.1177/175045891602600902.
5. Dhonneur G, Ndoko SK, Yavchitz A, Foucrier A, Fessenmeyer C, Pollian C, *et al*. Tracheal intubation of morbidly obese patients: LMA CTrach vs direct laryngoscopy. Br J Anaesth 2006;97:742–745. doi: 10.1093/bja/ael219.
6. Herman AG, Mahla ME. Awake intubating laryngeal mask airway placement in a morbidly obese patient with ankylosing spondylitis and unstable thoracic spine. J Clin Anesth 2016;32:62–64. doi: 10.1016/j.jclinane.2015.12.021.
7. Nightingale CE, Margarson MP, Shearer E, Redman JW, Lucas DN, *et al*. Members of the Working Party. Peri-operative management of the obese surgical patient 2015: Association of Anaesthetists of Great Britain and Ireland Society for Obesity and Bariatric Anaesthesia. Anaesthesia 2015;70:859–876. doi: 10.1111/anae.13101.
8. Apfelbaum JL, Hagberg CA, Caplan RA, Blitt CD, Connis RT, Nickinovich DG, *et al*. 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. doi: 10.1097/ALN.0b013e31827773b2.
9. MacIntyre PA, Ansari KA. Sevoflurane for predicted difficult tracheal intubation. Eur J Anaesthesiol 1998;15:462–466. doi: 10.1046/j.1365-2346.1998.00330.x.
10. De Hert S, Moerman A. Sevoflurane. F1000Res 2015;4:626. doi: 10.12688/f1000research.6288.1.
11. Wang H, Gao X, Wei W, Miao H, Meng H, Tian M. The optimum sevoflurane concentration for supraglottic airway device Blockbuster™ insertion with spontaneous breathing in obese patients: a prospective observational study. BMC Anesthesiol 2017;17:156. doi: 10.1186/s12871-017-0449-5.
12. Salihoglu Z, Karaca S, Kose Y, Zengin K, Taskin M. Total intravenous anesthesia versus single breath technique and anesthesia maintenance with sevoflurane for bariatric operations. Obes Surg 2001;11:496–501. doi: 10.1381/096089201321209413.
13. He L, Wang X, Zheng S. Effects of dexmedetomidine on sevoflurane requirement for 50% excellent tracheal intubation in children: a randomized, double-blind comparison. Paediatr Anaesth 2014;24:987–993. doi: 10.1111/pan.12430.
14. Yao Y, Qian B, Lin Y, Wu W, Ye H, Chen Y. Intranasal dexmedetomidine premedication reduces minimum alveolar concentration of sevoflurane for laryngeal mask airway insertion and emergence delirium in children: a prospective, randomized, double-blind, placebo-controlled trial. Paediatr Anaesth 2015;25:492–498. doi: 10.1111/pan.12574.
15. Zaballos M, Bastida E, Jiménez C, Agustí S, López-Gil MT. Predicted end-tidal sevoflurane concentration for insertion of a laryngeal mask supreme: a prospective observational study. Eur J Anaesthesiol 2013;30:170–174. doi: 10.1097/EJA.0b013e32835c5512.
16. Koh KF. Clinical update on managing the obstructed airway. Ann Acad Med Singapore 2002;31:253–256.
17. Chang CH, Kim SH, Shim YH, Kim JH, Shin YS. Comparison of the trapezius squeezing test and jaw thrust as indicators for laryngeal mask airway insertion in adults. Korean J Anesthesiol 2011;61:201–204. doi: 10.4097/kjae.2011.61.3.201.
18. Dinesh Kumar KK, Bhardwaj N, Yaddanapudi S. Comparison of trapezius squeeze test and jaw thrust as clinical indicators for laryngeal mask airway insertion in spontaneously breathing children. J Anaesthesiol Clin Pharmacol 2017;33:71–75. doi: 10.4103/0970-9185.202204.
19. Drage MP, Nunez J, Vaughan RS, Asai T. Jaw thrusting as a clinical test to assess the adequate depth of anaesthesia for insertion of the

laryngeal mask. Anaesthesia 1996;51:1167–1170. doi: 10.1111/j.1365-2044.1996.tb15062.x.
20. Bouvet L, Da-Col X, Rimmelé T, Allaouchiche B, Chassard D, Boselli E. Optimal remifentanil dose for laryngeal mask airway insertion when co-administered with a single standard dose of propofol. Can J Anaesth 2010;57:222–229. doi: 10.1007/s12630-009-9249-9.
21. Kammerer MR, Porter MM, Beekley AC, Tichansky DS. Ideal body weight calculation in the bariatric surgical population. J Gastrointest Surg 2015;19:1758–1762. doi: 10.1007/s11605-015-2910-4.
