Original Article

Evaluation of thyromental height test in prediction of difficult airway in obese surgical patients: An observational study

Address for correspondence: Abeer M. Ahmed, 01 El Sarayah Street, El Manyal, Cairo - 11559, Egypt. E-mail: abeer_ahmed@kasralainy.edu.eg

Submitted: 20-Jul-2021
Revised: 20-Oct-2021
Accepted: 05-Dec-2021
Published: 22-Dec-2021

Access this article online

Website: www.ijaweb.org

DOI: 10.4103/ija.ija_675_21

Quick response code

Abeer M. Ahmed, Monica N. Zaky, Nevan M. El-Mekawy, Mohamed A. Ollaek, Wael M. Sami, Dina M. Mohamed

Department of Anaesthesiology, Surgical ICU and Pain Management, Kasr Alainy Faculty of Medicine, Cairo University, Egypt

ABSTRACT

Background and Aims: Thyromental height test (TMHT) has revealed good potentials for predicting difficult laryngoscopy view (DLV) in non-obese patients, but its accuracy in obese patients is not evident. This study aimed to assess the validity of TMHT as a predictor of DLV in obese surgical patients. **Methods**: 105 patients, aged 18–60 years, with body mass index (BMI) >30 kg/m^2, scheduled for elective surgeries under general anaesthesia with an endotracheal tube inserted using conventional laryngoscope were included. Airway was assessed with TMHT, modified Mallampati test (MMT), neck circumference (NC) and NC/TMHT ratio. The DLV was defined as Cormack–Lehane grade ≥3. The primary endpoint was the validity of TMHT as a predictor of DLV. The secondary endpoints were to compare the accuracy of TMHT with that of the NC, MMT and NC/TMHT ratio as predictors of the difficult airway. **Results**: The BMI was 43.7 ± 6.6 kg/m^2. The DLV cases were 23/105 (21.9%). The MMT, TMHT and NC/TMHT ratio had the best predictive ability of DLV with areas under receiver operating characteristic curve of 0.91, 0.92 and 0.80; at cut-off values >2, <47 mm and >7.9, respectively. MMT and TMHT were the only predictors of DLV by multivariate analysis. **Conclusion**: In obese surgical patients, TMHT is an excellent predictor of DLV when the cut-off value is <47 mm.

Key words: Difficult intubation, difficult laryngoscopy, modified Mallampati, neck circumference, obesity, thyromental height

INTRODUCTION

Difficult airway remains a fundamental cause of anaesthesia-related perioperative morbidity and mortality.[1] Increased body mass index (BMI) is associated with difficult airway in intensive care and operating room settings, with an incidence of 15.8% when BMI exceeds 30 kg/m^2.[2]

Obesity definition requires a BMI >30 kg/m^2.[3] The redundant neck soft tissue, impaired neck mobility, and large chest and breasts render airway management difficult.[2] Obesity increases the risk of passive collapsibility of the upper airway with the loss of consciousness and decreases the functional residual capacity; both expose patients to rapid desaturation during periods of apnoea.[4]

Thyromental height test (TMHT) was first described in 2013 as a new bedside test for difficult laryngoscopy. It measures the height between the anterior border of the mentum and thyroid cartilage. TMHT can act as a surrogate for the amount of mandibular protrusion, dimensions of submandibular space and anterior position of the larynx.[5] Previous studies concluded that TMHT appears as a promising single anatomical

How to cite this article: Ahmed AM, Zaky MN, El-Mekawy NM, Ollaek MA, Sami WM, Mohamed DM. Evaluation of thyromental height test in prediction of difficult airway in obese surgical patients: An observational study. Indian J Anaesth 2021;65:880-5.

measure to predict the risk of difficult laryngoscopy view (DLV).[5,6]

To the best of our knowledge, no previous studies have assessed the performance of TMHT for predicting the difficult airway in obese patients. Therefore, this study hypothesised that TMHT does not predict difficult airway in obese patients undergoing general anaesthesia (GA). Our primary outcome was the validity of the TMHT as a predictor of DLV, and the secondary outcome was to compare the accuracy of TMHT with that of neck circumference (NC), modified Mallampati test (MMT) and NC/TMHT ratio as predictors of the difficult airway (both DLV and difficult intubation [DI]) in obese surgical patients.

