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Correlation between upper airway ultrasound and Cormack–Lehane grading during laryngoscopy – A prospective study

Sakshi Jain[1], Jayendra Arya[2], Arvind Rathiya[3], Sudhakar Dwivedi[4]

[1]Senior Resident, Department of Anaesthesiology, Shrimant Rajmata Vijayaraje Scindia Medical College and Hospital, Shivpuri, [2]Senior Resident, Department of Pediatrics, [3]Associate Professor, [4]Professor and Head, Department of Anaesthesiology, Shyam Shah Medical College, Rewa, Madhya Pradesh, India

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ABSTRACT

Background: Securing airway and adequate ventilation after induction of anesthesia is the utmost priority of anesthesiologists, failure of that can lead to hypoxic brain injury and death in a few minutes. **Aims and Objectives:** The aims of this study were to ascertain the role of ultrasonography in predicting difficult intubation by comparing different ultrasonographic parameters. **Materials and Methods:** One hundred patients posted for elective surgery under general anesthesia were studied. The study was carried out in two phases. The first phase – during the pre-anesthetic checkup, ultrasonographic measurements of Anterior neck soft-tissue thickness at the level of hyoid (ANS-Hyoid), anterior neck soft tissue thickness at the level of vocal cords (ANS-VC), pre-epiglottic space (Pre-E), distance from the epiglottis to the mid-point of the distance between the vocal cords (EVL), and the ratio of both (PES/EVL) was also done. In the second phase, Cormack–Lehane (CL) grade was noted during intubation. A Chi-square test was applied to correlate ultrasonographic parameters and CL grade. Sensitivity, specificity, an area under the receiver operating characteristic (ROC) curve, negative predictive value, and positive predictive value were calculated for various parameters. **Results:** In this study among the studied parameter, only ANS–VC was statistically significant in predicting difficult intubation ($P<0.0001$). ANS-VC >0.32 cm was 93.3% sensitive and 84.7% specific and had Area under the ROC curve of 85% in predicting CL grade 3 and 4 (difficult intubation). **Conclusion:** USG is a useful tool in predicting difficult intubation. ANS-VC >0.32 cm is a highly sensitive and specific predictor of difficult intubation, while other USG parameters are not indicative of difficult intubation.

Key words: Airway; USG; Cormack–Lehane grade; Difficult intubation; Direct laryngoscopy

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INTRODUCTION

The Cormack–Lehane (CL) score is often used to grade the direct laryngoscopic view of the airway.[1] Correlation of CL grade with ultrasonographic parameters is helpful to forecast difficult airways during laryngoscopy and can also help in avoidance of catastrophes of unsuccessful tracheal intubation. Although multiple screening tests are being used but even after using these multivariate predictors chances of encountering unanticipated difficult intubation are still high. This shows that these parameters have low sensitivity and specificity.[2,3] To avoid the devastating consequences of unsuccessful intubation, we need more sensitive and specific methods.[4] Other radiological modalities such as X-ray, CT scan, and MRI have also been used for airway assessment and it was proved that USG is also similarly useful as X-ray and CT. Considering USG being portable, easy, readily available, low cost, and free from radiological hazards, which makes it a better diagnostic tool for airway assessment.[5] This study was conducted to compares and correlates ultrasonographic parameters to CL grade and to discover any correlation

Address for Correspondence:
Dr. Jayendra Arya, Senior Resident, Department of Pediatrics, Associate Shyam Shah Medical College, Rewa - 486 001, Madhya Pradesh, India. **Mobile:** +91-7415936950. **E-mail:** jafriend9@gmail.com

between ultrasonographic parameters and CL grade to assess difficult airways.

Aims and objectives

The aims of this study were to ascertain the role of ultrasonography in predicting difficult intubation by comparing different ultrasonographic parameters.

