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Evaluation of the correlation between preoperative airway assessment tests, anthropometric measurements, and endotracheal intubation difficulty in obesity class III patients undergoing bariatric surgery

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Abstract

In this study, we investigated the correlation between airway assessment tests, anthropometric measurements, and the Modified Cormack– Lehane Classification (MCLC) assessed by videolaryngoscopy in patients undergoing bariatric surgery.

This study included 121 morbidly obese patients undergoing bariatric surgery. The body mass index, Modified Mallampati Score (MMS), thyromental distance, sternomental distance, interincisor distance, and neck, waist, and chest circumferences were recorded. The correlation between the airway assessment tests, anthropometric parameters, and the MCLC were analyzed. The time required for endotracheal intubation (EI) and the attempt required for EI were also recorded.

Thirty-three patients were found to be at risk of a difficult EI. The MMS, neck circumference, waist circumference, chest circumference, the time required for EI, and the number of attempts for EI were positively correlated with MCLC (all $P < .05$). As the MMS increased, the risk of a difficult EI increased ($P < .001$). The cutoff values of neck, waist, and chest circumference for the risk of a difficult EI were 41.5, 153.5, and 147.5 cm, respectively ($P < .05$).

This study indicates that the high MMS, as well as increased neck, waist, and chest circumference, should be considered EI difficulty in obese patients, even if a videolaryngoscopy is used.

Abbreviations: BMI = body mass index, CDL = conventional direct laryngoscopy, CL = Cormack–Lehane classification, EI = endotracheal intubation, IID = interincisor distance, MCLC = Modified Cormack–Lehane Classification, MMS = Modified Mallampati Score, MS = Mallampati Score, NPVs = negative predictive values, PPVs = positive predictive values, ROC = receiver operating characteristic, SMD = sternomental distance, TMD = thyromental distance, VL = videolaryngoscopy.

Keywords: airway assessment, anthropometric measurements, bariatric surgery, difficult endotracheal intubation, morbid obesity, videolaryngoscopy

Editor: Ibtesam Hilmi.

The authors have no funding and conflicts of interest to disclose.

All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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How to cite this article: Emik E, Gümüs-Özcan F, Demirgan S, Selcan A. Evaluation of the correlation between preoperative airway assessment tests, anthropometric measurements, and endotracheal intubation difficulty in obesity class III patients undergoing bariatric surgery. Medicine 2021;100:36(e27188).

Received: 26 March 2021 / Received in final form: 8 August 2021 / Accepted: 19 August 2021

http://dx.doi.org/10.1097/MD.0000000000027188

1. Introduction

In obese patients with excess fatty tissue accumulated in the breast, neck, thorax, and abdomen, access to the upper airway can be impeded, and thus, endotracheal intubation (EI) may become complicated.[1] The incidence of difficult laryngoscopy and EI in obese patients is higher; therefore, in these patients, difficult airway management is still the main concern for the anesthesia care provider.[2,3] Many studies have shown that numerous factors, such as a high Modified Mallampati Score (MMS),[3] a high body mass index (BMI),[4] increasing neck circumference,[5,6] and the neck circumference to thyromental distance ratio,[7] are predictors of difficult intubation in obese patients. However, there is still conflicting data on factors predicting EI difficulty.[8] Moreover, all of these factors were identified using conventional direct laryngoscopy (CDL).

Today, thanks to improvements in videolaryngoscopy (VL) technology, our approach to airway management has changed.[9] It leads to increased EI success by improving the glottic view and causing less airway trauma while decreasing the attempt and time required for EI.[10] Whereas specific predictors of difficult airways are useful in conventional direct laryngoscopic techniques, predictors of difficult airways for the VL technique are still uncertain.[11,12]

Therefore, in this study, we investigated the correlation between airway assessment tests, anthropometric measurements, and the Modified Cormack–Lehane Classification (MCLC) in class III obese patients, assessed by C-MAC-D-blade VL. Moreover, we aimed to evaluate the predictive accuracy of the preoperative airway assessment tests and anthropometric measurements on the risk of difficult EI.

