Modified Mallampati Test, Neck Circumference and Short Inter-Incisor Gap Are Risk Factors for Troublesome Intubation in Thai Obese Patients

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ABSTRACT

Background: Several alternative airway tools have now become primary devices for endotracheal intubation in obese patients. Since there were no guidelines to suggest which patient characteristics may be best suited for alternative techniques, we conducted this study to identify which airway bedside tests could predict the occurrence of troublesome intubation while performing conventional endotracheal intubation in obese Thai patients.

Methods: This cohort study was conducted in 200 obese patients who were expected to not use alternative tools for first-line management in a tertiary care university hospital. Troublesome intubation was defined using an intubation difficulty scale (IDS) score > 0. An IDS value of 0 means ideal intubation, i.e., one performed without effort, on the first attempt, practiced by one operator, using one technique, with no impediment of the tube passage. Eleven types of preoperative airway assessment – including malformation of central teeth in the upper jaw, a modified Mallampati test, an upper-lip bite test, the range of motion of the neck (flexion and extension), the inter-incisor gap, the hyomental distance, the thyromental distance, the sternomental distance, the neck circumference, and the length of the neck – were examined in all patients.

Results: The inter-observer reliability of raters was > 0.7 before initiation of the study. Overall, 52.5% of patients experienced troublesome intubation during conventional endotracheal intubation. According to a multivariate analysis, the independent risk factors were a modified Mallampati test, the neck circumference, and the inter-incisor gap.

Conclusion: Based on our findings, alternative airway tools should be the first line of airway management in the case of patients with a high modified Mallampati test, a large neck circumference, and a short inter-incisor gap.

Keywords: Difficult intubation, prediction, airway assessment, obesity

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INTRODUCTION

Obesity has become a growing health problem among Thais. According to a report by the World Health Organization, the prevalence of obesity among the adult Thai population increased from 15-20%[1] in 1990 to 25-30%[2] in 2011. Obese patients have a number of physiologic alterations, such as increased oxygen consumption, decreased chest wall compliance, and decreased functional residual capacity.[3] Regarding airway management, obese patients have been thought to be at a greater risk of airway-related adverse events compared with the general population.

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To aid anesthetic personnel in identifying difficult intubation, several bedside airway assessment tests have been proposed. Common airway assessment tests were malformation of the central teeth in the upper jaw, a modified Mallampati test, an upper lip bite test, the range of motion of the neck (flexion and extension), the inter-incisor gap, the hyomental distance, the thyromental distance, the sternomental distance, the neck circumference, and the length of the neck. Previous studies reported some potential risk factors for difficult intubation; a high Mallampati score (class III and IV)[4,5,6] and a large neck circumference have been identified as independent risk factors for difficult intubation in obese patients.[7,8] However, no data demonstrated the type of test which could identify difficult airway management among obese Thai patients.

Since 2003, the American Society of Anesthesiology Task Force on Management of Difficult Airways has utilized five terms for difficult airways, which are failed intubation, difficult tracheal intubation, difficult laryngoscopy, difficult mask ventilation, and difficult laryngeal mask airway ventilation.[9] However, these terms do not identify the cases that are suited for using alternative airway devices for first-line management. As it had become time for a paradigm change, many clinicians chose to use a video-laryngoscope for the first line of airway management in obese patients. We applied the term "patient with troublesome intubation", adapted from the definition proposed by Adnet and colleagues,[10] to identify a troublesome situation during endotracheal intubation. The validated intubation difficulty scale (IDS) score was already used among obese patients.[5,11] The IDS > 0 referred to the situation of a not ideal, or troublesome intubation. The IDS value was a sum of seven scores obtained from the following seven items: the number of attempts, the number of performers, the number of alternative intubation techniques used, the laryngoscopic view (defined by Cormack and Lehane), the lifting force applied during laryngoscopy, the necessity to apply external laryngeal pressure for optimized glottic exposure, and the position of the vocal cords at intubation.[10] The IDS score was collected during conventional endotracheal intubation.

We conducted this study to explore which airway bedside tests could identify patients at risk of troublesome intubation during the performance of conventional intubation on obese Thai patients.

