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# Correlation between neck circumference measurement and obesity type with difficult intubation in obese patients undergoing elective surgery

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**Ethics Committee Approval**
This study was approved by the Marmara University Pendik Training and Research Hospital ethics committee (approval no 09.2021.135). All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

**Conflict of Interest**
No conflict of interest was declared by the authors.

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## Abstract

**Background/Aim:** The number of obese patients undergoing elective surgery is increasing day by day. However, there are conflicting data in the literature about factors predicting difficult tracheal intubation in obese patients. The aim of this study was to evaluate the commonly used predictors of difficult intubation in obese patients (body mass index (BMI) >35 kg/m$^2$) who wish to undergo elective surgery and to examine the association of neck circumference and obesity type with difficult intubation.

**Methods**: This observational, cross-sectional, prospective study was performed after obtaining approval from the ethics committee. Obese patients over the age of 18 years, requiring tracheal intubation, undergoing elective surgery, and with a BMI greater than 35 were included in this study. Patients with a history of cervical spine anomaly or trauma, congenital facial anomaly or trauma affecting this region, those who would undergo emergency surgery, patients with a known history of difficult airway or upper respiratory tract disease, and those with planned awake intubation were excluded from the study. Preoperative anesthetic evaluation was performed for all patients, their relevant measurements were obtained, and medical histories were taken as required for the study. The association of the patients' BMI, Mallampati classification, thyromental distance, Cormack–Lehane grade, obstructive sleep apnea, neck circumference, and obesity type with difficult intubation was evaluated. Preoperative and peroperative measurements were recorded in the follow-up forms.

**Results**: A total of 85 patients, 62 females and 23 males, between the ages of 19 and 77 years were included in this study. A significant difference was found in the patients' BMI, neck circumference, thyromental distance, Mallampati classifications, and Cormack–Lehane grades in terms of intubation difficulty ($P$<0.001, $P$<0.001, $P$<0.001, $P$<0.01, $P$<0.01, respectively). Patients who underwent difficult intubation had lower thyromental distance but greater BMI, neck circumference, Mallampati classification, and Cormack–Lehane grade. It was determined that a neck circumference of >50 cm increased the risk of difficult intubation 8.323 times.

**Conclusion:** Neck circumference and thyromental distance are significant predictors for difficult intubation and laryngoscopy in morbidly obese patients.

**Keywords:** Obesity, Difficult intubation, Neck circumference, BMI

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## Introduction

Difficult airways, one of the major causes of perioperative mortality and morbidity, are a major cause of concern for anesthesiologists. Difficulty in managing the airway is the single most common cause of anesthesia-related death and brain damage [1]. Therefore, predicting a potentially difficult intubation means that measures can be taken to minimize the risk [2].

The number of obese patients undergoing elective surgery is increasing with each passing day, and anesthesiologists must be prepared to handle all perioperative care of obese patients. In particular, they should understand the effects of obesity on the airway and be prepared to manage the airway correctly [3, 5]. Several reviews in the literature reported that endotracheal intubation is more difficult in obese patients than in lean patients [6]. However, this claim is controversial because no other studies such an association [7-11]. While one study stated that morbid obesity increases the rate of difficult intubation three times, there are others in the literature that reported that there is no relationship between morbid obesity and difficult intubation [12, 13]. However, in general, airway management in obese patients is considered a challenge for many anesthetists [12].

Many attempts have been made to develop reliable predictors of difficult intubation and difficult laryngoscopy, but none of them have high diagnostic accuracy, particularly in obese patients [14]. The best known and recommended predictors include parameters such as the Mallampati classification, thyromental distance measurement, obstructive sleep apnea (OSA), male gender, and increased age [14, 15]. However, some studies in the literature report that none of these predictors yield satisfactory results in obese patients. There is limited literature and conflicting results about the relationship between neck circumference and difficult intubation [16, 17]. Contrary to two studies that reported that neck circumference greater than 43 cm was associated with difficult intubation, Neligan et al. [13] could not find a relationship between the neck circumference and difficult intubation in their study.