2. Materials and methods

2.1. Study design

This prospective observational clinical study was conducted in patients with a BMI $\geq$45 kg/m^2 who underwent elective bariatric surgery in the Anesthesiology and Reanimation Clinic of the University of Health Sciences, Bagcilar Training and Research Center, after obtaining informed consent of the participants and approval from the Ethics Board of Health Sciences University Istanbul Bagcılar Training and Research Hospital (17.08.2017-2017/599). The trial was registered at clinicaltrials.gov.tr (NCT04542187 Principal Investigator: EE, Release Date: September 4, 2020).

2.2. Patient population

The number of participants in this study was calculated based on a previous study.[4] A sample size calculator showed that 116 participants would be required to predict difficult EI in the current study (with 80% power, $\alpha = 0.05$ and $\beta = 0.2$). Patients were excluded for any of the following reasons: a history of difficult airway, limited neck movements, oral-pharyngeal cancer or reconstructive surgery, cervical spinal injury, or a facial anomaly or scar; requirement for quick EI while awake, or non-cooperativeness.

2.3. Study protocol

Age, sex, height, body weight, BMI, airway assessments, and anthropometric measurements, including the MMS, thyromental distance (TMD), sternomental distance (SMD), interincisor distance (IID), and neck, waist, and chest circumference measurements of all patients, were evaluated and recorded preoperatively. The MMS was assessed by Samsoon and Young Modifications, and scores were assessed from 1 to 4.[13] The TMD and SMD were measured with the neck fully extended. The TMD was measured between the upper border of the thyroid cartilage and the bony point of the mentum, and the SMD was measured between the upper border of the manubrium sterni and the bony point of the mentum.[14] The IID was measured when the patient opened his/her mouth, and the distance between the upper and lower incisors was obtained.[14] Neck circumference was measured at the level of the thyroid cartilage when the head was in a neutral position.[7,14] The chest and waist circumferences were measured around the widest circumference.[15]

After patients were admitted to the operating room, the intravenous route used was the dorsum of the hand, in which a 20G (Gauge) venous cannula was inserted, and a 2 to 4 mL/kg balanced crystalloid was infused. All patients were premedicated with 1–2 mg midazolam (Zolamid 15 mg/3 mL, Defarma, Turkey). Each patient was routinely monitored with standard monitoring, including 3-lead electrocardiography, noninvasive arterial pressure, peripheral oxygen saturation, and neuromuscular monitoring with the train of four (TOF)-Watch SX (Organon, Ireland) device. For the sniffing position, all patients were kept in the supine position with a 7 cm high pillow placed under the occiput to flex the neck relative to the torso and to slightly extend the head relative to the neck. After that, they were pre-oxygenated using a face mask with 100% oxygen for 3 minutes prior to induction of the anesthesia. Induction of anesthesia was performed with 2 mg/kg propofol (Propofol 1%, Fresenius kabi, Germany) and 1 μgr/kg fentanyl (Talinat, VEM, Turkey) based on lean body weight and 0.6 mg/kg rocuronium bromide (Esmeron Organon, Holland) based on ideal body weight. Following adequate paralysis (loss of responsiveness to TOF stimulations with TOF monitoring, all patients were routinely intubated using C-MAC D-blade VL (Storz 8402 ZX C-MAC Karl Storz, Germany). Anesthesia was maintained with inhalation of a 50% oxygen-medical air mixture and 2% sevoflurane (Sevoflurane, Abbott, England).

The time required for the EI was defined from insertion of the VL in the mouth to the endotracheal tube placement through the vocal cords and when expired carbon dioxide at capnography was observed. In cases of a peripheral oxygen saturation decrease (<90%), EI was stopped, and mask ventilation was resumed.

Since there is no validated classification for the glottic view with VL,[16] it was evaluated and recorded according to the MCLC modified by Yentis and Lee,[17] without any laryngeal pressure.

MCLC I-IIa was defined as the patients at no risk for difficult EI, MCLC IIb-III was defined as the patients at risk for difficult EI, and MCLC-IV was defined as the patients with difficult EI.[16–19] The following details were recorded: the time required for EI and the number of attempts needed for EI.

