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A Comparative Correlation Of Pre-Anaesthetic Airway Assessment Using Ultrasound With Cormack Lehane Classification Of Direct Laryngoscopy.

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Abstract:
Background: *Preoperative assessment for predictors of difficult airway continues to generate quest amongst anaesthesiologists, as that affects the approach to airway management. . Ultrasonographic airway assessment could be a useful adjunct, but at present, there are no well-defined sonographic criteria that can predict the possibility of encountering a difficult airway.*
Materials and Methods:*This was a prospective observational study conducted on 90 patients undergoing elective surgery under general anesthesia. Preoperative clinical and ultrasonographic assessment of the airway was done to predict difficult airway and was correlated with the Cormack Lehane (CL) grade noted at laryngoscopy. The sensitivity, specificity and accuracy of the parameters were assessed.*
Results:*The incidence of difficult laryngoscopy was 21.1%. We found that increase in anterior neck soft tissue distance at epiglottis (DSEM) is strongly associated with difficult laryngoscopy. We found that a cut-off value of 17.7 mm was able to predict difficult laryngoscopy with an accuracy of 77.2%, a sensitivity of 78.9%, and a specificity of 76.3%.*
Conclusion:*The ultrasonographic measurements in the Indian sub-population may not be very sensitive in predicting difficult airway with the exception of DSEM, which has reasonable correlation with Cormack Lehane grade for predicting difficult laryngoscopy.*
Key Words: *Airway, Cormack-Lehane grade, direct laryngoscopy,ultrasonography.*

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I. Introduction

Airway management is an essential component of clinical anaesthesia, and involves maintenance of a patient airway to facilitate gas exchange via mask ventilation or airway device. An important aspect of airway management is assessment of the patient's airway to predict the likelihood of ease or difficulty with bag mask ventilation or with laryngoscopy and intubation, enabling the anaesthesiologist to prepare for this challenging clinical scenario[1]. Several bedside physical airway assessment tests are available, but have a high inter-observer variability[2] and moderate to fair sensitivity and specificity[3].There are many anatomical parameters for evaluatingthe feasibility of tracheal intubation, one that can reliably predict a difficult intubation is the Cormack-Lehane classification obtained during direct laryngoscopy[4]. This is an invasive procedure that cannot be performed in an awake patient or for pre-anesthetic airway assessments in patients with no prior history of tracheal intubation.However, despite careful airway assessment, direct laryngoscopy sometimes results in unanticipated poor laryngeal views. Ultrasound (US) imaging technique has recently emerged as a novel, simple, portable, non-invasive tool helpful for pre-operative airway assessment and management[5,6,7,8,9].

II. Aim & Objectives

The aim was to assess the accuracy of ultrasound as a modality for pre-operative assessment of the airway.

The objectives of the study were:

1. To compare and correlate the ultrasound assessment of the airway with Mallampati grading, evaluated before anaesthesia induction.
2. To compare and correlate the ultrasound assessment of the airway before anaesthesia with Cormack Lehane classification during direct laryngoscopy under general anaesthesia.

III. Material & Methods

This prospective, double-blinded observational study on 90 patients undergoing elective surgery under general anaesthesia was conducted in the pre-operative holding area and the operation theatre complex of a tertiary care hospital.After institutional ethics committee approval and informed consent, adult patients between 18 and 70 years of age, of either sex, requiring general anaesthesia with endotracheal intubation for elective procedures were enrolled in the study. Patients withmouth opening too small to pass Macintosh blade 4, edentulous, head and neck anatomical pathologies, who were not able to extend their neck >30 degrees, previous history of difficult intubation, obesity (body mass index [BMI] >30 kg/m^2), scheduled for fibreoptic intubation, pregnant women and those requiring rapid sequence intubation were excluded.

During the pre-operativevisit,the oropharyngeal view was assessed using Mallampati grading(MPG) of the pre-anesthetic airway assessment by asking the patient to sit and open his or her mouth maximally and to protrude the tongue without phonation[10] and was documented as follows: Grade 1: Full visibility of tonsils, uvula and soft palate ,Grade 2: Visibility of hard and soft palate, upper portion of tonsils and uvula, Grade 3: Soft and hard palate and base of the uvula are visible and Grade 4: Only Hard Palate.

And then, the ultrasound view of the airway of all patients included in the study were assessed by portable ultrasound (A logiq e by GE HEATHCARE ultrasound system) with high frequency linear probe HFL 12L-RS/5-13 MHz and the four ultrasonographic parameters were measured by the same anaesthesiologist who had considerable experience of using ultrasound.

