The Importance of Increased Neck Circumference to Intubation Difficulties in Obese Patients

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BACKGROUND: Using the intubation difficulty scale (IDS), we sought to confirm that obese patients are more difficult to intubate than lean patients. We assessed classical bedside tests and included neck circumference.

METHODS: We prospectively compared the incidence of difficult tracheal intubation in 70 obese [body mass index (BMI) $\geq$30 kg/m^2] and 61 lean patients (BMI <30 kg/m^2). The IDS scores, categorized as difficult intubation (IDS >5) or not (IDS $\leq$5), and the patient data, were compared between lean and obese patients. Preoperative measurements [BMI, neck circumference (at the level of the thyroid cartilage), width of mouth opening, sternomental distance, and thyromental distance], medical history of obstructive sleep apnea syndrome, and several scores (Mallampati, Wilson, El Ganzouri) were recorded. The view during direct laryngoscopy was graded, and the IDS was recorded. We then compared patients with IDS $\leq$5 and >5, concerning each item.

RESULTS: The results indicate that difficult tracheal intubation is more frequent in obese than in lean patients (14.3% vs 3%; $P = 0.03$). In the patients with IDS > 5, thyromental distance, BMI, large neck circumference, and higher Mallampati score were the only predictors of potential intubation problems.

CONCLUSION: We found that problematic intubation was associated with thyromental distance, increasing neck circumference, BMI, and a Mallampati score of $\geq$3. Neck circumference should be assessed preoperatively to predict difficult intubation.

(Anesth Analg 2008;106:1132–6)

Difficulties with tracheal intubation significantly contribute to the morbidity and mortality associated with anesthesia.[1] Identifying situations and patients at risk for airway management problems is a key to optimal care and has been the focus of numerous publications.[2,3]

Several reviews have reported that endotracheal intubation is more difficult in obese than in lean patients.[2,4] However, this assertion remains controversial because other studies have found no evidence that tracheal intubation is more difficult in obese than in lean individuals.[5,6] One reason for these discrepancies is the lack of consensus on the definition of the term "difficult intubation," which varies among authors. However, an objective scoring system has been proposed to assess intubation difficulty: the intubation difficulty scale (IDS) score, which has been validated by Adnet et al.[7] This score uses several variables associated with difficult intubation and has already been used to compare obese with lean patients.[8]

Although obesity is thought to increase the risk of difficult intubation, increased body mass index (BMI) poorly predicts difficult laryngoscopy.[5,6] Prediction of difficult laryngoscopy in obese patients is challenging. Suggested predictors include history of obstructive sleep apnea (OSA) syndrome,[5,9–11] high Mallampati score,[5,9] increased age, male sex, short neck, and abnormal upper teeth.[9,12] Juvin et al. found that none of the classic factors for difficult intubation was satisfactory in obese patients.[8] However, they did not assess the finding of Brodsky et al. concerning the association between problematic intubation and large neck circumference.[5]

The aim of this study was to compare the incidence of difficult tracheal intubation, by means of the IDS score, between lean and obese patients assessed with classical bedside tests and neck circumference.

METHODS

After approval by our local ethics committee, all patients provided informed consent. All obese patients scheduled for surgery under general anesthesia with endotracheal intubation were enrolled in this prospective study at University Hospital of Toulouse. Obesity was defined as a BMI >30 kg/m^2. Concomitantly, all the lean (BMI <30 kg/m^2) adult patients

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Accepted for publication December 14, 2007.

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DOI: 10.1213/ane.0b013e3181679659

who were scheduled for surgery during the same period and who were intubated by the same anesthesiologists were included in the control group. Patients scheduled for regional anesthesia and general anesthesia without endotracheal intubation, or those with upper airway pathology (i.e., maxillofacial fractures, tumors, etc), cervical spine fractures and patients younger than 18 yr were excluded from the study.