All airway assessment tests and anthropometric parameters were recorded by the same anesthesiologist. EI and assessments of MCLC were routinely performed with a C-MAC D-blade VL by another anesthesiologist who was blinded to the data of the preoperatively assessed tests.

2.4. Primary and secondary outcomes

The primary outcomes were the correlation between the preoperative airway assessment tests (MMS, TMD, SMD, and IID), anthropometric measurements (BMI, neck, waist, and chest circumference), and MCLC assessed by VL as well as their predictive values for EI difficulty according to the MCLC. Secondary outcomes were the time required for EI and the number of attempts needed for EI.

2.5. Statistical methods

Statistical analyses were performed using SPSS Statistics 21 Statistical Package for the Social Sciences (SPSS Inc, Chicago, IL, USA). Continuous variables are expressed as the means ± standard deviations. The Kolmogorov–Smirnov test was used to investigate the normal distribution of continuous data. Student test was used for normally distributed continuous variables. The Mann–Whitney *U* test was used for variables that were not normally distributed. The chi-square and Fisher exact tests were used for noncontinuous variables. To evaluate the change in continuous variables, Pearson correlation analysis was used for parametric data, and Spearman correlation analysis was used for nonparametric data. In the evaluation of correlation coefficients, $r = 0.00$–0.24, 0.25–0.49, 0.50–0.74, and 0.75–1.00 were

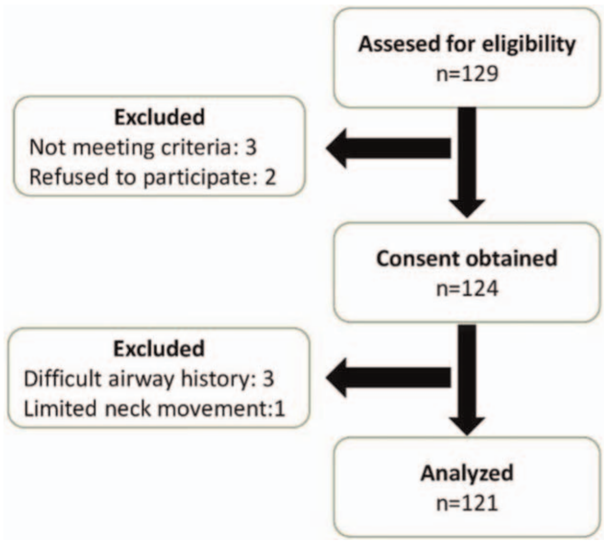

Figure 1. Study flow diagram.

considered weak, moderate, strong, and very strong, respectively. The cutoff points for statistically significant parameters were determined using receiver operating curve (ROC) analysis, which resulted in the best combination for sensitivity and specificity. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated in the presence of significant limit values. All variables at $P<.05$ were considered statistically significant.

3. Results

A total of 129 patients who underwent bariatric surgery were recruited for the study, and 121 patients aged 16 to 68 years with a BMI ≥45 kg/m2 were ultimately enrolled (Fig. 1). According to VL views, MCLC IIb-III, which indicates the risk of a difficult EI, was detected in 33 (27.3%) of the patients. None of the patients were observed to be in MCLC IV. All of the patients were intubated successfully. Demographic data and patient characteristics are shown in Table 1.

MMS, neck circumference, waist circumference, chest circumference, the time required for EI, and attempts required for intubation were positively correlated with MCLC ($P<.001$, .012, .008, .001, .001, and <.001 respectively). MMS and chest circumference were moderately correlated with MCLC ($r=0.378$ and 0.302, respectively), while neck circumference and waist circumference were weakly correlated ($r=0.228$ and 0.239). There was no correlation between age, height, weight, BMI, IID, TMD, or SMD with MCLC (Table 2).

