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Research Article

Evaluation of Ultrasound Guided Measurement of Anterior Neck Soft Tissue Thickness in Predicting Difficult Laryngoscopy in Obese Patients

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ABSTRACT

Background: The incidence of unanticipated difficult airway is 14.3-17.5% in obese. Preoperative difficult airway prediction is important to avoid postoperative morbidity and mortality. USG guided measurement of anterior neck soft tissue thickness can be used to predict difficult laryngoscopy in obese patients and we thus undertook this study to determine the role of USG guided measurement of anterior neck thickness at the level of vocal cords in difficult laryngoscopy prediction.

Methods: Sixty obese patients (BMI≥30kg/m2), 18-70 years of age of either sex, were included. Anterior neck soft tissue thickness was measured by ultrasound as the distance from the skin to the anterior commissure of vocal cord. Neck circumference was measured at mid neck just below the laryngeal prominence with the subjects standing upright and facing forward with shoulders relaxed. Thyromental distance, sternomental distance, Mallampatti score and neck circumference were also recorded.

Results: The cut off values of BMI (46.94 kg/m2), neck circumference (41.5 cm) and anterior neck soft tissue thickness (22.1mm). Four patients in the morbidly obese and 80% of the superobese patients had a difficult laryngoscopy. Sixteen (26.67%) patients had an anterior neck soft tissue thickness of >22.1mm. Of these, 11 (91.67%) patients had difficult laryngoscopy while one (8.33%) patient with anterior neck soft tissue thickness ≤ 22.1mm had difficult laryngoscopy ($P<0.05$). There was also significant association between neck circumference and BMI.

Conclusion: The USG guided measurement of anterior neck soft tissue thickness, BMI and neck circumference can reliably predict difficult laryngoscopy in obese patients.

Anticipation of the difficult airway is an area of primary concern for the anesthesiologists. Airway management failure can lead to local trauma and catastrophic complications [1]. Obesity is often associated with difficult intubation and complicated laryngoscopy. The incidence of unanticipated difficult airway is 14.3-17.5% in obese patients as compared to 5.8% in the general population [2]. Obese can have difficult mask ventilation due to increased pad of fat around neck and increased oropharyngeal soft tissue thereby increasing chances of difficult airway [3-4]. Therefore, preoperative prediction of difficult airway is especially important in morbidly obese patients to avoid postoperative morbidity and mortality.

Various clinical predictors like Mallampati classification, thyromental distance, inadequate mouth opening, prominent upper incisors, history of obstructive sleep apnoea (OSA), they are not very reliable [5] and may not be applicable in emergencies and critical care settings where patients may be confused, lethargic, unable to follow directions or appropriately position themselves [6]. An obvious predictor of difficult intubation in obese patients is a large neck circumference [7]. However, it does not provide information about the

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exact amount of tissue at a particular region in the neck. Ultrasonography (USG) is useful in anesthesia practice for visualising airway and non-airway structures successfully [8-9]. Since distribution of tissue at various topographic regions in the neck may provide a better indication of difficult intubation as compared to the neck circumference, the USG has emerged as a new tool for airway assessment, which is as reliable as a computer tomography scan in visualizing upper airway structures [10]. Parameters like USG quantification of anterior neck soft tissue thickness [11], submandibular USG assessment of hyomental distances and ratio and tongue size [12], ultrasonic measurement of pre-epiglottic space depth and distance from epiglottis to mid-point of vocal folds [13] have been studied in obese patients. However, despite these studies being done, USG guided airway assessment is still in its infancy regarding its feasibility and potential opportunities for its use in imaging for upper airway examination and, prior studies investigating the use of USG in evaluating difficult laryngoscopy have produced conflicting results [14].

Based on these information, we hypothesize that USG guided measurement of anterior neck soft tissue thickness can be used to predict difficult laryngoscopy in obese patients and we thus undertook this study to determine the role of USG guided measurement of anterior neck thickness at the level of vocal cords in predicting difficult laryngoscopy in obese patients.