There are few studies examining the relationship between neck circumference and difficult intubation in obese patients and no studies on whether the obesity type is a significant risk factor for difficult intubation. Therefore, in this study, we sought to evaluate the predictors of difficult intubation such as the Mallampati classification, BMI, thyromental distance, OSA in obese patients (>35 kg/m$^2$) undergoing elective surgery in our clinic, and we aimed to investigate the association of the neck circumference and obesity type with difficult intubation.

## Materials and methods

The study protocol was approved by Marmara University Medical Faculty, Ethics Committee for Clinical Studies (no: 09.2021.135) and conducted in accordance with the Declaration of Helsinki.

Patients above 18 years of age, with an American Society of Anesthesiologists (ASA) score of I–III, who were candidates for elective surgery, and whose BMI was >35 kg/m$^2$ were included in the study to investigate whether the neck circumference and obesity type constituted risk factors for difficult intubation in obese patients. The patients were operated under general anesthesia and underwent endotracheal intubation. Before the surgery, the patients were informed about the measurements and tests that would be performed on the face and neck, and they gave their informed consent. Patients with a history of cervical spine anomaly or trauma, congenital facial anomaly or trauma affecting this region, those who would undergo emergency surgery, patients with a known history of difficult airway or upper respiratory tract disease, and those with planned awake intubation were excluded from the study. The patients were evaluated by resident anesthesiologists before the operation. Pre-anesthetic evaluations were made by assessing for age, gender, physical condition according to the ASA, and the presence of OSA. The patients underwent physical examinations for height and weight measurements; the BMI was calculated on the basis of height and weight of the patients. The Mallampati score and thyromental distance assessments were noted. With the help of a tape measure, the neck circumference was measured at the level of the thyroid cartilage with the patient in neutral position. Before induction, patients underwent electrocardiogram, pulse oximetry, and noninvasive arterial blood pressure monitoring. Preoxygenation was administered for 3 minutes. Operating tables were set in the ramp position. Mask ventilation, performed with a face mask of appropriate size, was evaluated using the Han Classification, and difficult intubation was assessed with the IDS. Tracheal intubation was considered successful when a capnography waveform was observed, and the sounds of both lungs could be equally heard by auscultation.

**Statistical analysis**

For statistical analysis, the statistical software R version 2.15.3 (R Core Team, 2013) was used. The study data were reported using minimum, maximum, mean, standard deviation, median, first quartile, third quartile, frequency, and percentage. The Shapiro–Wilk test and graphical reviews were used to check whether quantitative data were normally distributed. The Mann–Whitney U test was used for inter-group assessments of non-normally distributed variables. Pearson's chi-squared test, Fisher's exact test, and Fisher–Freeman–Halton exact test were used to compare qualitative data. Multivariate logistic regression analysis was performed to identify the factors affecting difficult intubation. Statistical significance was set at $P<0.05$.

## Results

The data associated with the patients included in our study are presented in Table 1. The patients were between the ages of 19 and 77 years, with a mean age of 45.87 (13.33) years.

The BMI values of the cases ranged from 35 to 60 kg/m$^2$, with an average of 43.79 (6.05) kg/m$^2$; neck circumference ranged from 36 to 59 cm, with an average of 47.83 (6.41) cm; and thyromental distance ranged from 4.5 to 10 cm, with an average of 6.84 (1.13) cm. Neck circumference was <42 cm in 18.8% of the cases (n = 16) and ≥42 cm in 81.8% (n = 69).

The Mallampati classification of the cases ranged from 1 to 4, with an average of 2.31 (1.13) and the Cormack–Lehane grades ranged from 1 to 4, with an average of 1.96 (0.81). The

number of intubation attempts made on the cases ranged from 1 to 4, with an average of 1.59 (0.82).