Using ROC analysis, the optimal cutoff values to define risk of difficult EI were found to be 41.5, 153.5, and 147.5 cm for neck, waist, and chest circumferences, respectively. The ROC curve analyses are shown in Table 3 and Figure 2. The patients with a neck circumference >41.5 cm, waist circumference >153.5 cm, and chest circumference >147.5 cm were found to be at risk for a difficult EI according to MCLC. We have demonstrated that the cutoff values of the neck, waist, and chest circumferences had moderate to fair sensitivity (78.8%, 60.6%, and 75.8%, respectively), poor specificity (44.5%, 69.3%, and 47.7%, respectively), low PPVs (35.1%, 42.5%, and 35.2%, respectively), and relatively high NPVs (85.1%, 82.5%, and 84%, respectively) ($P<.05$, Table 3). Distribution of patients at risk for difficult EI according to cutoff values is shown in Table 4.

Table 1

Demographic data, airway physical examination tests, anthropometric measurements, and endotracheal intubation profiles of the patients.

	Number of patients (n = 121)
Age (year)	40.1 ± 11.0 (16–68)
Gender (n) f/m	94/27
Height (cm)	161 ± 9.0 (140–184)
Weight (kg)	126 ± 14.1 (100–165)
BMI (kg/m^2)	48.5 ± 3.6 (45–60.9)
MMS [I/II/III/IV] (n)	44/65/12/0
IID (cm)	4.6 ± 0.5 (3–5.5)
TMD (cm)	12.2 ± 1.2 (7–15)
SMD (cm)	14.8 ± 1.5 (10–19)
Neck circumference (cm)	42.9 ± 4.9 (32–58)
Waist circumference (cm)	151.2 ± 13.6 (102–184)
Chest circumference (cm)	149 ± 12.6 (95–191)
MCLC [I/IIa/IIb/III/IV] (n)	78/10/27/6/0
Time required for intubation (s)	11.2 ± 7.7 (5–46)
Attempt required for intubation First/second/third (n)	98/23/0

Data are presented as a number of the patients or mean ± standard deviation (IQR).
BMI = body mass index, IID = interincisor distance, MCLC = Modified Cormack Lahane Classification, MMS = Modified Mallampati Scores, SMD = sternomental distance, TMD = thyromental distance.

4. Discussion

In this study, we found positive correlations among the MMS; neck, waist circumference, chest circumference measurements; time and attempts required for EI; and the MCLC assessed by a VL. A high MMS and high neck (>41.5 cm), waist (>153.5 cm), and chest (>147.5 cm) circumferences were found to be predictive factors for the risk of a difficult EI in patients with morbid obesity.

Table 2

The correlation between patients' characteristics and MCLC.

	MCLC	
	r	*P*
Age (year)	0.146	.111
Height (cm)	−0.037	.689
Weight (kg)	0.020	.830
BMI (kg/m^2)	0.103	.262
IID (cm)	−0.114	.212
TMD (cm)	−0.117	.200
SMD (cm)	−0.109	.235
MMS	0.378	**<.001**
Neck circumference (cm)	0.228	**.012**
Waist circumference (cm)	0.239	**.008**
Chest circumference (cm)	0.302	**.001**
Time required for intubation (s)	0.547	**<.001**
Attempt required for endotracheal intubation (n)	0.650	**<.001**

Spearman correlation test was used to analyze data ($r=0.00$–0.24 weak, $r=0.25$–0.49 moderate, $r=0.50$–0.74 strong, $r=0.75$–1.00 very strong, $P<.5$). P values < .05 were considered statistically significant.
BMI = body mass index, IID = interincisor distance, MCLC = Modified Cormack–Lahane Classification, MMS = Modified Mallampati Scores, SMD = sternomental distance, TMD = thyromental distance.

Table 3

Cutoff value, sensitivity, specificity, PPV, and NPV of diagnostic screening tests for difficult endotracheal intubation.

	Cutoff value (cm)	AUC	Standard error	95 % CI Lower- Upper	Sensitivity	Specificity	PPV	NPV	*P*
Neck circumference	41.5	0.647	0.055	0.539–0.755	78.8	44.5	35.1	85.1	**.013**
Waist circumference	153.5	0.655	0.06	0.537–0.773	60.6	69.3	42.5	82.4	**.009**
Chest circumference	147.5	0.695	0.058	0.582–0.809	75.8	47.7	35.2	84	**.001**

Data are presented as measurement unit (cm). *P* values <.05 were considered statistically significant.
AUC = area under the ROC curve, CI = confidence interval, NPV = negative predictive value, PPV = positive predictive value.