The patient was asked to lie down supine with active maximal head tilt chin lift. The probe was then placed in the submandibular area in the midline. Without changing the position of the probe, the linear array of the ultrasound probe was rotated in the transverse planes from cephalad to caudal or plane "A" (a coronal plane to see the mouth opening) to plane "G" (an oblique transverse plane that bisects the epiglottis and posterior most part of vocal folds with arytenoids in one 2-dimensional view) as shown in figure 1.The further rotation of the ultrasound array was ceased at the first simultaneous visualization (in the same ultrasonic frame) of the epiglottis and posterior most part of vocal folds with arytenoids[11]. The following study measurements were obtained:

(a) The depth of the pre-epiglottic space (PES)

(b) The distance from the epiglottis to the midpoint of the distance between the vestibular ligaments (EVL)

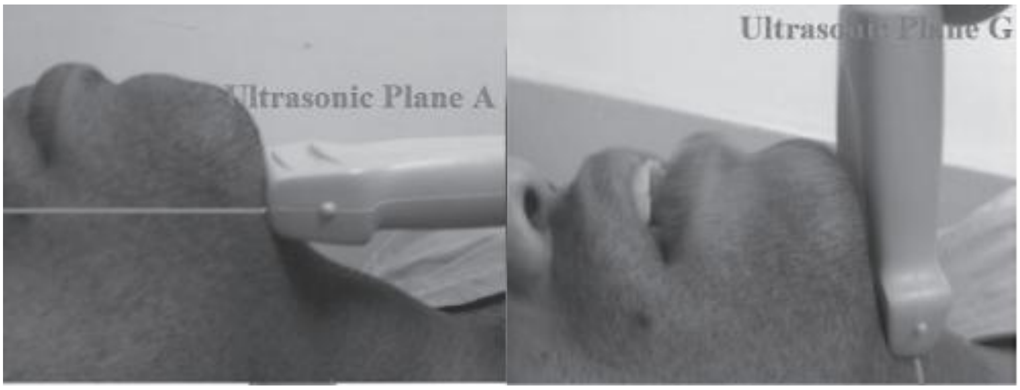

Fig.1: Ultrasonic planes (Planes A-G) for the ultrasound assessment of the airway

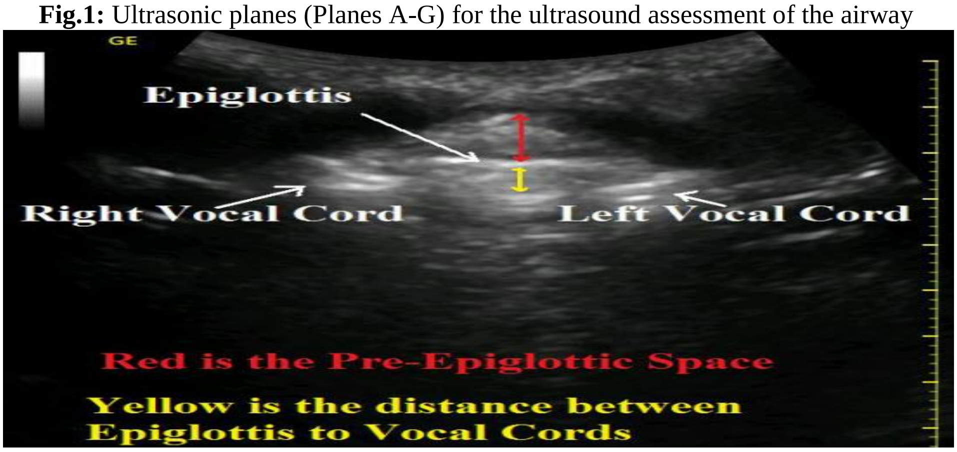

Fig. 2: Ultrasonographic Image Showing: (Red Arrow) The Pre-Epiglottic Space (PES) And (Yellow Arrow) The Distance Between Epiglottis To midpoint of Vocal Cords (EVL)

Then by changing head and neck to neutral position the other two USG parameters, the thickness of anterior neck soft tissue[12] were obtained with the transverse view at the following levels:
(c) At the level of hyoid bone i.e. the minimal distance from the hyoid bone to the skin (DSHB)
(d) At the level of the thyrohyoid membrane i.e. the distance from skin to epiglottis midway between the hyoid bone and thyroid cartilage (DSEM)

