

The Performance of the Neck Circumference for a Difficult Laryngoscopy in Obese Patients

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Background and Objective: There is conflicting evidence as to whether neck circumference (NC) is related to a difficult laryngoscopy in obese patients. The objectives of this study were to determine the performance of the NC in defining a difficult laryngoscopy, and to identify factors predicting a difficult laryngoscopy among those obese patients.

Material and Method: This prospective study was conducted in adult patients with a body mass index (BMI) of greater or equal to 30 kg/m² who underwent conventional endotracheal intubation. Preoperative NC, the modified Mallampati test (MMT), the thyromental distance (TM) and the sternomental distance (SM) were measured. A difficult laryngoscopy was defined as a Cormack-Lehane laryngoscopic view of grade III or IV.

Results: Five hundred patients (366 females; 134 males), with a mean BMI of 34.3±4.6 kg/m² (minimum = 30.0 kg/m², and maximum = 68.4 kg/m²) and who had elective surgery planned, were enrolled. The incidence of a difficult laryngoscopy was 7.2%. The overall performance of the NC using the area under the receiver operating characteristic curves of a difficult laryngoscopy was 0.574, with a 95% confidence interval (CI) of 0.53 to 0.618. The optimal cutoff point of the NC for a difficult laryngoscopy was 37.1 centimeters. It provided sensitivity and specificity of 75.5% (95% CI 57.8, 87.9) and 42.5% (95% CI 37.9, 47.2). The positive and negative predictive values were 9.2% and 95.6%. After multivariate analysis, factors affecting a difficult laryngoscopy were high grades of MMT (odds ratio (OR) 2.23, 95% CI 1.10, 4.50) and NC/TM (OR 1.78, 95% CI 1.15, 2.74).

Conclusion: The NC per se was not a good predictor of a difficult laryngoscopy. However, the ratio of the NC to the TM and the MMT were factors predicting a difficult laryngoscopy in obese patients.

Keywords: Obesity, Difficult intubation, Clinical prediction, Neck circumference

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Obesity has long been alleged to be a risk factor for difficult airway management even though most obese patients do not have apparently abnormal airway characteristics. The increased amount of fat deposition anterior to the laryngopharyngeal air space may impair the mobility of the pharyngeal structure, and the fat could, therefore, cause a collapse of the airway during general anesthesia⁽¹⁾. Both of these changes may be important risk factors for a difficult laryngoscopy in these obese patients. The quantification of neck tissue can be determined by imaging techniques, including X-rays, computed tomography (CT) scans and magnetic resonance

imaging (MRI), or performing ultrasonography⁽²⁾. However, all of those investigations are costly and need excessive time and expertise. Therefore, it is not practical to perform them in all pre-operative airway assessment in clinical practice.

The neck circumference (NC) is a useful tool for predicting metabolic syndrome. Men with an NC of 39 centimeters (cm) or greater, and women with an NC of 33 cm or greater, are at risk of establishing hypertension, diabetes mellitus, dyslipidemia and central obesity⁽³⁾. Apart from the routine bedside tests, which are the modified Mallampati test (MMT), the thyromental distance (TM) and the sternomental distance (SM), the NC has been proposed to be a new predictor of a difficult intubation in obese patients for a decade⁽⁴⁾. The perceived advantage of employing the NC is that this method of measurement is easy and reliable. The test does not depend on patients' cooperation, and the results do not differ when the

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patients feel exhausted after repeated measurements. The intraclass correlation coefficient between researchers is very high compared to other tests⁽⁵⁾. Nevertheless, there have been conflicting results for the predictive ability of the NC for a difficult intubation in obese patients^(6,7). Therefore, we conducted this study for two objectives: firstly, to determine the performance of the NC to define a difficult laryngoscopy, and secondly, to identify factors predicting a difficult laryngoscopy among those obese patients.

Material and Method

This study was part of a multi-center study. The presented study was approved by the Institutional Review Board (IRB), and informed consents were obtained from all participants. Inclusion criteria were obese adult patients aged 18 or more with a body mass index (BMI) of 30 kg/m² or greater, and scheduled to undergo general anesthesia with endotracheal intubation for elective surgery. If the patients had any one of the following exclusion criteria, they were excluded: patient refusal, patients with obvious malformations or pathology of the upper airway, cervical spine fracture, pregnancy, and history of difficult airway management (specifically, intubation by a special technique such as awake fiberoptic intubation or video laryngoscope).