Methods

This prospective observational study was conducted after approval from institutional ethics committee and registration with clinical trial registry of India (CTRI/2019/04/018770). Sixty obese patients (BMI≥30kg/m2), ASA class 1 and 2, age between 18 to 70 years of either sex, posted for elective surgeries and requiring general anesthesia with endo-tracheal intubation were included in this study, Patients with upper airway pathology, cervical spine fracture, facial fracture and maxillofacial abnormality, inter-incisor distance <3 cm, lose or prominent upper incisors, patients with past history of difficult intubation and pregnant patients were excluded from the study. Sample size was calculated based on a previous study by Ezri et al [11], this study observed that there were nine cases (18%) of difficult laryngoscopy. Taking this value as reference, the minimum required sample size with 10% margin of error and 5% level of significance was 57 patients. A written informed consent was obtained after explaining about the USG evaluation. On the day of surgery, patients were shifted to pre-operative room and made to sit comfortably on bed and body mass index (BMI), thyromental distance, sternomental distance and neck circumference were recorded. Thyromental distance (cm) was measured as the straight distance from the upper border of thyroid cartilage to the tip of the jaw with the head in full extension and the mouth closed. Thyromental distance ≥ 6.5 cm was considered easy laryngoscopy and < 6.5 cm was considered difficult laryngoscopy [15]. Sternomental distance (cm) was measured as the straight distance from the sternal notch to the tip of the jaw with the head in full extension and the mouth closed. Sternomental distance ≥ 12.5cm was considered easy laryngoscopy and < 12.5cm was considered difficult laryngoscopy [15].

Neck circumference was measured at mid neck just below the laryngeal prominence with the subjects standing upright and facing forward with shoulders relaxed. All the USG assessments were performed by the same anesthesiologist. The patient was asked to lie in supine position with head and neck in maximal extension, without a pillow. USG jelly was applied, linear USG probe (6-13 MHZ) was placed in the submandibular area in midline and rotated in transverse plane from cephalad to caudal till vocal cords were visualized. The distance from the skin to the anterior commissure of vocal cord was measured. Three measurements (central axis and approximately 15mm to the left and right of the central axis) were taken and averaged to obtain the soft tissue thickness (Figure 1).

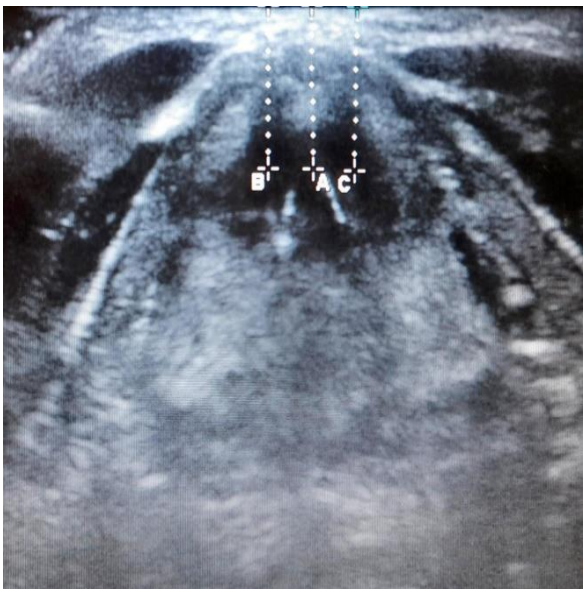
In operation theatre, baseline parameters of patients (heart rate, systolic and diastolic blood pressure, SpO2) were recorded. Drug doses were calculated as per lean body mass. All patients received standardized general anesthesia after preoxygenation and premedication with midazolam 1mg I.V. and fentanyl 2mcg/kg I.V., induction was done with propofol 2mg/kg I.V., adequate mask ventilation was checked and neuromuscular blockade was given with vecuronium 0.1 mg/kg I.V. Patients were placed in sniffing position on a standard operating room pillow with a height of 5 cm. Direct laryngoscopy was performed using a Macintosh blade (no.4 in males and no.3 in females) by an anesthesiologist who was unaware of the USG based assessment. Cormac-Lehane (CL) grade was noted. Trachea were intubated using a styleted endotracheal tube by the same anesthesiologist having at least 5 years' experience. No external laryngeal manipulation was done in the first attempt. In case the first attempt failed to provide an adequate laryngoscopic view, Backward, Upward and Rightward pressure (BURP) was applied, laryngoscopic grading was done. and trachea was intubated. After 3 failed attempts, the study was abandoned and alternative methods of securing the airway was pursued. Throughout the procedure, adequate ventilation and oxygenation was maintained. A CL grade of 1 or 2 was considered easy laryngoscopy whereas CL grade of 3 or 4 was considered difficult laryngoscopy. Primary outcome measure of this study was to predict difficult laryngoscopy using USG measurement of anterior neck soft tissue thickness. Secondary outcome measures were to predict difficult