MATERIALS AND METHODS

This was a prospective and observational study conducted from March 2020 to February 2021 in the Department of Anesthesiology, Shyam Shah Medical College and associated with Sanjay Gandhi Hospital and Gandhi Memorial Hospitals, Rewa, Madhya Pradesh. After being approved by the Institutional Ethics Committee, 100 patients who fulfilled inclusion criteria required general anesthesia with endotracheal (ET) tube for elective surgery were included in this study. Pregnant woman, patients with any feature of the difficult airway such as maxillofacial anomalies, restricted neck movements, and limited mouth opening (inter incisor gap <2 cm) and pediatric patients were excluded from the study. This study was conducted in two phases in the *first phase* ultrasonographic parameters were measured during a pre-anesthetic checkup with the Linear high-frequency probe (7L 4P, frequency 3–12 MHz) of the ultrasound machine (Mindray Biomedical Electronics Co P.R. Chine, Model Dc China). Patients were asked to lie in a supine position with a simple head extended (without a pillow). After confirmation of hyoid in USG, anterior neck soft-tissue thickness was measured at the level of the hyoid (Figure 1). Then, in the same patient position, patient was advice to phonate to visualize vocal cords and anterior neck soft-tissue (ANS) thickness was measured at the level of vocal cords[6] (Figure 2).

Then, the US probe was rotated in the transverse plane from cranial to caudal direction, until clear visualization of epiglottis was obtained which is a hypoechoic curvilinear structure. Thereafter, pre-epiglottic space (PES) and distance from epiglottis to midpoint between vocal cords were obtained with the oblique-transverse US view of the airway as described by Gupta et al.,[7] and the ratio of PES and EVL was calculated (Figure 3).

During the *second phase,* patients were shifted to the operation theatre. Monitors were attached baseline vitals recorded and continuously monitored. After adequate relaxation, tracheal intubation was attempted by direct laryngoscopy using an appropriate-sized Macintosh blade in a simple head extension position. Tracheal intubation was performed by an experienced anesthesiologist. He was kept blinded to the findings of pre-operative airway assessment.

Figure 1: Measurement of ANS-Hyoid

Figure 2: Measurement of ANS-VC

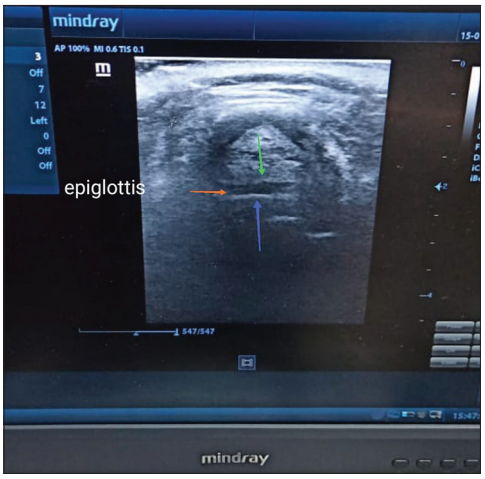

Figure 3: Ultrasonographic measurement of the ratio of the depth of pre-epiglottic space to distance from the epiglottis to mid-point between vocal cords (PES/EVL). Orange arrow –epiglottis. Green arrow – pre epiglottic space (PES). Purple arrow epiglottis to midpoint between vocal cords (EVL)

Intubation was classified as easy (CL Grade 1 and 2) or difficult (CL Grade 3 and 4). An appropriate-sized

endotracheal tube was inserted and anesthesia was well maintained.

Statistical analysis

The data were analyzed using the trial version of IBM SPSS Statistics for Windows, Version 20 IBM Corp, Armonk, NY, USA. The data collected were analyzed, continuous variables were presented as means with standard deviation (SD), and categorical variables were presented as frequency and percentages. The student's t-test was used for testing the significance of the mean in both groups. Qualitative data were analyzed using the Chi-square test. All the statistical results were considered significant at P<0.05. Predictive values of tests were measured by calculating negative predictive value (NPV), positive predictive value (PPV), sensitivity, specificity, and area under the ROC curve for all parameters.

RESULTS

Out of 100 patients, 57 were of CL Grade 1, 40 were of CL Grade 2, three patients were of CL Grade 3, and there were no patients of CL Grade 4.

In the present study, 46% (46/100) was male and 54% (54/100) were female (Figure 4). A total of 100 patients were included in the present study, in which 9% were between 19 and 25 years of age, 26% between 26 and 35 years of age, 30% were between 36 and 45 years of age, 26% between 46 and 55 years of age, and only 9% were between 56 and 60 years of age (Figure 5).