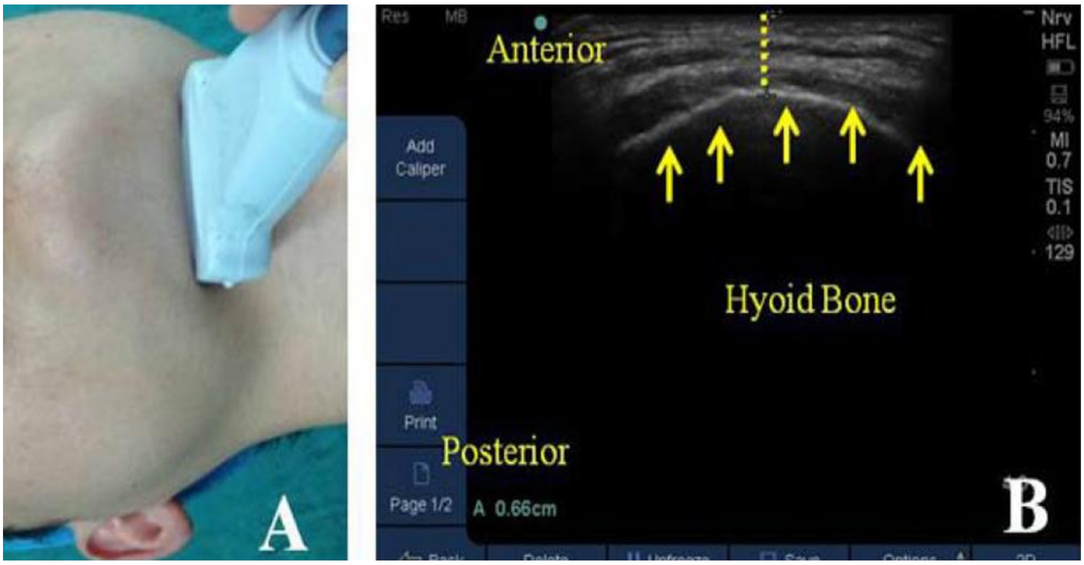

Fig.3: Ultrasound measurement of anterior neck soft tissue thickness: ultrasound probe in transverse position. (A) hyoid bone level; (B) yellow arrows denote hyoid bone, yellow dotted line denotes the minimum distance from skin to hyoid bone (DSHB).

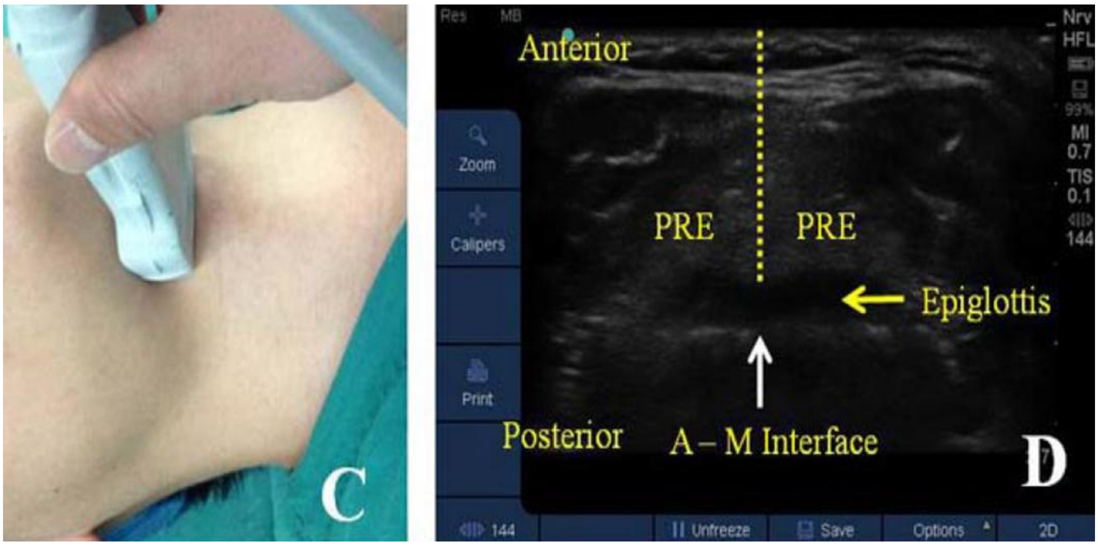

Fig.4: Ultrasound measurement of anterior neck soft tissue thickness: ultrasound probe in transverse position. (C) Thyrohyoid membrane level; (D)Ultrasonographic image Showing Distance between Skin to Epiglottis midway (DSEM) between hyoid and thyroid cartilage(Yellow dotted line), PRE (pre-epiglottic space), A-M interface (air-mucosal).

After receiving patient in the operating room, patient was monitored with routine intra-operative monitors, including pulse oximetry, non-invasive blood pressure and electrocardiography. Technique of anaesthesia was standardized for all the patients in the study. After anaesthesia induction with injection propofol 2-2.5mg/kg, fentanyl 1μg/kg and muscle relaxant rocuronium 0.6mg/kg intravenously, direct laryngoscopy and endotracheal intubation was carried out by an anaesthesiologist with atleast two years of experience of performing the procedure. All the patients were put in neutral position without neck overextension or over-bending. The Macintosh blade size 4 was used to expose the target larynx, and no external laryngeal pressure was used to facilitate the view.

During the intraoperative laryngoscopy, the Cormack and Lehane grading was recorded as the following:Grade 1: visualization of the entire laryngeal aperture, Grade 2: visualization of parts of the laryngeal aperture or the arytenoids, Grade 3: visualization of only the epiglottis and Grade 4: visualization of only the soft palate.

The Cormack Lehane grade I and II were recorded as easy laryngoscopy and grade III and IV as difficult laryngoscopy. Number of attempts at intubation, external pressure to facilitate intubation and use of any adjunct (gum elastic bougie) were also recorded.