laryngoscopy using BMI, neck circumference, thyromental distance and sternomental distance.

Statistical Analysis

Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean ± SD and median. Normality of data was tested by Kolmogorov-Smirnov test. Quantitative variables were compared using Independent t-test between the two groups. Qualitative variables were correlated using Chi-Square test/Fisher's Exact test. Receiver operating characteristic curve (ROC) was used to find out cut off point of parameters for predicting difficult laryngoscopy. A p value of <0.05 was considered statistically significant. The data analysis was done using SPSS version 21.0.

Figure 1- Anterior neck soft tissue thickness at the level of vocal cords.



Results

Mean age of the patients is 43.3 years with majority (91%) of patients between 18-50 years. There were 13 males and 47 females. Four, 13, 33 and 10 patients were obese (BMI- 30- 34.9 kg/m2), severe obese (BMI- 35-39.9 kg/m2), morbidly obese (BMI- 40-49.9 kg/m2) and super obese (BMI ≥ 50 kg/m2) respectively. Twelve patients had history of OSA. On airway examination; 17, 34, 9 and 0 patients had Modified Mallampati Grade 1, 2, 3 and 4 respectively. Laryngoscopy and intubation using the Macintosh laryngoscope could be done in all patients. Fifteen patients were intubated in the first attempt, while the maximum number of patients could be intubated in the second attempt after applying BURP (Table 1).

Laryngoscopy was easy in all the patients who had a BMI of less than 40 kg/m2, four patients in the morbidly obese group had difficult laryngoscopy while 80% of the superobese patients had a difficult laryngoscopy.

Using ROC curve, we found the cut off values of BMI (46.94 kg/m2), neck circumference (41.5 cm) and anterior neck soft tissue thickness (22.1mm). Interpretation of the area under the ROC curve showed that the performance of BMI, neck circumference and anterior neck soft tissue thickness for predicting difficult laryngoscopy was excellent (AUC 0.87; 95% CI: 0.76 to 0.94, AUC 0.83; 95% CI: 0.71 to 0.91 and AUC 0.87; 95% CI: 0.76 to 0.94 respectively) at cut off point of >46.94 kg/m2, >41.5 cm and >22.1 mm respectively (Table 2, Figure 2).

Significant association was seen in the distribution of anterior neck soft tissue thickness(mm) with easy/difficult laryngoscopy (p value<0.05). Using the cut off, it was seen that 16 (26.67%) patients had an anterior neck soft tissue thickness of >22.1mm. Of these, 11 (91.67%) patients had difficult laryngoscopy while one (8.33%) patient with anterior neck soft tissue thickness ≤ 22.1mm had difficult laryngoscopy.

The variable anterior neck soft tissue thickness(mm) was not normally distributed. Median (IQR) of anterior neck soft tissue thickness(mm) in difficult laryngoscopy was 25.48(24.03-27.37) which was significantly higher as compared to easy laryngoscopy [18(16.2-19.17)] (Table 3).

Significant association was seen in the distribution of BMI (kg/m²) with easy/difficult laryngoscopy (p value<0.05). The cut off value for BMI obtained from ROC was 46.94 kg/m². BMI was >46.94 kg/m² in 83.33% of patients with difficult laryngoscopy which was significantly higher as compared to easy laryngoscopy (20.83%). Mean ± SD of BMI (kg/m²) in difficult laryngoscopy was 52.26 ± 6.26 which was significantly higher as compared to easy laryngoscopy (42.34 ± 5.25).

