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Research Article

A STUDY TO CORRELATE ANTERIOR NECK SOFT TISSUE THICKNESS QUANTIFIED USING ULTRASOUND AND CORMACK LEHANE CLASSIFICATION FOR PREDICTING DIFFICULT LARYNGOSCOPY

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ABSTRACT
Background: Unanticipated difficult intubation remains a primary concern for anaesthesiologists. This study was done to correlate anterior neck soft tissue thickness quantified using ultrasound and cormack lehane classification for predicting difficult laryngoscopy. **Objectives:** To correlate anterior neck soft tissue thickness quantified using ultrasound, neck circumference and Cormack lehane classification for predicting difficult laryngoscopy. **Methods:** ASA grade 1 and 2 adult patients undergoing elective surgeries and receiving general anesthesia were included. Thickness of anterior neck soft tissue at hyoid bone, thyrohyoid membrane, and anterior commissure levels was obtained transversely across the anterior surface of the neck with a linear array ultrasound probe. Anesthesia was induced as per the standard protocol. Classification of laryngoscopic views is based on the Cormack Lehane grading. At the end, we are comparing, anterior neck soft tissue thickness quantified by ultrasound and cormack lehane classification which among these two is a better predictor of difficult laryngoscopy. **Results:** 22 out of 60 were characterized as difficult laryngoscopy group. The BMI, neck circumference, DSHB, DSEM, DSAC values were greater in difficult laryngoscopy group and were statistically significant. There was a strong positive correlation between CL grading and USG measurements like DSEM (r=0.608) and DSAC (r=0.594), moderate positive correlation between CL grading and DSHB(r=0.358) and were statistically significant. **Conclusion:** We concluded that ultrasound is a reliable tool to identify difficult airway by measuring the thickness of soft tissue in the anterior part of neck and BMI, neck circumference are good predictors of difficult laryngoscopy. Ultrasound guided measurement at the level of thyrohyoid membrane, anterior commisure are good predictor of difficult laryngoscopy among the three levels.
Key Words: Ultrasound, anterior neck soft tissue thickness, neck circumference, difficult laryngoscopy.

INTRODUCTION
Endotracheal intubation is one of the most important skills for anesthesiologists in securing the airway during general anesthesia and resuscitation. Failure to secure the airway can cause anesthesia-related life-threatening morbidity and mortality. Therefore, unanticipated difficult intubation remains a primary concern for anesthesiologists[1]. Theoretically, accurate preoperative airway evaluation can reduce or avoid unanticipated difficult intubation.

However, difficult laryngoscopy and tracheal intubation rate remains at 1.5 -13% due to poor reliability of traditional protocols, algorithms, and combinations of screening tools in identifying a potentially difficult airway[2].

Careful assessment, planning and preparation before the procedure can help in avoiding airway complication. There are several clinical predictors for difficult airway laryngoscopy or intubation – Mallampati score, upper lip bite test, interincisor distance, thyromental distance, sternomental distance and neck circumference. These have poor to modest sensitivity and specificity in difficult airway prediction.

No single test has been devised to predict a difficult airway accurately 100% of the time; however, a complete evaluation of airway and knowledge of difficult airway predictors can alert anesthesiologist to the potential difficulty and allow for appropriate planning[4].

Approximately 30% of anesthesia-related deaths result from failures of airway management, and an unanticipated difficult airway is an important source of peri-operative anesthetic complications and mortality[7].

Due to the portable, noninvasive characteristics, point-of-care ultrasound (US) technique has been widely used in the operating room. With improved visualization of airway structures, more studies have been focusing on airway structure and function. US can reliably image all of the structures visualized by CT, and the infrahyoid airway structure parameters measured by ultrasound agree well with the parameters measured by CT. The anterior neck soft tissue thickness measured by ultrasound at hyoid bone and thyrohyoid membrane levels can be used as an index to predict difficult laryngoscopy.