METHODS

This observational study was conducted in Cairo University hospitals, from January 2020 till January 2021, after approval by the institutional research ethics committee. The study was registered on ClinicalTrials.gov (NCT04212156) before the enrolment of the patients. Written informed consent was obtained from all patients. The Standards for Reporting of Diagnostic accuracy studies (STARD) guidelines were followed.

One hundred and five patients, aged 18–60 years, of American Society of Anesthesiologists (ASA) physical status II and III with BMI >30 kg/m^2 who were scheduled for elective surgeries under GA with an endotracheal tube (ETT) inserted using a conventional laryngoscope were included. Patients with neuromuscular disorders, craniofacial abnormalities, uncooperative and who needed awake intubation were excluded**.** The airway assessment was performed preoperatively by a research team member who was not involved in the endotracheal intubation and assessment of the laryngeal view. The following tests were accomplished; TMHT was measured while the patient was lying supine in a 'ramped' position; this position was maintained during intubation,[7] using a digital depth gauge (INSIZE, China). The TMHT was the vertical distance measured between the anterior border of the thyroid cartilage directly on the thyroid notch and the anterior border of the mentum.[5] NC was measured using a tape at the level of the cricoid cartilage while the patient was in the same position.[8] MMT was assessed while the patient was seated in a neutral position.[9] During the statistical analysis, NC/TMHT ratio was calculated.

Patients were monitored using non-invasive blood pressure, pulse oximeter, and electrocardiograph. Patients were pre-oxygenated with 100% oxygen for 3 min; anaesthesia was induced intravenously using fentanyl 1 μg/kg, propofol 1.5–2 mg/kg and succinylcholine 1–1.5 mg/kg lean body weight. Mask ventilation was maintained until fasciculations disappeared, and a constant diminish in the train-of-four appeared on the peripheral nerve stimulator. Using a Macintosh laryngoscope, an anaesthesiologist with 10 years of experience determined the best laryngeal view using Cormack–Lehane (CL) grading system from I–IV (grade I: full view of the glottis; grade II: glottis partly exposed, anterior commissure not seen; grade III: only epiglottis seen; grade IV: epiglottis not seen).[10] Grades I and II were categorised as easy laryngoscopy, and grades III and IV as difficult laryngoscopy. External neck manipulation was used to obtain the best view. Difficult tracheal intubation was defined as the requirement of more than two attempts or more than 10 min for proper insertion of the ETT using conventional laryngoscopy, while failed tracheal intubation was defined as failed conventional intubation after more than three intubation attempts and 10 min passed or by using an alternative technique to secure the airway.[11]

Our primary outcomes were the accuracy, sensitivity, specificity, positive and negative predictive values (PPV and NPV), and a cut-off value of the TMHT as a predictor of DLV in obese patients. The secondary outcomes were to assess the accuracy of the TMHT as a predictor of DI in obese patients and compare these values with those of the NC, MMT and NC/TMHT ratio in the prediction of both DLV and DI.

The sample size was calculated using MedCalc software to detect an area under the receiver operating characteristic (AUROC) curve of 0.75 with a null hypothesis AUROC of 0.5. We considered that the DLV rate in obese patients would be 17%[12]; we calculated a minimum number of 100 patients (with at least 17 DL cases) for a study power of 90% and an alpha error of 0.05. The number was increased to 105 for possible dropouts. Statistical analysis was performed using the statistical package for the social science (SPSS) program, version 23 (Chicago, IL, USA). Quantitative normally distributed data were expressed as mean and standard deviation or median and range. Qualitative categorical data were expressed as a ratio. The normality of data distribution was assessed using the Kolmogorov–Smirnov test and the Shapiro–Wilk test. Normally distributed data were compared using Student's t-test, while non-normally distributed data were compared using the Mann-Whitney test or the Kruskal-Wallis test as appropriate. A P value < 0.05 was considered statistically significant. MedCalc software was used to construct the receiver operating characteristic (ROC) curve. For this purpose, binary variables were created as easy versus difficult laryngoscopy and easy versus difficult intubation. The AUROC curve was used to calculate the ideal cut-off point for BMI, MMT, TMHT, NC and NC/TMHT ratio using the Youden index. The sensitivity, specificity, PPV and NPV were all calculated. A multivariate regression analysis was used to evaluate age, BMI, MMT, TMHT and NC as predictors of the difficult airway; variables with P value < 0.05 were considered statistically significant.