Significant association was seen in the distribution of neck circumference(cm) with easy/difficult laryngoscopy (p value<0.05). The cut off obtained from ROC for neck circumference was 41.5 cm. Ten (83.33%) patients with neck circumference >41.5 cm had difficult laryngoscopy while only 2 out of 47 patients who had a neck circumference ≤41.5 cm had a difficult laryngoscopy. Median (IQR) of neck circumference(cm) in difficult laryngoscopy was 44(42.75-46.25) which was significantly higher as compared to easy laryngoscopy [38.25(37-40.12)].

Significant association was seen in the distribution of history of OSA with easy/difficult laryngoscopy (p value<0.05). History of OSA was present in 75% of patients with difficult laryngoscopy which was significantly higher as compared to 6.25% of patients with easy laryngoscopy.

For prediction of difficult laryngoscopy, anterior neck soft tissue thickness had highest sensitivity (91.67%) as compared to the BMI (83.33%) and neck circumference (83.33%). The specificity of anterior neck soft tissue thickness 89.58%, was less than that of neck circumference (93.75%) while greater than that of BMI (79.17%). Specificity of thyromental distance and sternomental distance was also good but their sensitivity was very low (16.67% and 25% respectively). The highest negative predictive value was found in anterior neck soft tissue thickness (97.7%) and highest positive predictive value was found in neck circumference (76.9%). Thus, the diagnostic accuracy of anterior neck soft tissue thickness, BMI and neck circumference was 90%, 80% and 91.67% respectively. On performing univariate logistic regression, BMI, neck circumference, anterior neck soft tissue thickness(mm) and history of OSA were the significant predictors of difficult laryngoscopy with odds ratio of 15.4, 54.60, 60.63 and 45 respectively.

On multivariate logistic regression, after adjusting for confounding factors, only anterior soft tissue thickness was a significant independent predictor of difficult laryngoscopy with adjusted odds ratio of 20.66. (Table 4).

No significant association was seen in the distribution of thyromental distance(cm) with easy/difficult laryngoscopy (p value>0.05). Thyromental distance was <6.5 cm in 7 (11.67%) patients. Of these, 2 (16.67%) patients had difficult laryngoscopy while 10 (83.33%) patients with thyromental distance ≥ 6.5 cm had difficult laryngoscopy. Mean ± SD of thyromental distance (cm) in easy laryngoscopy was 8.17 ± 1.71 and difficult laryngoscopy was 8.19 ± 1.63 with no significant association between them.

No significant association was seen in the distribution of sternomental distance (cm) with easy/difficult laryngoscopy (p value>0.05). Sternomental distance was <12.5 cm in 10 (16.67%) patients. Of these, 3 (25%) patients had difficult laryngoscopy while 9 (75%) patients with sternomental distance ≥ 12.5 cm had difficult laryngoscopy. Mean ± SD of sternomental distance(cm) in easy laryngoscopy was 14.43 ± 2.25 and difficult laryngoscopy was 13.83 ± 2.39 with no significant association between them.

No significant association was seen in the distribution of Modified Mallampati Grade with easy/difficult laryngoscopy (p value>0.05). Modified Mallampati Grade was 2 in majority of patients (56.66%). Majority of the patients with Modified Mallampati Grade 1, 2 and 3 had easy laryngoscopy 94.11%, 73.52% and 77.77% respectively.

Figure 2- ROC curve of BMI, neck circumference and anterior neck soft tissue thickness for predicting difficult laryngoscopy

