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Prediction of Difficult Laryngoscopy in Obese Patients by Ultrasound Quantification of Anterior Neck Soft Tissue[1]

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Abstract

Prediction of difficult laryngoscopy in obese patients is challenging. In 50 morbidly obese patients, we quantified the neck soft tissue from skin to anterior aspect of trachea at the vocal cords using ultrasound. Thyromental distance <6 cm, mouth opening <4 cm, limited neck mobility, Mallampati score >2, abnormal upper teeth, neck circumference >45 cm, and sleep apnoea were considered predictors of difficult laryngoscopy. Of the nine (18%) difficult laryngoscopy cases, seven had obstructive sleep apnoea history; whereas, only 2 of the 41 easy laryngoscopy patients did (P<0.001). Difficult laryngoscopy patients had larger neck circumference [50 (3.8) vs. 43.5 (2.2) cm; P<0.001] and more pre-tracheal soft tissue [28 (2.7) mm vs. 17.5 (1.8) mm; P<0.001] [mean (SD)]. Soft tissue values completely separated difficult and easy laryngoscopies. None of the other predictors correlated with difficult laryngoscopy. Thus, an abundance of pretracheal soft tissue at the level of vocal cords is a good predictor of difficult laryngoscopy in obese patients.

Keywords

Anaesthesia; Neck; Obesity; Ultrasound

Although obesity is thought to increase the risk of difficult intubation, increased body mass index (BMI) poorly predicts difficult laryngoscopy [1–3]. The best way to predict a difficult laryngoscopy in obese patients remains debatable. Suggested predictors include history of sleep apnoea [2,4,5], high Mallampati score [2,3], increased age [2], male sex [2], short neck, and abnormal upper teeth [2,6].

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A large neck circumference is a better predictor of difficult laryngoscopy than BMI [3]. Circumference, though, 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 thus provide a better indication of difficult intubation than neck circumference. We therefore tested the hypothesis that difficult laryngoscopy can be predicted in morbidly obese patients by the amount of neck soft tissue as quantified by ultrasound.

Methods

With IRB approval and written informed consent, we enrolled 50 morbidly obese patients (BMI> 35 $kg \cdot m^{-2}$) [7] scheduled for laparoscopic weight reduction surgery (LapBand) under general anaesthesia with endotracheal intubation. Patients who were pregnant or had upper airway pathologies (maxillo-facial fractures, tumours, etc), cervical spine fractures, full stomach, hiatal hernia, gastro-oesophageal reflux, or a history of difficult laryngoscopy or intubation were excluded from the study.

Protocol

Ultrasound quantification of anterior neck soft tissue was performed with a Diasonics US linear probe (Diasonics Vingmed Ultrasound [DVU], GE Ultrasound Israel, Tirat Carmel, Israel) at a frequency of 5.0 MHz. The distance from the skin to the anterior aspect of the trachea was measured at three levels: vocal cords (zone 1 – Fig. 1), thyroid isthmus (zone 2), and suprasternal notch (zone 3). The amount of soft tissue at each zone was calculated by averaging the amounts of soft tissue in millimetres obtained in the central axis of the neck and ≈ 1.5 mm to the left and right of the central axis. The same radiologist (GG) performed all ultrasound measurements the night before surgery.

After 5 minutes of preoxygenation, anaesthesia was induced with fentanyl (1 $mg \cdot kg^{-1}$), thiopental (3–4 $mg \cdot kg^{-1}$), and succinylcholine (1 $mg \cdot kg^{-1}$). Laryngoscopy was performed with full muscle relaxation. An anaesthesiologist (TE), unaware of the ultrasound results, performed all laryngoscopies. The laryngoscopy was carried out in “sniffing” position with a size 3 Macintosh blade, and the trachea was intubated with a styleted endotracheal tube. The laryngoscopy view was graded according to Cormack and Lehane’s scale [8]; external laryngeal pressure (BURP -back, up, and rightward pressure) [9] was applied for grading. With a grade III view, a gum elastic bougie was inserted underneath the epiglottis, and the endotracheal tube was threaded over it. If intubation failed after three attempts, the patient was awakened, and the procedure was cancelled.

Measurements

Standard anaesthesia monitoring consisted of ECG, pulse oximetry, capnography, non-invasive blood pressure, and temperature measurements.