RESULTS

A total of 105 patients (82 females and 23 males) who met our inclusion criteria were enroled and completed the study. Their mean age was 38.3 ± 11 years, and BMI 43.7 ± 6.6 kg/m^2 with ASA physical status classification II/III as 84/21. The cases that encountered DLV were 23 of 105 (21.9%), while the cases that encountered DI were 8 of 105 (7.6%). There were no cases of failed intubation.

Patients were divided according to their laryngoscopic view into easy laryngoscopy ($n = 82$) and difficult laryngoscopy ($n = 23$) groups. The difficult laryngoscopy group revealed a significantly higher MMT, shorter TMHT, larger NC and higher NC/TMHT ratio, while the BMI was comparable in both groups [Table 1]. Patients were then divided according to the intubation conditions into easy intubation ($n = 97$) and difficult intubation ($n = 8$) groups. Again, the difficult intubation group revealed a significantly higher BMI and MMT, shorter TMHT and higher NC/TMHT ratio, while both groups were comparable regarding the NC [Table 1].

The BMI, MMT, TMHT, NC and NC/TMHT ratio were used to construct the ROC curve to assess their ability to predict cases with DLV [Figure 1-a]. The best predictive ability of DLV was found with the MMT, TMHT and NC/TMHT ratio. The AUROC curve for the MMT, TMHT and NC/TMHT ratio was 0.91, 0.92 and 0.80; at cut-off values >2, <47 mm and >7.9, respectively [Table 2].

Another ROC curve was constructed using the same parameters to assess their ability to predict DI [Figure 1-b, Table 3]. MMT, TMHT and NC/TMHT ratio revealed a good ability to predict cases with DI with an AUROC of 0.87, 0.85 and 0.75 at cut-off values of >2, <47 mm and >9, respectively.

The good ability of both MMT and TMHT in predicting patients with suspected DLV and DI was confirmed by multivariate analysis, which revealed that the MMT and TMHT were the only predictors of DI, while only MMT could predict DI in obese surgical patients [Table 4].

DISCUSSION

In the current study that included obese patients who underwent elective surgeries under GA with the ETT inserted using direct laryngoscopy, the main findings were that the TMHT and MMT were excellent clinical predictors of DLV with an excellent ability to preclude DLV when the tests were negative. Although a large NC revealed a weak predictive value, NC/TMHT ratio provided a high predictive ability of DLV. An increased BMI did not predict DI.

In obese patients, excess fat deposition on the cervical structures leads to a small pharyngeal area and inadequate glottis exposure to direct laryngoscopes, which increases the prevalence of DLV and DI.[13,14] The magnetic resonance imaging of obese patients with obstructive sleep apnoea shows more fat deposition around the collapsible segments of the pharynx.[15] The

Table 1: Airway characteristics according to laryngoscopic view and intubation conditions

Airway measure	Laryngoscopic view			Intubation conditions		
	Easy n=82	Difficult n=23	P	Easy n=97	Difficult n=8	P
BMI (kg/m^2)	43.5±6.5	44.7±7.2	0.441	43.6±6.3	46.3±10.3	0.042
MMT (grade)	2 (1-3)	3 (2-4)	0.001	2 (1-4)	3 (2-4)	0.032
TMHT (mm)	58.2±8.9	44.1±6.1	0.0001	56.1±10	43.6±6.9	0.0001
NC (cm)	41.5±3.5	43.3±2.7	0.02	41.8±3.4	42.8±3.5	0.221
NC/TMHT ratio	7.7±1.5	9.5±1.4	0.0001	8±1.6	9.6±1.8	0.011

Data are expressed as mean±standard deviation (SD) or median (range). BMI - Body mass index, MMT - Modified Mallampati test, TMHT - Thyromental height test, NC - Neck circumference. P<0.05 is statistically significant