An insufficient laryngoscopic view is 1 reason for a potentially difficult EI.[19] It is more difficult to provide an optimal glottic view and EI in obese patients.[5,20] Many studies have shown that when using a VL, glottic visualization improves, and the incidence of Cormack–Lehane Classification (CL) grade III–IV decreases.[9,20–23] In our study, MCLC III was observed in only 6 patients, and none of the patients were in MCLC IV. Additionally, MCLC IIb has been reported previously to have a high risk of difficult EI.[16–18] In previous studies, the rate of difficult EI with VL was reported to range from 4% to 27% in obese patients.[11,16,23] Together with MCLC IIb, the risk of a difficult EI in the current study was 27%.

BMI is the most evaluated risk factor for difficult EI in obese patients. There are controversial results in studies with CDL in obese patients.[3,4,6,15] Higher BMI was not shown to be a risk factor for a difficult EI with VL.[11,24,25] VL improves the glottic view with its video component and blade features, providing a wide-angle view and thereby reducing risk factors for a difficult EI.[9–12,24] In the current study, higher BMI was not found to be a risk factor for a difficult EI with a VL. It was demonstrated that IID <3.5 cm, SMD <12.5 cm, and TMD <6 cm are predictive values for difficult EI.[26] Our results also showed that these values were not found to be associated with risk for difficult EI.

The MMS is commonly used as a preoperative assessment test because it is simple and has a positive correlation with CL grade.[2] Studies have demonstrated that a higher Mallampati Score (MS) is associated with obesity and that MS ≥3 is related to difficult EI with CDL.[5–7,13,15,27] Other studies have shown that EI success is higher with VL in patients with an MS higher than 3.[11,23] On the other hand, Marrel et al demonstrated that MS is related to the glottic view and is the best independent predictor for a difficult EI in both the CDL and VL.[28] We demonstrated that there was a moderately positive correlation between MMS and MCLC and that a higher MMS was a predictive factor for difficult EI.

The neck circumference measurement is 1 of the most common parameters used as a predictive test for a difficult EI.[29,30] Brodsky et al reported that with a neck circumference of 60 cm, the incidence of EI difficulty increased 7-fold compared to a neck circumference of 40 cm.[6] Other studies demonstrated that neck circumferences >50[30] and ≥43 cm[5] were strongly related to difficult EI. Studies conducted with a VL reported that there is no correlation between a large neck circumference and a difficult EI.[11,23] Additionally, it has been demonstrated that there is no relation between chest or waist circumference and difficult EI.[15,29] In our study, we found that neck, waist, and chest circumference were positively correlated with MCLC. According to our results, among the anthropometric measurements, the parameter that correlates most with MCLC is chest circumference (moderate correlation).

In the current study, in patients with a neck, waist, and chest circumference greater than 41.5, 153.5, and 147.5 cm, respectively, the risk of a difficult EI increased almost 3.5-, 1.5-, and 3-fold, respectively. However, as cutoff values of the neck, waist, and chest circumferences had moderate to fair sensitivity (78.8%, 60.6%, and 75.8%, respectively), poor specificity (44.5%, 69.3%, and 47.7%, respectively), and low PPVs (35.1%, 42.5%, and 35.2%, respectively), so these cutoff values are

