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ORIGINAL RESEARCH

Evaluation of efficacy of ultrasonographic airway parameters for predicting difficult airway in patients undergoing elective surgery under general anesthesia – A prospective observational study

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ABSTRACT

Background: There is currently no established set of standardized ultrasonographic criteria that support the prediction of a difficult airway. The objective of this work is to assess airway characteristics by ultrasonography, including the pre-epiglottis space, the distance between the epiglottis and the midpoint of the vocal cords (Pre E/E-VC), and the ratio of hyomental distance in both normal and extended head angles. The objective of this study is to see if these measures can predict a difficult airway in patients by associating them with the intraoperative Cormack Lehane (CL) grading. Conducting a preoperative sonographic assessment of the airway provides favourable prediction results for difficult laryngoscopy procedures. **Materials and Methods**: A prospective observational study included 174 patients who were scheduled for elective surgery that mandated tracheal intubation and general anaesthesia. The midway vocal cord distance (E-VC) between the vocal cords and the epiglottis, as well as the pre-epiglottic gap (Pre-E) depth, were evaluated using ultrasound. Furthermore, the head was placed in both neutral and extended positions to determine the Hyomental distance ratio (HMDR) using sonographic methods. The main objective was to assess the ability of Pre-E/E-VC or HMDR to predict difficult laryngoscopy procedures performed on patients with Cormack-Lehane Grade 3, 4, or above. The second objective was to establish a correlation between these indicators and CL grade. **Results:** In this study, 17.8% of patients had difficulty with intubation. The Pre-E/E-VC ratio's mean ± standard deviation (SD) was 1.95±0.20 for difficult intubation (CL Grades 3 and 4) and 1.25±0.38 for easy intubation (CL Grades 1, 2) ($P < 0.001$). For simple intubation (CL Grades 1, 2), the HMDR mean ± SD was 1.30±0.05; for difficult intubation (CL Grades 3 and 4) it was 1.16±0.05 ($P < 0.001$). When predicting difficult Laryngoscopy, pre-E/E-VC ratios greater than 1.90 cm showed a 92% sensitivity and an 85 % specificity, while HMDR values less than 1.16 had a 70% sensitivity and an 85% specificity ($P < 0.001$). **Conclusion:** When compared to HMDR, the sonographic measurement of the Pre-E/E-VC ratio proves to be a more reliable indicator of CL grading. A pre-E/E-VC ratio greater than 1.90 indicates a challenging laryngoscopy case (CL Grade 3,4). This finding underscores the potential of ultrasonography to accurately predict CL grading, unlike HMDR. Therefore, the inclusion of ultrasonography in routine pre-anaesthetic examinations can significantly enhance the prediction of a problematic airway. Pre-E/E-VC and HMDR are indeed useful indicators for predicting difficult airways, and their significance cannot be overstated.

Keywords: ultrasonographic airway parameters, difficult airway, general anaesthesia, Cormack lahane grading, Intubation.

INTRODUCTION

Accurately predicting a difficult airway in patients posted for elective surgery under general anaesthesia is critical to preoperative planning and patient safety. The ability to foresee airway management challenges allows anaesthesiologists to strategize and implement appropriate interventions, minimising complications during anaesthesia induction and intubation. Preoperatively, physical examination techniques such as the Mallampati classification, thyromental distance

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(TMD), and neck circumference have been employed to assess airway difficulty. However, these methods have inherent limitations, including subjectivity and variability in predictive accuracy The scoring systems of Wilson and Samson and Young utilize anatomical factors like thyromental distance, mouth opening size, neck extension, jaw protrusion, and the upper lip bite test. However, it has been shown that the Cormack-Lehane categorization is the most trustworthy of these techniques [1].

In recent years, ultrasonography has emerged as a valuable tool in the anaesthesiologist's arsenal, offering a non-invasive, objective, and reproducible means of evaluating airway anatomy. This introduction explores the evolution of ultrasonographic techniques in airway assessment, their methodological advantages, and their potential to enhance the predictive accuracy for difficult airways in patients undergoing elective surgeries[2]. Ultrasonography, with its real-time imaging capabilities, allows for a detailed examination of the airway structures that are not visible through conventional physical examination. The 'anterior neck soft tissue thickness (ANS), the distance from skin to the hyoid bone (DSHB), the hyomental distance (HMD), the tongue thickness (TT), the distance from skin to the epiglottis (DSE), and the distance from skin to the vocal cords (DSVC) hyomental distance ratio (HMDR) ' are essential ultrasonographic airway parameters [3].

