Comparative study of sonographic measurement of PRE-E/E-VC ratio versus Hyomental distance ratio to correlate Cormack–Lehane grading for airway assessment

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ABSTRACT

Background: Predicting a difficult airway preoperatively overcomes the hurdles of unanticipated difficult airway management. Cormack–Lehane grading (CL Grading) best describes the view of larynx. However, direct laryngoscopy cannot be used to predict difficult airway for patients undergoing intubation for the 1st time. On the other hand, ultrasound is a safe and painless procedure. This study was done to correlate airway ultrasound findings with CL Grading by direct laryngoscopy. The patients selected were undergoing elective surgeries under general anesthesia. **Aims and Objectives:** The aims of the present study were to correlate the ultrasound view of the airway with the Cormack–Lehane classification by direct laryngoscopy. **Materials and Methods:** A group of 94 patients, aged 18–60 years, ASA I/II were selected who underwent elective surgical procedures under general anesthesia requiring intubation by direct laryngoscopy. Pre-epiglottic (PRE-E) depth and epiglottic vocal distance (E-VC) were measured along with hyomental distance ratio (HMDR) by ultrasound. The ultrasound parameters were then compared with CL Grading during laryngoscopy. **Results:** The PRE-E depth/epiglottic vocal cord distance correlated better than hyomental distance ratio in predicting CL Grading (P = 0.000). **Conclusion:** The PRE-E/E-VC ratio was a better predictor of CL Grading than the HMDR.

Key words: Cormack–Lehane grading; Epiglottis vocal cord distance; Hyomental distance; Pre-epiglottic depth; Ultrasound

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INTRODUCTION

Tracheal intubation is one of the most difficult aspects in the field of anesthesiology. As a result, predicting a difficult airway preoperatively overcomes the hurdles of unanticipated difficult airway management. There are many methods of physical airway assessment, but they have shown moderate to fair sensitivity and specificity. Cormack–Lehane grading (CL Grading) best describes the view of larynx. However, laryngoscopy being an invasive procedure, it cannot be used to predict difficult airway for patients undergoing intubation for the 1st time.[1,2] On the other hand, ultrasound is a safe and painless procedure. Certain parameters measured in airway ultrasound helped in pre-operative airway assessment and hence, further management of airway was made easier.[3]

Ultrasound uses sound waves of frequency more than 20,000 Hz for the formation of images. The principle behind ultrasound is that electrical energy is converted to mechanical waves that traverse the tissues, hit the target, and get reflected back. The reflected mechanical waves gets

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converted back into electrical energy forming images on the screen. This conversion of waves is by the piezoelectric transducer which is present in the probe being used. The conversion of electrical impulses to mechanical sound waves is known as reverse piezoelectric effect, and the conversion of mechanical waves back into electrical energy is termed as direct piezoelectric effect. The probe is selected according to the structure that we need to visualize. Airway structures are superficial structures and best visualized with high frequency linear probes (5–12 hz) [4,5]

The primary aspect for ultrasound-guided airway assessment is visualizing the important structures. The epiglottis and the vocal cords are visualized simultaneously at the level of thyroid cartilage[3,6] using a linear probe in the transverse plane. The vocal cords can, further, be confirmed by their movement during respiration and phonation.[3,7] The hyoid bone is visualized clearly above thyroid cartilage in the submandibular space. The pre-epiglottic (PRE-E) depth is the distance between skin and epiglottis, whereas epiglottic vocal cord distance is the distance between epiglottis and midpoint of the vocal cords.[1,3,8] The hyoid bone is visualized and its distance from mentum is measured in neutral position of the neck and also in extended position with maximum head tilt and chin lift.

As there are few studies regarding pre-operative ultrasound airway assessment and its correlation with CL Grading, this study was taken up to see the efficacy of the ultrasound parameters in predicting airway.

Aims and objectives

The study focused on the correlation between the ultrasound findings of airway and CL Grading viewed during direct laryngoscopy.

Primary objective

1. Sonographic measurement of PRE-E distance/ epiglottis vocal cord distance and hyomental distance ratio (HMDR).
2. Correlation of the above measurements with CL Grading.

Secondary objective

Anticipating a difficult airway.

MATERIALS AND METHODS

This study was a prospective observational study and was conducted on patients undergoing elective surgical procedures in General Surgery/Reconstruction Surgery/ Orthopedic/Gynecology operating rooms in a tertiary care center of eastern India from January 2019 to May 2019 (5 months).

The power of the study has been assumed to be 80% with 5% probability of type 1 error (confidence interval of 95%).

