Correlation of Preoperative Airway Assessment by Ultrasound Recorded Parameters and Conventional Physical Parameters with Cormack Lehane Grading to Predict Difficult Laryngoscopy: A Cohort Analytical Study

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Abstract: ***Background**: Conventional physical parameters have shown low Sensitivity (52.17%) and low Specificity (70%). Ultrasound based airway assessment has been proposed recently as a useful, simple, noninvasive helpful bedside technique with high Sensitivity (75%) and Specificity (97.96%) for predicting difficult airway as compared to physical parameters. **Materials and Methods:** This cohort analytical study involved total of 67 patients (aged 18-60 years, ASA grades I and II) requiring elective endotracheal intubation. Clinical parameters (Mallampati grading, Thyromental distance, Hyomental distance) and ultrasound parameters (distance from skin to hyoid bone, distance from skin to anterior commissure, distance from skin to thyroid isthmus, distance from skin to epiglottis midway, Ratio of pre-epiglottic depth to epiglottis vocal cord distance) were assessed preoperatively and then corelated with Cormack-Lehane grading after induction. An experienced anesthesiologist performed laryngoscopy and intubation to predict difficult laryngoscopy. Cormack-Lehane grade 3 and 4 was defined as difficult laryngoscopy. **Results**: Our study showed that ultrasound assessment of anterior neck soft tissues can effectively predict difficult laryngoscopy. Distance from skin to hyoid bone is the key parameter with a cut-off of 1.21 cm provides 85.79% sensitivity and 84.78% specificity for difficult laryngoscopy, with Area under curve of 0.899 indicating a strong positive correlation with Cormack-Lehane grade at cut-off value of 1.21 cm. **Conclusion**: This confirms the relationship between ultrasound parameters and difficult laryngoscopy. All ultrasound parameters had correlation with difficult laryngoscopy with Distance from skin to hyoid bone being most potential predictor of difficult laryngoscopy with sensitivity 85.79%, specificty 84.78%, negative predictive value 92.86%, diagnostic value 85.07% at cut-off value of 1.21cm.**

Keywords: Difficult airway, Airway ultrasound, Mallampatti grading, Distance from skin to hyoid bone, Han's scale, Cormack-Lehane grading, Difficult laryngoscopy

1.Introduction

Securing airway is of paramount importance for anesthesiologists. Preoperative assessment of patient's airway enables the anesthesiologist to predict the ease of visualizing glottis and to perform intubation, thus plays a vital role to reduce mortality and morbidity related to difficult laryngoscopy (DL). Outcome of DL include damage to teeth, airway trauma, need for surgical airway, cardiopulmonary arrest, brain injury or even death. Incidence of DL and intubation among Indian population is 9.7% and 4.5%. Though, accurate airway assessment by conventional method is a part of Pre-anesthetic checkup (PAC), but they have shown low sensitivity (Sn) (52.17%) and low specificity (Sp) (70%) in predicting difficult airway. Ultrasound (USG) based airway assessment has been proposed recently as a useful, simple, noninvasive bedside technique with high Sn (75%) and Sp (97.6%) for difficult airway assessment. Therefore, the current investigation was carried out to correlate the preoperative airway assessment by ultrasound recorded parameters and conventional physical parameters with Cormack-Lehane (CL) grading to predict DL and also to find out cut-off values of USG parameters.

2.Materials and Method

A cohort analytical study was conducted in the Department of Anaesthesiology and Pain Medicine, Pt. J.N.M Medical college and Dr. B.R.A.M Hospital, Raipur (C.G.) after receiving approval from the Institutional Scientific and Ethics committee. Each patient was subjected to thorough PAC during which detailed history, complete general and systemic examination including physical parameters were recorded. After a cranio-caudal sagittal scan of neck with linear probe of frequency of 5 to 10 hz placed in transverse axis, USG parameters (Fig 1) were measured. Anaesthesia was induced with fentanyl 2 to 4 μ/ kg iv, propofol 2 to 3 mg/kg iv till end point of induction was achieved. Then mask ventilation was performed followed by succinylcholine 1 to 2mg/kg iv administration to facilitate laryngoscopy and intubation. Direct laryngoscopy was attempted using a Macintosh blade by an experienced anesthesiologist who was blinded to ultrasound and physical parameters to assess CL grading.