IV. Observation And Results

A total of 90 eligible patients (51 females, 39 males) were included in this study, out of which 19 patients (21.1%) were categorized as difficult laryngoscopy (CL grade III) and 57.8% of patients with difficult laryngoscopy in our study were females. No differences were noted in age, gender, BMI, ASA status and MPG among easy and difficult laryngoscopy groups.

A correlation was computed to assess the relation between PES, EVL, DSHB and DSEM with Mallampati grading. There was a very weak negative and a very weak positive correlation of PES and EVL with Mallampati grading with regression coefficient of $r = -0.083$ ($p=0.437$) and $r = 0.116$ ($p=0.276$) respectively. There was also a weak positive correlation of DSHB and DSEM with Mallampati grading with correlation coefficient of $r= 0.227$ ($p= 0.037$) and $r = 0.238$ ($p=0.031$) respectively. So, among the four ultrasonographic parameters studied there existed a significant correlation of DSHB and DSEM with Mallampati grading.

The relation between PES, EVL, DSHB , DSEM with Cormack Lehane grading was also computed and there was a very weak negative and a very weak positive correlation of PES and EVL with CL grading with regression coefficient of $r = -0.122$ ($p=0.251$) and $r = 0.121$ ($p=0.256$) respectively. There was also a weak positive and moderate positive correlation of DSHB and DSEM with Cormack Lehane grading with correlation coefficient of $r= 0.387$ ($p<0.001$) and $r = 0.546$ ($p<0.001$) respectively. So, amongst the four ultrasonographic parameters studied both DSHB and DSEM showed a significant correlation with CL grading.

The ultrasonographic measurements in difficult laryngoscopy group had a mean PES, EVL, DSHB and DSEM of 2.04±0.681,7.15±3.103, 14.48±4.720 and 23.37±2.159 respectively whereas easy laryngoscopy group had mean of 2.21±0.598, 6.49±2.447, 11.96±3.839 and 16.44±3.125 with p value of 0.323, 0.321, 0.071 and <0.001 respectively . Among the four ultrasonographic measurements, DSEM was statistically significant ($p<0.001$) for predicting difficult laryngoscopy.

The ROC(Receiver Operator Characteristic) curve is a graphical display of sensitivity and specificity and the AUC(area under the curve) is an effective measure for assessing the inherent validity of the test. To further assess the roles of MPG, PES, EVL, DSHB and DSEM in predicting difficult laryngoscopy, the ROC curves were drawn and the optimal cut-off values with their sensitivity and specificity were III(42.1%, 78.9%), 1.7 mm (31.5%, 73.2%), 7.8 mm (36.8%, 76.1%), 12.4 mm (63.2%, 76.1%) and 17.7 mm (78.9%, 76.3%) respectively. The areas under the curve (AUCs) were different from the area under the reference line (area=0.5) as shown in figure 9. The AUC for MPG, PES, EVL, DSHB and DSEM were 0.637, 0.547, 0.551, 0.675 and 0.772 with the p value of 0.261, 0.523, 0.497, 0.172 and <0.001 respectively. The AUC of DSEM is 0.772 and closest to 1indicating that it has the highest validity among the parameters studied.

Table 1 : Showing association of Mallampati grading with Cormack-Lehane grading

MPG	**CL Grade I**		**CL Grade II**		**CL Grade III**	
	No.	**%age**	**No.**	**%age**	**No.**	**%age**
MPG I	17	56.7	10	24.4	4	21.1
MPG II	9	30.0	20	48.8	7	36.8
MPG III	3	10.0	10	24.4	6	31.6
MPG IV	1	3.3	1	2.4	2	10.5
Total	30	100	41	100	19	100

Chi-square=13.07; P-value=0.042 (Statistically Significant)

Perusal of the data presented in the table above revealed that the association of Mallampati grading with Cormack Lehane grading and was found to be statistically significant association with p value =0.042.