In current study, we evaluated the utility of ultrasonogram in predicting difficult laryngoscopy by measuring the thickness of soft tissue in the anterior part of neck at three different levels, namely skin to Hyoid bone, Skin to Epiglottis at thyrohyoid membrane and Skin to Anterior commissure

METHODOLOGY:

The data was collected in a pretested proforma meeting the objectives of the study. This is a prospective observational study, after approval of the research protocol by the hospital ethics committee for human studies and obtaining personal informed consent, American Society of Anesthesiologists(ASA)grade 1 and 2 adult patients undergoing elective surgeries and receiving general anesthesia were be included in this study. Exclusion criteria are patients who had facial, cervical, pharyngeal and epiglottis surgical or trauma history, patients with most teeth lost, patients with anterior neck swelling like thyroid swellings and patients with arthritis.

The age, sex, body weight, body height, BMI, neck circumference and the modified mallampati score(MMS) was recorded.

Ultrasound measurements was performed by the primary investigator with the patient supine and the head and neck in neutral position. The thickness of anterior neck soft tissue at hyoid bone, thyrohyoid membrane, and anterior commisure levels were obtained transversely across the anterior surface of the neck with a 7-13MHz HFL38x linear array ultrasound probe attached to a SonoSite S-nerve machine (SonoSite Inc., Bothell, WA, USA). At hyoid bone level, the minimal distance from the hyoid bone to skin surface (DSHB) was measured. At thyrohyoid membrane level, the distance from the skin to epiglottis midway (DSEM) between the hyoid bone and thyroid cartilage was measured. At anterior commisure level, the minimal distance from skin to anterior commisure (DSAC) was obtained.

After anesthesia induction with midazolam 0.05mg/kg, propofol 2mg/kg, fentanyl 2 microgram/kg, and succinyl choline 2mg/kg, endotracheal intubation was carried out by experienced anaesthesiologists. The macintoshblades were used to expose the target larynx, and no external pressure is used to facilitate this process. Classification of laryngoscopic views

is based on the method described by Cormack and Lehane. Grade 1is full view of the glottis. Grade 2 is partial view of glottis or arytenoids. Grade 3 is only epiglottis seen. Grade 4 is neither glottis nor epiglottis visible. Grade 1 and 2 are categorized as easy laryngoscopy. Grade 3 and 4 are categorized as difficult laryngoscopy. Grade 3 and 4 were considered difficult laryngoscopy.

At the end, we compared, the neck circumference, the anterior neck soft tissue quantified by ultrasound at 3 levels, which among these is a better predictor of difficult laryngoscopy.

RESULTS

Study design: This is a prospective observational study conducted on adult patients who underwent elective surgery under general anesthesia, to correlate anterior neck soft tissue thickness quantified using ultrasound and CL grading for predicting difficult laryngoscopy.
Among our study participants, 40% were male and 60% were female

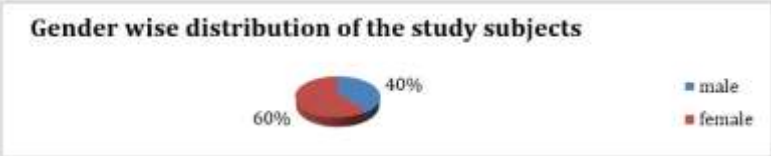

Figure 1: Gender wise distribution of the study subjects

Table 1: Distribution of the study subjects according to laryngoscopy

Frequency distribution - CL grading		
Laryngoscopy	**Frequency**	**Percent**
Easy (CL grade 1 &2)	38	63.3
Difficult (CL grade 3&4)	22	36.7
Total	60	100.0

Table 2: Comparison of laryngoscopy with weight, height and BMI

	Easy laryngoscopy (n=38)		**Difficult laryngoscopy(n=22)**		**P value**
	Median	**IQR**	**Median**	**IQR**	**0.001**
WEIGHT	69	11	80	13	0.001
HEIGHT	160	10	161	7	0.428
BMI	26.5	3	30.92	3	0.001

weight and BMI values were higher in difficult laryngoscopy and results were statistically significant

Table 3: comparison of laryngoscopy with airway evaluating parameters

	Easy (n=38)		**Difficult(n=22)**		**P value**
	median	**IQR**	**median**	**IQR**	
DSHB(cm)	0.36	0.09	0.425	0.1225	0.001
DSEM(cm)	0.41	0.1075	0.58	0.135	0.001
DSAC(cm)	0.41	0.1	0.63	0.103	0.001
Neck circumference(cm)	34.5	3	39	3	0.001