MATERIALS AND METHODS

This prospective cohort study was part of a multi-center study. This part of the data was obtained from Siriraj Hospital, which is a tertiary university hospital. The study was approved by Siriraj Institution Review Board (Si. 621/2555), and informed consent was obtained from all patients. Patients enrolled in the study comprised adult obese patients, defined by a body mass index ≥ 30 kg/m^2, who were undergoing elective surgery under general anesthesia ± combined regional anesthesia with conventional endotracheal intubation. Patients were excluded if they had any one of the following conditions: any upper airway pathology or obvious malformations of the upper airway (i.e. maxillofacial fractures or tumors), a cervical spine fracture, pregnancy, a full stomach, a history of difficult intubation or failed intubation or needing alternative intubation techniques, or initially managed with alternative airways such as fiberoptic intubation, video-laryngoscope or laryngeal mask airway.

Before initiation of the study, types of preoperative airway assessment – including malformation of central teeth in the upper jaw, a modified Mallampati test, an upper lip bite test, the range of motion of the neck (flexion and extension), the inter-incisor gap, the hyomental distance, the thyromental distance, the sternomental distance, the neck circumference and the length of neck – were reviewed and clearly defined by five experienced anesthesiologists. Subsequently, two research assistants were trained to do the examination with five obese volunteers and a series of photographs until the results of the inter-observer reliability of the principle investigator and the two assistants were > 0.7.

Anesthetic protocol

Standard monitors, including pulse oximeter, non-invasive blood pressure and electrocardiogram, were applied before conducting anesthesia.

All tracheal intubations were performed by anesthetists with more than two-year full-time experience, and they were blinded to the detail of the patient assessment. The anesthesiologists who conducted the anesthesia were not restricted by a study protocol, and they were free to choose the laryngoscopic position and intubating technique judged best to achieve optimal visualization in each particular patient. A size 3 or 4 Macintosh laryngoscope blade was used for the first laryngoscopy in each case. The patient was positioned with pillows under the head with the neck extended as appropriate. In the case of unanticipated difficult airway management, an airway technician was available 24 hours. Alternative airway devices such as fiberoptic laryngoscopy, video-laryngoscopy or a surgical airway kit could be provided within 10 minutes after an emergency call. The decision making of intubation, i.e., time to stop trying conventional intubation or choices of alternative airway devices, was at the discretion of the in-charge anesthesiologists. Patients received preoxygenation, breathing 100% oxygen through a facemask for more than three minutes. General anesthesia was induced with 5-7 mg/kg sodium thiopental or 1.5-2.5 mg/kg propofol, and intubating dose of muscle relaxants.

Definition of the outcome criteria

The intubation difficulty scale (IDS) score, which was validated by Adnet et al,[10] was used in this study. This score used several variables associated with difficult intubation, and had already been used to compare obese and non-obese patients.[7] The IDS value of 0 means ideal intubation, i.e., one performed without effort, on the first attempt, practiced by one operator, using one technique, with no impediment of the tube passage. The score value increased when an additional attempt was added. A sum score of 0 referred to a patient with ideal intubation, while a score > 0 referred to a patient experiencing troublesome intubation while a conventional endotracheal intubation was being performed.[10]

Statistical analysis

The measurements from two research assistants and the primary investigator were compared. Concordance of the measurements of continuous variables was assessed using intraclass correlation (ICC). As for the categorical variables, the percentage observer agreement was used to define the concordance of the examination. The strength of agreement for values of ≥ 0.7 were adopted (< 0.00 = poor concordance; 0.00-0.20 = slight concordance; 0.21-0.40 = fair concordance; 0.41-0.60 = moderate concordance; 0.61-0.80 = substantial concordance; and 0.81-1.00 = almost perfect concordance).[12]

Statistical analysis was conducted using a software program, SPSS version 18, SPSS Inc., Chicago, IL, USA. Descriptive statistics were used to examine preoperative characteristics, the number of patients in each IDS scores' group, and the incidence of adverse events. The patients were assigned to two groups: patients with an ideal intubation (IDS =0), and patients with troublesome intubation (IDS > 0). Eleven airway assessment tests were compared using the Chi-square test for categorical variables and the Student's t-test for continuous variables. Subsequently, variables with $p < 0.2$ from univariate analysis were entered into a multiple logistic regression model of patients with troublesome intubation. Data were presented as a mean ± standard deviation (SD) and a number (percent), as appropriate. Crude odds ratio, adjusted odds ratio and 95% confidence interval (95% CI) were reported to consider the strength of association between types of airway examination and patients with troublesome intubation. $P < 0.05$ (2-sided) were considered to indicate statistically significant differences.

