Morbid Obesity and Tracheal Intubation

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The tracheas of obese patients may be more difficult to intubate than those of normal-weight patients. We studied 100 morbidly obese patients (body mass index >40 kg/m^2) to identify which factors complicate direct laryngoscopy and tracheal intubation. Preoperative measurements (height, weight, neck circumference, width of mouth opening, sternomental distance, and thyromental distance) and Mallampati score were recorded. The view during direct laryngoscopy was graded, and the number of attempts at tracheal intubation was recorded. Neither absolute obesity nor body mass index was associated with intubation difficulties. Large neck circumference and high Mallampati score were the only predictors of potential intubation problems. Because in all but one patient the trachea was intubated successfully by direct laryngoscopy, the neck circumference that requires an intervention such as fiberoptic bronchoscopy to establish an airway remains unknown. We conclude that obesity alone is not predictive of tracheal intubation difficulties.

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The tracheas of obese patients may be more difficult to intubate than those of normal-weight patients (1–3). This has not been our experience working in a busy bariatric surgical center. We prospectively studied morbidly obese surgical patients to identify which factors might complicate direct laryngoscopy and tracheal intubation in obese patients.

Methods

With permission from our Human Subjects Committee, 100 consecutive morbidly obese patients undergoing elective surgery at Stanford University Medical Center consented to be studied. Morbid obesity was defined as a body mass index (BMI) >40 kg/m^2. Preoperatively, a complete medical history was obtained. Significant comorbidities, including snoring or a diagnosis of obstructive sleep apnea (OSA) syndrome, were recorded. Height and weight were used to calculate BMI.

On the day of surgery, the faculty anesthesiologist assigned to the case asked the patient to extend his or her neck, open his or her mouth, protrude the tongue, and phonate. The resulting view was scored (4). Neck circumference (cm) at the level of the thyroid cartilage and the width of mouth opening (cm) were measured. The thyromental distance (cm) and the sternomental distance (cm) were measured with the neck extended. Any problems with range of motion of the head and neck and the condition of the teeth were noted.

Preoperatively, patients received IV metoclopramide and sodium citrate by mouth. In the operating room patients were positioned with pillows or towels under their shoulders, with their head elevated and neck extended. Patients breathed 100% oxygen by face mask for a minimum of 3 min or until their oxyhemoglobin saturation was 100%.

Cricoid pressure was applied, followed by a rapid-sequence anesthetic induction with an IV induction drug (thiopental or propofol) and succinylcholine to facilitate tracheal intubation. Initial intubation attempts were performed by the anesthesia resident under the supervision of one of the authors. The choice of laryngoscope blade (MacIntosh No. 3 or 4; Miller No. 2) was made by the laryngoscopist. In general, a styletted 8.0-mm-inner-diameter endotracheal tube was used for men and a 7.0-mm-inner-diameter tube for women.

The view upon direct laryngoscopy was graded and recorded as follows. With Grade 1 view, the vocal cords were completely visible; with Grade 2, only the arytenoids were visible; with Grade 3, only the epiglottis was visible; and with Grade 4, the epiglottis was not visible (5). The numbers of attempts at tracheal intubation were recorded.

Tracheal intubation was classified as easy if the product of the graded laryngoscopy view times the

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number of intubation attempts was <3 and was classified as problematic when it was ≥3. In no instance was a bougie used to assist intubation.

Logistic regression was used to quantify the relationship between ease of intubation and patient characteristics by using the following model:

$$P(D) = \frac{1}{1 + e^{-(\alpha + \Sigma\beta_i X_i)}},$$

where P(D) is the probability of a problematic intubation, X_i is patient characteristic i, α is a model parameter for $X_i = 0$, and β_i is a model parameter for patient characteristic i.

The best model was determined by stepwise selection. The χ^2 distribution was used to assess significant model improvement.

Data are reported as median (interquartile range) unless specified otherwise. Continuous variables were compared by using Wilcoxon's ranked sum test or the Kruskal-Wallis test. Categorical variables were compared by using Fisher's exact test or Pearson's χ^2 test. P values <0.05 were considered statistically significant. All analyses were performed with S-PLUS 2000® (Mathsoft, Inc., Seattle, WA).

Results

Seventy-eight women and 22 men aged 44 yr (interquartile range, 36–51 yr) were studied. Weight was 137 kg (interquartile range, 124–156 kg), height was 168 cm (interquartile range, 160–173 cm), and BMI was 47.5 kg/m^2 (interquartile range, 43.9–56.6 kg/m^2). Forty-four patients had a history suggestive or diagnostic of OSA; 56 had no evidence of OSA.