Statistical analysis

Statistical analysis was carried out using statistical packages for IBM SPSS vs 22 for Windows. Continuous data i.e. all USG parameters were expressed as mean±SD, whereas categorical data like age, gender, body mass index, ASA grading, Mallampatti grading (MPG), Thyromental distance (TMD), Hyomental distance (HMD), CL grading were expressed in frequencies and percentages and described using contingency tables. The chi-square test was used to see the association between physical parameters with (Easy Laryngoscopy) EL & DL. Independent t-test was used to compare values of USG parameters with EL and DL. Pearson's correlation was use to analyse relationship of ultrasound distances with CL grading. Pearson's correlation coefficient is denoted by R, R value =0.00-0.199 (no correlation), 0.20 -0.399 (low correlation), 0.40-0.599 (moderate correlation), 0.60-0.799 (high correlation), 0.80-1 (perfect correlation). Receiver operating curve (ROC) were used to determine Sn, Sp, Negative predictive value (NPV), Positive predictive value (PPV), Diagnostic accuracy and cut-off values of USG parameters.

3.Results

Total of 87 patients were included in the study, 10 were excluded due to not meeting the exclusion criteria (submucosal fibrosis, pregnancy, receding mandible, cervical spine pathology, neck masses) following preanesthetic assessment and 10 discontinued due to lack of cooperation. Eventually data of 67 were collected and analysed (Figure1). Demographic distribution of patients shown in table 1, age range was 18 to 60 years**.** Maximum number of patients belonged to 26 to 35 years of age i.e. 24 (35.8%) The study had 42 females and 25 males and BMI ranged from 18 to 30 kg/m^2. All patients had ASA grade II. On evaluation of physical parameters (MPG, TMD, HMD), with increasing grade more patients faced difficulty in laryngoscopy (p-value <0.001) showing significant association between physical parameters and CL grading Table 2. In the study sample, mean±SD of DSHB was 0.98 ± 0.16 cm in EL group and 1.25 ± 0.30 cm in DL group with p-value of <0.001* which was highly significant. The DSHB was correlated with risk of DL (R value=0.507) showing positive correlation of DL with increasing DSHB distance. The mean ± SD of DSHB and other USG airway distances increased according to DL level. (Table 3) In the present study, the ROC Curve of DSHB was a good predictor for detecting DL. The Area under the curve (AUC) for DSHB was 89.9% (p-value<0.001). The best cut-off that maximizes sensitivity and specificity is 1.21cm for DSHB. In contrast, the other USG parameters were poor predictors with p-values >0.05. (Table 4, Figure 3) Among Conventional physical parameters, MPG holds the highest Sn 98.39%, Sp of 94.98, NPV of 92% and diagnostic accuracy of 97.56%. Likewise, among all USG parameters, DSHB for DL holds highest Sn of 88.89%, Sp of 70.69%, NPV of 92.86% and diagnostic accuracy of 85.07% followed by DSAC for DL. (Table 5).

