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Difficult Mask Ventilation in Obese Patients: New Predictive Tests?

Obez Hastalarda Zor Maske Ventilasyonu: Yeni Prediktif Testler?

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Abstract

Aim: The aim of our study was to evaluate specific factors in predicting difficult mask ventilation (DMV) in obese patients undergoing elective surgery.

Methods: This prospective and observational study was performed in 90 obese patients. We assessed age, height, weight, sex, body mass index (BMI), dental structure, presence of facial hair, modified Mallampati test result, mouth opening, thyromental distance (TMD), sternomental distance, mandibular protrusion, mandibular length, neck circumference (NC), neck length, upper lip bite test result, height to TMD ratio, NC to TMD ratio (NC/TMD), and history of snoring and Obstructive Sleep Apnea syndrome for estimation of DMV.

Results: The mean age of the patients was 40.9±9.4 years and the mean BMI was 44.7±6.2 kg/m^2. Of all patients 38.9% were determined to have DMV. Clinical variables associated with DMV were male gender, mandibular length, snoring, NC, and NC/TMD. Multiple logistic regression analysis showed that male gender (p=0.047) and snoring (p=0.02) were independent factors.

Conclusion: We believe that NC/TMD and ML are predictive tests for DMV in obese patients. Tests and measurements at the bedside are not sufficient alone and we believe that they will be more reliable when considered together

Keywords: Mandibular length, mask ventilation, neck circumference/ thyromental distance, obesity.

Öz

Amaç: Çalışmamızın amacı elektif cerrahi uygulanan obez hastalarda maske ventilasyonunun zorluğunun belirlenmesinde spesifik faktörlerin etkisini değerlendirmektir.

Yöntemler: Bu prospektif ve gözlemsel planlanan çalışmaya 90 hasta dahil edildi. Zor maske ventilasyonu (ZMV) tahmininde yaş, boy, kilo, cinsiyet, vücut kitle indeksi (VKİ), diş yapısı, sakal varlığı, modifiye mallampati testi, ağız açıklığı, tiromental mesafe (TM), sternomental mesafe, mandibula protrüzyonu, mandibula uzunluğu (MU), boyun çevresi (BÇ), boyun uzunluğu, üst dudak ısırma testi, boyun çevresi/ tiromental mesafe (BÇ/TM) oranı, horlama ve obstrüktif sleep apne sendromu varlığının etkisini değerlendirdik.

Bulgular: Ortalama yaş ve VKİ sırasıyla 40,9±9,4 yıl ve 44,7±6,2 kg/ m^2 idi. Olguların %38,9'unun ZMV olduğu belirlendi. ZMV ile ilişkili klinik değişkenler erkek yaş, MU, horlama, BÇ ve BÇ/TM oranı idi. Çoklu regresyon analizi, erkek cinsiyetin (p=0,047) ve horlamanın (p=0,02) bağımsız faktörler olduğunu ortaya koymuştur.

Sonuç: Obez hastalarda BÇ/TM ve MU'nun ZMV için prediktif testler olduğunu düşünüyoruz. Yatak başı yapılan testler ve ölçümlerin tek başına yeterli olmadığını, birlikte değerlendirildiğinde daha güvenilir olacağına inanıyoruz

Anahtar Sözcükler: Mandibular uzunluk, maske ventilasyonu, boyun çevresi/tiromental mesafe, obezite.

Introduction

Obesity is generally acknowledged as a global phenomenon that increases morbidity and reduces life expectancy (1). According to World Health Organization data, in 2014, there were more than 1.9 billion overweight adults worldwide, above the age of 18, and more than 600 million obese people. Thus, most patients requiring anesthesia for surgery will be overweight or obese (2,3).

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The Fourth National Audit Project on major complications of airway management in the United Kingdom reported that obese patients had double the risk of airway problems and morbidly obese patients were four times more likely to develop airway problems during an anaesthetic (4). In obese patients, not only the external airway but also the anatomy of the oropharynx and larynx is altered . Without regard to the total body fat of obese patients, parapharyngeal fat dimensions increase in parallel with visceral and abdominal fat distribution.

Obesity is related to restrictive pulmonary disease due to increased intraabdominal pressure. This reduces functional residual capacity, causing low oxygen reserves, disrupted gas exchange and shortened safe apnea time before desaturation. As a result, it is known that there is a limited duration to solve airway problems in "can't intubate, can't ventilate" situations (5-7).