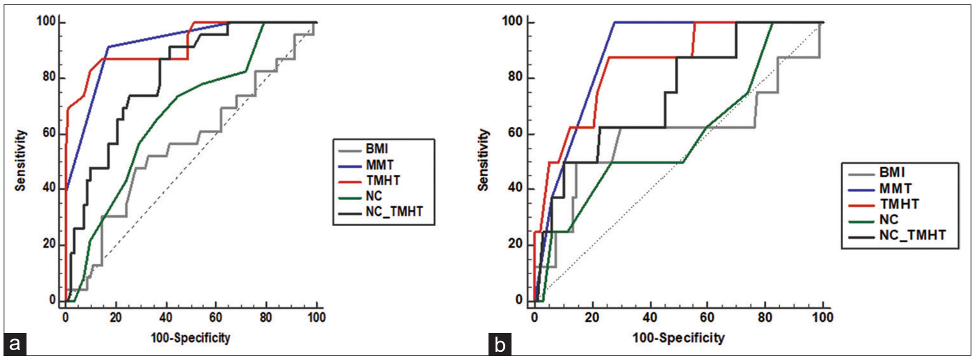

Figure 1: ROC Curves; Predictive ability of different airway measures for difficult laryngoscopy (a) and difficult intubation (b). Abbreviations: BMI - Body mass index, MMT - Modified Mallampati test, TMHT - Thyromental height test, NC - Neck circumference, NC-TMHT - Neck circumference to thyromental hight test ratio

Table 2: Predictive ability of BMI, MMT, TMHT NC, and NC/TMHT ratio for difficult laryngoscopy

	AUROC	95% CI	*P*	Sensitivity	Specificity	+v predictive	-ve predictive	Cut-off value
BMI	0.56	0.46-0.65	0.42	48%	72%	32%	83%	>46.8
MMT	0.91	0.85-0.96	0.0001	91%	83%	60%	97%	>2
TMHT	0.92	0.85-0.96	0.0001	83%	90%	70%	94%	<47
NC	0.67	0.57-0.75	0.005	74%	55%	33%	73%	>41
NC/TMHT	0.80	0.71-0.87	0.0001	91%	59%	38%	96%	>7.9

AUROC - Area under receiver operator curve, BMI - Body mass index (kg/m^2), MMT - Modified Mallampati test (grade), TMHT - Thyromental height test (mm), NC - Neck circumference (cm), CI - Confidence interval. *P*<0.05 is statistically significant

Table 3: Predictive ability of BMI, MMT, TMHT, NC and NC/TMHT ratio for difficult intubation

	AUROC	95% CI	*P*	Sensitivity	Specificity	+v predictive	-ve predictive	Cut-off value
BMI	0.60	0.49-0.69	0.5	50%	85%	22%	95%	>49
MMT	0.87	0.78-0.93	0.0001	99%	73%	58%	94%	>2
TMHT	0.85	0.77-0.91	0.0001	88%	74%	22%	97%	<47
NC	0.55	0.45-0.65	0.6	75%	51%	60%	94%	>41
TMHT/NC	0.75	0.65-0.82	0.007	63%	77%	19%	96%	>9

AUROC - Area under receiver operator curve, BMI - Body mass index (kg/m^2), MMT - Modified Mallampati test (Grade), TMHT - Thyromental height test (mm), NC - Neck circumference (cm), CI - Confidence interval. *P*<0.05 is statistically significant

Table 4: Multivariate analysis of age, BMI, MMT, TMHT and NC for prediction of difficult laryngoscopy and difficult intubation

Airway measure	Difficulty Laryngoscopy			Difficult Intubation		
	Odds ratio	95% CI	*P*	Odds ratio	95% CI	*P*
Age	1	0.91-1.09	0.961	1.01	0.94-1.07	0.878
BMI (kg/m^2)	0.78	0.77-1.01	0.252	1.05	0.91-1.19	0.551
MMT (class)	27.48	3.8-200.2	0.001	3.71	1.01-13.6	0.042
TMHT (mm)	0.78	0.66-0.93	0.005	0.88	0.75-1.04	0.122
NC (cm)	1.23	0.82-1.85	0.331	0.86	0.59-1.27	0.461

BMI - Body mass index (kg/m^2), MMT - Modified Mallampati test (Grade), TMHT - Thyromental height test, NC - Neck circumference, CI - Confidence interval. *P*<0.05 is statistically significant

ultrasound assessment of the neck soft tissue in obese patients reveals excessive pre-tracheal soft tissue at the vocal cords and suprasternal notch levels.[16] The abnormal fat distribution could influence airway measures involving neck structures resulting in different cut-off values with different predictive abilities compared to non-obese.