The attending anaesthesiologist (TE) evaluated the following variables preoperatively:

- History of obstructive sleep apnoea: diagnosed with polysomnography.
- Abnormal upper teeth: loose or protruding upper teeth, or partially missing upper incisors or canines.
- A thyromental distance < 6 cm (with the neck extended).
- Impaired temporomandibular joint mobility: inter-incisor gap less than 4 cm and inability to move the lower teeth in front of the upper teeth.
- Limited neck movements: inability to extend and flex the neck > 90º [10].

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- Back of the mouth view: modified Mallampati scale [11].
- Neck circumference in cm: measured at the thyroid cartilage [12].

Data Analysis

Continuous data are expressed as means (SDs); categorical data are expressed as numbers of occurrences (percentage). Laryngoscopy views graded 3 or 4 were defined as difficult. Easy and difficulty intubations were compared; two-sided Student's *t*-test was employed for continuous variables and chi-square or Fisher exact tests, as appropriate, for non-continuous variables. Results were considered statistically significant when $P < 0.05$.

Results

Demographic, laryngoscopy, and ultrasound data are presented in Table 1. The BMI, thyromental distance < 6 cm, mouth opening < 4 cm, limited neck movement, and Mallampati scores of 3 or 4 were each similar in the patients with difficult and easy laryngoscopies.

There were nine cases (18%) of difficult laryngoscopy. Seven of the nine patients with difficult laryngoscopy had a history of obstructive sleep apnoea whereas only two of the 41 patients with easy laryngoscopy did ($P < 0.001$). Patients with difficult laryngoscopy had a larger neck circumference [50 (3.8) cm] than patients with easy laryngoscopy [43.5 (2.2) cm]; $P < 0.001$). The difficult laryngoscopy patients also had much more soft tissue in zone 1 [(28 (2.7) mm] than did patients with easy laryngoscopy [17.5 (1.8) mm, $P < 0.001$ - Fig. 2], as well as in zone 3 [33(4.3) vs 27.4 (6.6), $P < 0.013$].

Zone 1 soft tissue appears to be the best predictor of a difficult laryngoscopy. The range of zone 1 soft tissue for those with difficult laryngoscopy (24–32 mm) was mutually exclusive from those patients with an easy laryngoscopy (15–22 mm); hence, the zone 1 soft tissue values completely separated the difficult and easy laryngoscopies (Fig. 2). In contrast, the range for neck circumference had some overlap for those with difficult (45–57 cm) and easy (38–48 cm) laryngoscopy.

Discussion

Quantification of neck soft tissue at the level of the vocal cords and suprasternal notch was the best predictor of difficult laryngoscopy, with no overlap in values for the difficult and easy laryngoscopies. MRI and CT scans have been used to demonstrate the presence of abundant soft neck tissue in the pharynx, retropharynx, suprascapular region, and lateral neck region of obese patients [12,13]. However, MRI and CT scans are costly, may involve some risks to the patients, and require excessive time to be practical. Instead, we describe a novel means of predicting difficult laryngoscopy in obese patients: ultrasound quantification of the anterior neck soft tissue. Neck ultrasound measurements are as accurate as MRI for quantification of fat depth [14], but are inexpensive, rapid, and easy to perform.

Few published studies have focused on the distribution of fat in the anterior neck region. Whittle *et al*. [15] demonstrated the presence of excessive fat in the submandibular region. In an MRI study, they found that although the total amount of body fat is greater in women than in men, more fat tissue is distributed to the neck in males. This may explain why the incidence of obstructive sleep apnoea and difficult intubation is greater in men [16,17]. However, no gender-related difference in laryngoscopy difficulty was observed in our group.

The disposition of excessive soft tissue to the vellopalate, retropharynx, and submandibular regions may partially explain the mechanism of supraglottic airway collapse during sleep or anaesthesia, but it still does not explain the difficulties in viewing the vocal cords during direct

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laryngoscopy. Most likely, the increased amount of pre-tracheal neck soft tissue in these patients impaired laryngoscopy by reducing anterior mobility of pharyngeal structures.

Among the other potential predictors we evaluated, neck circumference and a history of sleep apnoea were the only other useful predictors of difficult laryngoscopy. Our results thus confirm the work of Brodsky *et al.* [3] 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. Thus, thyromental distance, mouth opening, neck mobility, Mallampati score, and abnormal teeth poorly predicted difficulty laryngoscopy in this population.