Sample size calculation

The incidence of difficult laryngoscopy and tracheal intubation, with reference to a study published in study by Rana et al.,[1] ranges from 1.5% to 13%. Taking a median value of 6.5%, the sample size is calculated as follows:

$$\text{Sample size} = Z^2 * P * (100-P)/e^2$$

Where Z=Standard deviation (at 95% confidence interval the value is 1.96)
P=Prevalence (6.5%)
e=Allowable error (5%)

Hence sample size = $(1.96)^2 \times (6.5) \times (100–6.5)/5^2$
= 94

($P<0.05$; two-tailed asymptotic statistical test and power of the statistical test are 80%).

Inclusion criteria

The following criteria were included in the study:

1. ASA I, II
2. Patients aged 18–60 years of age
3. Undergoing elective surgeries under general anesthesia requiring tracheal intubation.

Exclusion criteria

The following criteria were excluded from the study:

1. ASA III, IV
2. Pediatric age group
3. Pregnancy
4. Obese patients
5. Patient refusal to give consent for the procedure.

Procedures

After getting Institutional Ethical Committee clearance, patients were selected according to inclusion and exclusion criteria and the procedure was explained to them. Written informed consent was taken. Routine investigations done for pre-anesthetic check-up were seen, proper history and clinical examination were also done before the procedure. Ultrasound parameters were measured in transverse plane[6,8] with a linear probe and noted.

The patient lies in supine position with hands by the side in the pre-operative holding room. The ultrasound machine used was that of Samsung. After explaining the procedure, the ultrasound parameters were measured. The high-frequency linear ultrasound probe[1,6] (5–12 Hz) in transverse plane was placed over the mentum and gradually descended until the arched thyroid cartilage was visualized. At this level, the epiglottis and vocal cord are visualized simultaneously. The pre-epiglottic depth and the epiglottic vocal cord distance measured and noted. Placing the probe slightly above in the submandibular[1,8] space, the hyoid bone was visualized and the hyomental distance was measured in neck extended position with maximum head tilt and chin lift and also neutral position.[1,9] The ultrasound image visualized is shown in Figure 1.

After shifting the patients to operating room, general anesthesia was administered by standard protocol. Premedication with inj. Midazolam 0.05 mg/kg i.v. followed by pre-oxygenation with 100% oxygen for 3 min, induction with inj. Propofol 2 mg/kg i.v. and muscle relaxant with inj. succinylcholine 1 mg/kg was used. Direct laryngoscopy was performed by a senior anesthesiologist. During direct laryngoscopy, the CL Grading was noted. The parameters were compared accordingly. The CL Grading[10] was done as follows:

Grade 1: Entire vocal cords are visible
Grade 2: Posterior part of vocal cords seen
Grade 3: Epiglottis is seen
Grade 4: Epiglottis is not visible

The ultrasound findings were then correlated with CL Grading.

Statistical analysis

Data were collected on a Microsoft Excel® sheet and were analyzed using software SPSS 23.

The predictive value of the experimental tests was completely analyzed and assessed by estimating various factors such as specificity, sensitivity, positive predictive value (PPV), and negative predictive value (NPV). To assess the optimal cutoff scores, receiver operating characteristic (ROC) graphs were plotted and the area under the curve was calculated to assess the prognostic accuracy.

The results are mentioned below accordingly.

RESULTS

Tables 1a and b show the demographic data. Table 2 represents ASA grade. The age of the selected study subjects is normally distributed (both Kolmogorov –Smirnov and Shapiro–Wilk test of normality value is significant). Mean age is 45.5 years. Median is 49 years (Minimum – 21 years; Maximum – 60 years) and standard deviation 11.54.

All three of them are normally distributed according to Kolmogorov–Smirnov and Shapiro–Wilk test.

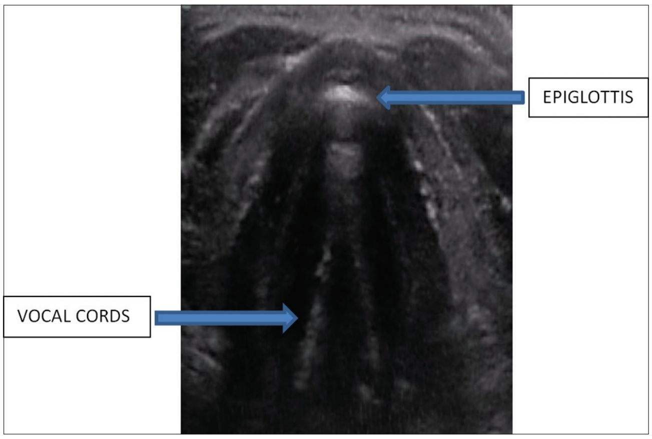

Figure 1: Shows the arched thyroid cartilage with epiglottis and vocal cords in an ultrasound image