The median neck circumference was 46.0 cm (interquartile range, 42.0–49.0 cm), the sternomental distance was 14.0 cm (interquartile range, 12.0–17.0 cm), and the thyromental distance was 9.5 cm (interquartile range, 8.0–11.0 cm).

In 30, 37, 32, and 1 patients, Mallampati scores were 1, 2, 3, and 4, respectively. During initial laryngoscopy, the view of the larynx was Grade 1 in 75 patients, Grade 2 in 16 patients, and Grade 3 in 9 patients. No patient had a Grade 4 view. In 92, 5, and 2 patients, the trachea was intubated on the first, second, and third attempts, respectively. A failed intubation with direct laryngoscopy occurred in one patient.

In 97 patients the tracheas were intubated by the anesthesia resident; 3 patients required intubation by the faculty anesthesiologist. In 12 patients, intubation was problematic. Tables 1 and 2 compare the characteristics of patients with easy intubation and those with problematic intubation. Problematic intubation was associated with higher Mallampati scores and with larger neck circumferences.

In the logistic regression analysis, neck circumference was the only patient characteristic that did have a significant effect on the probability of problematic intubation ($P = 0.02$; model parameters: $\alpha = -7.75$, SE 2.58; and $\beta_{\text{neck circumference}} = 0.12$, SE 0.05). Including other patient characteristics in the model did not result in significant improvement. The logistic regression model predicts that the odds of a problematic intubation in a particular patient with a neck circumference 1 cm larger than that of another patient are 1.13 (95% confidence interval, 1.02 to 1.25) times the odds of the patient with a 1-cm smaller neck circumference. With a neck circumference of 40 cm, the probability of a problematic intubation was approximately 5%, and at 60 cm the probability of a problematic intubation was approximately 35% (Fig. 1).

A larger neck circumference was associated with men ($P < 0.001$), a higher Mallampati score ($P = 0.0029$), Grade 3 views during laryngoscopy ($P = 0.0375$), and OSA ($P = 0.0372$) (Fig. 2).

Discussion

A "difficult airway" has been defined as the clinical situation in which a conventionally trained anesthesiologist experiences problems with mask ventilation, with tracheal intubation, or with both (6). The incidence of difficult laryngoscopy and tracheal intubation is unknown, but it may be as frequent as 7.5% in the normal surgical population (5,7). The medical literature on this subject is confusing because poor laryngoscopic view does not always equate with difficult tracheal intubation. For example, seven of nine patients in our study with a Grade 3 laryngoscopy view had their trachea intubated on the first attempt.

The tracheas of obese patients are believed to be more difficult to intubate than those of normal-weight patients (1–3). In one study 9 (15%) of 68 morbidly obese patients were categorized preoperatively as difficult to intubate, and 4 underwent awake intubation because their preoperative evaluation predicted difficulty (8). The criteria used to predict difficulty were not described.

Difficult intubation, defined as inadequate exposure of the glottis by direct laryngoscopy, was reported to increase with increasing BMI (2). We found no association between increasing weight or BMI with problematic intubation. Only three patients qualified as having a difficult intubation with the criteria described by Karkouti et al. (9), that is, number of direct laryngoscopy attempts plus the grade of laryngoscopy view >4. In our study, this incidence was no more frequent than what might be expected in the normal surgical population (5).

Table 1. Patient Characteristics (Continuous Variables) Stratified by Problematic and Easy Intubation

	Problematic intubation (n = 12)			Easy intubation (n = 88)			
Variable	Median	25th pct	75th pct	Median	25th pct	75th pct	P value[a]
Age (yr)	44	39.5	49.5	44	36	51.5	0.9957[b]
Height (cm)	168	159.7	176.9	168	160.3	171.2	0.6471[b]
Weight (kg)	124.8	124	144.1	137	122.3	156.8	0.858
BMI (kg/m^2)	46.5	42.5	47.3	48.9	44.2	58.1	0.9393
Neck circumference (cm)	50.5	44.7	54	46	42	48	0.0326
Sternomental distance (cm)	13.5	12.7	16.2	12	14	17	0.4979
Thyromental distance (cm)	9.5	7.7	10	9.5	8	11	0.6556
Mouth opening (cm)	5	4.1	5.2	5.5	4	6.3	0.1284

Neck circumference is significantly larger in patients with problematic intubations.
BMI = body mass index; Pct = percentile.
[a] Wilcoxon's ranked sum test.
[b] Two tailed.