Airway assessment tests

Pre-operative airway assessments, including the NC, the MMT, the TM and the SM, were evaluated by a group of well-trained research assistants on the day before surgery. The MMT was assessed while a patient sat upright with the head in a neutral position. The patient was asked to open his or her mouth as wide as possible, and to protrude the tongue to the maximum without phonation. The NC was measured at the level of the cricoid cartilage, perpendicular to the long axis of the neck. The TM and the SM were measured in the seated position, with the head fully extended and the mouth closed. The straight line between the thyroid notch and the bony point of the mentum (the TM), and the straight distance between the upper border of the manubrium sterni and the bony point of the mentum (the SM) were measured by using a ruler.

Anesthetic protocol

Standard monitors, including an electrocardiogram, a pulse oximetry and a non-invasive arterial

blood pressure monitor, were utilized before the anesthetic induction period. Preoxygenation was conducted by administering 100% oxygen via a facemask for more than three minutes. The endotracheal intubations were performed by an experienced anesthetist who had worked in the operating theater for at least two years. An independent, in-charge anesthesiologist monitored patients' status and made decisions during the intraoperative period, including the patients' positions, the choice of anesthetics, the types of laryngoscope blades as well as the management of any unanticipated difficult-airway events.

Definition of the outcome criteria

A difficult laryngoscopy was defined as grade III or IV of the Cormack-Lehane laryngoscopic view. The Cormack-Lehane laryngoscopic view was classified into four grades as follows: grade I view: the vocal cords were completely visible; grade II: only the arytenoids were visible; grade III: only the epiglottis was visible; and grade IV: the epiglottis was not visible. The invisible laryngeal inlet might be associated with a difficult intubation⁽⁸⁾.

Statistical analysis

The sample size calculation was based on an expected the NC's ability to classify correctly a patient as having a Cormack-Lehane laryngoscopic view either of grade III or IV, or of grade I or II. A prospective power analysis was performed to determine the number of cases with a Cormack-Lehane laryngoscopic view of grade III or IV that would be required. This showed that a sample size of 35 patients with a Cormack-Lehane laryngoscopic view of grade III or IV would yield an anticipated sensitivity and specificity of 90% with 10% range of 95% CI (two-tailed). The expected prevalence of difficult intubations in obese patients arose from previous literature, which was reported as 13.8%⁽⁹⁾. Hence, the total number of obese subjects required was at least 250.

The statistical analysis was conducted using a software program, SPSS version 18.0, SPSS Inc., Chicago, IL, USA. Descriptive statistics were used to examine the patients' characteristics and airway assessment tests. A receiver-operating characteristic (ROC) curve was plotted to represent the overall accuracy and the optimal cutoff point of the NC for identifying of a difficult laryngoscopy. The performances of the NC test were summarized by the sensitivity, specificity, positive predictive value (PPV),

negative predictive value (NPV) and likelihood ratios. As for identifying factors predicting a difficult laryngoscopy, the BMI and four, airway-assessment tests were compared using Chi-square or Fisher's exact test for non-continuous variables, and two-tailed student's t test for continuous variables. Subsequently, variables with $p < 0.2$, or clinical meaningful variables, were entered into a multiple logistic regression analysis of patients with a difficult laryngoscopy. The non-continuous data were presented as number of occurrences and percentage, while the continuous data were presented as mean \pm standard deviation (SD). The crude odds ratio, the adjusted odds ratio and the 95% CI were reported to consider the strength of association between the types of airway assessment tests and the patients with a difficult laryngoscopy. The statistical significance was defined as a p -value of smaller than 0.05.

Results

A prospective observational study was conducted at a tertiary university-based hospital, during the 18-month period from 1 March 2013 to 30 September 2014. Five hundred obese patients (366 females; 134 males), with a mean BMI of 34.3 ± 4.6 kg/m² (minimum = 30.0 kg/m²; maximum = 68.4 kg/m²) and for whom planned elective surgery was undertaken, were recruited to fulfill the study termination criterion of having at least 35 patients with a difficult laryngoscopy. Other demographic data and pre-operative assessment tests of the patients are shown at Table 1.

In the operating theatre, most patients were placed in a sniffing position (91%), and most direct laryngoscopies were successful performed by using a McIntosh laryngoscope blade number 3 (85.8%). General anesthesia was mostly induced by propofol (96.6%), and patients were intubated by administering non-depolarizing muscle relaxants (75.2%) or succinylcholine (24.8%). The distributions of the percentages of the Cormack-Lehane laryngoscopic views were 61.6%, 31.2%, 6.0% and 1.2% for views I, II, III and IV, respectively. Overall, the incidence of a difficult laryngoscopy then was equal to 7.2% (36 out of 500 patients). No failed intubation was reported in this study.