In obese patients, difficult airway management, especially difficult mask ventilation (DMV), is frequently reported (8). The incidence of DMV in obese individuals has been reported to be 1.4-24% (8-10). According to the American Society of Anesthesiologists (ASA), DMV is defined as the clinical situation developing when it not possible for the anesthesiologist to provide adequate ventilation because of one or more of the following problems: inadequate mask seal, excessive gas lead or excessive resistance to the ingress or egress of gas (11).

In our study, the aim was to determine predictive factors for DMV or impossible mask ventilation (IMV) in obese patients with low physiological reserve to ensure preparation of appropriate airway choices.

Methods

Our study was performed between May and November 2014 after obtaining approval from the Bülent Ecevit University Ethics Committee (meeting no: 2014-84-08/04) and patient consent. This prospective and observational study included 90 obese ASA 1-3 patients aged 18-65 years with a body mass index (BMI) ≥30 who underwent elective surgery under general anesthesia. Patients requiring regional anesthesia, awake and/or rapid intubation or emergency entubation, and pregnant patients were excluded.

The patients were preoperatively assessed for age, height, weight, BMI, dental structure, presence of beard, modified Mallampati test results, mouth opening [inter-incisor gap (cm)], thyromental distance (cm), sternomental distance (cm), mandibular protrusion, mandibular length (ML), neck circumference (NC), neck length, upper lip bite test, height to thyromental distance ratio (RHTMD), NC to TMD (NC/TMD), history of snoring, and Obstructive Sleep Apnea syndrome (OSAS) by an anesthesiologist blind to the study.

Table 1. Mask ventilation scale(12)

Grade	Grade description
1	Ventilated by mask
2	Ventilated by mask with oral airway/other adjuvant with or without muscle relaxant
3	Difficult mask ventilation (inadequate to maintain oxygenation, unstable or requiring two practitioners with or without muscle relaxant)
4	Unable to mask ventilate with or without muscle relaxant

All patients had no premedication with routine monitoring. All patients received preoxygenation with 100% O_2 for 5 minutes using appropriate masks. Anesthesia was induced with 2 mg/kg propofol and 1 µg/kg fentanyl according to total body weight, and rocuronium 0.6 mg/kg according to ideal body weight. The patients had mask ventilation with the head positioned 30°C up. Mask ventilation and intubation were performed by the same anesthesiologist blind to the study. Mask ventilation was graded according to a four point scale described by Han et al. (12) (Table 1). All patients were intubated without problems with a video laryngoscope (Storz C-MAC® Video Laryngoscope, Germany).

Statistical Analysis

Statistical Package for the Social Sciences (SPSS) v.19.0 (IBM Corp. in Armonk, NY) was used for statistical analysis. Descriptive statistics are given with frequency and percentage for categorical variables and mean, standard deviation, median and minimum-maximum values for continuous variables. The Shapiro-Wilk test was used to evaluate the normality of the variables. The independent samples t-test and the Mann-Whitney U test were used for normally distributed and non-normally distributed variables, respectively. Yates' correction and Fisher's exact tests were used to test relationship between categorical variables. All variables with a p value below 0.05 in univariate analysis were entered into a multivariate logistic regression model. For all statistical comparisons, a p value of less than 0.05 was considered statistically significant.

Results

A total of 90 patients (58 female and 32 male) with a mean age of 40.9±9.4 years and a BMI of 44.7±6.2 kg/m^2 were included in the study. Of all the patients 38.9% were determined to have DMV. Surgeries were, in order, bariatric surgery (76.7%), lumbar disc hernia (6.7%), shoulder surgery (3.3%), percutaneous nephrolithotomy (3.3%), abdominal surgery (2.2%), and thyroidectomy (7.8%). The other patient characteristics are shown in (Table 2). In univariate analysis, risk factors for DMV were identified. There was a significant difference in the presence of history of snoring and OSAS, NC ≥43 cm, male gender,

Table 2. Patient demographics and preoperative variables	
Age (year) ± SD	41±9
F/M (%)	58/32 (64.4/35.6%)
Height (cm) ± SD	163±9
Weight (kg) ± SD	118±19
BMI (kg/m²) ± SD	43.6±6.2
Mallampati: 1/2/3 (%)	10/58/22 (11.1/64.4/24.4%)
ASA: 1/2/3 (%)	4/66/20 (4.4/73.3/22.2%)
Beard (%)	17 (18.9%)
History of snoring (%)	74 (82.2%)
OSAS diagnosis (%)	8 (8.9%)
Sternomental distance ≥12.5 cm (%)	81(90%)
TMD ≥6 cm (%)	88 (97.8%)
ML ≥9 cm (%)	86 (95.6%)
Mask numbers: 3/4/5 (%)	5/46/39 (5.6/51.1/43.3%)
Upper lip bite test grade: 1/2/3 (%)	59/31/0 (65.6/34.4/0%)
Neck circumference ± SD	44±4.4
NC/TMD ± SD	4.8±1.09
RHTMD ± SD	18.4±3.63