Preoperatively, a complete medical history was obtained. Significant comorbidities, including snoring and diagnosis of OSA syndrome, were recorded. Height and weight were used to calculate BMI. Neck circumference (cm) (at the level of the thyroid cartilage) and the width of mouth opening (cm) (measured as the interincisor gap with the mouth fully opened) were measured. The thyromental distance (cm) and the sternomental distance (cm) were measured with the neck extended. For each patient, other variables that may predict difficult intubation were collected: the modified Mallampati classification without phonation (class I: soft palate, fauces, uvula, and pillars visible; class II: soft palate, fauces, and uvula visible; class III: soft palate and base of uvula visible; and class IV: soft palate not visible),[13] presence or absence of impaired temporomandibular joint mobility (inability to move the lower teeth in front of the upper teeth); limited neck movement: inability to extend and flex the neck to a range around 90 degrees; presence or absence of abnormal protruding upper teeth, retrognathie, and macroglassie. Then, the Wilson et al. and El Ganzouri et al. scores were calculated.[4,14]

Hydroxyzine (100 mg) was given orally as premedication around 2 h before surgery. In the operating room, patients were positioned with pillows or towels under their shoulders, with the head elevated and neck extended in the sniffing position.[15] Each patient was routinely monitored by an electrocardiogram, pulse oximetry, and noninvasive arterial blood pressure. Patients breathed 100% oxygen by facemask for a minimum of 3 min. Anesthesia was then induced with propofol (2–2.5 mg/kg) and succinylcholine (1 mg/kg), for facilitation of endotracheal intubation with the dosages previously recommended.[16] Cricoid pressure was applied as described by Sellick[17] and released if it disturbed the intubation.

The laryngoscopy view was graded according to Cormack and Lehane's scale[18] as follows: grade 1 view, the vocal cords were completely visible; grade 2, only the arytenoids were visible; grade 3, only the epiglottis was visible; and grade 4, the epiglottis was not visible. Intubation difficulty was assessed with the IDS developed by Adnet et al.[7] on the basis of seven variables associated with difficult intubation, which were recorded by the anesthesiologist in charge of the patient. They are as follows: N1, number of additional intubation attempts; N2, number of additional operators; N3, number of alternative intubation techniques used; N4, laryngoscopy view as defined by Cormack and Lehane (grade 1, N4 = 0; grade 2, N4 = 1; grade 3, N4 = 2; and grade 4, N4 = 3); N5, lifting force applied during laryngoscopy (N5 = 0 if inconsiderable and N5 = 1 if considerable); N6, need to apply external laryngeal pressure to improve glottic pressure (N6 = 0 if no external pressure or only the Sellick maneuver was applied and N6 = 1 if external laryngeal pressure was used); and N7, position of the vocal cords at intubation (N7 = 0 if abducted or not visible and N7 = 1 if adducted). The IDS score is the sum of N1 through N7. A score of 0 indicated intubation under ideal conditions. An IDS score from 1 to 5 indicated slight difficulty, and an IDS score >5 indicated moderate to major difficulty.[7] Then, we defined two groups of patients according to the IDS values: those with an IDS score ≤5 (i.e., easy and slight difficulty) and those with an IDS score >5 (i.e., difficult intubation).

Before the trial and based on the previous study of Dhonneur et al.,[19] a power calculation for a 17% difference in the success rate with a probability level α of 0.05 and power of 0.80 (1-β) yielded a sample size of 57 patients for each group. We enrolled more patients in each group to allow for drop out. Statistical analysis was performed using the Statview software (SAS Institute Inc., version 5.0, Cary, NC). Data are presented as mean ± SD or percent. χ^2 Test or Student's *t*-test was performed when appropriate. Then, we performed a logistic regression to discriminate if BMI and neck circumference are independently correlated to a difficult intubation. $P < 0.05$ was considered statistically significant.

RESULTS

Seventy morbidly obese and 61 nonobese patients were enrolled in this prospective study. Demographic data and preintubation variables are shown in Table 1.

No intubation was impossible in this series. The incidence of difficult intubation (IDS >5) was more frequent in the obese than in the lean patients ($n = 10$, 14.5% in group O vs $n = 2$, 3% in group NO; $P < 0.03$, Table 1).