The overall performance of the NC using the area under the receiver operating characteristic curves of a difficult laryngoscopy was 0.574, with a 95% confidence interval (CI) of 0.53 to 0.618 (Fig. 1). The optimal cutoff point of the NC for a difficult

Table 1. Demographic data and preoperative airway assessment tests

Variables	Mean \pm SD or number (%)
Age (years)	51.1 \pm 14.4
Gender	
Female	366 (73.2)
Male	134 (26.8)
ASA classification: II, III	435 (87.0), 65 (13.0)
Department	
General surgery	106 (21.2)
Head-neck-breast	96 (19.2)
ENT, Eye	65 (13.0), 27 (5.4)
Gynecology	64 (12.8)
Orthopedics	63 (12.6)
Neurology	33 (6.6)
Others	46 (9.2)
Comorbidities	
None	145 (29)
Hypertension	229 (45.8)
Diabetic mellitus	109 (21.8)
Obstructive sleep apnea	21 (4.2)
Body mass index (kg/m ²)	34.3 \pm 4.6
Modified Mallampati test	
Class I, II	114 (22.8), 171 (34.2)
Class III, IV	124 (24.8), 91 (18.2)
Neck circumference (cm)	38.9 \pm 3.8
Thyromental distance (cm)	9.0 \pm 1.2
Sternomental distance (cm)	16.1 \pm 2.0

ASA = The American society of anesthesiologists; ENT = ear, nose and throat; SD = standard deviation

laryngoscopy was 37.1 cm. It provided sensitivity and specificity of 75.5% (95% CI 57.8, 87.9) and 42.5% (95% CI 37.9, 47.2). The positive and negative predictive values were 9.2% and 95.6% (Table 2). As for factors predicting a difficult laryngoscopy, five physical examinations were included in univariate analysis. In order to avoid the multicollinearity problem, only three independent factors were entered into a multiple logistic regression model (Table 3). Two factors were found to be related to a difficult laryngoscopy: high grades of MMT (odds ratio (OR) 2.23, 95% CI 1.10, 4.50) and the NC/TM (OR 1.78, 95% CI 1.15, 2.74).

Discussion

The scheme of glottic views developed by Cormack and Lehane⁽⁷⁾ has become a standard measurement, and it facilitates communication between clinicians and researchers. A number of definitions of a difficult airway sometimes refer to a high-grade

laryngeal view, even though it does not always lead to a difficult intubation. As shown in both a study by Arne et al and in our study, many of the patients with Cormack-Lehane grade III and IV views were not associated with the occurrence of a difficult or a failed intubation⁽¹⁰⁾. Nevertheless, the possibility of there being a difficult laryngoscopy in obese patients should be considered. Comparing to a previous study conducted in Thailand, the incidence of a difficult laryngoscopy in obese patients was higher than in the general population⁽¹¹⁾. Failure to see the glottis by line of sight may result in troublesome management, the need to change airway equipment, or a long intubation

time⁽¹²⁾. Since the patients have a number of physiologic alterations, such as decreased functional residual capacity, decreased chest wall compliance and increased oxygen consumption⁽¹³⁾, the awkward situation may lead to adverse perioperative events.

There is ongoing research to identify a single, routine, airway-assessment test to predict the occurrence of a difficult airway. Shiga et al reported common bedside tests for the prediction of a difficult intubation, including the Mallampati classification, the inter-incisor gap, the TM and the SM. However, each test yielded poor to moderate pooled sensitivity⁽¹⁴⁾. The NC has been an attractive screening test for predicting a difficult laryngoscopy in obese patients as it is simple and reasonable. Gonzalez et al demonstrated that an NC of more than 43 cm was a good predictor for a difficult intubation, with a sensitivity of 92%⁽⁶⁾. Brodsky et al also showed that the probability of a problematic intubation increased 5% if the NC was at 40 cm, and the probability was 35% when the NC was at 60 cm⁽⁴⁾. Compared with our study, the optimal cutoff point of the NC for a difficult laryngoscopy was only 37.1 cm, with the area under the receiver operating characteristic curves of 0.574 (95% CI 0.53, 0.618). The poor predictive value of the NC in our study could be explained by different ethnics. Europeans tend to have a larger body composition than Asians.