The sample size was calculated using the current recommendation of statisticians for multiple logistic regression analysis, i.e., that the number of patients with troublesome intubation should be five to ten times the number of risk factors. Therefore, approximately 55- 110 cases of patients with troublesome intubation were needed. Using the previous incidence reports of troublesome intubation (IDS > 0), which was 67%[5], 105 cases with troublesome intubation were therefore considered to be adequate for this study.

RESULTS

The inter-observer reliability of the principle investigator and two assistants have been presented in Table 1. The assistants trained three sessions before they provided favorable results. Most tests showed either substantial or almost perfect reliability, but some tests, such as the measurement of the length of the neck, the hyomental distance and the thyromental distance, demonstrated slight to fair reliability during the first and second training sessions. The assistants were trained until almost perfect results were obtained before the initiation of the study.

The study participants included 213 adult patients who underwent elective surgery from May 1, 2013 to December 31, 2013. Thirteen cases were excluded from the study because the anesthesiologists changed the anesthetic plan to using video-laryngoscopy (6 cases) or a laryngeal mask airway (5 cases), or to conducting spinal anesthesia (2 cases). Overall, data from the remaining 200 patients were included in the final analysis.

The mean age of patients was 51 years, with 29% of patients being male and the remaining 71% being female. The average body mass index was 34.7 ± 5.3 kg/m^2 (range 30-68.4 kg/m^2). Around two thirds of patients had at least one coexisting disease, and common diseases were diabetic mellitus and hypertension. Obstructive sleep apnea was diagnosed in ten patients. Surgical procedures and surgical areas have been detailed in Table 2.

Most direct laryngoscopies (84%) were successful, using a McIntosh laryngoscope blade number 3. Other laryngoscopies were possible by using a McIntosh laryngoscope blade number 4 (8%), a McCoy laryngoscope blade (6%) and a Miller blade (1.5%). Insufficient anesthesia during intubation, i.e., moving, coughing or breathing, revealed in 10 cases. The distribution of IDS scores is presented in Table 3. Ideal intubation, with an IDS value = 0, represents 47.5% of all intubations. Overall, troublesome intubation occurred in 52.5% of all obese patients. The percentage of intubations with slight difficulty, i.e., with an IDS value of 1-5, was 52% (104 out of 200). Moderate to major difficulty of intubation (IDS = 12) occurred in only one case. No failed intubation was reported in this study.

Eleven airway examinations were analyzed to identify which factors were related to patients with troublesome intubation. Based upon a univariate analysis, five factors were found to be statistically significant: the inter-incisor gap, the neck circumference, the length of the neck, the upper-lip bite test, and the modified Mallampati test (Table 4). Using a multiple logistic regres-

TABLE 1. Intraclass correlation coefficient (ICC) and percentage observer agreement of airway examination compared between principal investigator (PI) and two assistances (A1, A2).

Variables	ICC or percentage observer agreement					
	Session 1		Session 2		Session 3	
	PI: A1	PI: A2	PI: A1	PI: A2	PI: A1	PI: A2
Inter-incisor gap	0.99	0.83	0.71	0.94	0.99	0.99
Neck circumference	0.90	0.91	0.97	0.97	0.99	0.99
Length of neck	-0.85	0.31	0.41	0.12	0.93	0.87
Hyomental distance	0.37	0.50	0.60	0.51	0.93	0.99
Thyromental distance	0.41	0.30	0.25	0.13	0.72	0.95
Sternomental distance	0.85	0.42	0.97	0.78	0.99	0.98
Malformation of teeth	100	100	100	100	100	100
Mallampati classification	0	80	80	60	100	100
Upper Lip Bite test	80	80	80	80	100	100
Range of motion of neck						
Flexion	100	100	100	100	100	100
Extension	100	100	100	100	100	100

TABLE 2. Demographic data of 200 obese patients.