DSHB, DSEM, DSAV and neck circumference values were found to be higher in difficult laryngoscopy group and the results were statistically significant

Table 4: one- way anova test

ONE-WAY ANOVA TEST							
CL Grading		**N**	**Mean**	**SD**	**95% CI**		**P-value N**
					Lower Bound	**Upper Bound**	
DSHB (cm)	**1**	11	0.34	0.041	0.31	0.37	
	2	27	0.37	0.048	0.35	0.38	
	3	18	0.39	0.057	0.36	0.42	**0.007**
	4	4	0.39	0.050	0.31	0.47	
	Total	60	0.37	0.052	0.36	0.38	
DSEM (cm)	**1**	11	0.40	0.070	0.35	0.45	
	2	27	0.39	0.085	0.35	0.42	
	3	18	0.56	0.097	0.50	0.60	**0.0001**
	4	4	0.61	0.058	0.51	0.69	
	Total	60	0.46	0.117	0.42	0.48	
DSAC (cm)	**1**	11	0.40	0.095	0.33	0.46	
	2	27	0.43	0.079	0.39	0.46	
	3	18	0.56	0.084	0.51	0.59	**0.0001**
	4	4	0.58	0.080	0.44	0.70	
	Total	60	0.47	0.106	0.44	0.49	

The one-way ANOVA determined between Cormack lehane(CL) grading and USG parameters like DSHB, DSEM and DSAC. The results were statistically significant between CL grading and USG parameters like DSHB(p=0.007), DSEM(p=0.0001) and DSAC(p=0.001). As the mean USG measurement like DHSB, DSEM, DSAC values increases CL grading also increased. Therefore as the mean value increases the difficulty in intubation also increases

ROC Analysis:

Table 5: Area under curve of airway predicting parametes.

Test Result Variable(s)	**Area**	**P-value**	**95% CI**	
			Lower Bound	**Upper Bound**
DSHB (cm)	**0.722**	**0.022**	**0.558**	**0.885**
DSEM (cm)	**0.660**	**0.010**	**0.513**	**0.806**
DSAC (cm)	**0.736**	**0.015**	**0.565**	**0.906**

Receiver operating characteristic curve was drawn and area under curve was calculated to assess the best airway parameters among DSHB, DSAC, DSEM. Among the variables assessed, the highest area under curve was observed in DSAC(cm)- 0.736, followed by DSHB(cm)- 0.722 and DSEM (cm)- 0.66. All the variables were statistically significant in assessing the difficult laryngoscopy ($p<0.05$).

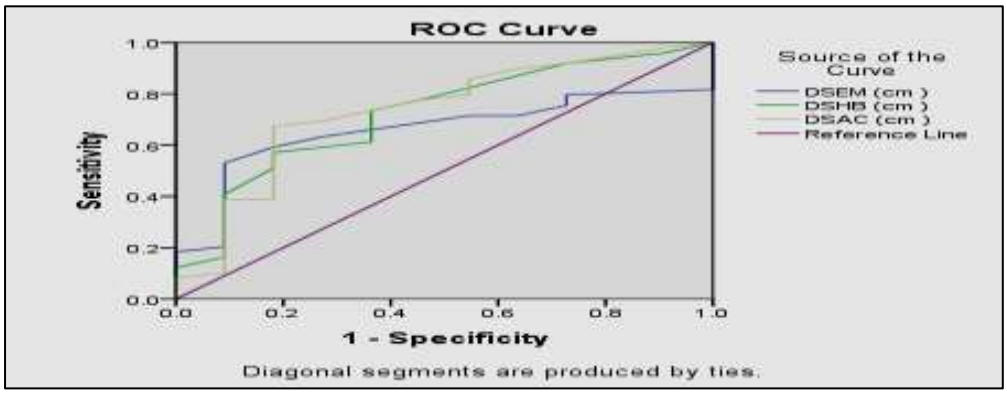

Figure 2: Area under curve of airway evaluating parameters

Table 6: cut off, sensitivity and specificity for predicting parameters.