4.Discussion

ROC analysis of determines DSHB is a good predictor for detecting DL with AUC of 89.9% (p-value<0.001) at cut-off value of 1.21cm with sensitivity 85.71%, specificity 84.78%, yielding a diagnostic accuracy of 85.07%. The derived cut-off value for DSAC is 0.85cm with sensitivity 71.43% and specificity 50%, yielding a diagnostic accuracy 56.72%. Similarly, DSTI had a cut-off value of 0.89cm with sensitivity 0.95% and specificity 19.57%, yielding a diagnostic accuracy of 38.81%. The derived DSEM cut-off value is 0.85cm with sensitivity of 66.67% and specificity of 34.78%, yielding a diagnostic accuracy of 44.78%. The derived Pre-E/EVC ratio cut-off value was 1.11cm. Pre-E/EVC ratio demonstrated a sensitivity 76.19%, specificity 34.78% and diagnostic accuracy of 47.76. Increased age correlated with DL due to epiglottis abnormalities, difficult head neck movements, decreased collagen and elastin in hyoepiglottic ligament, poor dental condition, high mallampatti score, higher cervical joint rigidity. Females generally experience easier laryngoscopy due to anatomical differences (i.e. anatomical neck fat distribution). Higher BMI was associated with DL because of fat deposits, larger tongue, narrowed airway, large tonsils, thick neck. These findings align with previous studies by Alessandri F et al[1], Adhikari S et al[2], Wu J et al[3], Reddy P et al[4], Mohammadi S et al[5], Parmeshwari A et al[6], Nazir I et al[7], Gupta M et a[8], Das D et al[9].

Association of Conventional physical parameters with CL grading: Highly significant association (p<0.001) between MPG and laryngoscopy difficulty was observed. Higher MPG indicates a larger tongue base relative to oropharyngeal opening leading to DL. Previous studies by Reddy P et al[4], Nazir I et al[7], Chhabra AR et al[10] also found a strong association (p<0.001) between MPG and CL grading.

Similarly, highly significant association (p<0.001) between (TMD) and laryngoscopy difficulty was noted. Conversely, Reddy P et al[4] found no significant association (p=0.155) in their study, suggesting variability in TMD's predictive value.

Our study established a highly significant association (p<0.001) between HMD and DL. Das D et al[9] also identified a significant association between HMD and difficult laryngoscopy.

Mean distance of DSHB was significantly higher in DL (1.25 ± 0.30 cm) compared to EL at (0.98 ± 0.16 cm) with p=0.001, indicating a positive correlation with CL grade. The R-value for DSHB was 0.507, suggesting a strong correlation; as DSHB increased, so did the CL grade. Other ultrasound parameters (DSTI, DSAC, DSEM, Pre-E/EVC ratio) showed no significant differences between EL and DL (p>0.05).

Previous studies by Gupta M et al[8] and Das D et al[9] found a significant correlation of Pre-E/EVC ratio (Das D et al[9], AUC 0.87) with CL grading whereas Reddy P et al[4] reported significant results for Anterior soft tissue neck (ANS-VC), (p=0.014) but not for Anterior soft tissue neck (ANS-hyoid). Reddy P et al[4] and Mohammadi S et al[5] confirmed no significant correlation of Pre-E/EVC ratio with CL grades. Chhabra AR et al[10] found significant results for Anterior soft tissue (ANS-E), (p=0.001), while ANS-H and Anterior soft tissue neck anterior commissure (ANS-AC) were not significant. Overall, DSHB emerged as the most reliable predictor of laryngoscopy difficulty.

Our study performed ROC curve analysis to determine cut-off values for ultrasound parameters predicting DL showing the ***cut-off value of DSHB*** 1.21cm because the best cut-off that maximizes sensitivity and specificity is 1.21cm for DSHB. The AUC for DSHB was 89.9%, which was statistically significant (p<0.001). Consequently, the DSHB demonstrates a Sn of 85.71%, Sp of 84.78%, NPV of 92.86% yielding a diagnostic accuracy of 85.07% for DL.

Wu J et al [] analysed that DSHB had a Sn of 84.78%, Sp of 85.71% and highest NPV of 92.86% yielding a diagnostic accuracy of 85.07% for detection of DL which was similar to our study.

The ***cut-off value of DSTI*** was set at 0.89cm that demonstrated a Sn of 80.95%, Sp of 19.57%, and NPV of 69.23% yielding a diagnostic accuracy of 38.81% for DL.