Variables	Mean ± SD or number (%) (n = 200)
Age (year)	51.1 ± 14.6
Gender	
Male	58 (29)
Female	142 (71)
Body mass index (kg/m^2)	34.7 ± 5.3
ASA Classification	
II	178 (89)
III	22 (11)
Specialties	
Head neck breast surgery	42 (21)
General surgery	37 (18.5)
Orthopedics	34 (17)
Otolaryngology	27 (13.5)
Gynecology	17 (8.5)
Neurology	11 (5.5)
Others	31 (16)
Surgical area	
Head and neck	66 (33)
Abdomen	46 (23)
Breast	32 (16)
Extremities and spine	31 (15.5)
Other	25 (12.5)

sion, only three of those factors were subsequently found to be independently related to troublesome intubation: the inter-incisor gap, the neck circumference, and the modified Mallampati test (Table 5). Regarding adverse events, intraoperative desaturation occurred in five patients, and tooth avulsion occurred in one patient. Eight cases reported oral tissue injury characterized by abrasion at the lip, gum or soft palate, and sixteen cases complained of a sore throat within 24 hours postoperatively.

DISCUSSION

Several alternative airway management devices have increased in popularity as primary devices for obese patients undergoing surgery in our institution because those devices offer a better glottic visualization than conventional direct laryngoscopy. Among these tools, videolaryngoscopy is now considered by many anesthesiologists as their first choice for intubation technique. Nevertheless, Paolini and colleagues

TABLE 3. The number of patients classified by the intubation difficulty scale (IDS) scores.

IDS scores	Number (%) (n = 200)	Degree of difficulty
0	95 (47.5)	Easy
1	62 (31)	Slight difficulty
2	21 (10.5)	Slight difficulty
3	16 (8)	Slight difficulty
4	3 (1.5)	Slight difficulty
5	2 (1)	Slight difficulty
12	1 (0.5)	Moderate to major difficulty

TABLE 4. Univariate analysis of factors associated with troublesome intubation.

Types	Patients with ideal intubation (n=95)	Patients with troublesome intubation (n=105)	p value	Crude OR (95%CI)
Inter-incisor gap (cm.)	5.13 ± 0.73	4.96 ± 0.72	0.108	0.73 (0.49,1.07)
Neck circumference (cm.)	37.87 ± 3.18	39.69 ± 4.05	0.001	1.15 (1.06,1.25)
Length of neck (cm.)	10.65 ± 1.73	10.93 ± 1.57	0.223	1.11 (0.94,1.32)
Hyomental distance (cm.)	4.82 ± 0.72	4.795 ± 0.81	0.826	0.96 (0.67,1.38)
Thyromental distance (cm.)	9.41 ± 1.03	9.54 ± 1.25	0.405	1.11 (0.87,1.42)
Sternomental distance (cm.)	15.9 ± 2.23	16.04 ± 2.33	0.565	1.04 (0.92,1.17)
Malformation of teeth	18 (50)	18 (50)	0.74	1.13 (0.55-2.33)
Upper lip bite test			0.26	
I	56 (48.7)	59 (51.3)		1
II	35 (50)	35 (50)		0.95 (0.52-1.72)
III	4 (26.7)	11 (73.3)		2.61 (0.79-8.68)
Modified Mallampati test			0.006	
I	29 (64.4)	16 (35.6)		1
II	28 (45.9)	33 (54.1)		2.14 (0.97-4.71)
III	15 (29.4)	36 (70.6)		4.35 (1.85-10.25)
IV	23 (53.5)	20 (46.5)		1.58 (0.67-3.71)
Limit neck movement				
Flexion	0	0		
Extension	3 (42.9)	4 (57.1)	0.802	2.61 (0.27-5.57)

proposed some potential drawbacks of the routine use of video-laryngoscopy in a recent review, identifying that safety in airway management depends on multiple factors, including clinical skills, efficient tools, planning and experience. Using video-laryngoscopes may provide a false sense of security, leading anesthesiologists to omit a basic airway examination.[13] In addition, as these devices are expensive, they cannot be provided to all hospital levels. In addition, data has not proved the cost-effectiveness and safety of using sophisticated devices for first-line airway management.