Table 1a: Gender distribution

Gender	Number	Percentage
Male	48	51.1
Female	46	48.9

Table 1b: The distribution of BMI

	Height	Weight	BMI
Number of subjects	94	94	94
Mean	159.09	61.38	24.14
Median	158.5	60	24
Standard deviation	10.2	8.535	1.06
Minimum	140	45	22.3
Maximum	177	76	26.7

BMI: Body mass index

Table 2: ASA grade

ASA grade	Frequency	Percentage
ASA I	58	61.7
ASA II	36	38.3
Total	94	100

Above Tables 2 and 3 shows distribution of hyomental distance ratio and PRE-E/E-VC in the patients selected for the study. The values are normally distributed according to both Kolmogorov–Smirnov and Shapiro–Wilk test.

Table 4 compares HMDR with Cormack–Lehane grading (CL GRADE). Figure 2 shows bar diagram representation of distribution of CL Grading.

The Chi-square comparison of HMDR with CL grading is found to be statistically insignificant with $P=0.095$ (>0.05) (this result was derived by dividing HMDR into two groups with values less than/equal to and more than the median value).

The Chi-square comparison of HMDR with CL grading is found to be statistically insignificant with $P=0.095$ (>0.05) {HMDR was divided into two groups with values less than

Table 3: Distribution of HMDR and PRE-E/E-VC ratio

Number of patients=94	Mean	SD	Median	Min	Max
HMDR	1.17	0.09	1.2	1.05	1.31
PRE-E/E-VC	0.89	0.42	0.78	0.29	1.78

HMDR: Hyomental distance ratio

Table 4: Comparison of HMDR with CL grading

CL grade	HMDR		Total
	<1.2	>1.2	
Grade 1	34 (50%)	34 (50%)	68 (100%)
Grade 2	17 (70.8%)	7 (29.2%)	24 (100%)
Grade 3	2 (100%)	0	2 (100%)
Total	53 (56.4%)	41 (43.6%)	94 (100%)

Data are presented as number of patients (proportions). HMDR: Hyomental distance ratio, CL: Cormack–Lehane

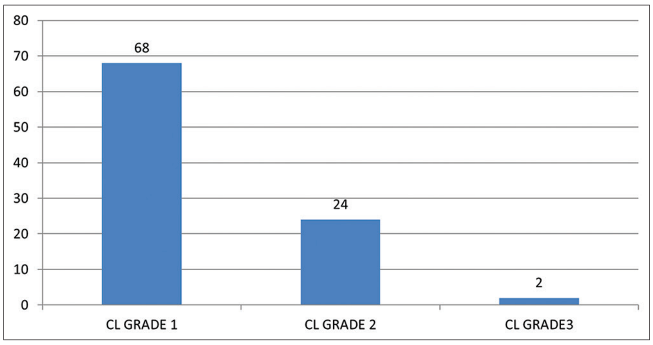

Figure 2: Distribution of CL grading

and more than the median value}. Independent sample t-test was done between HMDR values in continuous scale and CL grading as categorical variable. It is also found to be statistically insignificant with P=0.115 (>0.05).

Table 5 shows the distribution of PRE-E/E-VC values in patients selected for study. The values are normally distributed according to both Kolmogorov Smirnoff & Shapiro Wilk test

Table 6 shows comparison of PRE-E/E-VC with CL grading is found to be statistically significant with P=0.000 (<0.05) {PRE-E/E-VC was divided into four groups with values of reference journal}. Independent sample t-test was done between PRE-E/E-VC values in continuous scale and CL grading as categorical variable. It is also found to be statistically significant with P=0.000 (<0.05).

Table 7 shows predictive value of hyomental distance ratio and ratio of pre-epiglottic space and distance between the midpoint of the epiglottis and vocal cord.

HMDR grading (Figure 3)

The grading by HMDR has strong negative correlation and area under curve was found to be under the curve (AUC) of 0.90 and regression coefficient of −0.62 (Table 8). The cutoff value of predicting difficulty of HMDR was found to be 1.09 (Table 9), with a sensitivity of 76.3% and specificity of 83.3%. The NPV and PPV of HMDR were found at 89.1% and 64.3% (Table 7).