The ***cut-off value of DSAC*** was set at 0.85cm. DSEM demonstrated a Sn of 71.43%, Sp of 50%, and NPV of 79.31%, yielding a diagnostic accuracy of 56.72% for DL.

At 0.85 cm **cut-off value of DSEM**, it had sensitivity of 66.67%, specificity of 34.78%, and NPV of 69.57%, yielding a diagnostic accuracy of 44.78%. Nazir I et al[7] derived a cut-off value of 1.77cm for DSEM through ROC curve with an AUC of 0.772 exhibiting Sn of 78.9% and Sp of 76.3%. In study done by Pinto J et al [11]**,** USG derived anterior neck soft tissue thickness at level of midway between thyrohyoid (DSEM) in 74 patients requiring endotracheal intubation-based cut-off value of DSEM 2.75cm indicates DL.

The reason for difference of results could be explained by different airway anatomies in patients of different races and different levels of experience in performing airway sonography.

The anatomical airway model suggested by Greenland describes the upper airway is shaped by two curves: 1. Oropharyngeal curve (Primary curve) 2. Pharyngo-glottic tracheal curve (Secondary curve). Adequate laryngoscopic visualization requires both curves to be aligned with visual Axis. A large skin to epiglottis distance could be the result of higher upward concavity of the secondary curve thereby worsening direct laryngoscopic view. Thus, DSEM is important predictor for predicting difficult intubation.

The variation observed in our data was due to population anthropometric differences as DSEM is too dependent on length of epiglottis.

At 1.11cm **cut-off value of Pre-E/EVC ratio**, it had sensitivity of 76.19% and specificity of 34.78%, NPV of 76.19% yielding a diagnostic accuracy of 47.76% in present study.

Das D et al[6] established the cut-off value of Pre-E/EVC ratio for predicting difficult laryngoscopy at 1.81cm with a Sn of 83.4%, Sp of 81.4%, NPV of 90.8% and positive predictive value 64.3.

Chhabra AR et al[5] established the cut-off value of ultrasound parameters like ANS-E, ANS-H, and ANS-AC using ROC curve. They derived the cut–off value of ANS-E >1.67cm to predict DL with 64.71% Sn, 78.45% Sp, 46.1% PPV and 88.35% NPV. The AUC of ANS-E was 0.735 with a p-value <0.001 which was statistically significant. The ANS-AC and ANS-H distances were not found to be significant as they had p values of 0.638 and 0.28; respectively.

5. Conclusion

Present study emphasized the utility of both conventional and USG guided parameters in preoperative airway assessment, DSHB being the most reliable ultrasound parameter. In conclusion, the integration of ultrasound-guided parameters, particularly DSHB, alongside conventional physical parameters, enhances the prediction of difficult airways in preoperative assessments. This combined approach can improve patient safety and outcomes in airway management during general anesthesia.

6. Limitations

Acknowledging limitations is crucial for accurately interpreting findings. It addresses gap in literature to pave for future research.

1. Small sample size (n=67) and female predominance limited generalizability of findings to larger population.
2. USG usage requires skills and training with steep learning curve. A high level of physical agility and knowledge of appropriate sonoanatomy is required to become in its use.
3. Inexperience in initial stages of using USG may skew the outcome to certain degree.
4. Obese patients were not included, thereby excluding difficult mask ventilation and laryngoscopy.
5. Exclusion of Patients with DL, allowed us to study the USG measurements as independent predictive assessments of difficult airway and to DL in patients with no clinical predictable difficulty.