In summary, we report the results of 50 morbidly obese patients in whom 9 had difficult laryngoscopy. Among the potential predictors of difficult laryngoscopy, the amount of pre-tracheal soft tissue was the only measure that fully distinguished easy laryngoscopies from difficult one. Other useful predictors were neck circumference and a history of sleep apnoea. These results suggest that pre-tracheal soft tissue, as assessed by ultrasound, warrants additional study as a predictor of difficult laryngoscopy in morbidly obese patients.

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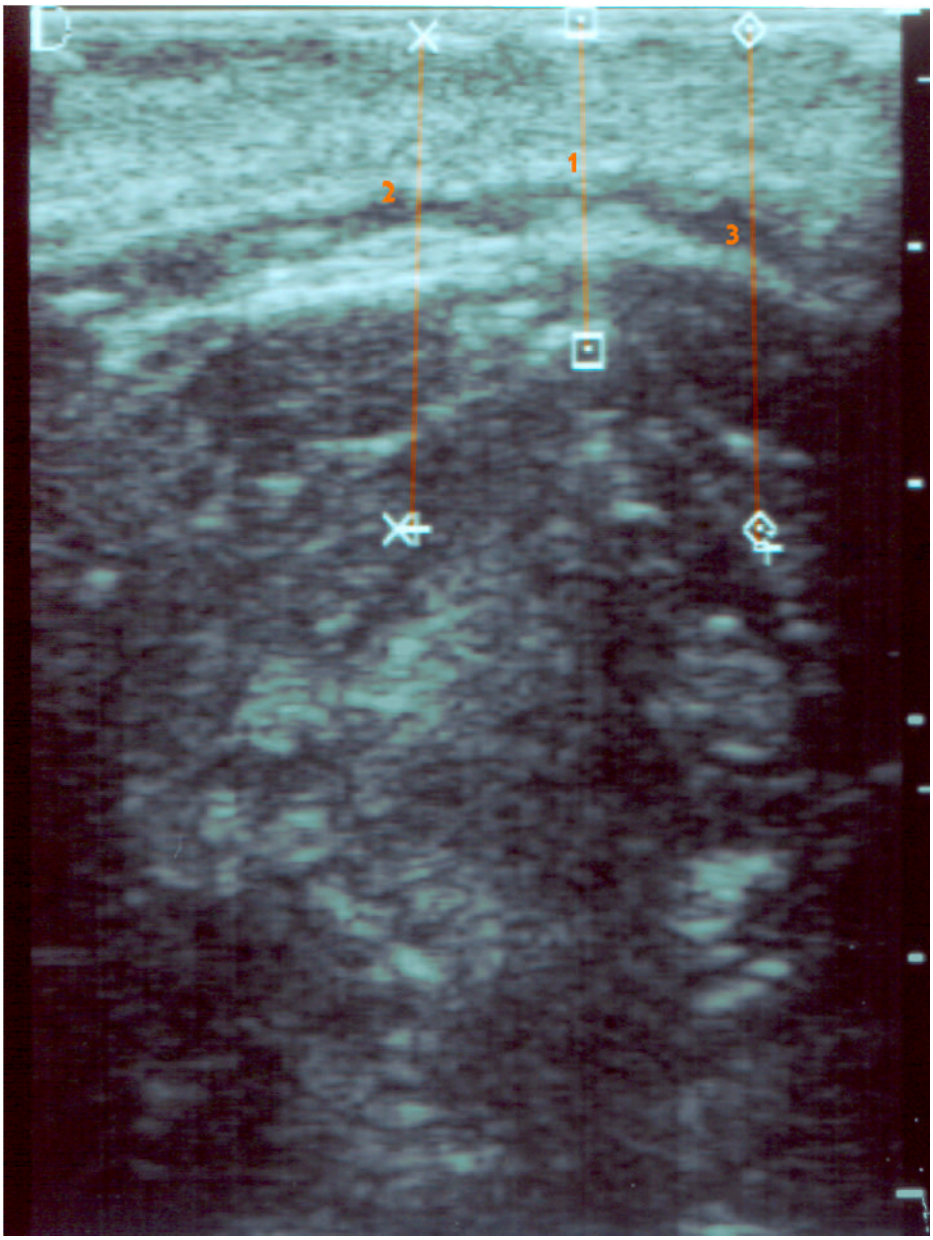

Fig. 1.
Transverse ultrasound view of the anterior cervical soft tissue at the level of the vocal cords.