- Age – In this study, 40% of patients who had CL Grade 1 had an age between 19 and 60 years that mean age of patients was 40.93 years with SD±10.20, while 45% of patients who had CL Grade 2 had an age between 20 and 58 years with means 39.20±11.09 and 15% patients with CL Grade 3 were of age between 23 and 56 years with mean±SD, 43.67±10.81, age of these patients was comparable. (P=0.365) (Table 1).
- BMI – BMI in a patient with CL grade 1 was 24.02±1.32, while in patients with CL Grade 2 was 24.05±1.40 and in patients with CL Grade 3 was 24.99±2.11. BMI was comparable in CL Grade 1, 2, and 3 (P=0.076) (Table 1).

Table 2 shows the distribution of ultrasonographic parameters on basis of easy and difficult intubation. Patients with easy intubation (CL Grades 1 and 2) had a mean ANS-VC of 0.24±0.08 cm and patients with difficult intubation (CL Grades 3 and 4) had a mean ANS-VC of 0.34±0.05cm and there was a statistically significant difference between easy and difficult intubation group (P<0.0001).

ROC curve= receiver operating characteristic curve

The area under the ROC curve was used to find the best cutoff point for ANS-VC (Figure 6) and it was found that ANS-VC>0.32 was associated with difficult intubation with for area under the ROC curve 0.847 (between 0.8 and 0.9) which is considered good for discriminating easy and difficult intubation. Figures 7 and 8 showing area under ROC curve for ANS-Hyoid and PES/EVL, respectively.

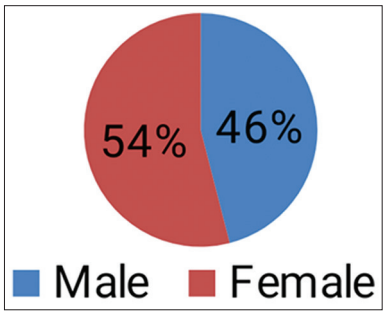

Figure 4: Distribution of patients according to sex

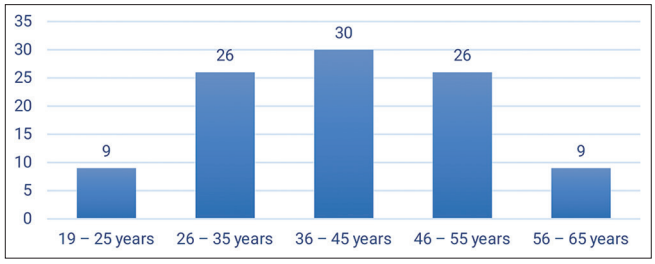

Figure 5: Distribution of patients according to age

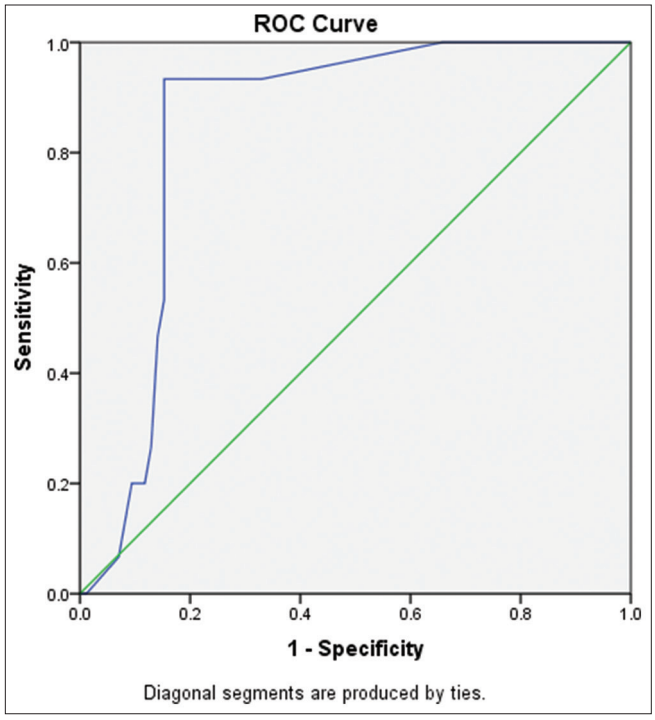

Figure 6: ROC curve for ANS-VC

Table 3 showing sensitivity, specificity, NPV, PPV, and AUC for the studied parameters. ANS-VC has a sensitivity of 93.3% specificity of 84.7, PPV 51.8%, NPV 98.6%, and an area under the ROC curve of 0.847 in the prediction of difficult intubation.