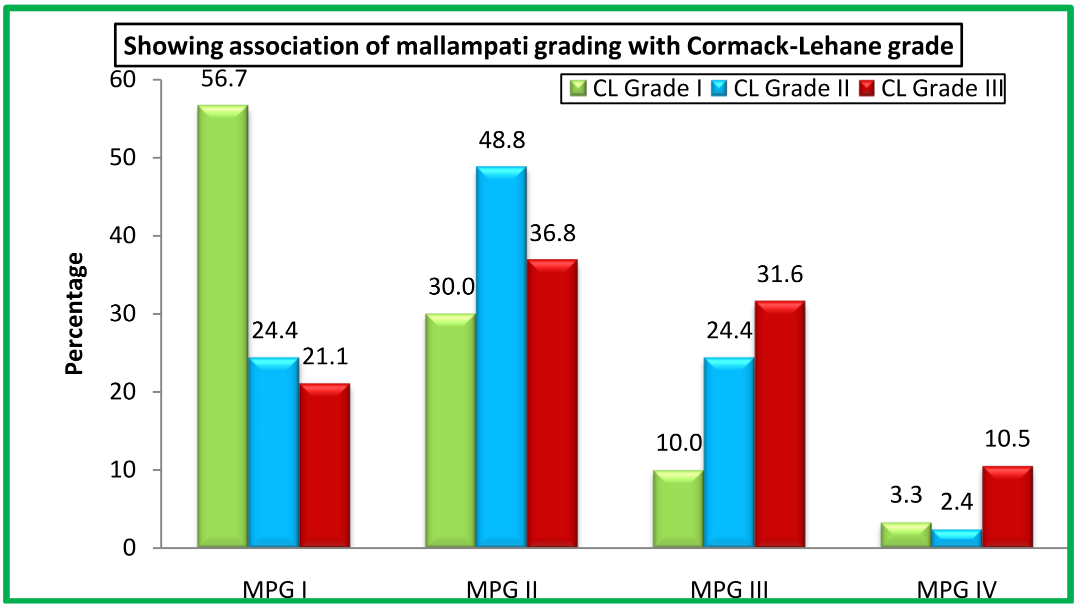

Fig. 5: Graph showing association of Mallampati grading (MPG) with Cormack Lehane grading.

Table 2: Ultrasonographic measurements for predicting difficult laryngoscopy

Parameter (in mm)	Difficult Laryngoscopy [n=19]		Easy Laryngoscopy [n=71]		P-value
	Mean	SD	Mean	SD	
PES	2.04	0.681	2.21	0.598	0.323
EVL	7.15	3.103	6.49	2.447	0.327
DSHB	14.48	4.720	11.96	3.839	0.071
DSEM	23.37	2.159	16.44	3.125	<0.001*

Statistically Significant Difference (P-value<0.05)

The data presented in the above table depicts the ultrasonographic measurements for predicting difficult laryngoscopy. Among 90 study patients 19 belonged to difficult laryngoscopy group(CL III & IV) representing 21.1% of the study population. The mean value of PES= 2.04±0.681, EVL= 7.15±3.103, DSHB=14.48±4.720 and DSEM 23.37±2.159 were seen in difficult laryngoscopy whereas mean value of PES= 2.21±0.598, EVL= 6.49±2.447, DSHB=11.96±3.839 and DSEM 16.44±3.125 were seen in easy laryngoscopy(CL I & II). The p value for PES, EVL, DSHB and DSEM are 0.323, 0.327, 0.071 and <0.001 respectively.

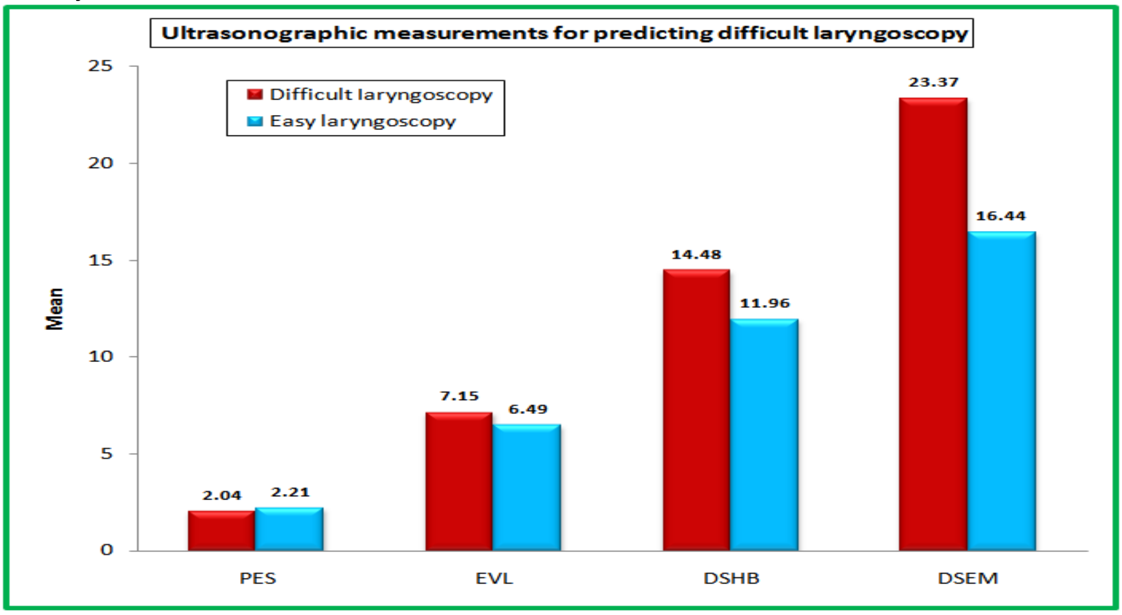

Fig.6: Graph depicts difficult and easy laryngoscopy on the basis of mean values of the ultrasonographic measurements.