F/M: Female/male, BMI: Body mass index, ASA: American Society of Anesthesiologists, OSAS: Obstructive Sleep Apnea syndrome, TMD: Thyromental distance, ML: Mandible length, NC/TMD: Neck circumference/thyromental distance, RHTMD: Height/thyromental distance ratio, SD: Standard deviation

Table 3. Univariate analysis of the variables associated difficult mask ventilation status (p<0.05)			
Variables	**Easy DMV; %**	**Difficult DMV; %**	**p**
F/M	46.7% 14.4%	17.8% 21.1%	p=0.006
History of snoring No Yes	15 (27.3%) 40 (72.7%)	1 (2.9%) 34 (97.1%)	p=0.008
History of OSAS No Yes	53 (65.4%) 2 (22.2%)	28 (34.6%) 7 (77.8%)	p=0.025
NC <43 cm ≥43 cm	46.7% 14.4%	17.8% 21.1%	p=0.013
NC/TMD <5 cm ≥5 cm	43 (78.2%) 12 (21.8%)	19 (54.3%) 16 (45.7%)	p=0.021
ML <9 cm ≥9 cm	0 55 (61.1%)	4 (4.4%) 31 (34.4%)	p=0.02

DMV: Difficult mask ventilation, F/M: Female/male, OSAS: Obstructive Sleep Apnea syndrome, NC: Neck circumference, NC/TMD: Neck circumference/thyromental distance, ML: Mandible length

Table 4. Independent predictors of difficult mask ventilation according to multivariate logistic regression model								
	B	**SE**	**Wald**	**df**	**p**	**Exp (B)**	**95% CI of Exp (B)**	
							Lower	**Upper**
Fixed	17.096	18808.6	0.000	1	0.999	-	-	-
Male sex	-1.317	0.516	6.520	1	0.011	0.268	0.097	0.736
Snoring	2.646	1.137	5.415	1	0.020	14.097	1.518	130.906
NC/TMD	0.398	0.246	2.625	1	0.105	1.489	0.920	2.409

NC/TMD: Neck circumference/thyromental distance, CI: Confidence interval, SE=stantard error

ML ≥9 cm and NC/TMD <5 cm were significantly different between patients with and without DMV (Table 3).

To estimate easy and DMV, the variables of history of snoring, sex and NC/TMD were taken into the model. Since only four patients had a ML below 9 cm, ML was removed from the model. The remaining three variables explained 35.7% of the variation in easy/DMV, with snoring and sex observed to be significant (p=0.020 and 0.011) for differentiation of easy/DMV. Snoring was assessed to increase the risk of DMV by 14.097 times while being a male increased the risk by 3.73 times (Table 4).

Discussion

Currently, the prevalence of obesity and accompanying health risks continue to increase. Difficulties in securing mask ventilation and airway in obese patients are common (13). Difficult airway is defined as a situation where a conventionally-trained anesthesiologist encounters difficulty with face mask ventilation, intubation or both (14). The most dangerous situation in airway management is the situation where tracheal intubation is difficult or impossible and ventilation with a mask is insufficient or cannot be completed (patients who can't be intubated or ventilated). The prediction of DMV is therefore of vital importance (11). The incidence of DMV in the general population and obese patient population has been reported to be 1.4-24% and 8.8-14%, respectively (9,10,15-18). In our study, the incidence of DMV was found to be 38.9%. Contrary to other studies, the male percentage in our study was higher which we believe may

have caused the difference. The incidence of IMV is much lower than that of DMV. Langeron et al. (9) reported that only one patient in 1502 (0.07%) had IMV, and Kheterpal et al. (15) reported an incidence of 0.16%. In our study, no patient was observed to have IMV.