Then, we compared patients (obese and lean) with an IDS score ≤5 and those with an IDS score >5 (Table 2). No difference was found between groups concerning: sex, ASA physical status, age, mouth opening <35 mm, mandibular recession, buck teeth, mandibular subluxation, macroglossia, Cormack score, OSA syndrome, neck mobility <90 degrees. Items reaching statistical significance or with a trend are shown in Table 2. Logistic regression found that neck circumference and large BMI are independently correlated to a difficult intubation with a $P = 0.0012$ [odd ratio, 1.373 (1.133–1.664)] for neck circumference and $P = 0.0497$ [odd ratio, 1.066 (1–1.135)] for BMI. Information on the accuracy of the tests and statistically significant difference between IDS ≤5 and >5 are given in Table 3 (see Appendix for definitions).

Table 1. Demographic Data

	Group O (n = 70)	Group NO (n = 61)	P
Sex (M/F)	14/86	53/47	0.0001
ASA (I/II/III)	50/46/4	62/36/2	NS
Age (yr)	43 ± 12	47 ± 18	NS
Weight (kg)	116 ± 22	71 ± 11	<0.0001
Height (cm)	164 ± 9	169 ± 10	NS
BMI	44 ± 8	24 ± 3	<0.0001
Neck circumference	42 ± 5	39 ± 4	0.003
Thyromental distance	9 ± 3	8 ± 2	0.03
Sternomental distance	15 ± 4	14 ± 3	NS
MO <35 mm	4%	10%	NS
Mallampati I/II/III/IV	53/24/19/4	74/23/3/0	0.009
Mandibular recession	10%	10%	NS
Buck teeth	7%	8%	NS
MS	11%	1.5%	0.03
Macroglossia	17%	0%	<0.05
Cormack score 1/2/3/4	66/22/6/6	72/24/2/2	NS
Sleep apnea syndrome	13%	0%	<0.05
Neck mobility <90°	10%	11%	NS
Wilson score >2	67%	16%	<0.0001
El-Ganzouri >4	27%	11%	0.03
IDS >5	14.5%	3%	0.03

Data are expressed as percentages or as mean ± SD.

BMI = body mass index; IDS = intubation difficulty scale; MO = Mouth opening; MS = Mandibular subluxation; NO = non obese; O = obese.

Table 2. Demographic Data Comparison of IDS >5 and <5

	Group IDS >5 (n = 12)	Group IDS <5 (n = 119)	P
BMI	46 ± 12	34 ± 3	0.0002
Neck circumference	47 ± 4	40 ± 4	<0.0001
Mallampati score >3	67%	13%	<0.0001
Thyromental distance	10 ± 3	8 ± 3	0.03
Sternomental distance	17 ± 5	14 ± 4	0.08
Wilson score >2	75%	40%	0.02
El-Ganzouri >4	17%	20%	0.08

Data are expressed as percentages or as mean ± SD.

BMI = body mass index; IDS = intubation difficulty scale.

Table 3. Tests for Difficult Intubation

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
NC >43 cm	92	84	37	99
Mallampati score >3	67	87	33	96
BMI	83	50	14	96
NC + Mall	58	92	44	96
TD >6 cm	100	82	35	100
WS >2	75	60	16	96

Data are expressed as percentages or as mean ± SD.

BMI = body mass index; Mall = Mallampati score; NC = neck circumference; NPV = negative predictive value; PPV = positive predictive value; TD = thyromental distance; WS = Wilson score.

DISCUSSION

This study confirms that problems with difficult intubation are more frequent in obese than in lean patients.[8] Moreover, neck circumference and Mallampati score >3 were identified as important predicting factors.[5]