Preoperative airway assessment is important in the detection of patients at risk of difficult airway management. Shiga and colleagues reported

TABLE 5. Multiple logistic regression of factors associated with troublesome intubation.

Types	b	SE (b)	p value	Adjusted OR (95%CI)
Inter-incisor gap (cm.)	-0.506	0.232	0.029	0.60 (0.38,0.95)
Neck circumference (cm.)	0.143	0.044	0.001	1.15 (1.06,1.26)
Length of neck (cm.)	0.127	0.097	0.190	1.14 (0.94,1.37)
Upper lip bite test				
II	-0.514	0.353	0.145	0.60 (0.30,1.20)
III	0.410	0.659	0.534	1.51 (0.41,5.48)
Modified Mallampati test				
II	0.825	0.428	0.054	2.28 (0.99,5.28)
III	1.308	0.460	0.004	3.70 (1.50,9.10)
IV	0.209	0.462	0.650	1.23 (0.50,3.05)

a meta-analysis of 50,760 patients enrolled from 35 studies. Four types of tests, namely, the Mallampati classification, the thyromental distance, the sternomental distance and the inter-incisor gap, were commonly used to predict difficult intubation. However, each test yielded poor to moderate pooled sensitivity (22-62%), but good pooled specificity (82-97%).[14] One concern arising from the interpretation of these tests was how good the inter-observer reliability was. It was still uncertain whether true prediction was possible. Since tests with low reliability estimates were not valid, the results would have unreliable predictive value. We confirmed the reliability of each test by describing the tests adequately and training the raters in the same technique, utilising an expert to ensure favorable results.

Our study demonstrated that around a half of the obese patients experienced troublesome intubation during conventional endotracheal intubation. Independent risk factors for unfavorable conditions were the modified Mallampati test, the neck circumference and the inter-incisor gap. The Mallampati classification, first described by Mallampati et al, has become the most well known and the most common diagnostic test for predicting difficult intubation since 1985.[15] The scoring system was subsequently revised by Samsoon and Young.[16] Patients were assessed while they sat with their head in a neutral position, with their tongue maximally protruded without phonation. The test was useful in obese patients, who usually had a big and a large base of tongue in relation to the oral cavity. The test may possibly indicate whether displacement of the tongue by the laryngoscope blade is likely to be easy or difficult. Similar to previous studies, a high Mallampati score was an independent risk factor for difficult airway management.[5,6]

The neck circumference was a screening measurement which could identify patients who were overweight or obese. Men with a neck circumference ≥ 39.5 cm and women with a neck circumference ≥ 36.5 cm were correlated with obesity, in a report from Israel.[17] A large amount of neck soft tissue caused difficulty in airway management. In a study by Gonzalez et al, a neck circumference > 43 cm was associated with difficult intubation (IDS > 5) in obese patients.[7]

The inter-incisor gap was the maximal distance between the upper and lower incisors or gingival, measured while the patients sat in a neutral position. Previous literature did not demonstrate a relationship between a short inter-incisor gap and difficult airway management among obese patients. Krobbuaban and colleagues reported an optimal cut-point of inter-incisor gap for predicting difficult laryngoscopy among general Thai patients. The cut-point of the gap < 3.5 cm revealed 39% sensitivity and 69% specificity. Nevertheless, the inter-incisor gap was not identified as an independent factor for difficult airway management in their study.[18]

There are several limitations to this study. First, we could not demonstrate an optimal cut-point which had good sensitivity and specificity to identify patients with troublesome intubation. This may be because the sample size was not large enough to evaluate the diagnostic performance of each test. A further study should be conducted to specify the appropriate cut-point for predicting difficult airway management. Additionally, compared with the incidence in other papers, the incidence of difficult intubation that occurred in our study was very low (only 0.5%). It is possible that obesity in different ethnic groups results in different anatomic features of the airway.

In conclusion, alternative airway tools should be the first line of airway management or they should be available for added vigilance in the case of patients with possible risk factors for troublesome endotracheal intubation. The three independent risk factors for unfavorable conditions were a high modified Mallampati test, a large neck circumference, and a short inter-incisor gap.

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Conflicts of interest:

The principal investigator and co-investigators do not have a financial relationship with a commercial entity that has an interest in the subject of this manuscript.

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