Table 1: Information on demographic features

| | Min-Max (Median) | Mean (SD) |
|---|---|---|
| Age | 19-77 (45) | 45.87 (13.33) |
| BMI | 35-60 (43) | 43.79 (6.05) |
| Neck circumference | 36-59 (47) | 47.83 (6.41) |
| Thyromental distance | 4.5-10 (7) | 6.84 (1.13) |
| Mallampati | 1-4 (2) | 2.31 (0.93) |
| Cormaclehen degree | 1-4 (2) | 1.96 (0.81) |
| Number attempt | 1-4 (1) | 1.59 (0.82) |
| | n | % |
| Gender | | |
| Female | 62 | 72.9 |
| Male | 23 | 27.1 |
| DM | | |
| + | 50 | 58.8 |
| - | 35 | 41.2 |
| HT | | |
| + | 50 | 58.8 |
| - | 35 | 41.2 |
| OSA | | |
| + | 66 | 77.6 |
| - | 19 | 22.4 |
| Neck circumference | | |
| <42 | 16 | 18.8 |
| ≥42 | 69 | 81.2 |
| Restricted neck movement | | |
| + | 67 | 78.8 |
| - | 18 | 21.2 |
| Obesity type | | |
| Peripheral | 20 | 23.5 |
| Central | 65 | 76.5 |
| Ramp | | |
| No | 0 | 0.0 |
| Yes | 85 | 100.0 |
| Difficult Mask | | |
| No | 47 | 56.0 |
| Yes | 37 | 44.0 |
| Instrument used for intubation | | |
| Direct laryngoscope (DL) | 57 | 67.1 |
| DL+Guide | 14 | 16.5 |
| VL | 11 | 12.9 |
| VL+Guide | 3 | 3.5 |
| Intubation | | |
| Resident (experience <2 years) | 16 | 18.8 |
| Resident (experience 2 years) | 44 | 51.8 |
| Specialist | 25 | 29.4 |

Approximately 72.9% of the patients (n = 62) were female and 27.1% (n = 23) were male.

Diabetes mellitus (DM) was present in 41.2% of the cases, hypertension (HT) in 41.2%, and OSA in 22.4%. Approximately 21.2% of the patients had limited neck mobility. About 23.5% had peripheral obesity and 76.5% had central obesity.

Ramps were used in all cases. Mask ventilation was difficult in 44% of the cases.

Approximately 67.1% of the patients were intubated with the Macintosh blade, 16.5% with the Macintosh blade and guide, 12.9% with a video laryngoscope, 3.5% with a video laryngoscope and guide.

There was no difference in the age of the patients in terms of intubation difficulty ($P$>0.05). A significant difference was found in the patients' BMI, neck circumference, thyromental distance, Mallampati classifications, and Cormack–Lehane grades in terms of intubation difficulty ($P$<0.001, $P$<0.001, $P$<0.001, $P$<0.01, $P$<0.01, respectively). Patients who underwent difficult intubation had lower thyromental distance but greater BMI, neck circumference, Mallampati classification, and Cormack–Lehane grade. There was no significant difference in the percentage of intubation difficulty in terms of gender, DM, HT, OSA, and neck circumference ($P$>0.05).

The percentage of intubation difficulty was higher in patients with neck circumferences ≥42 cm, limited neck mobility, presence of central obesity, and difficult mask ventilation ($P$=0.002, $P$=0.001, $P$=0.029, and $P$<0.001, respectively). The cut-off values associated with difficult intubation were established for BMI, neck circumference, thyromental distance, Mallampati classification, and Cormack–Lehane grades. According to the evaluations, these cut-off values were >46 kg/m$^2$ for BMI, >50 cm for neck circumference, ≤6.5 cm for thyromental distance, >2 for Mallampati classification, and >2 for Cormack–Lehane grade.