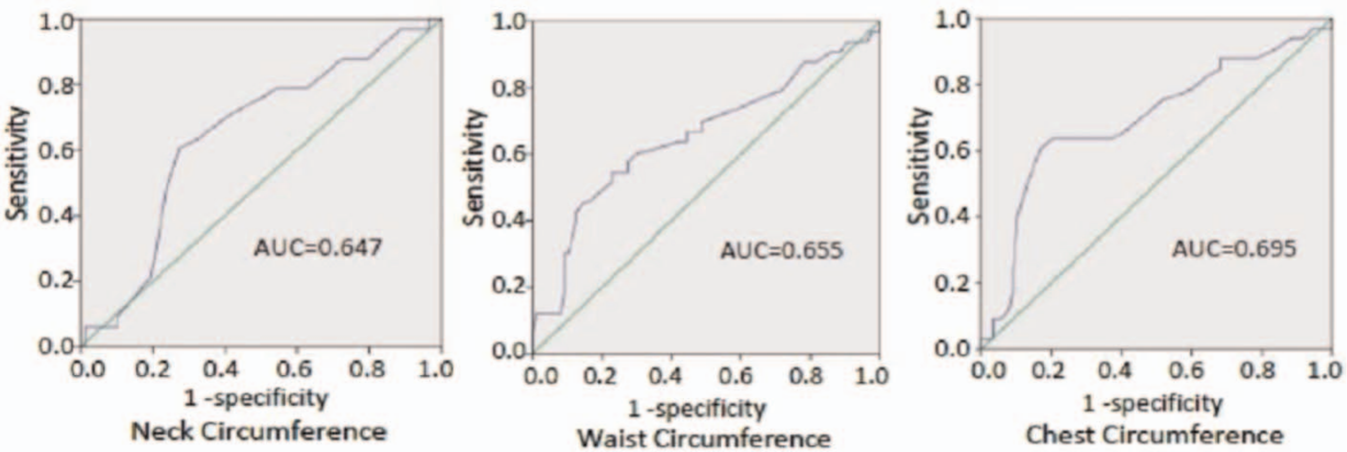

Figure 2. ROC curve analysis of diagnostic screening tests for difficult intubation. AUC = area under the curve, ROC = receiver operating characteristic.

Table 4

Distribution of patients at risk for difficult endotracheal intubation according to cutoff values.

	MCLC I-IIa n=88 (%) no risk for difficult endotracheal intubation	MCLC IIb-II n=33 (%) risk for difficult endotracheal intubation	*P*
Neck circumference (cm)			
>41.5 n=74	48 (54)	26 (78)	**.021**
≤41.5 n=47	40 (45)	7 (21)	
Waist circumference (cm)			
>153.5 n=47	27 (30)	20 (60)	**.003**
≤153.5 n=74	61 (69)	13 (39)	
Chest circumference (cm)			
>147.5 n=71	46 (52)	25 (75)	**.023**
≤147.5 n=50	42 (47)	8 (24)	

Data are presented as the number and percentage (%) of patients. Fisher Exact test was used to analyze data. *P* values <.05 were considered statistically significant.

not strong enough to predict difficult EI with VL. Nevertheless, it can be considered a sign of possible EI difficulty. In addition, since the cutoff values of these 3 parameters have relatively high NPVs (85.1%, 82.5%, and 84%, respectively), values below the cutoff can be considered as low probability of difficulty of EI.

Video laryngoscopy increases the first-attempt EI success rate and shortens the time needed for EI.[21–23,30] First attempt EI success was shown to be 93% to 96% with VL.[21,23,25] However, some studies have shown that despite the use of VL, there may be EI difficulty, which is related to higher CL scores. Higher CL scores also cause multiple attempts and longer times required for EI even when using VL.[11,31] Additionally, when a perfect view of the glottis is provided, VL does not always guarantee EI.[10,32] In our study, the number of attempts and time required for EI were strongly correlated with MCLC. We found that EI success was 100% in our patients.

Because of the lack of a validated classification of a glottic view with a VL, we used MCLC and a risk of a difficult EI defined only according to the MCLC. This can be criticized as there was no actual failed EI in our study.

In conclusion, C-MAC with a D blade VL can be used safely in class III morbidly obese patients. Even if VL is used, class III obese patients with higher MMS and neck, waist, and chest circumference should still be considered at risk for difficult EI. While using VL, a poor glottic view leads to multiple attempts and a prolonged time required for successful EI.

Acknowledgments

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors and we had not assistance in writing this manuscirpt. The authors declare no conflicts of interest.

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