Pre-E/E-VC ratio (Figure 4)

Pre-E/E-VC had a strong positive correlation with AUC of 0.87 and correlation coefficient of +0.68 (Table 8). The cutoff value of Pre-E/E-VC for predicting difficult laryngoscopy was 1.81 (Table 10) with a sensitivity of 83.4% and specificity of 81.4%. The NPV of Pre-E/E-VC was 90.8 % and PPV 59.8 % (Table 7).

DISCUSSION

Airway assessment is a basic procedure before administering any kind of anesthesia. There are many modalities for airway assessment such as Mallampati classification, thyromental distance assessment, atlanto-occipital joint movement, mouth opening, inter-incisor gap and many other factors. All these tests can very well be done in the pre-operative room to predict the airway.[8] First, these methods are time consuming as a number of tests need to be done to come to a conclusion. Second, they have shown to have low specificity and sensitivity in various studies.[7,11,12] Moreover, using transnasal fibreoptic for airway, assessment is questionable.[13,14] Hence, a better and easier method becomes necessary to determine airway preoperatively.

This study demonstrated that ultrasound-guided airway assessment and its correlation with CL Grading detect the degree of difficulty to a great extent. During direct laryngoscopy, a McIntosh blade is introduced into the oral cavity. The tip of the blade hinges against the hyoepiglottic ligament and displaces the tongue and epiglottis for visualization of vocal cords. Hence, increased PRE-E depth increases the difficulty of visualizing the vocal cords as proper displacement of tongue and epiglottis is not possible. Similarly, vocal cords placed high up makes visualization of larynx difficult, and it indicates a decreased epiglottic vocal cord distance.

We found PRE-E distance/epiglottic vocal cord distance correlates very well to CL Grading compared to hyomental distance ratio. We used this ratio, because the larger the PRE-E space and smaller the epiglottic vocal cord distance, the resultant ratio correlated well with higher grades of CL Grading. At the same time, if PRE-E space is very large along with large epiglottic vocal cord distance, the ratio appeared small, and predicted lower CL Grading and easy intubation. Our study observed only three grades of Cormack–Lehane classification.

Table 5: Grouping of PRE-E/E-VC values with frequency and percentage

Groups (PRE-E/E-VC values)	Frequency	Percentage
0–1.4	74	78.7
1.4–1.7	18	19.1
1.7–1.8	2	2.1
Total	94	100

Table 6: Comparison of PRE-E/E-VC with Cormack–Lehane Grading

CL grade	PRE-E/E-VC			Total
	0–1.4	1.41–1.7	1.71–1.8	
Grade 1	68 (100%)	0	0	68 (100%)
Grade 2	6 (25%)	17 (70.8%)	1 (4.2%)	24 (100%)
Grade 3	0	1 (50%)	1 (50%)	2 (100%)
Total	74 (78.7%)	18 (19.1%)	2 (2.1%)	94 (100%)

Data are presented as number of patients (proportions). CL: Cormack–Lehane

The term hyomental distance ratio was first introduced by Huh et al[15]. and Wojtczak JA[16] for airway assessment. Takenaka et al.[17] defined the ratio of the HMD in the neutral position (HMDn) and at the extreme of head extension (HMDe) as the hyomental distance ratio (HMDR) and demonstrated that it was a good predictor of a reduced occipitoatlantoaxial complex extension capacity in patients with rheumatoid arthritis. Huh et al.[15] measured hyomental distance ratio in lying position and compared it with Mallampati scoring system and thyromental distance. In our study, we compared hyomental distance ratio with CL Grading which is similar to the study conducted by Rana et al.,[1] but they have not used any numerical values. In our study, we observed, if the ratio was <1.2, most cases showed CL Grading 2/3, but the result was not statistically significant.

Huh et al[15] showed that hyomental distance ratio was a significant predictor of difficult intubation, but they correlated Mallampati classification and not CL Grading. Hence, only using Mallampati classification is not a reliable predictor of difficult intubation.