Multivariate logistic regression analysis was performed to identify the factors affecting difficult intubation (Table 2). Intubation difficulty was included in the analysis as a dependent variable, and BMI, neck circumference, thyromental distance, Mallampati classification, Cormack–Lehane grade, restricted neck mobility, obesity type, and mask ventilation difficulty were included as independent variables. The model derived from the analysis performed using the backward elimination method was statistically significant ($\chi^2$=73.640, $P$<0.001). Neck circumference, thyromental distance, Mallampati classification, and Cormack–Lehane grade were found to have significant effects in the model. A neck circumference of >50 cm increased the risk of difficult intubation 8.323 times [odds radio (OR) (95% confidence interval (CI)) = 8.323 (1.175, 58.970); $P$=0.034]. A thyromental distance of ≤6.5 cm increased the risk of difficult intubation 40,475 times [OR (95% CI) = 40.475 (3.227, 507.637); $P$=0.004]. A Mallampati classification score >2 was increased the risk of difficult intubation 16,129 times [OR (95% CI) = 16,129 (1.606, 161.967); $P$=0.018]). A Cormack–Lehane grade >2 increased the risk of difficult intubation by a factor of 13.449 [OR (95% CI) = 13.449 (1.294, 139.827); $P$=0.030].

Table 2: Comparisons for difficult intubation

| | Difficult Intubation | | Test value | $P$-value |
|---|---|---|---|---|
| | No Median (Q1,Q3) | Yes Median (Q1,Q3) | | |
| Age | 47 (38.5, 56.5) | 43 (37, 50) | -1.410 | [a]0.159 |
| BMI | 41 (38, 45.25) | 50 (47, 51) | -4.008 | [a]<0.001* |
| Neck Circumference | 45 (41.25, 48.5) | 53 (51, 57) | -4.897 | [a]<0.001* |
| Thyromental distance | 7 (6.75, 8) | 6 (5.5, 6) | -5.293 | [a]<0.001* |
| Mallampati | 2 (1, 2) | 3 (3, 3) | -5.595 | [a]<0.001* |
| Cormaclehen level | 2 (1, 2) | 3 (2, 3) | -6.054 | [a]<0.001* |
| | n (%) | n (%) | Test value | $P$-value |
| Gender | | | 1.435 | [c]0.231 |
| Female | 46 (74.2) | 16 (25.8) | | |
| Male | 14 (60.9) | 9 (39.1) | | |
| Diabetes Mellitus (DM) | | | 1.713 | [c]0.191 |
| DM (-) | 38 (76) | 12 (24) | | |
| DM (+) | 22 (62.9) | 13 (37.1) | | |
| Hypertension (HT) | | | 0.392 | [c]0.531 |
| HT(-) | 34 (68) | 16 (32) | | |
| HT(+) | 26 (74.3) | 9 (25.7) | | |
| Obstructive Sleep Apnea (OSA) | | | 1.899 | [c]0.168 |
| OSA(-) | 49 (74.2) | 17 (25.8) | | |
| OSA(+) | 11 (57.9) | 8 (42.1) | | |
| Neck circumference (cm) | | | 8.213 | [b]0.002* |
| <42 | 16 (100) | 0 (0) | | |
| ≥42 | 44 (63.8) | 25 (36.2) | | |
| Restricted Neck Mobility (RNM) | | | 11.053 | [c]0.001* |
| RNM(-) | 53 (79.1) | 14 (20.9) | | |
| RNM(+) | 7 (38.9) | 11 (61.1) | | |
| Obesity type | | | 4.747 | [c]0.029* |
| Peripheral | 18 (90) | 2 (10) | | |
| Central | 42 (64.6) | 23 (35.4) | | |
| Face Mask Difficulty | | | 33.850 | [b]<0.001* |
| Difficult(-) | 46 (95.8) | 2 (4.2) | | |
| Difficult(+) | 14 (37.8) | 23 (62.2) | | |

[a] Mann-Whitney U test, results are presented as median (first quartile, third quartile), [b] Fisher's exact test, [c] Pearson chi-square test, * $P$<0.05

## Discussion

The number of obese patients undergoing elective emergency operations is increasing with every passing day. Difficult intubation and difficult mask ventilation defined as difficult airways are observed at increased rates in obese and morbidly obese patients. In our study, we determined that neck circumference, thyromental distance, Mallampati classification and Cormack–Lehane grade are independent risk factors for difficult intubation in obese patients.