In their study, Langeron et al. (9) reported that age >55 years, BMI >26 kg/m^2, edentulous mouth, history of snoring and presence of facial hair were independent factors for DMV. Kheterpal et al. (15) indicated BMI of 30 kg/m^2 or greater as the most important factor for grade 3 DMV. In studies of obese patients, independent factors for DMV were reported to be male gender, large NC, high Mallampati score, limited jaw protrusion, and age ≥49 years (17,18). In our study, univariate analysis revealed that the risk factors were history of snoring, history of OSAS, NC ≥43 cm, male gender, ML ≥9 cm, and NC/TMD <5 cm.

Many factors contribute to DMV, facial anomalies are among common reasons. Long and narrow mandible is a common facial anomaly. Cavities formed at the corners of the mouth and lower corners of the mask may cause air leak and DMV (19,20). In a study assessing the effect of horizontal ML on endotracheal intubation difficulty, a ML <9 cm was determined to be a predictive factor for difficult intubation (p<0.001) (21). In our study, there was a significant effect of ML above 9 cm on the incidence of DMV (p<0.02).

BMI and waist circumference have been reported to contribute to the prediction of non-abdominal, abdominal subcutaneous and visceral fat. They are the first steps to determine the distribution and level of obesity (22). Recently, NC has been used to define excessive weight and obesity. NC is positively correlated with age, weight, waist and hip measurements in both sexes. Additionally, NC is considered an upper body obesity index (23,24). Increased fat tissue in the pharyngeal walls causes changes in the anatomy of the upper airway. Deposition of fat in the lateral walls reduces the airway diameter and the oropharynx gains an elliptical shape. As NC reflects increased palatal and pharyngeal soft tissue, it may make mask ventilation and intubation difficult (25). In a study that compared the ease of intubation in obese and lean patients with intubation difficulty scale, they showed difficult intubation in patients with a NC of more than 35 cm (26). Cattano et al. (18) reported that a NC ≥40 cm in the general population and ≥43 cm in obese patients was correlated with DMV (p=0.002). Another study found that the best discriminating point for NC was 46 cm, with the risk of DMV increasing linearly as NC increased (17). In our study, a cut-off value for NC was identified as 43 cm, and we believe that in accordance with the literature NC ≥43 cm is correlated with DMV (p=0.01).

Obesity is believed to predispose individuals to OSAS because of mass loading of the upper airway by adipose tissue in the neck (27). Approximately 5% of morbidly obese patients have OSAS (28). Horner et al. (29) showed that there was more fat in areas surrounding the collapsible segments of the pharynx in patient with OSAS on magnetic resonance imaging. In another study, it was stated that male sex and high adipose tissue distribution were associated with poorer pulmonary gas exchange (30). Snoring is an indicator of increased upper airway resistance and possible OSAS. Several studies suggested that the prevalence of habitual snoring was strongly dependent on BMI and NC (31,32). As a result, obese patients with OSAS or increased risk of OSAS or snoring history have an increased risk of DMV and difficult intubation (33,34). In our study, in accordance with the literature, the incidence of DMV was high in those with OSAS diagnosis and history of snoring (p=0.03, p=0.008).

Studies researching new indices for difficult intubation reported that, evaluation of RHTMD and NC/TMD might be useful screening for difficult intubation (35,36). The literature is silent as no study has been done in adults to find the relationship of DMV with RHTMD and, NC/TMD. In our study of obese patients, of these parameters, only a NC/TMD <5 cm was identified to have a statistically significant effect on DMV (p<0.021).

Conclusion

In conclusion, male sex, snoring history, NC ≥43 cm, ML ≥9 cm and NC/TMD <5 cm were correlated with DMV in obese patients.

The sample size is small to conclusively state the results of our study if we compare with similar studies in adults. Further studies with larger sample size are needed for investigation of new indices, such as ML, NC/TMD, and RHTMD in the obese population.

We assume that NC/TMD and ML measurements are predictive tests for DMV in obese patients. As preoperative airway examination should be carefully completed, especially in obese patients, tests and measurements at the bedside are not sufficient alone and we believe that they will be more reliable when considered together. In case of difficulties in predicting DMV and placement of any airway apparatus, we suggest that airway equipment such as face mask, oral/nasal airway, laryngeal mask should be prepared or different airway methods should be planned.

Authorship Contributions

Surgical and Medical Practices: B.G.A., Ö.P. Concept: B.G.A., G.K., H.A. Design: H.A., R.D.O. Data Collection or Processing: Ö.P., G.K., R.D.O. Analysis or Interpretation: B.G.A., H.A., Literature Search: G.K., R.D.O., Ö.P. Writing: B.G.A.

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