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Consort Diagram

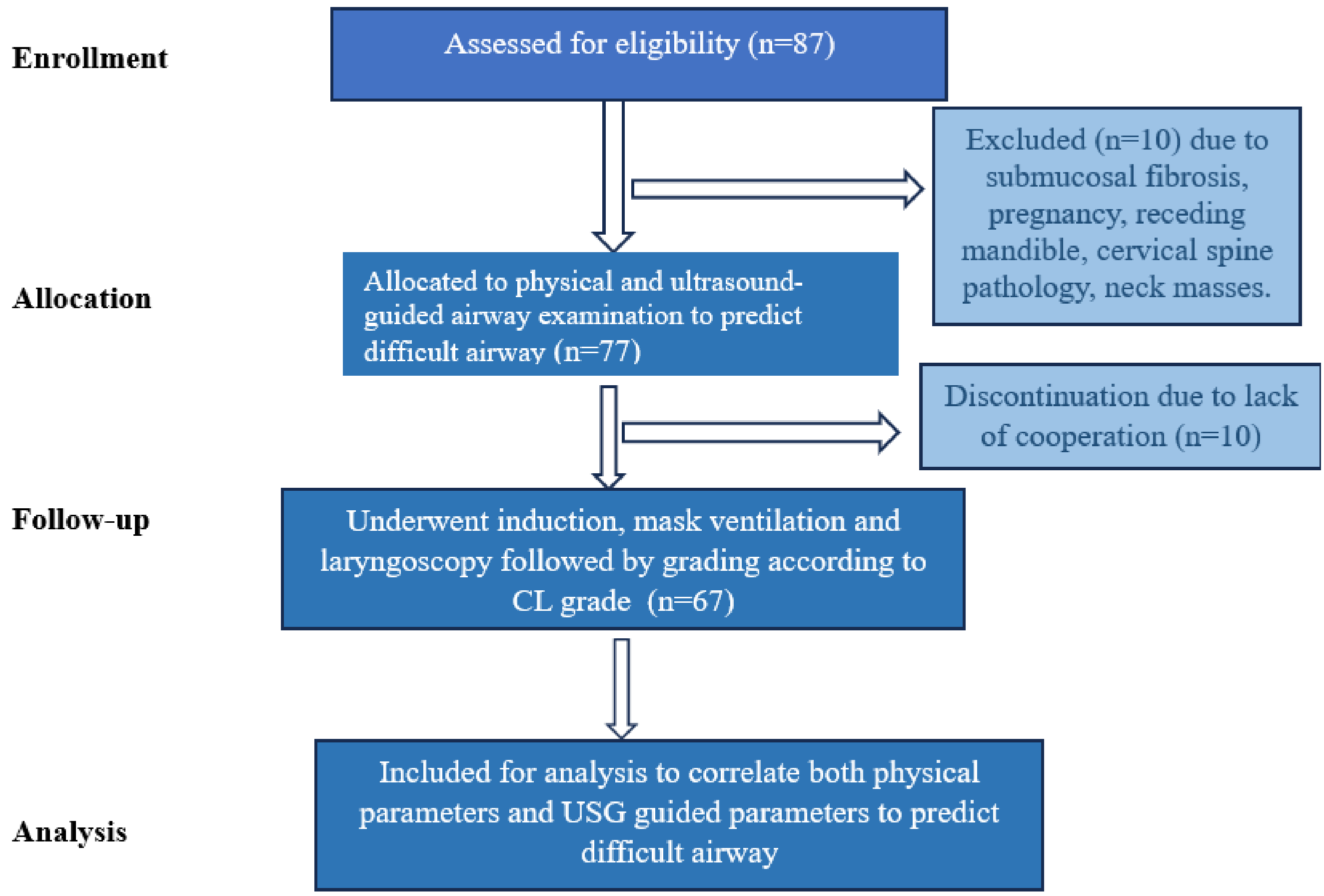


Figure 1: Ultrasound image of upper airway distances

Table 1: Demographic distribution of patients

Variables		Number of patients (%)
Age	18-25	13 (19.4%)
	26-35	**24 (35.8%)**
	36-45	13 (19.4%)
	46-55	8 (11.9%)
	55-60	9 (13.4%)
Gender	Male	25
	Female	42
ASA grade	II	67 (100%)
BMI (kg/m2)	<22Kg/m²	35 (52.2%)
	>22Kg/m²	32 (47.8%)