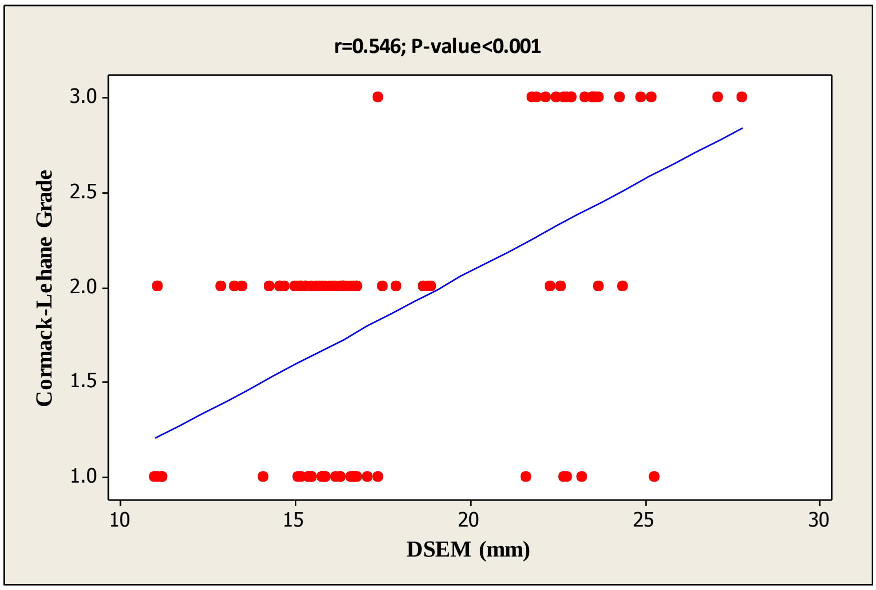

Fig.7: Scatter Plot of DSEM VS CL Grade

A Pearson correlation was computed to assess the relationship between DSEM and Cormack Lehane grading. There was a moderate positive correlation between the two variables, r = 0.546, $p<0.001$.

Table 3: Sensitivity and specificity of DSEM distance values (mm) at an optimal cutoff

DSEM (mm)	**Value**	**95% CI**
Sensitivity	78.9	54.4-93.9
Specificity	76.3	64.5-85.4
AUC	0.772	0.671-0.854
Optimal Cutoff	17.7	-

Above table exhibits sensitivity and specificity of 78.9% and 76.3% respectively at an optimal cut-off value for DSEM distance of 17.7mm and shows the accuracy of 0.772 which is considered fair in prediction of difficult laryngoscopy.

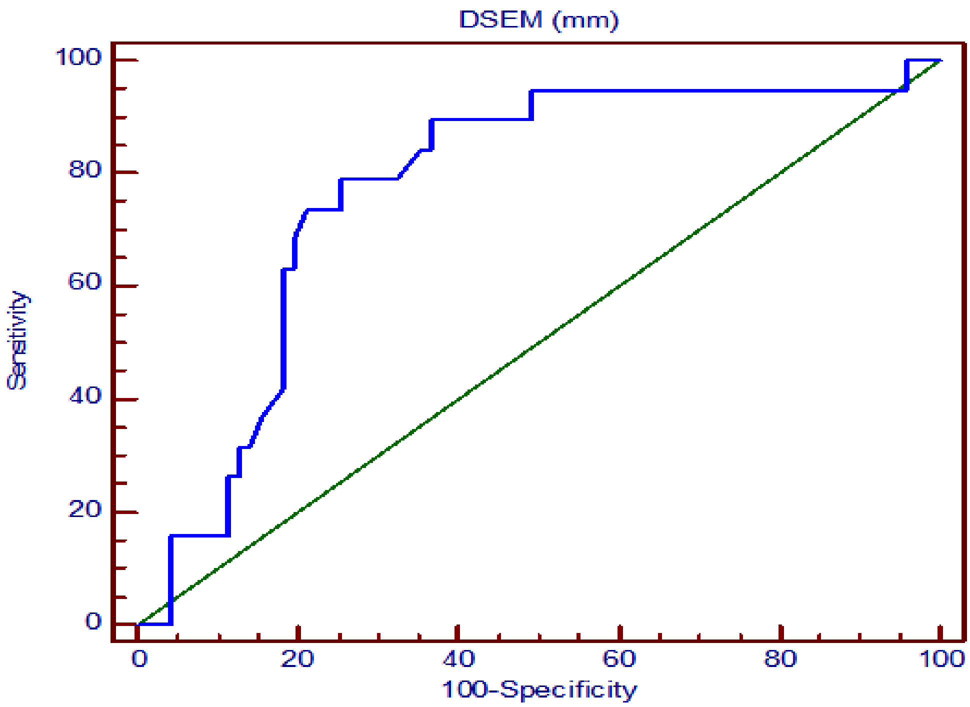

Fig.8: The ROC(Receiver Operator Characteristic) curve for distance of skin to epiglottis(DSEM) at the thyrohyoid membrane level.