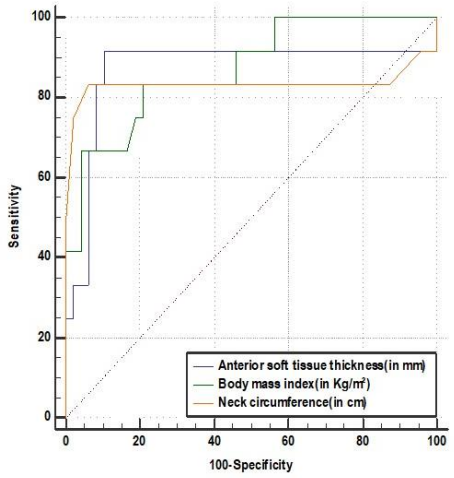


Table 1- Demographic details intubation attempts

Age in Years (Mean)		43.3
Sex (Male/Female), N		13/47
Body Mass Index, kg/m2	Obese (30-34.9)	4 (6.7%)
	Severe obese (35-39.9)	13 (21.7%)
	Morbid obese (40-49.9)	33 (55%)
	Super obese (≥50)	10 (16.7%)
History of OSA, N	Present	12
	Absent	48
Mallampatti Score:1/2/3/4		17/34/9/0

OSA: Obstructive sleep apnoea

Table 2- Receiver operating characteristics curve of body mass index, neck circumference and anterior neck soft tissue thickness for predicting difficult laryngoscopy.

For predicting difficult laryngoscopy	Area under the ROC curve (AUC)	Standard Error	95% Confidence interval (CI)	P value	Cut off
Body mass index (kg/m²)	0.87	0.05	0.76 to 0.94	<0.0001	>46.94

Neck circumference (cm)	0.83	0.10	0.71 to 0.91	0.0018	>41.5
Anterior neck soft tissue thickness (mm)	0.87	0.08	0.76 to 0.94	<0.0001	>22.1

ROC: Receiver operating characteristic curve

Table 3- Association of anterior neck soft tissue thickness(mm) with easy/difficult laryngoscopy.

Anterior neck soft tissue thickness(mm)	Easy (n=48)	Difficult (n=12)	Total	P value	Test performed
≤22.1{easy}	43 (89.58%)	1 (8.33%)	44 (73.33%)	<0.0001	Fisher Exact test
>22.1{difficult}	5 (10.42%)	11 (91.67%)	16 (26.67%)		
Mean ± SD	18.45 ± 3.02	24.82 ± 3.51	19.72 ± 4.02		
Median(IQR)	18 (16.2-19.17)	25.48 (24.03-27.37)	18.36 (16.35-22.34)	0.0001	Mann Whitney test;74
Range	15.26-27.4	15.16-27.93	15.16-27.93		

SD: Standard Deviation, IQR: Interquartile range

Table 4- Multivariate logistic regression to find out risk factors of difficult laryngoscopy after adjusting for confounding factors.

Taking difficult laryngoscope as dependent variable	Beta coefficient	Standard error	P value	Odds ratio	95% C.I. for Odds ratio	
					Lower	Upper
Body Mass Index (kg/m²)						
≤46.94{easy}				1.000		
>46.94{difficult}	1.47	1.38	0.28	4.36	0.29	65.67
Anterior soft tissue thickness(mm)						
≤22.1{easy}				1.000		
>22.1{difficult}	3.02	1.39	0.03	20.66	1.34	317.93
Neck circumference(cm)						
≤41.5{easy}				1.000		
>41.5{difficult}	1.79	1.26	0.15	6.00	0.50	71.77
History of OSA	2.40	1.34	0.07	11.06	0.78	155.38

CI: Confidence Interval; OSA: Obstructive sleep apnoea

Discussion

In our study, we found that four parameters, i.e. anterior neck soft tissue thickness at the level of vocal cords, BMI, neck circumference, history of OSA showed significant association with difficult laryngoscopy ($p<0.05$). A study was conducted by Erzi et al [11], who evaluated and compared anterior neck soft tissue thickness at three sites viz vocal cords, thyroid isthmus and suprasternal notch and found that anterior neck soft tissue thickness at the level of vocal cords was the best predictor for 9(18%) cases of difficult laryngoscopy. In their study, patients with difficult laryngoscopy had more pretracheal soft tissue as compared to patients with easy laryngoscopy. This is consistent with our findings as we found that mean ± SD of anterior soft tissue thickness at the level of vocal cords in difficult laryngoscopy was significantly higher as compared to easy laryngoscopy. Similar results were found in a study conducted by Jin et al [16]. In their study, 22 patients had difficult laryngoscopy with the anterior neck soft tissue thickness 23.0±3.0 mm, which was significantly higher than that in the patients with easy laryngoscopy (11.9±2.2 mm). They concluded that the obese patients with difficult laryngoscopy had anterior neck soft tissue greater than 20 mm [16]. In another study by Reddy et al, anterior neck soft tissue thickness of >0.23 cm at the level of vocal cords was 85.7% sensitive in predicting difficult laryngoscopy [17]. Yadav et al [18], studied USG measurement of anterior soft tissue