Table 2: Distribution of patients according to Conventional Physical parameters

Physical parameters	Grade	Number of patients (%)	CL grading		P - value
			EL	DL	
MPG	Grade I	0 (0%)			
	Grade II	44 (65.7%)	44 (95.7%)	0 (0%)	**<0.001****
	Grade III	16 (23.9%)	2 (4.3%)	14 (66.7%)	
	Grade IV	7 (10.4%)	0 (0%)	7 (33.3%)	
TMD	Grade I	4 (6%)	4 (6.9%)	0	**<0.001****
	Grade II	**42 (62.7%)**	42 (69%)	0	
	Grade III	21 (31.3%)	0	21 (100%)	
HMD	Grade I	0 (0%)	0	0	**<0.001****
	Grade II	**52 (77.6%)**	44 (95.7%)	8 (38.1%)	
	Grade III	15 (22.4%)	2 (4.3%)		

Table 3: Pearson's correlation coefficients (R value) of USG parameters in EL and DL

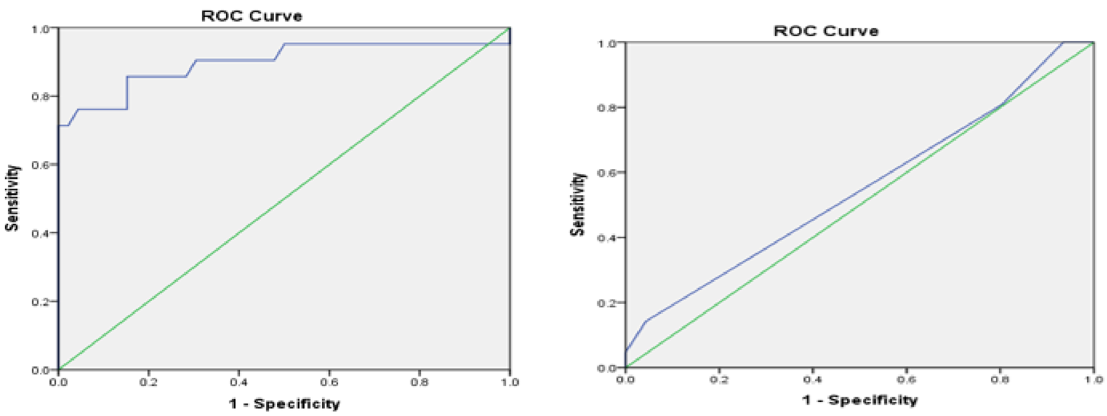
USG Parameter	EL (N=46)	DL (N=21)	P-value	R-value
	Mean ± SD	Mean ± SD		
DSHB	0.98 ± 0.16 cm	1.25 ± 0.30 cm	0.001*	0.507
DSTI	0.88 ± 0.03 cm	0.90 ± 0.06 cm	0.105	0.133
DSAC	0.83 ± 0.04 cm	0.85 ± 0.05 cm	0.103	0.170
DSEM	0.84 ± 0.04 cm	0.86 ± 0.05 cm	0.348	0.089
Pre-E/EVC ratio	1.09 ± 0.08 cm	1.14 ± 0.15 cm	0.166	0.185