Several studies have assessed the validity of TMHT in predicting DLV [Table 5], but its accuracy is still a matter of debate. Most of these studies did not consider the influence of the increased BMI on the test's predictive ability or the cut-off value. Etezadi *et al*.[5] enroled 314 patients with a BMI of 25.8 ± 4.3 kg/m^2. The authors reported a high predictive ability of TMHT for DLV at a cut-off value <50 mm. Jain *et al*.[17] revealed a cut-off value similar to that in the original study,[5] for their study population whose BMI was 24.7 ± 2.7 kg/m^2. In 2018,[6] the validity of a cut-off value of 50 mm was tested in a study with 340 patients

Table 5: Predictive ability TMHT for DL in the current study compared to previous studies

The study	AUROC	Sensitivity	Specificity	PPV	NPV	Cut-off value
Our study.	0.92	83%	90%	70%	94%	< 47 mm
Etezadi *et al*.,[5] 2013	0.98	98%	82.6%	99.3%	98.6%	< 50 mm
Jain *et al*.,[17] 2017	0.95	75%	97%	73%	97%	< 50 mm
Selvi *et al*.,[18] 2017	0.72	91.9%	52.2%	14.7%	98.6%	< 50 mm
Rao *et al*.,[6] 2018	0.92	84.6%	98.9%	88%	98%	< 50 mm
Yabuki *et al*.,[19] 2018	0.68	50%	68%	1.5%	99%	≤ 50 mm
Yabuki *et al*.,[19] 2018	0.53	66.7%	53%	1.4%	99%	≤ 54 mm
Mostafa *et al*.,[20] 2019	0.85	73.3%	81.9%	36.7%	96.6	≤ 57 mm

AUROC- Area under the receiver operating characteristic curve, PPV - Positive predictive value, NPV - Negative predictive value

with a BMI of 23.4 ± 2 kg/m^2. The authors confirmed the superiority of TMHT over the MMT, thyromental distance (TMD) and sternomental distance (SMD) tests in predicting DLV. In our study and the previously mentioned studies,[5,17] DLV was defined as C-L grade III and IV, but Rao *et al*.[6] defined DLV as C-L grade IIb and above; this leads to an incidence of DLV (26/316) 8.2%. However, if they had defined the DLV as C-L grade III and IV, the incidence would have been lesser (3/316) 0.9%, and the TMHT accuracy would have differed.

The influence of increased body weight on the test's predictive ability and its cut-off value was evident in the current study. The study reported an excellent predictive ability of TMHT with an AUROC curve of 0.92 with high sensitivity and specificity (83% and 90%, respectively) at a cut-off value <47 mm. In another study,[18] the authors assessed the TMHT in 451 surgical patients. They reported sensitivity and specificity as 91.9% and 52.2%, respectively, at a cut-off value <50 mm, but the best compromise between sensitivity and specificity (64.9% and 78.02%, respectively) was obtained at a cut-off value <43.5 mm. The latter small cut-off value could be explained by the wide body weight range (30–145 kg) of their study population.

The craniofacial changes may also influence the TMHT accuracy and cut-off values. In a study[19] involving 609 Japanese surgical patients with a BMI of 22.7 ± 3.6 kg/m^2, the investigators compared two cut-off values, 50 mm and 54 mm, and they revealed that AUROC analysis indicated that TMHT ≤ 54 mm is the best cut-off value for predicting DLV with 65.8% sensitivity and 55.6% specificity, and the AUROC for the TMHT was not superior to that for the TMD test or MMT. They attributed the discrepancy between their results and the previous study[5] to using external, backward, upward and rightward pressure to improve the C-L laryngoscopic grading. However, another reason is the difference in craniofacial characteristics in the Japanese population.[21,22] In line with the aforementioned study,[19] another study[20] reported a good predictive ability of TMHT at a cut-off value <57 mm in patients aged ≥65 years. The authors attributed the different cut-off value in the elderly population to the effect of the ageing process on the airway morphology.