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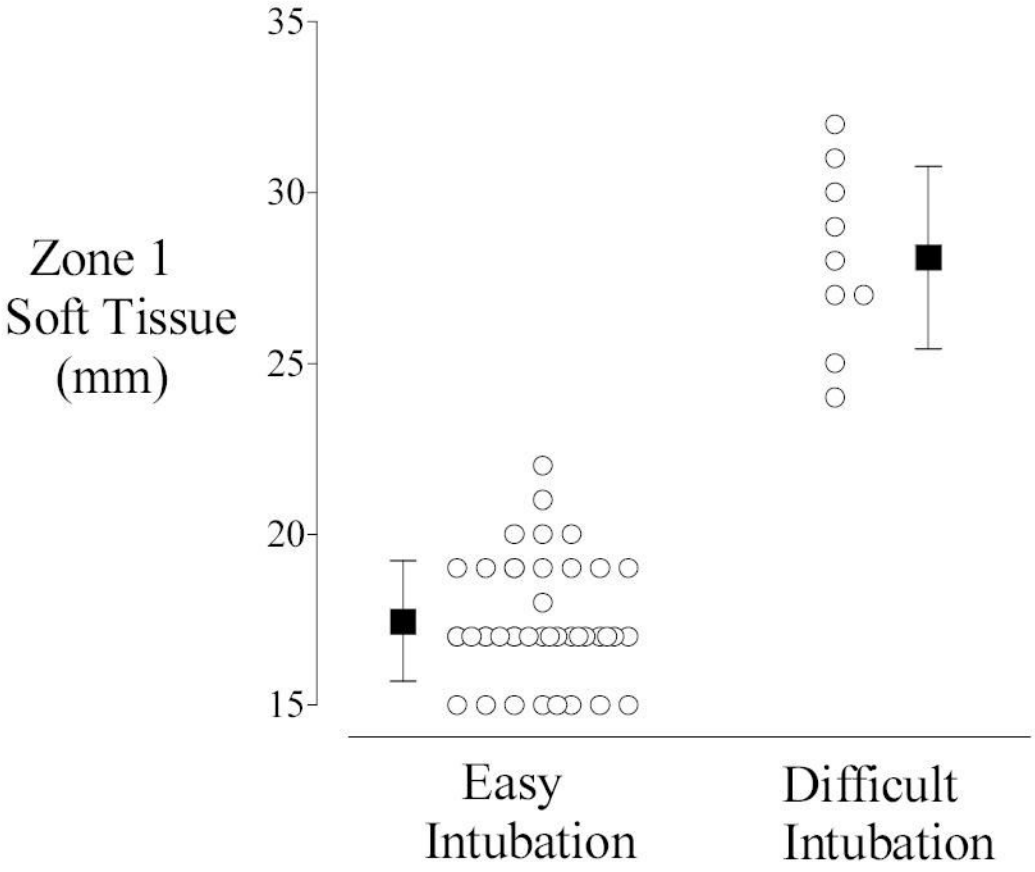

Fig. 2.
The amount of zone 1 soft tissue (circles) in individual patients whose tracheas were easy or difficult to intubate. Squares show group means with standard deviations.

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Table 1

Predictors of Difficult Laryngoscopy.

	Difficult laryngoscopy n=9	Easy laryngoscopy n=41	*P*
Age (yr)	33.6 (6)	38.8 (8.4)	0.93
Sex (male/female)	7 / 2	14 / 27	0.02
Body mass index (kg/m^2)	44 (4.8)	43 (4)	0.47
Mallampati score			0.07
1	0	15 (37%)	
2	6 (67%)	20 (49%)	
3	3(33%)	6 (14%)	
TMD < 6 cm	3 (33%)	8 (20%)	0.37
Upper teeth pathology	2(22%)	11 (27%)	0.77
Mouth opening < 4 cm	1(11%)	4 (10%)	0.9
Neck mobility problems	1(11%)	6(15%)	0.8
Neck circumference (cm)	50 (3.8)	43.5 (2.2)	<0.001
Ultrasound Zone 1 soft tissue (mm)	28 (2.7)	17.5 (1.8)	<0.001
Ultrasound Zone 2 soft tissue (mm)	25 (1.3)	22.8 (5)	0.16
Ultrasound Zone 3 soft tissue (mm)	33 (4.3)	27.4 (6.6)	0.013

TMD = thyromental distance; results expressed as mean (SD) or numerical value (percent).