Apart from exhibiting an accurate association between difficult laryngoscopy and diverse ultrasonic assessments, further research has underscored the significance of many ultrasonic airway characteristics in forecasting challenging intubation [4].Two of these measurements are the distance between the vocal cord midpoint (EVC) and the epiglottis, and the pre-epiglottic space (PreE) depth[5]. Better predictive values for difficult airway prediction can be found in the Pre-E/E-VC and hyomental distance ratio (HMDR), which is the distance ratio of hyomental distance at neutral and extended head positions[6].But the outcomes can differ.

This study aimed to assess the effectiveness of Pre-E/E-VC and HMDR in predicting difficult laryngoscopy in Indian people. The secondary aim was to relate the ultrasonography-guided parameters with the clinical parameter Cormack-Lehane grading during surgery in order to forecast difficult laryngoscopy and intubation procedures. These objectives guided our research and are crucial for understanding the study's focus.

MATERIALS AND METHODS

With approval from the Institutional Ethics Committee (ref no: BLDE(DU)/IEC/779/2022-23), this observational study was carried out at the Department of Anaesthesiology at B.LD.E's (Deemed to be University) Shri B.M. Patil Medical College from August 2022 to March 2024. Prior to surgery, written informed permission was acquired from each patient.

Inclusion for the study

Patients with physical statuses of I or II, as defined by the American Society of Anaesthesiologists (ASA), who required endotracheal intubation during general anesthesia for elective procedures, ranging in age from 18 to 60, were included in the study.

Criteria for exclusion

Individuals who are edentulous, unable to give consent for the treatment, have an interincisor gap of less than 3 cm, have head and neck diseases, have altered sensorium, or are incapable of obeying orders are not allowed.

Sample size

Based on the study conducted by Rana et al. [7], With the anticipated Proportion of Predicting difficult intubation in all elective surgeries under GA at 12.5%, the study would require a sample size of 174 patients with a 95% level of confidence and 5% absolute.

Formula used is z = Z2PQ/ME2

Methodology

The ratio of the pre-epiglottic space (Pre-E) to the distance between the epiglottis and the midway of the vocal cords' alignment (E-VC) is a measure that measures the extent of the pre-epiglottic space. The hyomental distance ratio (HMDR) is a predictor of airway difficulty. The preoperative examination was the time to measure these ratios.

Pre-E/E-VC

The hypoechoic, triangular real vocal cords are defined by hyperechoic vocal ligaments that surround them at their innermost point. The anterior commissure refers to the point where the voice cords meet in the front. The midline target of the high-frequency linear probe was the submandibular region. The midline of the high-frequency linear probe was situated in the submandibular area. The US probe's linear array was aligned in a transverse plane from the head to the tail without interruption until the screen simultaneously showed the posterior vocal folds with arytenoids and the epiglottis. The thyrohyoid membrane results in the epiglottis appearing as a hypoechoic curvilinear structure when viewed from an oblique transverse angle. The anterior limit was defined by the brilliant linear contact of the mucosal air, its posterior boundary, and the hyperechoic area before the epiglottis(figure 1)