In the current study, the low PPV of TMHT (70%) means that only 70% of the obese cases in whom the TMHT predicted DLV would be truly difficult cases. This could be attributed to the low prevalence of the studied problem. Another finding is the high specificity (90%) and the high NPV (94%), which means that 94% of the cases in which the TMHT predicted no DLV would be easy laryngoscopy, which was in line with previous studies.[5,6,17]

In the present study, MMT ≥3 was an excellent predictor of DLV with AUROC 0.91 compared to 0.82 in non-obese patients.[6] The Mallampati score was previously reported to be a significant predictor of DLV in obese patients, and this was attributed to the better alignment of Mallampati score with C-L grades.[10]

The role of neck circumference in predicting DLV and DI is still debatable.[8,21] Our results revealed a weak predictive ability of the NC, and the multivariate analysis revealed no role of an increased NC in predicting DLV or DI. Thus, we incorporated NC with TMHT as NC/TMHT ratio to increase their diagnostic benefits compared to NC alone.[23] This ratio can be a surrogate indicator for the excessive soft tissue mass surrounding the airway in obese patients. A similar result was obtained when NC to TMD ratio was previously investigated as a predictor of DI in obese patients.[24]

The results of the current study also revealed that the BMI was comparable in patients with easy laryngoscopy and DLV, and the multivariate analysis revealed no role for increased BMI in predicting DLV or DI. In agreement with these results, a meta-analysis[25] revealed that obesity increased the risk of DLV and DI when the MMT is ≥3, but there is no association between obesity and risk of DI compared with non-obesity.

The study has some limitations. First, we included only patients scheduled for elective surgeries; hence, our results cannot be extrapolated to the emergency, obstetric, or intensive care unit settings. Second, we did not include other previously investigated parameters in obese patients, such as TMD, SMD and neck extension. Third, we did not consider the age and sex-related morphometric variations.