Test Result Variable(s)	Cut off	Sensitivity	Specificity
DSHB (cm)	**0.335**	73.5%	83.6%
DSEM (cm)	**0.545**	87.1%	95.9%
DSAC (cm)	**0.445**	83.3%	91.8%
Neck circumference(cm)	**37**	89.2%	75.7%

Cut off, specificity and sensitivity were calculated for the variables to assess difficult laryngoscopy. With the cut offs provided in the table, the highest sensitivity was found in neck circumference with 89.2% followed by DSEM (cm)- 87.1%, DSAC(cm)- 83.3% and DSHB(cm)- 73.5%. The highest specificity was found in DSEM(cm)- 95.9% followed by DSAC(cm)- 91.8%, DSHB(cm)- 83.6% and neck circumference 75.7%.

Table 7: Pearson's correlation between CL grading and USG measurement

Pearson's correlation between CL grading and USG measurements		
USG measurements	**Correlation Coefficient(r)**	**P-value**
DSHB	0.358	0.005
DSEM	0.608	0.0001
DSAC	0.594	0.0001

There was a strong positive correlation between CL grading and USG measurements like DSEM (r=0.608) and DSAC (r=0.594), moderate positive correlation between CL grading and DSHB(r=0.358) and were statistically significant ($p<0.05$).

DISCUSSION

Preoperative assessment of the airway of the patient enables the anaesthesiologist to predict the ease of visualising the glottis and to perform intubation. Many bedside physical airway assessment tests are available, but they have a high inter-observer variability and moderate to fair sensitivity and specificity. They may also be difficult to apply in emergency and critical care settings, where patients are frequently confused, uncooperative and unable to follow directions. The idea of using ultrasound for assessment of tissues in close proximity to the larynx is based on the observation of the process of direct laryngoscopy. Researchers have hypothesised that increased anterior neck soft tissue thickness could impair the forward mobility of the pharyngeal structures and that an increase in the pre epiglottic space or a decrease in the distance from the epiglottis to the vocal cords could be associated with more difficult laryngoscopy and intubation. There is limited literature available that compares the ultrasound parameters to the Cormack-Lehane (CL) grade and physical parameters. Ultrasound has become a part of the anaesthesiologists' armamentarium to help various procedures in the

operation room and critical care areas. Imaging of the airway is a newer application of ultrasound.[13]

Therefore, we conducted this study to correlate anterior neck soft tissue (at various levels) quantified using ultrasound and Cormack lehane grade in predicting difficult laryngoscopy.

Study was conducted on 60 ASA 1 and 2 patients aged between 18-60years who underwent elective surgery under general anesthesia in hospitals attached to Bangalore medical college and research institute. The age, sex, body weight, height, BMI, neck circumference and the modified mallampati score was recorded. Using ultrasound the thickness of anterior neck soft tissue at hyoid bone, thyrohyoid membrane and anterior commisure levels were obtained..

The ultrasound measurements were then compared with the Cormack lehane grade during direct laryngoscopy under general anaesthesia.

In our study, the BMI value was 30.92 kg/m^2 for difficult laryngoscopy and 26.5 kg/m^2 for easy laryngoscopy group. Therefore, BMI values were higher in difficult laryngoscopy group and results were statistically significant ($p< 0.001$). Wu J[11] *et al.* conducted study on 203 patients of age 20-65 year. No differences were noted in sex, age, and height, but body weight and BMI values in the difficult laryngoscopy group were higher. The BMI value was 25.63±2.80 kg/m2 for the difficult laryngoscopy group, and 23.61±3.43 kg/m2 for the easy laryngoscopy group ($P<0.05$). Results were consistent in both the studies.

In our study, the neck circumference was 34.5cm for easy laryngoscopy group and 39cm for difficult laryngoscopy group ($p < 0.001$). Therefore, neck circumference values were found to be higher in difficult laryngoscopy group and the results were statistically significant. This was in comparison with the study conducted by R S Ambrose *et al.*[38] where the neck circumference was >40cm in predicting difficult airway.