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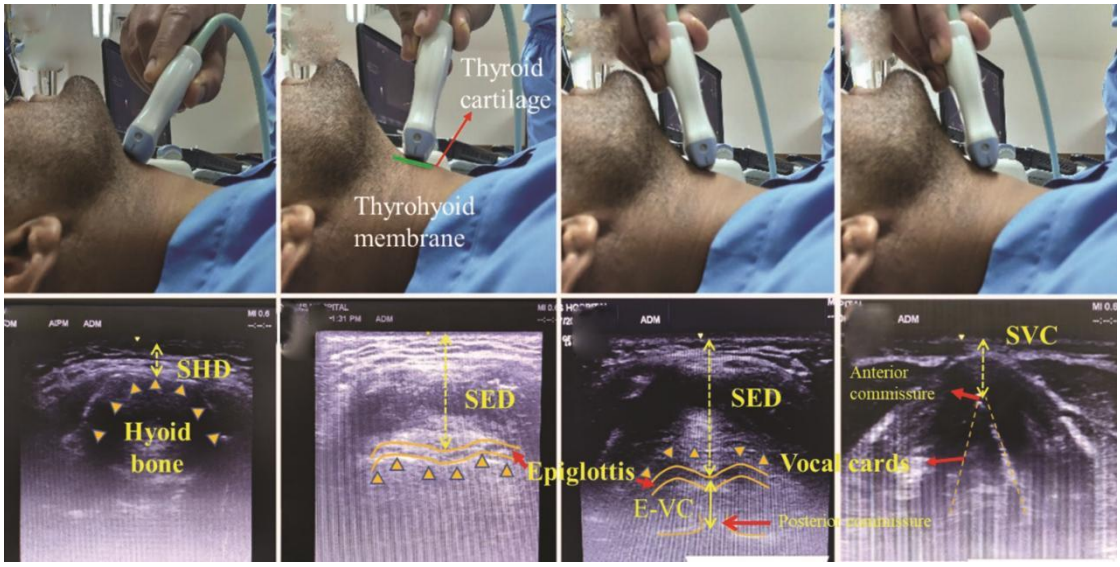

Figure 1: Ultrasonic measurement of Pre E/E-VC

Pre-E and E-VC were both measured, and the ratio was computed.

HMDR

A conventional curvilinear probe is used to evaluate the submandibular region, which is positioned in the mid-sagittal plane(ultra sonic measurement figure 2). The HMDR echo is the ratio of the hyomental distances recorded when the head is fully stretched to the hyomental distances measured when the head is in the neutral position. How far apart are the front edges of the hyoid bone and the symphysis menti That's the hyomental distance. The measurements were taken the day prior to the surgery and anaesthesia using a curvilinear ultrasound transducer.

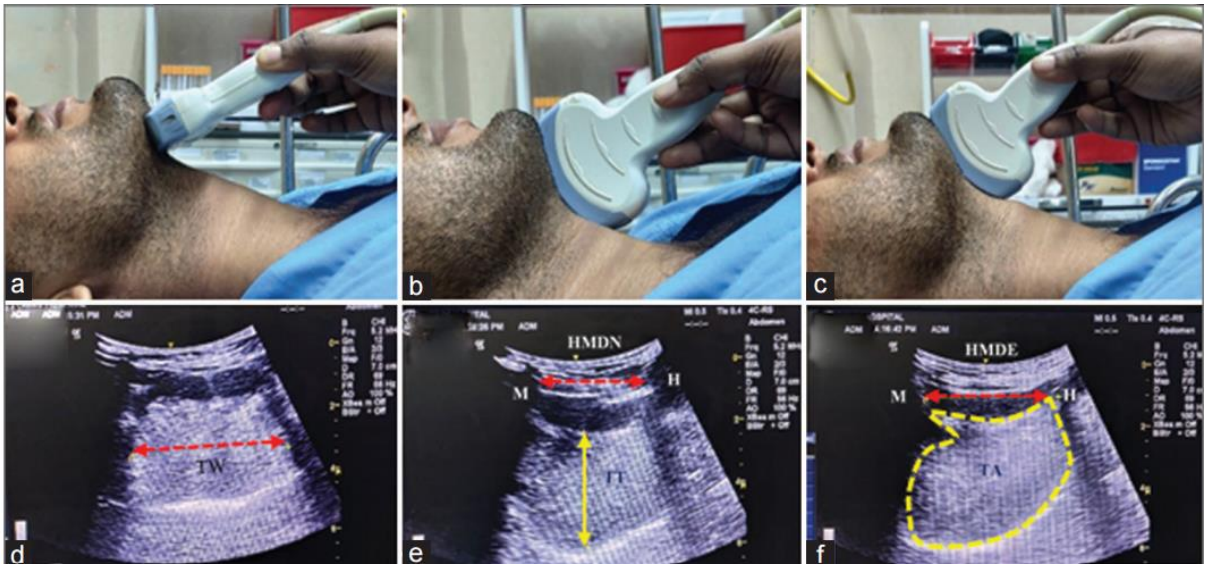

Figure 2: Ultrasonic measurement of HMDR

'Cormack Lehane's scale;
Grade 1-vocal cords visible.
Grade 2-only posterior commissure or arytenoids visible.
Grade 3-only epiglottis visible.
Grade 4- None of the above is visible'.
Intubation was considered difficult if;
'The view on Laryngoscopy was Cormack and Lehane grade III or IV.
Three attempts at tracheal intubation.
Duration longer than 10 minutes.
Failure to intubate or if special manoeuvres are required to facilitate intubation.'