Three independent factors were entered into a multiple logistic regression model. The variables were chosen based on previous reports and concerns about having a sufficient number of events per variable⁽¹⁵⁾. Weight-for-height indices have long been used to indicate the amount of body fat accumulation. The relationship between different cutoff points of the BMI and the risk of comorbidities has been demonstrated in several studies^(3,16). However, the BMI

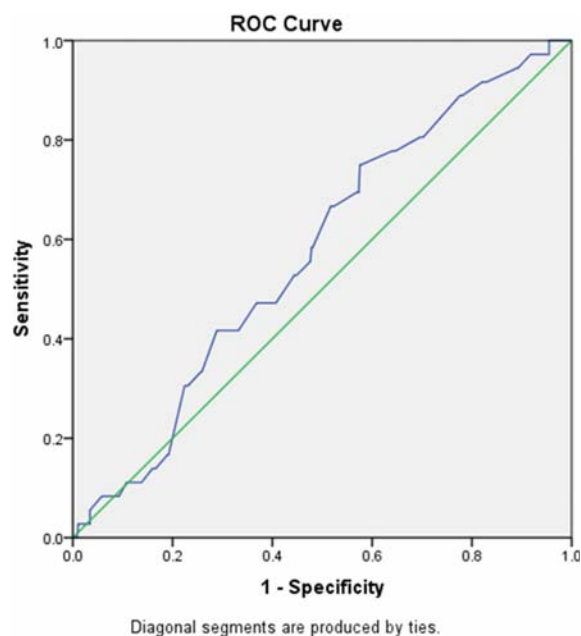


Fig. 1 Receiving Operating Characteristic (ROC) curve of the neck circumference among obese patients.

Table 2. The performance of the neck circumference based on ROC curve analysis

NC (cm)	sensitivity	specificity	PPV	NPV	LR+	LR-
35	0.94	0.11	0.08	0.96	1.06	0.51
36	0.89	0.22	0.08	0.96	1.15	0.50
37	0.78	0.36	0.09	0.95	1.22	0.62
37.1	0.75	0.42	0.09	0.96	1.30	0.59
38	0.67	0.48	0.09	0.95	1.29	0.69
39	0.53	0.56	0.08	0.94	1.19	0.85
40	0.47	0.63	0.09	0.94	1.28	0.84

cm = centimeters; PPV = positive predictive value; NPV = negative predictive value; LR+ = positive likelihood ratio; LR- = negative likelihood ratio

Table 3. Factors associated with difficult laryngoscopy

Factors	Mean \pm SD or number (%)		Crude OR (95% CI)	<i>p</i> -value ¹	Adjusted OR (95% CI)	<i>p</i> -value ²
	LV I-II (n = 464)	LV III-IV (n = 36)				
BMI (kg/m ²)						
<35	314 (62.8)	28 (5.6)	1	0.2	-	
\geq 35	150 (30)	8 (1.6)	0.60 (0.27, 1.34)	-	0.54 (0.24, 1.22)	0.14
MMT						
Class I, II	271 (54.2)	14 (2.8)	1	0.02		
Class III, IV	193 (38.6)	22 (4.4)	2.20 (1.10, 4.42)	-	2.23 (1.10, 4.50)	0.03
NC (cm)	38.8 \pm 3.8	39.6 \pm 3.5	-	0.19	-	
TM (cm)	9.0 \pm 1.2	8.5 \pm 1.1	-	0.02	-	
SM (cm)	16.2 \pm 2.1	15.5 \pm 1.6	-	0.04	-	
NC/TM	4.4 \pm 0.7	4.7 \pm 0.7	1.77 (1.16, 2.70)	0.01	1.78 (1.15, 2.74)	0.01

BMI = body mass index; MMT = modified Mallampati test; NC = neck circumference; TM = thyromental distance; SM = Sternomental distance; NC/TM = the ratio of neck circumference to thyromental distance; LV = Cormack-Lehane laryngoscopic view; cm = centimeters; SD = standard deviation.

p-value¹ came from univariate analysis, *p*-value² came from multiple logistic regression analysis

cutoff point which refers to morbid obesity did not reflect fat distributions. We could not assume that a high BMI would correlate with an increase in adipose tissue deposits in the head and neck region. As a result, the BMI was not a good predictor of a difficult laryngoscopy in obese Thai patients.

Two significant factors affecting a difficult laryngoscopy were high grades of MMT and the ratio of the NC to the TM. The MMT seemed to be useful in general patients as well as in obese patients⁽¹¹⁾. The insertion of the McIntosh laryngoscope blade requires either the compression or the retraction of the base of the tongue anteriorly to reveal the larynx. A high grade MMT may indicate that a large tongue, having occupied most of the area in the oral cavity, had obscured visualization of the laryngeal structure. Kim et al proposed a new index that assumed a difficult intubation would occur in obese patients who had a big or a short neck. The NC/TM might represent the distribution of fat in the neck better than the NC alone⁽⁹⁾. According to the result of Kim's study, we may conclude that the NC/TM was a good predictor for predicting a difficult laryngoscopy and a difficult intubation among Asians.