22. Brimacombe J, Berry A. A proposed fiber-optic scoring system to standardize the assessment of laryngeal mask airway position. Anesth Analg 1993;76:457.
23. Siddik-Sayyid SM, Aouad MT, Taha SK, Daaboul DG, Deeb PG, Massouh FM, *et al*. A comparison of sevoflurane-propofol versus sevoflurane or propofol for laryngeal mask airway insertion in adults. Anesth Analg 2005;100:1204–1209. doi: 10.1213/01.ANE.0000148166.29749.3B.
24. Bonnin M, Therre P, Albuisson E, Beaujard H, Barthelemy I, Mondie JM, *et al*. Comparison of a propofol target-controlled infusion and inhalational sevoflurane for fibreoptic intubation under spontaneous ventilation. Acta Anaesthesiol Scand 2007;51:54–59. doi: 10.1111/j.1399-6576.2006.01186.x.
25. Kati I, Demirel CB, Huseyinoglu UA, Silay E, Yagmur C, Coskuner I. Comparison of propofol and sevoflurane for laryngeal mask airway insertion. Tohoku J Exp Med 2003;200:111–118. doi: 10.1620/tjem.200.111.
26. Xue FS, Yuan YJ, Wang Q, Liu JH, Liao X. Comments on "propofol versus sevoflurane for fiberoptic intubation under spontaneous breathing anesthesia in patients difficult to intubate". Minerva Anestesiol 2011;77:470–471.
27. Xue FS, Liu QJ. Tracheal intubation awake or under anesthesia for potential difficult airway: look before you leap. Chin Med J 2018;131:753–756. doi: 10.4103/0366-6999.226891.
28. Chang CH, Shim YH, Shin YS, Lee KY. Optimal cond itions for laryngeal mask airway insertion in children can be determined by the trapezius squeezing test. J Clin Anesth 2008;20:99–102. doi: 10.1016/j.jclinane.2007.09.007.
29. Sivalingam P, Kandasamy R, Madhavan G, Dhakshinamoorthi P. Conditions for laryngeal mask insertion. A comparison of propofol versus sevoflurane with or without alfentanil. Anaesthesia 1999;54:271–276. doi: 10.1046/j.1365-2044.1999.00663.x.
30. Keller C, Brimacombe J, Pühringer F. A fibreoptic scoring system to assess the position of laryngeal mask airway devices. Interobserver variability and a comparison between the standard, flexible and intubating laryngeal mask airways. Anasthesiol Intensivmed Notfallmed Schmerzther 2000;35:692–694. doi: 10.1055/s-2000-8164.
31. Shiraishi T. Awake insertion of the air-Q^{TM} intubating laryngeal airway device that facilitates safer tracheal intubation in morbidly obese patients. Br J Anaesth 2013;111:1024–1025. doi: 10.1093/bja/aet389.
32. Keller C, Brimacombe J, Kleinsasser A, Brimacombe L. The laryngeal mask airway ProSeal(TM) as a temporary ventilatory device in grossly and morbidly obese patients before laryngoscope-guided tracheal intubation. Anesth Analg 2002;94:737–740. doi: 10.1097/00000539-200203000-00048.
33. Hanna SF, Mikat-Stevens M, Loo J, Uppal R, Jellish WS, Adams M. Awake tracheal intubation in anticipated difficult airways: LMA Fastrach vs flexible bronchoscope: a pilot study. J Clin Anesth 2017;37:31–37. doi: 10.1016/j.jclinane.2016.10.040.
34. Wang HX, Miao HH, Gao X, Wei W, Ding GN, Zhang Y, *et al*. Optimum end-tidal concentration of sevoflurane to facilitate supraglottic airway device insertion with propofol at induction allowing spontaneous respiration in obese patients: a prospective observational study. Medicine 2017;96:e8902. doi: 10.1097/MD.0000000000008902.
35. Ezri T, Warters RD, Szmuk P, Saad-Eddin H, Geva D, Katz J, *et al*. The incidence of class "zero" airway and the impact of Mallampati score, age, sex, and body mass index on prediction of laryngoscopy grade. Anesth Analg 2001;93:1073–1075. doi: 10.1097/00000539-200110000-00055.
36. Nakajima R, Nakajima Y, Ikeda K. Minimum alveolar concentration of sevoflurane in elderly patients. Br J Anaesth 1993;70:273–275. doi: 10.1093/bja/70.3.273.

How to cite this article: Wan L, Shao LJZ, Liu Y, Wang HX, Xue FS, Tian M. A feasibility study of jaw thrust as an indicator assessing adequate depth of anesthesia for insertion of supraglottic airway device in morbidly obese patients. Chin Med J 2019;132:2185–2191. doi: 10.1097/CM9.0000000000000403