Cormack and Lehane view grades 3 and 4 were deemed to be difficult airways.

According to Cormack and Lehane's classification, easy visualization falls into grades 1 and 2. Both bilateral lung field auscultation and capnography were used to confirm the intubation.

Statistical Analysis

Data were collected in Microsoft Excel 2020 for further statistical analysis. Whereas frequency and

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proportion were used to represent categorical data, mean and standard deviation were used to report quantitative data. To ascertain the association between two or more variables, chi square tests were employed, whereas t-tests were utilized to ascertain the mean difference between two variables. Using the recover operating curve (ROC), the cutoff values for the predictive parameters of the problematic laryngoscope were ascertained. A statistically significant P-value was defined as less than 0.05.

RESULTS

In total, 174 patients—99 men and 75 women—were a part of the study. The patients were split into 143 patients (82%) in the easy group and 31 patients (17%) in the difficult group based on clinical assessment. Table 1 illustrates the comparable mean age, weight, and height distributions between the easy and difficult groups after laryngoscopy; these differences were not statistically significant.(figure 3)

Table 1: Mean age, weight, and height distributions

Parameter	Group	
	Easy Laryngoscopy (n=143)	Difficult Laryngoscopy (n=31)
Age	44.45±8.30	45.6±8.54
Weight	60.16±5.91	60.7±5.88
Height	158.6±3.06	159.02±2.51
BMI	23.47±2.48	23.95±2.47

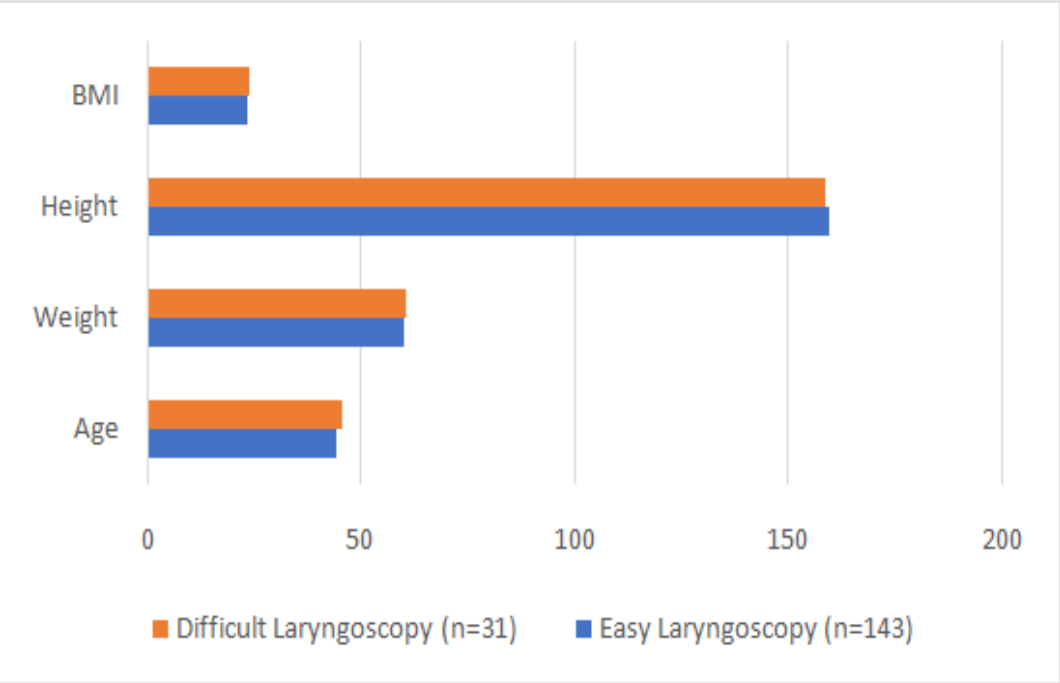

Figure3: Mean distribution of Age, weight and height distribution between easy and difficult laryngoscopy