Table 7: Predictive value of ultrasonography measured hyomental distance ratio and ratio of pre-epiglottic space and distance between the midpoint of the epiglottis and vocal cord

Variable parameters	Cormack–Lehane Grades (CL 1, 2)		Cormack–Lehane Grades (CL 3, 4)	
	Specificity	Negative predictive value (%)	Sensitivity	Positive Predictive value (%)
Pre-E/E-VC ratio	81.4	90.8	83.4	59.8
HMDR	83.3	89.1	76.3	64.3

HMDR: Hyomental distance ratio

Table 8: Estimation of AUC of ROC curve with correlation coefficient

	AUC of ROC curve (95% CI)	Correlation coefficient
HMDR	0.90 (0.77–0.98)	0.62
Pre-E/E-VC ratio	0.84 (0.70–0.88)	0.68

HMDR: Hyomental distance ratio, ROC: Receiver operating characteristic

Table 9: Calculation of cut off value of HMDR

CL grade	Cut value of HMDR	Sensitivity	Specificity	1-Specificity
1	1.07	0.91	0.31	0.69
2	1.09	0.77	0.82	0.18
3	1.09	1	0.79	0.21

HMDR: Hyomental distance ratio, CL: Cormack–Lehane

Table 10: Calculation of cut off value of Pre-E/E-VC ratio

CL grade	Cut off value of Pre-E/E-VC	Sensitivity	Specificity	1-Specificity
1	1.41	0.63	0.83	0.17
2	1.71	0.81	0.78	0.22
3	1.81	1	0.77	0.23

CL: Cormack–Lehane

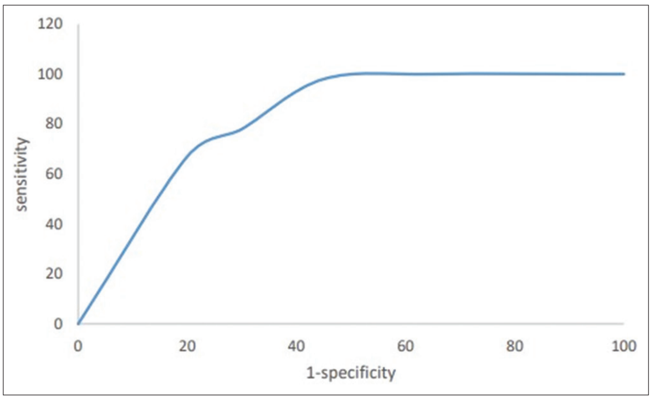

Figure 3: Graphical representation of ROC. FOR HMDR grading

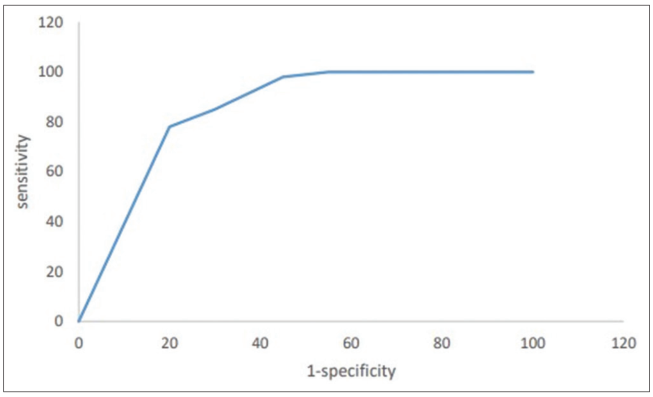

Figure 4: Graphical representation of ROC for pre-grading Pre-E/E-VC ratio

Reddy et al[7] showed the utility of ultrasound and its application in airway assessment. However, they used anterior neck soft tissue as the parameter for predicting airway.

Osman and Sum[6] showed role of ultrasound in airway management on a broader aspect. They have focused on point of care ultrasound, visualization of airway structures for predicting airway, endotracheal tube placement, and many other such aspects. They have not specified any parameter for predicting airway.

In our study, the ratio of PRE-E distance/epiglottic vocal cord distance showed significant correlation with CL Grading that is similar to the study conducted by Rana et al.[1] The findings in our study were as follows:

PRE-E/E-VC	CORMACK–LEHANE
0–1.4	1
1.41–1.7	2
>1.7	3

Limitations of the study

The sample size was small and obese patients were not included in the study. Hence, longer-term trials involving larger sample size are required to fully assess the efficacy of the PRE-E/E-VC as predictor of airway.

CONCLUSION

The PRE-E/E-VC ratio is a better predictor of CL Grading than the HMDR, and thus, it is a better predictor to anticipate difficult endotracheal intubation compared to HMDR.

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Authors' Contributions:
DD- Concept and design of the study, Prepared first draft of manuscript, Data collection, Statistical analysis, Interpreted the results, Review of literature, Revision; **DB-** Concept and design of the study, Interpreted the results, Reviewed the literature and manuscript preparation, Supervision of the entire study; **BPMH-** Concept, coordination, statistical analysis and interpretation; **AC-** Data collection, Statistical analysis, Interpreted the results, Review of literature, Revision, Corresponding author.

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