Table 2. Patient Characteristics (Categorical Variables) Stratified by Problematic and Easy Intubation

Variable	Category	Problematic intubation (n)	Easy intubation (n)	P value
Sex	Male	4	18	0.4559[a]
	Female	8	70	
Sleep apnea	Yes	6	50	0.8915[b]
	No	6	38	
Mallampati	1	0	30	0.0305[a]
	2	5	32	
	3	7	25	
	4	0	1	

Mallampati classification was different between these two groups; higher Mallampati scores were associated with problematic intubation.
[a] Fisher's exact test.
[b] Pearson's χ^2 test.

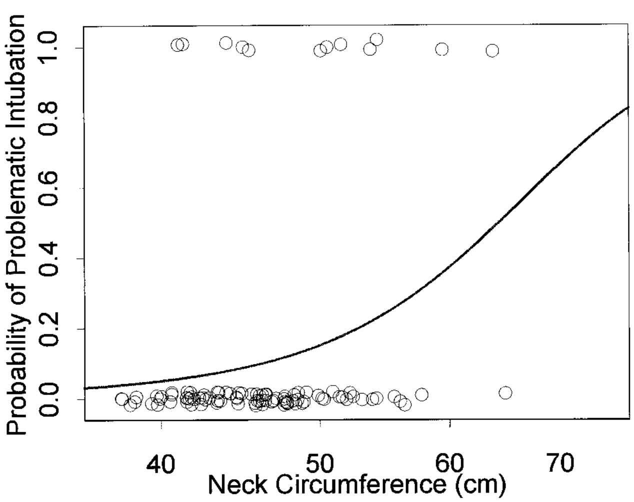

Figure 1. The graph shows on the x axis the neck circumference (cm) and on the y axis the probability of problematic intubation. The circles are the jittered data. The line is the model fit. At a neck circumference of 40 cm, the probability of a problematic intubation is approximately 5%, and at 60 cm, the probability of a problematic intubation is approximately 35%.

There have been many attempts to develop a score to measure the complexity of endotracheal intubation. Most methods are quite complicated, involving numerous variables (10). We defined a new category called "problematic" intubation to describe patients in whom the potential for intubation difficulties was present, but in whom actual difficulty with establishing the airway may or may not have occurred.

Other factors that have been associated with difficult laryngoscopy include short sternomental distance; short thyromental distance; large neck circumference; limited head, neck, and jaw movement; receding mandible; and prominent teeth (5,11). Of these factors, only large neck circumference was associated with problematic intubation in our patient population.

Logistic regression identified neck circumference as the best single predictor of problematic intubation. Mallampati score inclusion did not further improve the model in our limited study with only 12 problematic intubations. In patients with a large neck, the view during direct laryngoscopy was poorer. Neck circumference measured at the level of the superior border of the cricothyroid cartilage has also been correlated with increasing severity of OSA in obese patients (12). The incidence of difficult intubation in OSA patients with large necks is claimed to be several times more frequent than nonobese patients with OSA (13). Although 44% of our patients had a history of OSA, we did not encounter the incidence of intubation difficulties previously reported.