Ultrasound parameters

Table 2: Mean distribution of Pre E, E-VC and Pre E/ E-VC among study population

Parameter	Group		p-value
	Easy Laryngoscopy (n=143)	Difficult Laryngoscopy (n=31)	
Pre E(mm)	1.80±0.46	2.23±0.19	<0.001
E-VC(mm)	1.51±0.46	1.15±0.16	<0.001
Pre E/E-VC	1.25±0.38	1.95±0.20	<0.001

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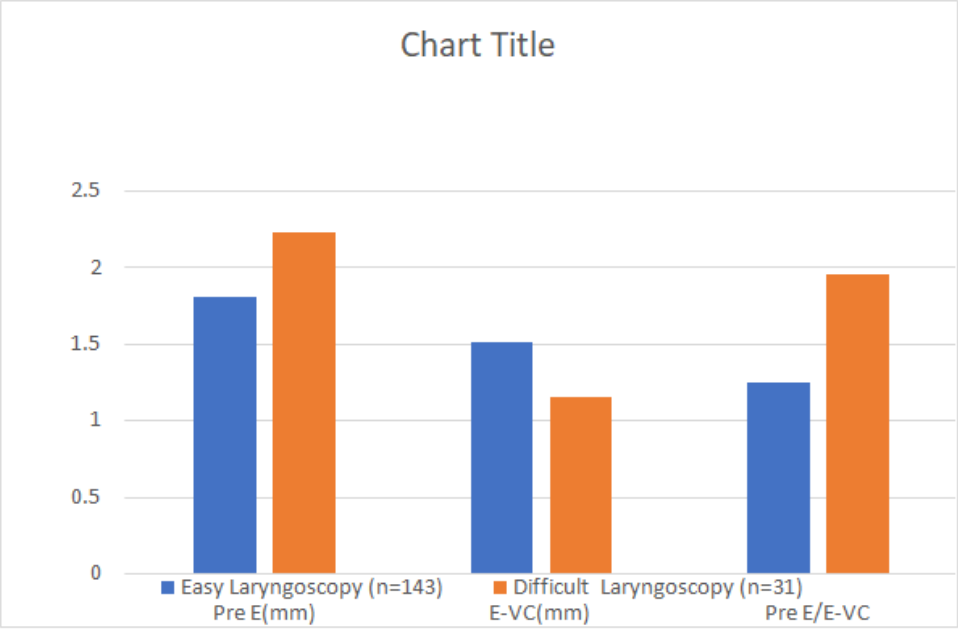

Figure 4: Mean distribution of Pre-E, E-VC and Pre E/ E-VC among study population

Mean Pre-E values between the easy and difficult groups were statistically highly significant (figure 4), mean E-VC was statistically highly significant, and the pre-E and E-VC(Pre E/E-VC) ratio was also statistically highly significant(table 2).

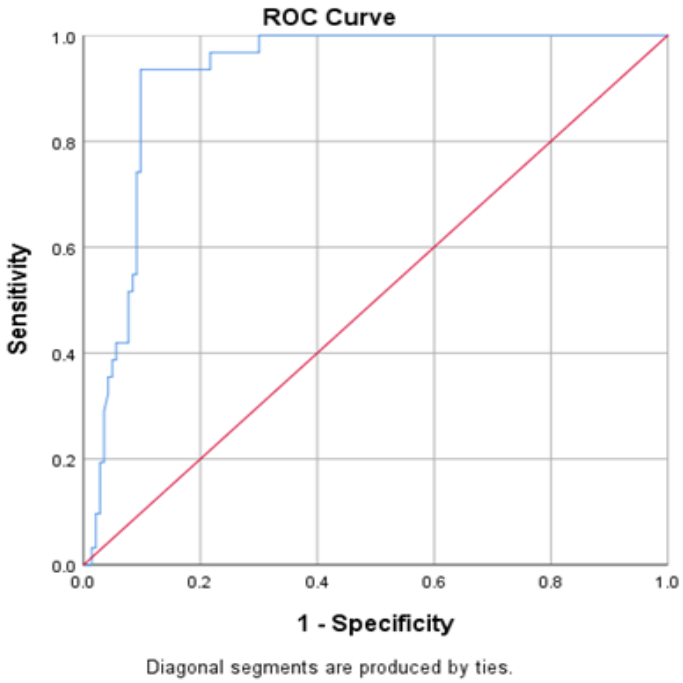

Figure 5: ROC to find Pre E/E-VC cutoff value to predict difficult airway

The earlier graph shows that the Pre E/E-VC cutoff value was 1.90 and the ROC curve AUC was 0.923, indicating a high degree of specificity (P value <0.001) and sensitivity (92%) (Figure5).