There is conflicting evidence in the literature about the relationship between obesity and difficult tracheal intubation [17]. Although Butler et al. [18] found the Mallampati classification to be useless in evaluating preoperative intubation difficulty in their study, there are other studies showing that the Mallampati test is a more valuable predictor when supported by other airway assessment tools. Ittichaikulthol et al. [19] found the modified Mallampati test alone to have low sensitivity and specificity as a predictor of difficult intubation, but they reported that the combined use of thyromental distance and modified Mallampati test yielded significant results. Shailaja et al. [20] and Özdilek et al. [21] showed that a score of III–IV in Mallampati classification in obese patients is a predictor of difficult intubation. In our study, we found that the Mallampati classification was an independent risk factor for difficult intubation in obese patients, and that the risk of difficult intubation increased 16.129 times when the Mallampati score was >2.

There are different interpretations in the literature as to whether obesity alone is a risk factor for difficult intubation [22]. While some studies failed to associate obesity and BMI with difficult intubation, others concluded that obesity increases the risk of difficult intubation [12, 23]. The reason for this difference is that there is no universal definition of difficult tracheal intubation and there is no linear relationship between BMI and difficult intubation and the threshold value for BMI. Lundstrom et al. [2] reported that a BMI >35 kg/m$^2$ is an independent risk factor for difficult and unsuccessful intubation. In their study which compared normal-weight and obese patients (n = 263), Juvin et al. [16] found that the rate of difficult intubation was higher in obese patients. In contrast, Brodsky et al. studied 100 morbidly obese patients and stated that obesity is not an independent risk factor for difficult intubation [10]. Riad et al. [17] showed that a high BMI is an independent predictor for difficult intubation in a study conducted in 2016, and they reported that a BMI higher than 50 kg/m$^2$ increased the risk of difficult intubation five times. In a meta-analysis by Shiga et al., the risk of difficult intubation was three times higher in morbidly obese patients than in normal-weight patients [12]. In contrast, Neligan et al. [13] and Brodsky et al. [10] did not find a relationship between morbid obesity and difficult intubation. In our study, we found that a BMI value higher than 46 kg/m$^2$ was significant for difficult intubation in obese patients.

OSA is a risk factor for difficult mask ventilation and difficult intubation in obese patients. Considering the high closing pressure of the pharyngeal airway in OSA patients, this association is easily understood [24]. Some studies in the literature showed high rates of OSA in patients with difficult tracheal intubation. Siyam et al. [25] and Kim et al. [26] showed that tracheal intubation with direct laryngoscopy is more difficult in OSA patients than in patients without OSA, but no comparison was made between the BMIs of the patients in these studies.