In our study, DSHB, DSEM, DSAC values were found to be higher in difficult laryngoscopy group and the results were statistically significant. There was a strong positive correlation between CL grading and USG measurements like DSEM ($r=0.608$) and DSAC ($r=0.594$), moderate positive correlation between CL grading and DSHB($r=0.358$) and were statistically significant ($p<0.05$). We concluded that anterior neck soft tissue thickness at various levels is a good predictor of difficult laryngoscopy.

This is similar to the results obtained by Avani shah *et al.*[36]. In his study he concluded that ultrasonographic measurement of anterior neck soft tissue thickness at the level of vocal cord, hyoid bone and thyrohyoid membrane can be used to predict difficult laryngoscopy. DSAC is a potential predictor of difficult laryngoscope. A value of more than 0.51cm correlates well with Cormack Lehane grades for difficult layngoscopy. It is also more sensitive than physical parameters such as MMS.

Koundal V *et al.*[35] observed that there was positive correlation of DSHB, DSEM, and pre-E/E-VC($r= 0.551, 0.701, 0.787$; $p= 0.00$). He concluded that strong positive correlation of pre-E/E-VC, DSEM makes these ultrasound parameters reliable predictors for difficult laryngoscopy. Our study result was consistent with the USG parameter, DSEM of this study.

Adhikari S[6] *et al.* concluded in his study that sonographic measurements of anterior neck soft tissue thickness at the level of hyoid bone and thyrohyoid membrane can be used to differentiate difficult and easy laryngoscopies. Clinical screening tests did not correlate with ultrasound measurements, and ultrasound could predict difficult larngosocpy, indicating the limitations of the conventional screening tests for predicting difficult laryngoscopy. Results were same as our study results of USG parameters.

In our study, the areas under the ROC curve of DSHB, DSEM and DSAC were 0.722cm, 0.66cm and 0.736cm respectively and were significantly compared with the reference line ($p<0.05$). This results consistent with Wu J *et al.*[11] study. In his study he was found that the

AUCs of DSEM, DSHB and DSAC were all over 0.7, indicating they were all good parameters in predicting difficult laryngoscopy.

Yadav U[30] et at conducted a prospective observational study on 200 patients and concluded that sonographic predictors (anterior soft tissue thickess at the level of vocal cord, hyoid bone) can help in identifying difficult laryngoscopy. Combination of clinical and ultrasonographic parameters showed better validity when compared to individual tests. The conclusion of our study was correlating with USG parameter of this study.

In our study, the cutoff values of DSHB, DSEM and DSAC were 0.335cm, 0.545cm and 0.445cm respectively to assess difficult laryngoscopy. Cutoff value of DSEM was comparably to the study by R S Ambrose *et al.*[38]. In their study of 120 patients who underwent general anaesthesia, the distance between skin to epiglottis distance measured using USG showed that 0.265cm ± 3.26cm was risk factor for difficult intubation. Also this results correlates with the study done by Mohammadi ss[18] *et al.* who described difficult intubation in patients with BMI >25kg/m^2. He concluded that the correlation between CL grade and DSEM with cutoff value >0.42cm was significant for predicting of difficult intubation.

LIMITATIONS OF OUR STUDY

- Glottis exposure by laryngoscope is a very complicated procedure, and many subjective and objective factors such as the provider's skills and experience, airway secretions, and abnormalities of anatomical structures are involved in this procedure. Therefore, the small sample size might pose problem in concluding the results.
- The investigators were not totally blinded to the purpose of the study, and some clinical signs might indicate the possibility of difficult laryngoscopy, which can cause some bias during ultrasound measurements.
- Interobserver variability is another main drawback.
- There were no control variables such as experience of anesthesia providers and number of attempts

CONCLUSION

We concluded from our study conducted on 60 patients aged between 18-60years belonging to ASA1 and 2 that ultrasound is a reliable tool to identify difficult laryngoscopy. Anterior neck soft tissue thickness at the level of thyrohyoid membrane, anterior commisure and hyoid bone quantified using ultrasound are better predictor of difficult laryngoscopy. BMI, neck circumference are also good predictors of difficult laryngoscopy

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