Table 3: Mean distribution of HMDN, HMDE and HMDR among study population

HMD	Group		p-value
	Easy Laryngoscopy (n=143)	Difficult Laryngoscopy (n=31)	
HMDN(cm)	4.15±0.35	4.36±0.38	<0.001
HMDE(cm)	5.38±0.45	5.04±0.47	<0.001
HMDR(cm)	1.30±0.05	1.16±0.05	<0.001

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The clinical and statistical significance of the Mean of (HMD) Hyomental distance between the easy and difficult groups at a neutral position (HMDN), in an extended position (HMDE), between the easy and difficult laryngoscopy groups (figure 6), and between the ration of HMDN and HMDE (HMDR) (table 3).

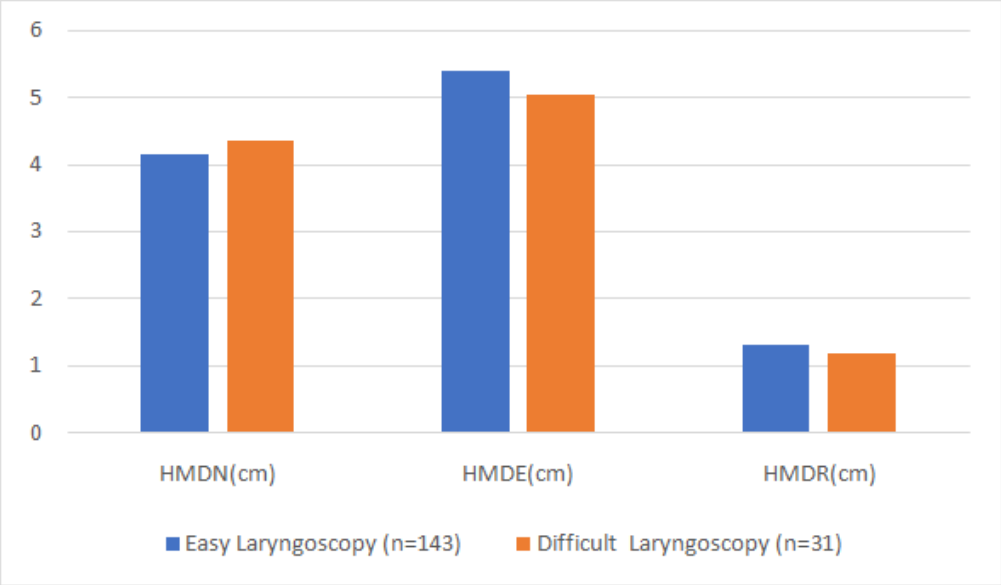

Figure 6: Mean distribution of HMDN, HMDE and HMDR among the study population

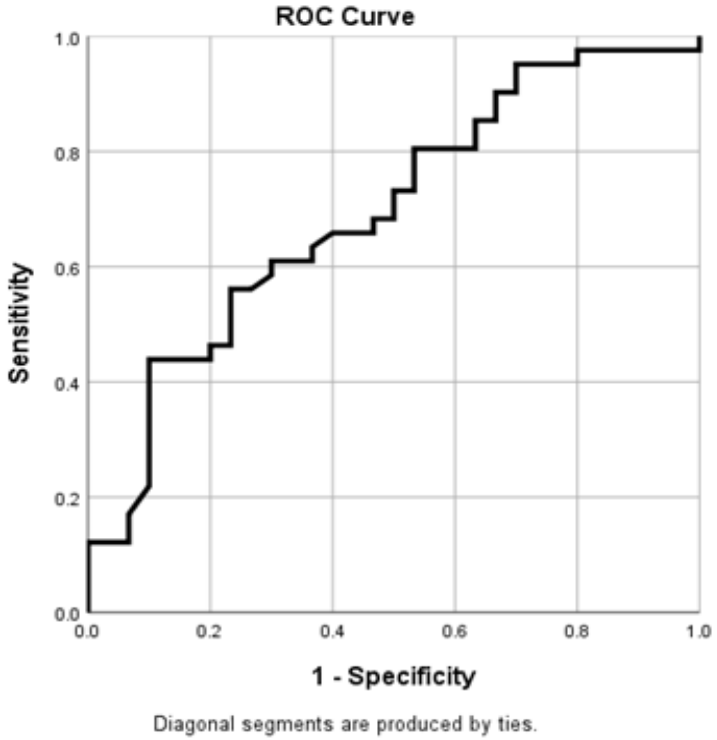

Figure 7: ROC to find HMDR cutoff value to predict difficult airway

The cutoff value of HMDR to predict a difficult airway was 1.14, with a sensitivity of 70% and a specificity of 85 %, and it's statistically highly significant, (figure7).

DISCUSSION

Demographic Profile and Distribution of CL Grading

The current study examined the Pre E/E VC ratio and HMDR, two ultrasound-guided airway measures, as indicators of challenging laryngoscopy (Cormack–Lehane Classification 3, 4). The current study comprises 174 patients of both sexes who were admitted for elective surgery under general anaesthesia and ranged in age from 20 to 60. There

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were more men than women in the study, and most of the patients were in grade 1 of the CL grading system, with grades 2 through 4 coming next. These findings support our observations that the majority of patients in the current study were in the age range of 41 to 50 years old, followed by 51-60 years old.We found that 82.2% of patients had a simple laryngoscopy and 17.8% of patients had a tough one. The majority of participants (51%), with a mean age of 35.76 years, were females in a study by Yadav et al.Of the 200 patients, 32 (16%) underwent a challenging laryngoscopy, whereas 168 (84%) underwent an uncomplicated one.

Another study by Harjai et al. The ages of the '150 adult patients ranged from 18 to 65, with 64 men (42.7%) and 86 women (57.3%). Compare 13.3% of laryngoscopies (20 patients) was difficult; The study adopted several parameters, including interincisor gap (IIG), modified Mallampati grading (MPG), neck circumference/thyromental distance (NC/TMD), and ratio of height to thyromental distance (RHTMD), to assess the clinical airway before surgery