CONCLUSION

In obese surgical patients, TMHT and MMT are excellent predictors of DLV when the cut-off values are <47 mm and score >2, respectively. A large NC is a weak predictor, but an increased NC/TMHT ratio >7.9 has a better predictive ability of DLV. An increased BMI does not predict DLV.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Kaniyil S, Pavithran P, Rajesh MC, Arun Krishna AK, Venugopal V, Samuel SJ. All India difficult airway association guidelines in practice-A survey. Indian J Anaesth 2021;65:471-8.
2. Sajayan A, Wicker J, Ungureanu N, Mendonca C, Kimani PK. Current practice of rapid sequence induction of anaesthesia in the UK-A national survey. Br J Anaesth 2016;11:69-74.
3. Weir CB, Jan A. BMI classification percentile and cut off points. Environ Res Public Health 2020;17:3832.
4. Melo LC, Silva MA, Calles AC. Obesity and lung function: A systematic review. Einstein (Sao Paulo) 2014;12:120-5.
5. Etezadi F, Ahangari A, Shokri H, Najafi A, Khajavi MR, Daghigh M, *et al*. Thyromental height: A new clinical test for prediction of difficult laryngoscopy. Anesth Analg 2013;117:1347-51.
6. Rao KVN, Dhatchinamoorthi D, Nandhakumar A, Selvarajan N, Akula HR, Thiruvenkatarajan V. Validity of thyromental height test as a predictor of difficult laryngoscopy: A prospective evaluation comparing Modified Mallampati score, interincisor gap, thyromental distance, neck circumference, and neck extension. Indian J Anaesth 2018;62:603-8.
7. Lim WY, Fook-Chong S, Wong P. Comparison of glottic visualisation through supraglottic airway device (SAD) using bronchoscope in the ramped versus supine 'sniffing air' position: A pilot feasibility study. Indian J Anaesth 2020;64:681-7.
8. Eiamcharoenwit J, Itthisompaiboon N, Limpawattana P, Suwanpratheep A, Siriussawakul A. The performance of neck circumference and other airway assessment tests for the prediction of difficult intubation in obese parturients undergoing cesarean delivery. Int J Obstet Anesth 2017;31:45-50.
9. Ittichaikulthol W, Chanpradub S, Amnoundetchakorn S, Arayajarernwong N, Wongkum W. Modified Mallampati test and thyromental distance as a predictor of difficult laryngoscopy in Thai patients. J Med Assoc Thai 2010;93:84-9.
10. Samsoon GL, Young JR. Difficult tracheal intubation: A retrospective study. Anaesthesia 1987;42:487-90.
11. Langeron O, Cuvillon P, Ibanez-Esteve C, Lenfant F, Riou B, Le Manach Y. Prediction of difficult tracheal intubation: Time for a paradigm change. Anesthesiology 2010;117:1223-33.
12. Yousef GT, Abdalgalil DA, Ibrahim TH. Orotracheal intubation of morbidly obese patients, comparison of GlideScope(®) video laryngoscope and the LMA CTrach™ with direct laryngoscopy. Anesth Essays Res 2012;6:174-9.
13. De Jong A, Molinari N, Pouzeratte Y, Verzilli D, Chanques G, Jung B, *et al*. Difficult intubation in obese patients: Incidence, risk factors, and complications in the operating theatre and in intensive care units. Br J Anaesth 2015;114:297-306.
14. Singh M. Supraglottic airway devices in airway management of obese patients. J Anaesthesiol Clin Pharmacol 2019;35:546-7.
15. Horner R, Mohiaddin R, Lowell D, Shea SA, Burman ED, Longmore DB, *et al*. Sites and sizes of fat deposits around the pharynx in obese patients with obstructive sleep apnoea and weight matched controls. Eur Respir J 1989;2:613-22.
16. Komatsu R, Sengupta P, Wadhwa A, Akça O, Sessler DI, Ezri T, *et al*. Ultrasound quantification of anterior soft tissue thickness fails to predict difficult laryngoscopy in obese patients. Anaesth Intensive Care 2007;35:32-7.
17. Jain N, Das S, Kanchi M. Thyromental height test for prediction of difficult laryngoscopy in patients undergoing coronary artery bypass graft surgical procedure. Ann Card Anaesth 2017;20:207-11.
18. Selvi O, Kahraman T, Senturk O, Tulgar S, Serifsoy E, Ozer Z. Evaluation of the reliability of preoperative descriptive airway assessment tests in the prediction of the Cormack-Lehane score: A prospective randomised clinical study. J Clin Anesth 2017;36:21-6.
19. Yabuki S, Iwaoka S, Murakami M, Miura H. Reliability of the thyromental height test for prediction of difficult visualisation of the larynx: A prospective external validation. Indian J Anesth 2019;63:270-6.
20. Mostafa M, Saeed M, Hasanin A, Badawy S, Khaled D. Accuracy of thyromental height test for predicting difficult intubation in elderly. J Anesth 2020;34:217-23.
21. Gonzalez H, Minville V, Delanoue K, Mazerolles M, Concina D, Fourcade O. The importance of increased neck circumference to intubation difficulties in obese patients. Anesth Analg 2008;106:1132-6.
22. Schorr F, Kayamori F, Hirata RP, Danzi-Soares NJ, Gebrim EM, Moriya HT. Different craniofacial characteristics predict upper airway collapsibility in Japanese-Brazilian and White Men. Chest 2016;149:737-46.
23. Roth D, Pace NL, Lee A, Hovhannisyan K, Warenits AM, Arrich J, *et al*. Airway physical examination tests for detection of difficult airway management in apparently normal adult patients. Cochrane Database Syst Rev 2018;5:CD008874.
24. Kim WH, Ahn HJ, Lee CJ, Shin BS, Ko JS, Choi SJ, *et al*. Neck circumference to thyromental distance ratio: A new predictor of difficult intubation in obese patients. Br J Anaesth 2011;106:743-8.
25. Wang T, Sun S, Huang S. The association of body mass index with difficult tracheal intubation management by direct laryngoscopy: A meta-analysis. BMC Anesthesiol 2018;18:79.