There is limited data and conflicting evidence in the literature regarding the relationship between neck circumference and difficult intubation. In addition, the cut-off value for neck circumference, which may be associated with difficult intubation, has not been exactly established [17]. In addition to publications stating that neck circumference alone is not a significant predictor for difficult intubation, Gonzalez et al. [7] conducted a study with 70 morbidly obese and 61 non-obese patients, in which intubation was categorized as difficult at IDS >5 and not difficult at IDS = 5 and below, and they found that a neck circumference of >43 cm increased the risk of difficult intubation in both obese and non-obese patients. Langeron et al. [21] also emphasized that a neck circumference of >43 cm is a risk factor for difficult intubation. In their study conducted in 2002, Brodsky et al. [10] reported that neck circumference is an independent risk factor for difficult intubation and that the risk of difficult intubation increases seven times as the neck circumference increases from 40 cm to 60 cm. Riad et al. [17] conducted a study with 104 morbidly obese patients in 2016 and showed that neck circumference >42 cm was an independent risk factor for difficult intubation, and it increased the risk of difficult intubation five times. Contrary to these studies, in their study conducted with 180 obese patients in 2009, Neligan et al. [13] stated that neck circumference was significant in the prediction of difficult laryngoscopy but was not useful in the prediction of difficult intubation. However, in their study conducted with 120 obese patients in 2018, Özdilek et al. [21] reported that neck circumference was not a risk factor for difficult mask ventilation or for difficult laryngoscopy. In line with studies using ultrasound measurement, which reported that large neck circumference contributes to difficult intubation due to fat deposition in the anterior soft tissue of the neck, Raju Vegesna et al. [27] showed that neck circumference has the highest significance as a parameter in terms of difficult intubation [28]. In their study that compared 123 obese and 125 non-obese patients, Kim et al. [26] found that neck circumference/thyromental distance ratio is a better predictor of difficult intubation than the Mallampati classification or neck circumference measurement alone. Consistent with the studies by Brodsky et al. [10] and Riad et al. [17], our study found that neck circumference was an independent risk factor for difficult intubation in obese patients, and neck circumference >50 cm increased the risk of difficult intubation eight times.

There are some studies in the literature claiming that BMI cannot distinguish between adipose tissue and lean body mass; therefore, a high BMI alone is not significant for obesity and accompanying complications. These studies stated that obesity pathology is closely related to body fat distribution [4, 29-31]. These views emphasize that what matters is not the patient's actual BMI, but visceral adiposity, which defines where this excess weight is stored. Whether a person has an apple- or pear-shaped body morphology matters. Apple-shaped individuals have proportionally more abdominal fat, a case defined as central obesity. Many studies have found them to be at higher risk for

perioperative complications [31, 32]. Although waist circumference and BMI are related to each other, it has been frequently stated in the literature that waist/height ratio (central obesity) means a higher risk rate in terms of type 2 diabetes, dyslipidemia, HT, and cardiovascular diseases [32]. However, there are very limited data in the literature on the relationship between obesity type and difficult airway/difficult intubation. In a study examining the effects of morbid obesity on the difficult airway, it was found that the risk of difficult intubation is higher in males than in females because most morbidly obese women carry excess weight on their hips and thighs (classical "pear" shape), whereas morbidly obese men carry excess weight on their trunks and abdomen. They also reported that morbidly obese men have more pretracheal fat mass and larger back fat pads, resulting in anatomical changes in the upper neck and airway that increase the risk of difficult intubation. This view is supported by some studies suggesting that there is a significant relationship between neck circumference and central obesity and that the height of the neck circumference is an indicator for central obesity. The multivariate logistic regression analysis performed in this study showed that central obesity type is not an independent risk factor for difficult intubation but has a significant association with difficult intubation.

**Limitations**

One of the limitations of our study was the inability to standardize the evaluation of patients in terms of difficult intubation owing to the different levels of education, skill, and experience of the anesthetists who performed intubation.

Secondly, our use of a video laryngoscope as the first choice instead of the Macintosh blade in some patients who were believed to be at high risk for difficult intubation may have resulted in a failure to make objective evaluations among patients in defining difficult intubation.

In addition, because there are few studies examining whether the type of obesity is significant in terms of difficult intubation in obese patients, we believe that new studies with a larger number of patients should be performed by a single anesthesiologist and practitioner following standardized techniques.

**Conclusion**

Thus, the findings of this study showed that BMI, neck circumference, thyromental distance <6.5 cm and Mallampati classification >2 are important predictor factors in morbidly obese patients. These important measurements should be evaluated in the pre-anesthesia examination for possible difficult intubation.

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