and predict a difficult laryngoscopy approach. Furthermore, these factors were associated with CL grading. Conversely, 130 patients had 86.7% of their laryngoscopies proceed without any complications. After direct laryngoscopy, the statistics for patients categorized by CL grade revealed that 77 patients (51.3%) had CL Grade I, whereas 53 patients (35.3%) had CL Grade II. Thirteen patients, accounting for 13.3% of the total, had CL Grade III, although none of the patients achieved CL Grade IV.

Sharma M et al. included 99 patients, 30 (30.3%) of whom were men and 69 (69.7%) of whom were women. The age range covered by this group was 18 to 65. Twenty-nine (29.3%) had CL grade 1, forty-seven (47.5%) had CL grade 2, and twenty-three (23.2%) had CL grade 3(P-value <0.01). The writers encountered no CL grade 4s. According to Anushaprasath et al., 23 out of 130 cases (17.7%) had a difficult laryngoscopy (CL grades 3 and 4). An additional study conducted by Rana et al. 'found that 40 patients (33%) had CL Grade 1, 65 patients had CL Grade 2 (54%), 10 patients had CL Grade 3 (8.1%), and five patients had CL Grade 4. As a result, 87.5% of laryngoscopies were simple, and 12.5% were challenging'.

Hyomental Distance Ratio predicting difficult airways

The mean hyomental distance between the groups at the neutral position (HMDN) was statistically highly significant. Also, in the extended position (HMDE), it was statistically highly significant. The ratio of HMDN and HMDE in easy and difficult laryngoscopy groups (1.30±0.05 vs 1.16±0.05) was also statistically highly significant, and in the present study Cut off the value of HMDR to predict difficult airway was 1.14, with a sensitivity of 70% with the specificity 85%, and it's statistically highly significant.

In a research study conducted by Sharma M et al. [8], it was discovered that the HMDR exhibited a noteworthy association with CL grading, with a cutoff of <1.18 for higher CL grades. The study also yielded results on sensitivity (56.52%), specificity (71.05%), negative predictive value (84.37%), and accuracy (67.6%; P-value = 0.01). Furthermore, a recent meta-analysis reported that there was a significant 0.07 cm mean difference in HMDR between problematic and simple airways. Research has determined that a cutoff value of 1.08 corresponds to a 75% sensitivity and an 85% specificity. "Even in obese and severely obese patients, the HMDR can be a significant component of ultrasonography parameters for challenging airway conditions; these patients had an HMDR of 1–1.05.