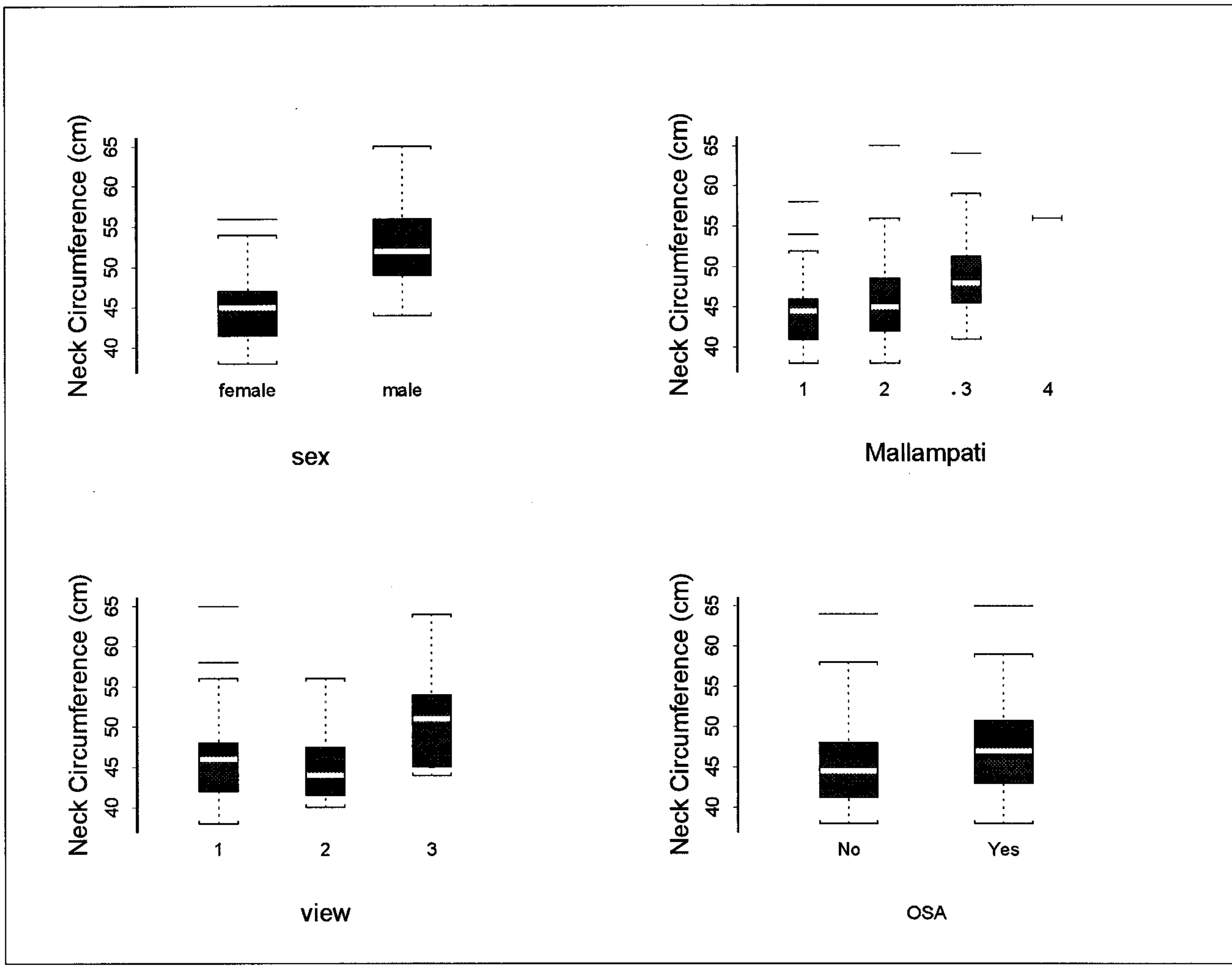

Figure 2. Boxplots show the distribution of patient neck circumference, stratified by sex, Mallampati classification, graded view on laryngoscopy, and obstructive sleep apnea (OSA). The horizontal line in the interior of each box is the median. The height of the box is the interquartile distance, which is the difference between the third quartile and first quartile. The whiskers extend to a distance of 1.5 times the interquartile distance. Horizontal lines indicate outliers. Larger neck circumferences are associated with men, higher Mallampati classification, Grade 3 laryngoscopy views, and OSA.

The trachea was successfully intubated with three or fewer direct laryngoscopy attempts in all but one patient. The failed intubation was a 38-year-old, 181-cm-tall, 141-kg man with a BMI of 43.1 kg/m^2. He had a history of OSA. His neck circumference was large (59 cm), with a sternomental distance of 20 cm and a thyromental distance of 14 cm. He had a Mallampati 3 view of his oropharynx. Laryngoscopy with a MacIntosh No. 4 blade revealed a Grade 3 view. Three attempts with direct laryngoscopy were unsuccessful. His lungs were easily ventilated via mask. A fiberoptic bronchoscope was introduced, the glottis visualized, and the endotracheal tube passed over the fiberoptic bronchoscope into the trachea without incident.

In conclusion, we found that neither absolute obesity nor increasing BMI was associated with problematic intubation in morbidly obese patients. Problematic intubation was associated with increasing neck circumference and a Mallampati score of ≥3. A poor view during direct laryngoscopy was not a factor in successful intubation because in all but one patient the trachea was intubated by direct laryngoscopy. Therefore, the degree of obesity or neck size that justifies interventions such as elective, awake fiberoptic bronchoscopy for intubation remains unknown (14). The experience and ability of the laryngoscopist are probably the most important determinants for establishing an airway in the morbidly obese patient. Because anesthesia residents successfully intubated the trachea in almost all our patients, the success rate would be expected to be even higher when fully trained anesthesiologists manage the airway.

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