Table 4: The area under the ROC curves (AUC) for MPG, PES, EVL, DSHB and DSEM

Parameter	AUC	SE	95% CI	P-value
MPG	0.637	0.074	0.529-0.736	0.261
PES	0.547	0.081	0.438-0.652	0.523
EVL	0.551	0.079	0.443-0.656	0.497
DSHB	0.675	0.0843	0.569-0.771	0.172
DSEM	0.772	0.0585	0.671-0.854	<0.001*

Statistically Significant Difference (P-value<0.05)
AUC ± SE – area under the ROC curves ± Standard Error; 95% CI – Confidence Interval; MPG – Mallampati Grading; PES – pre-epiglottic space distance; EVL – distance between epiglottis and vestibular ligaments; DSHB – distance between skin and hyoid bone; DSEM – distance between skin and epiglottis

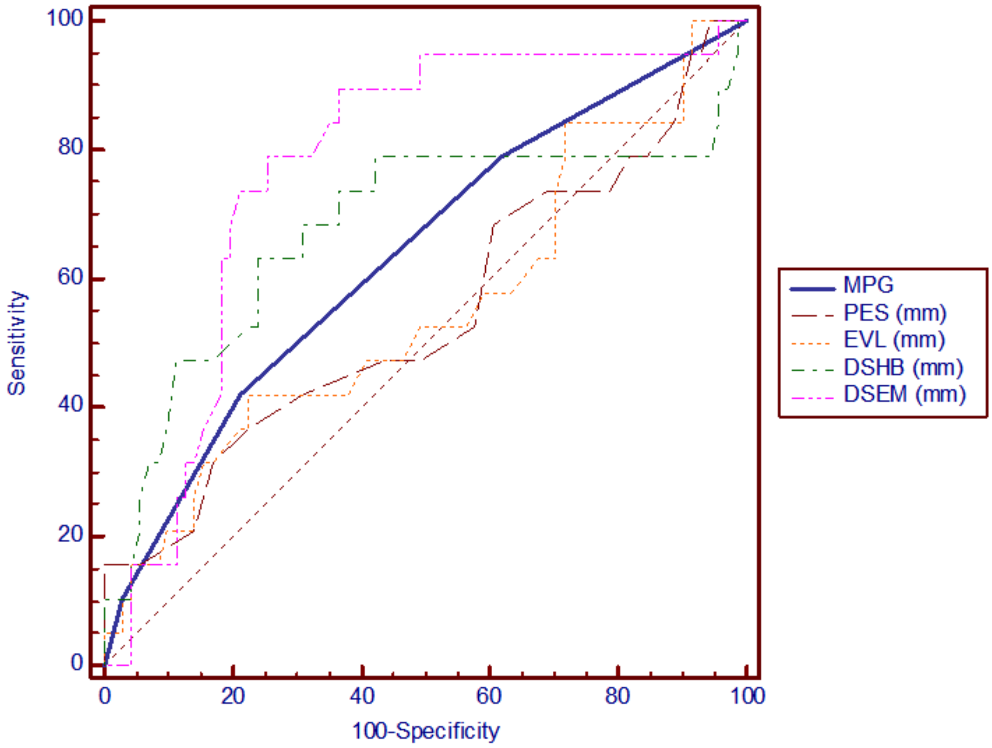

Fig.9: Receiver operating characteristic (ROC) analyses for DSEM (pink dotted line), DSHB (green dotted line), MPG (solid blue line), EVL (red dotted line) and PES (brown dotted line). Cormack –Lehane grading of glottis exposure over II was considered the threshold of difficult laryngoscopy during the study. Black dotted diagonal line= reference line.

V. Discussion

There are several traditional indices of predicting difficultlaryngoscopy, but none of them are 100% sensitive and specific. Ultrasound is a new addition to the anesthesiologist's armamentarium, which has revolutionized care in several areas. The role of ultrasound in airway assessment is still primitive, with no established standard parameters to predict a difficult laryngoscopy.The study was designed to establish a comparative correlation of Mallampati grading and ultrasound assessment of the airway as preoperative predictor of difficult airway with Cormack Lehane assessment during direct laryngoscopy under general anaesthesia in distinguishing easy and difficult laryngoscopy.

The parameters assessed by ultrasound in our study were (i) the depth of the pre-epiglottic space (PES) (ii) the distance from the epiglottis to the midpoint of the vestibular ligament (EVL) (iii) the minimal distance from the hyoid bone to skin (DSHB) and (iv) the distance from the skin to epiglottis (DSEM) at thyrohyoid membrane level.

The prevalence of difficult laryngoscopy in our study was 21.1% which was higher than the reported incidence. In the current study, the comparative correlation of pre-epiglottic space depth (PES) and epiglottis to midpoint of vestibular ligaments (EVL) with Cormack Lehane (CL) grading for prediction of difficult laryngoscopy showed a very weak negative correlation of PES and a very weak positive correlation of EVL with CL grading. The p value for both ultrasound measurement was statistically insignificant (p>0.05)

In a study conducted at the Wayne University, Detroit, United States[11], attempted to predict the Cormack Lehane grade using a non-invasive technique such as ultrasound. They found a strong positive correlation of pre-epiglottic space with Cormack-Lehane grading with regression coefficient of 0.595 (p = 0.0008); and a strong negative correlation of the distance between the epiglottis and vocal cords with Cormack-Lehane grading with regression coefficient of -0.966 (p= 0.0001). However, in the current study none of the above measured values of PES and EVL revealed a strong correlation with the Cormack Lehane grading. The reason for the difference of results could be explained by the different airway anatomies in patients of different races and different levels of experience in performing airway sonography. We also correlated in our study PES and EVL with Mallampati grading (MPG) and found a very weak negative and a very weak positive correlation of PES and EVL with MPG, which was statistically insignificant and was not evaluated in Gupta et al.'s study.