The association between obesity and difficult intubation is still a matter of debate. This association was previously found in noncomparative studies[20,21] or in studies of small numbers of patients.[4,22] For example, for Wilson et al., a body weight over 95 kg, was considered a risk factor for difficult intubation.[4] As the patient's height was not recorded, a tall patient could have easily been confused with an obese patient just on the basis of weight. In the same way, negative previous studies that failed to demonstrate a higher occurrence of difficult intubation in morbidly obese patients also failed to distinguish between difficult intubation and difficult laryngoscopy.[5,6,23] In addition, some of these studies were performed with a small number of patients,[6] or without control (i.e., lean) patients.[5] Poor laryngoscopic view does not always equate with difficult tracheal intubation. The medical literature on this subject is confusing because of the lack of consensus on the definition of "difficult intubation," which varies among authors. There have been many attempts to develop a score to measure the complexity of endotracheal intubation. Most methods are quite complicated, involving numerous variables. An objective scoring system has been proposed to assess intubation difficulty: the IDS score, which has been validated,[7] and already used in obese patients.[8] Effectively, Juvin et al. showed that intubation was more difficult in obese patients, using IDS as in our study, whereas the incidence of difficult laryngoscopy (i.e., Cormack class III or IV) was similar in obese and lean patients, as in our results.[8]

Finding a bedside test that is effective for predicting difficult intubation is still challenging.[1] Among the potential predictors we evaluated, thyromental distance, BMI, neck circumference, and a Mallampati score >3 were the only useful bedside test predictors of difficult intubation. Our results thus confirm the work of Brodsky et al.[5] who showed that neck circumference at the thyroid cartilage is a valuable predictor of difficult laryngoscopy in obese patients. Interestingly, all other putative predictors were similar in the two populations. Moreover, neck circumference also seems to be a predictive test in lean patients. Circumference does not indicate the amount of soft tissue at various topographic regions within the neck. Distribution of fat in specific neck areas, especially the anterior neck, may provide a better indication of difficult intubation than neck circumference. By using magnetic resonance imaging measurements in obese patients with and without OSA syndrome, Horner et al. demonstrated that more fat was present in areas surrounding the collapsible segments of the pharynx in patients with OSA syndrome.[24] This may explain why some obese patients are easy to intubate/ventilate, while others are not. Furthermore, difficult intubation had been significantly associated with OSA.[10] Erzi et al. tested the hypothesis that difficult laryngoscopy could be predicted in morbidly obese patients by the quantification of neck soft tissue at the level of the vocal cords and suprasternal notch using ultrasonography.[25] Among the potential predictors of difficult laryngoscopy, the amount of pretracheal soft tissue quantified by ultrasound was the only measure that fully distinguished easy laryngoscopies from difficult one.[25] These results suggest that pretracheal soft tissue, assessed by ultrasound, warrants additional study as a predictor of difficult laryngoscopy in morbidly obese patients. As the use of ultrasound devices in anesthesiology becomes more common, they could prove to be useful as predictors for difficult laryngoscopies.

This study has several limitations. It was not blinded and randomized; however, it was impossible to maintain blindness. Moreover, the study design situations closely resembles real life. Lastly, OSA syndrome was only assessed clinically and not by polysomnography.[26]

In conclusion, we found that a difficult intubation (IDS >5) was associated with thyromental distance, increasing neck circumference, BMI, and a Mallampati score of ≥3 in obese patients. This study supports the use of assessing neck circumference preoperatively to predict a potentially difficult intubation.

APPENDIX: DEFINITION OF TERMS

True positive = a difficult intubation that had been predicted to be difficult.
False positive = an easy intubation that had been predicted to be difficult.
True negative = an easy intubation that had been predicted to be easy.
False negative = a difficult intubation that had been predicted to be easy.
Sensitivity = the percentage of correctly predicted difficult intubations as a proportion of all intubations that were truly difficult, i.e.:

$$\text{True positives}/(\text{true positives} + \textit{false negatives})$$

Specificity = the percentage of correctly predicted easy intubations as a proportion of all intubations that were truly easy, i.e.:

$$\text{True negatives}/(\text{true negatives} + \textit{false positives})$$

Positive predictive value = the percentage of correctly predicted difficult intubations as a proportion of all predicted difficult intubations, i.e.:

$$\text{True positives}/(\text{true positives} + \textit{false positives})$$

Negative predictive value = the percentage of correctly predicted easy intubations as a proportion of all predicted easy intubations, i.e.:

$$\text{True negatives}/(\text{true negatives} + \textit{false negatives})$$

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