neck and tongue thickness in adult surgical patients and found that incidence of difficult laryngoscopy (CL-III and IV) was 11.3%. They found that there is a significant difference between easy and difficult laryngoscopy using USG parameters. (P= 0.001). On multivariate logistic regression after adjusting for confounding factors, we found that anterior neck soft tissue thickness was the significant independent predictor of difficult laryngoscopy with adjusted odds ratio of 20.66. This is consistent with a study conducted by Wu et al, who quantified USG measurements of anterior neck soft tissue thickness at the level of hyoid bone, thyrohyoid membrane, and anterior commissure levels to predict difficult laryngoscopy. In their study they found that anterior neck soft tissue thicknesses measured at the level of anterior commissure of vocal cords was an independent predictor of difficult laryngoscopy [19]. In contrast, Komatsu R et al found no significant association of anterior neck soft tissue thickness with difficult laryngoscopy in obese patients [14]. This may be due to the fact that their study was conducted in United States based population in comparison to the Indian population in our study.

Fotopoulou G et al, also found significant association of OSA (15.5% vs 2.2%, P < 0.001) with difficult laryngoscopy as was also seen in our study. In their study, though the incidence of poor laryngoscopic view was similar between obese and lean participants, but difficult intubation was more frequent in the obese group (20% vs 2%, P< 0.001) [20].

Our study found a significant association of BMI with difficult laryngoscopy. This is in line with the study conducted by Fotopoulou [20], but is in contrast with the findings of the study conducted by Ezri where they found that mean (SD) of BMI (kg/m2) in patients with difficult laryngoscopy was 44 (4.8) as compared to 43 (4) in patients with easy laryngoscopy (p value 0.47), suggesting that no significant association was found with BMI [11].

According to our study, difficult laryngoscopy was significantly associated with both OSA and neck circumference. Neck circumference was 83.33% sensitive and 93.75% specific in predicting difficult laryngoscopy. Study conducted by Ezri et al also determined that large neck circumference and history of OSA were significant predictors of difficult laryngoscopy [11]. But this was in contrast with the findings of the study by Siriussawakul et al which suggested that neck circumference was 75.5% sensitive and only 42.5% specific in predicting difficult laryngoscopy [21].

In our study we found that thyromental distance was not a predictor of difficult laryngoscopy. This result is supported by studies conducted by Ezri et al [11], Adhikari et al [22], and Kim et al [23] while a study conducted by Fotopoulou et al suggested that it is an independent predictor of difficult laryngoscopy [19]. We also found that sternomental distance could not predict difficult laryngoscopy. This is supported by result of study by Kim et al who concluded that sternomental distance ≤14.9 cm was only 47.1% sensitive in predicting difficult laryngoscopy; [23] but is in contrast to results of study by Fotopoulou et al [20]. Ozdilek et al also suggested that sternomental distance ≤ 16 cm was a predictor of difficult laryngoscopy [24].

Some studies suggest that Modified Mallampati Grading can successfully predict difficult laryngoscopy like those conducted by Hekiert et al [25], Parameswari et al [26] and Ozdilek et al [24]. On the contrary, our study observed that Modified Mallampati Grading had no role in predicting the same. This finding of our study is supported by few other studies which were undertaken by Ezri et al [11] and Adhikari et al [22].

Our study has certain limitations, lack of control population comprising of lean individuals posed some limitation in comparing the predictive ability among obese and non-obese individuals.

Conclusion

In conclusion, the USG guided measurement of anterior neck soft tissue thickness, BMI and neck circumference can reliably predict difficult laryngoscopy in obese patients with anterior neck soft tissue thickness being the most significant independent predictor of difficult laryngoscopy in obese patients.

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