In our study, we used the skin to hyoid bone (DSHB) and skin to epiglottis (DSEM) at the level of thyrohyoid membrane, as a measure of the anterior neck soft tissue. DSHB showed a weak positive and DSEM showed a moderate positive correlation with CL grading which were statistically significant with(P<0.001) .

In a pilot study by AdhikariS et al[13], the sonographic measurements of anterior neck soft tissue were greater in the difficult laryngoscopy group compared to the easy laryngoscopy group. They gave a cut-off value of 2.8 cm at the thyrohyoid membrane level to detect difficult laryngoscopy. However, they could not validate this cut-off value since only six patients were in the difficult laryngoscopy group.

However, in our study we got the optimal cut-off value of 1.7 cm at the level of the thyrohyoid membrane which could be used in distinguishing easy from difficult laryngoscopy. The difference in the range of cut-off value which is smaller than previous report may be related to the ethnicity and BMI of the patients. The study subjects were Indians; in contrast, Adhikari et al studied whites and African Americans. Difference in neck fat tissue distribution between different ethnic groups is well documented in prior studies Komatsu R et al[14]**.**

Wu J et al[12]**,** in their study on 203 patients, have shown that the thickness of the anterior neck soft tissue measured by ultrasound can be a predictor of difficult laryngoscopy. They found that the skins to hyoid distance (DSHB) as well as skin to epiglottis distance (DSEM) were good predictors of difficult laryngoscopy. They also correlated DSHB and DSEM with MPG and found small positive correlations of DSHB and DSEM with MPG. In our study, skin to hyoid distance (DSHB) did not prove to be a significant predictor of difficult laryngoscopy (p = 0.071), when compared to skin to epiglottis distance (p<0.001) for prediction of difficult laryngoscopy. However in our study, there was a weak positive correlation of DSHB and DSEM with Mallampati grading, which was statistically significant and in consonance with above study.

However, Pinto J et al[15]had found that larger distance from skin to epiglottis is strongly associated with difficult laryngoscopy (p< 0.001, 2-sided t test). They could predict difficult laryngoscopy with an accuracy of 74.3%, a sensitivity of 64.7%, and a specificity of 77.1% which was in accordance to our study.

In the present study, 21.1% (N=19) of the patients belonged to the difficult laryngoscopy group, which is higher than the reported incidence. But of these only 42.1% (N=8) required more than one attempt for successful intubation. The patients requiring the use of adjunct (6.6%, N=6) for intubation and all belonged to difficult laryngoscopy group. In all the 19 patients (21.1%) belonging to difficult laryngoscopy group (CL grade III) external pressure was applied to improve the Cormack- Lehane grade. None of the patients belonging to difficult laryngoscopy group had a Cormack Lehane grade IV or were in the category of 'Can't Intubate, Can't Ventilate' condition.

Hence the outcome of the present study suggests that ultrasound is a useful tool in airway assessment and out of the four ultrasonographic parameters studied only the skin to epiglottis distance(DSEM) measured at thyrohyoid membrane level is a good predictor of difficult airway.

In this study, variables such as dentition of the patients, experience of the anaesthesia providers, laryngoscopy equipment used, number of intubation attempts, external laryngeal pressure, use of adjunct(gum elastic bougie) and view of the glottis (first view, best view or view immediately before passing the endotracheal tube); were controlled. These variables were standardized by implementing following protocol: edentulous patients were excluded; anaesthesia providers with more than 2 years of experience intubated all the patients; Macintosh blade size 4 was used for both female and male patients; intubation attempts, use of adjunct (gum elastic bougie) and external pressure to facilitate intubation were all recorded for each patient; first view of glottis was recorded and used to grade Cormack-Lehane.

A small sample size of 90, may limit the conclusions that can be reached and may be reason for low sensitivity and specificity. The easy and difficult laryngoscopy groups were uneven, with no patient falling in Cormack-Lehane grade IV. Inexperience in the initial stages of using the ultrasound may have skewed the outcome to a certain degree.

VI. Conclusion

Hence, we conclude that ultrasound can be used to assess the airway pre-operatively and several sonographic parameters can be measured. In our study, among the four ultrasonographic parameters studied the skin to epiglottis distance (DSEM) measured at the thyrohyoid membrane level is a good predictor of difficult airway.

The exact values of these variables measured sonographically that would correlate with difficult airway needs to be established through future research.

CONFLICTS OF INTEREST

There are no conflicts of interest.

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