This study had some limitation. First, we could not establish what were the authentic causes of the difficult laryngoscopies among these obese patients. In addition, we did not collect other details of anthropometric measurement. Further studies should

try to enroll patients who had a fat distribution predominately at their head and neck area instead of enrolling all obese patients diagnosed with a BMI above a high cutoff point.

In conclusion, our results demonstrated that the NC did not properly predict a difficult laryngoscopy among obese patients. Instead, the difficulty was independently associated with high grades of MMT and large and short necks, which were represented by the ratio of the NC to the TM.

What is already known on this topic?

The neck circumference (NC) has been proposed to be a new predictor of a difficult intubation in obese Europeans. A problematic intubation increased if the neck circumference was at 40 cm, and the probability was 35% when the circumference was at 60 cm.

What this study adds?

The NC alone was not a good bedside test for predicting a difficult laryngoscopy, but the combination of NC and TM, and the MMT were factors predicting a difficult laryngoscopy among obese Thai patients.

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Potential conflicts of interest

None.

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ความสามารถในการทำนายภาวะ difficult laryngoscopy โดยใช้เส้นรอบคอในผู้ป่วยที่มีภาวะอ้วน

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วัตถุประสงค์: ในปัจจุบันยังไม่มีข้อมูลที่ระบุแน่ชัดว่าเส้นรอบคอของผู้ป่วยที่มีภาวะอ้วนมีความสัมพันธ์กับภาวะ difficult laryngoscopy หรือไม่ การศึกษานี้จึงมีวัตถุประสงค์เพื่อศึกษาความสามารถในการทำนายภาวะ difficult laryngoscopy ของเส้นรอบคอ และหาปัจจัยอื่นที่ใช้ทำนายภาวะ difficult laryngoscopy ในผู้ป่วยอ้วน

วัสดุและวิธีการ: การศึกษานี้เป็นการศึกษาไปข้างหน้าทำการศึกษาในผู้ป่วยอายุมากกว่า 18 ปีที่มีดัชนีมวลกายมากกว่าหรือเท่ากับ 30 กิโลกรัมต่อตารางเมตรที่ได้รับการผ่าตัดภายใต้การระงับความรู้สึกทั่วตัวและใส่ท่อหายใจ ผู้ป่วยจะได้รับการตรวจวัดค่าเส้นรอบคอการตรวจ modified Mallampati test (MMT) ระยะความยาวของ thyromental และ sternomental ค่าจำกัดความของภาวะ difficult laryngoscopy คือ Cormack-Lehane laryngoscopic view grade III-IV

ผลการศึกษา: มีผู้ป่วย 500 คนที่มาผ่าตัดแบบไม่เร่งด่วนเข้ารวมการศึกษาเป็นเพศหญิง 366 คน และเพศชาย 134 คนมีค่าดัชนีมวลกายเฉลี่ย 34.3 ± 4.6 กิโลกรัมต่อตารางเมตร (ค่าต่ำสุดคือ 30.0 กิโลกรัมต่อตารางเมตรและค่าสูงสุดคือ 68.4 กิโลกรัมต่อตารางเมตร) อุบัติการณ์ของภาวะ difficult laryngoscopy เกิดขึ้นร้อยละ 7.2 ความสามารถในการทำนายภาวะ difficult laryngoscopy จากพื้นที่ใต้กราฟ receiver operating characteristics คือ 0.574 โดยมีช่วงความเชื่อมั่น 95% confidence interval (CI) ที่ 0.53 ถึง 0.618 ค่าเส้นรอบคอที่เหมาะสมที่สุดที่ใช้ในการทำนายภาวะ difficult laryngoscopy คือ 37.1 เซนติเมตรซึ่งให้ค่าความไวร้อยละ 75.5 (95% CI 57.8, 87.9) ความจำเพาะร้อยละ 42.5 (95% CI 37.9, 47.2) ค่า positive และ negative predictive value ร้อยละ 9.2 และ 95.6 ตามลำดับสำหรับปัจจัยที่มีผลต่อภาวะ difficult laryngoscopy ได้แก่ MMT grade III-IV และค่าสัดส่วนเส้นรอบคอต่อระยะ thyromental

สรุป: เส้นรอบคอของผู้ป่วยเพียงอย่างเดียววันนั้นไม่สามารถใช้เป็นปัจจัยในการทำนายภาวะ difficult laryngoscopy ที่แม่นยำอย่างไรก็ตามผลการศึกษาพบว่า MMT และค่าสัดส่วนเส้นรอบคอต่อระยะ thyromental สามารถใช้ในการทำนายภาวะ difficult laryngoscopy ในผู้ป่วยที่อ้วนได้