A further study by Anusha Prasath et al. claims that a decreased occipitoatlantoaxial extension is indicated by the hyomental distance ratio. It is a more accurate and descriptive predictor of challenging larynx visualization [9]. "They observed a statistically significant difference in the hyomental distance ratio between the groups that underwent easy and difficult laryngoscopy; in predicting difficult laryngoscopy (AUC 0.631; P value 0.0273), the cutoff value of HMDR >0.846 had good sensitivity of 82.61% and a negative predictive value of 91.8%; poor specificity of 42.06% and a positive predictive value of 23.5%." Huh J. and others [10], According to their research, the HMDR cutoff point of 1.2 showed an 88% sensitivity and a 60% specificity in identifying challenging laryngoscopies. A significant negative correlation between the HMDR and CL grade was discovered by Rana et al.,"The cutoff value of HMDR for difficult laryngoscopy prediction was ≤1.0850 using receiver operating curves and Youden's index, with a sensitivity of 75% and specificity of 85.3%. with an area under the curve (AUC) of 0.871 and a regression coefficient of − 0.466 (95% CI: -0.956 to 0.786; P = 0.00)."

Pre E, E-VC and Pre E/ E-VC

In the present study, the Mean Pre-E values between the easy (CL grading 1,2) and difficult groups (CLgrading 3,4) were statistically highly significant; the mean E-VC was statistically highly significant, and the ratio of pre-E and E-VC between easy and difficult groups (1.25±0.38 cm vs 1.95±0.20cm) which was also statistically highly significant. The cutoff value of Pre-E/E-VC to predict difficult airway was 1.90, with a sensitivity of 92% and a specificity of 85% (p value<0.01), and it was statistically highly significant.

According to Sharma M et al., the PreE/E-VC has also been shown to be very helpful in diagnosing difficult airways based on the ratio of depth of PreE to E-VC. "The majority of research has found that difficult airways are associated with a higher mean PreE/EVC [11]. An 'AUC of 0.59 with a cutoff value of 1.77 with a specificity of 77.6% and negative predictive value of 84.2%', with a corresponding sensitivity and

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specificity of 80% and 80% (P-value =0.01), was found in their study.

A different study by Koundal et al. found that a cutoff of 1.87 resulted in 82% and 83% (P-value <0.01) sensitivity and specificity, respectively [12]. This provides support for the cutoff value of 1.90 in the current study results. Reddy et al. conducted some investigations with varying findings; the PreE/E-VC value for problematic airways was 1.29 ± 0.44 with an undetermined cutoff value.

In the research conducted by Rana and colleagues, the Pre-E/E-VC ratio values for CL Grades 3 and 4 (P = 0.00) were 1.87 ± 0.243, 2.22 ± 0.29, and 1.33 ± 0.335, respectively, while for CL Grades 1, 2, the values were 1.62 ± 0.264. Pre-E/E-VC mean values were 1.09 ± 0.38 for CL Grades 1 and 2, 1.28 ± 0.37 for CL Grade 3, and 1.29 ± 0.44 for CL Grade 3 in the Reddy et al. study. However, during the course of the study, the authors did not come across a patient with CL 4. The study's Pre-E and E-VC ratio values for the simple and difficult laryngoscopy groups were (mean ± SD: 1.25±0.38 vs 1.95±0.20).

The current study's area under the curve (AUC) for pre-E/E-VC and CL grading was 0.923, indicating a significant positive correlation. With a sensitivity of 92% and specificity of 85% (P value <0.01), the threshold value for predicting problematic laryngoscopy is found to be >1.90 using receiver operating curves and Youden's index.

Out of 174 patients, 31 patients had difficult airways. These patients were managed using the BURP technique (Applying backwards, upward, Rightward and posterior pressure on the larynx), gum elastic bougie, and video laryngoscopy, and 2 patients required a Fibreoptic bronchoscope. No patient had any desaturation or other airway-related complications in the study.

HMDR and Pre-E/E-VC ratios can be used to predict difficult airways, but Pre-E/E-VC has more sensitivity than HMDR (92% VS 72%).

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