Table 4: ROC Curve Analysis and Cut-off various USG Parameters for DL

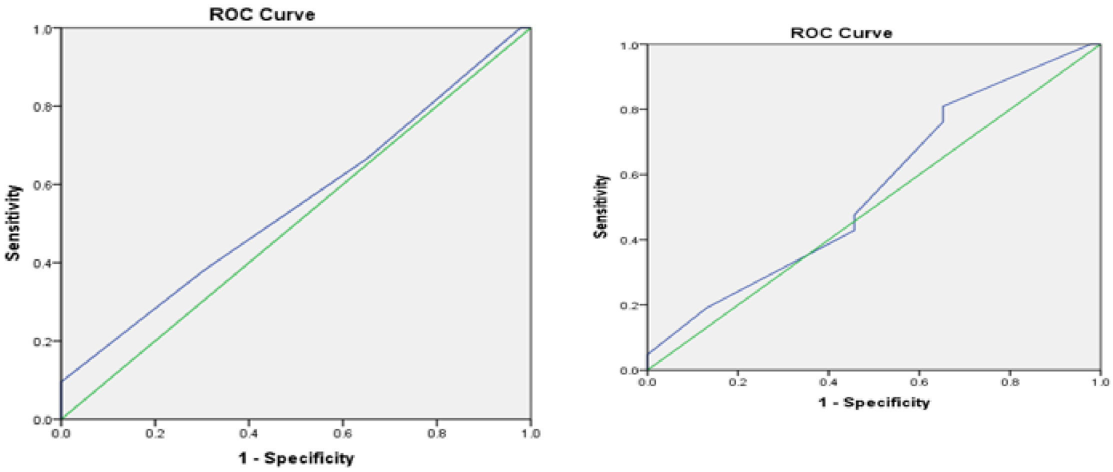
USG Parameters	Cutt off	Area under Curve	SE	p-value	95% CI Lower	95% CI Upper
DSHB	**1.21cm**	**0.899**	0.053	<0.001**	0.796	1.000
DSTI	0.89cm	0.550	0.078	0.516	0.397	0.703
DSAC	0.85cm	0.601	0.075	0.188	0.454	0.748
DSEM	0.85cm	0.548	0.079	0.530	0.394	0.702
Pre-E/EVC ratio	1.11cm	0.554	0.074	0.478	0.408	0.700

Table 5: Comparison of physical parameters with USG parameters

Statistics	**Conventional physical parameters for DMV and DL**			**USG Parameters**				
	MPG	**TMD**	**HMD**	**DSHB**	**Pre-E/EVC ratio**	**DSAC**	**DSTI**	**DSEM**
Sensitivity	98.39%	94%	89.88%	85.71%	76.19%	71.43%	80.95%	77.78%
Specificity	94.98%	92.76%	90.85%	84.78%	34.78%	50%	19.57%	36.21%
NPV	92%	89%	90%	92.86%	76.19%	79.31%	69.23%	91.30%
Accuracy	97.56%	93.75%	87.88%	85.07%	47.76%	56.72%	38.81%	41.79%

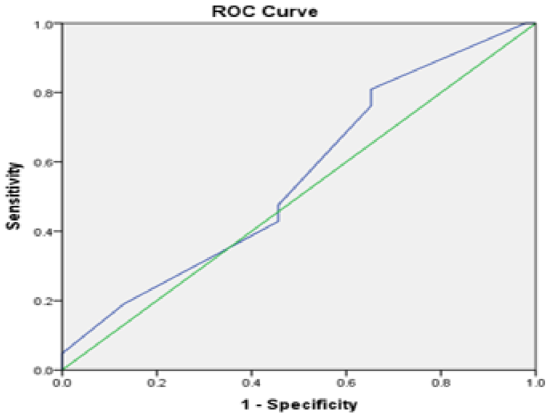


DSHB; AUC=0.899 (95% CI:0.677 to 0.902) DSTI; AUC=0.550 (95% CI :0.397 to 0.703)



DSEM; AUC=0.548 (95% CI :0.394 to 0.702) Pre-E/EVC; AUC =0.554 (95% CI:0.408 to 0.702

Figure 3: ROC Curve Analysis of USG Parameters for DL



PreE /EVC ratio; AUC =0.554 (95% CI:0.408 to 0.700

Figure 3: ROC Curve Analysis of USG Parameters for DL