DISCUSSION

The present study finds that ANS-VC is a useful tool in the assessment of difficult laryngoscopy, and the thickness of anterior neck soft tissue at the level of vocal cords (ANS-VC) >0.32 cm correlates well with difficult intubation with a high sensitivity and specificity (93.3% and 84.7%, respectively). The present study also finds that ANS-Hyoid and PES/EVL show a low propensity in predicting easy and difficult intubation.

In a study to evaluate airway using ultrasound and to correlate the findings with CL grading, Gupta et al.,[7] observed a significant correlation between the ratio of PES/EVL with CL grade. Wu et al.,[8] carried out

Table 1: Comparison between the mean of demographic parameters with different CL grades (n=100)

Variable	CL Grade	N	Mean	SD	Min.	Max.	ANOVA	
							F	P-value
Age	1	40	40.93	10.2	19	60	1.02	0.365
	2	45	39.2	11.09	20	58		
	3	15	43.67	10.81	23	56		
Weight (kg)	1	40	62.15	5.66	53	72	3.79	0.026
	2	45	62.67	6.08	49	70		
	3	15	67.13	7.64	55	80		
Height (m)	1	40	1.61	0.06	1.5	1.7	1.31	0.275
	2	45	1.61	0.06	1.48	1.7		
	3	15	1.64	0.07	1.56	1.8		
BMI	1	40	24.02	1.32	19.96	25.91	2.64	0.076
	2	45	24.05	1.4	20.94	28.72		
	3	15	24.99	2.11	20.99	28.76		

Table 2: Distribution of USG parameters according to ease of intubation

Variables	Intubation (easy or difficult)	N	Mean	SD	Min.	Max.	t-test	P-value
ANS Hyoid	Easy (CL Grade 1–2)	85	0.39	0.14	0.12	0.96	0.087	0.931
	Difficult (CL Grade 3–4)	15	0.38	0.05	0.3	0.45		
ANS – VC	Easy (CL Grade 1–2)	85	0.24	0.08	0.08	0.48	4.88	<0.0001
	Difficult (CL Grade 3–4)	15	0.34	0.05	0.22	0.43		
PES	Easy (CL Grade 1–2)	85	1.02	0.25	0.27	1.7	0.042	0.967
	Difficult (CL Grade 3–4)	15	1.02	0.07	0.9	1.13		
EVL	Easy (CL Grade 1–2)	85	0.9	0.24	0.45	1.68	1.376	0.172
	Difficult (CL Grade 3–4)	15	0.82	0.12	0.45	0.97		
PES/EVL	Easy (CL Grade 1–2)	85	1.16	0.25	0.24	2.18	0.783	0.435
	Difficult (CL Grade 3–4)	15	1.21	0.15	1.01	1.49		

PES: Pre-epiglottic space

Table 3: Comparative sensitivity, specificity, PPV, NPV, and AUC of observed parameters

Variable	Sensitivity%	Specificity%	PPV%	NPV%	AUC
ANS-HYOID	60	50.6	17.6	87.8	0.545
ANS-VC	93.3	84.7	51.8	98.6	0.847
PES	53.3	47.1	15.1	85.1	0.484
EVL	57.6	60	20.3	88.9	0.607
PES/EVL	60	51.8	18	95.4	0.602

Table 4: Comparison of ultrasonographic parameters between various similar previous studies

Study	Year	Sample size	Relevant predictors	Sensitivity	Specificity	Area under ROC
Gupta *et al*.[7]	2012		Pre-E/-EVC	67–68%		
Wu J *et al*.[8]	2014	203	DSHB, DSEM, DSAC	DSHB- 85.7% DSEM- 100% DSAC- 75%	DSHB- 85.1% DSEM- 66.3% DSAC -80.6%	DSHB-0.92 DSEM-0.90 DSAC-0.85
Soltani Mohammadi *et al*.[9]	2016	53	No correlation			
Reddy *et al*.[10]	2016	100	ANS0-VC>0.23	85.7%	57.0%	0.73
Imran *et al*.[11]	2018	90	DSEM>17.7 mm	78.9	76.3	
Shah *et al*.[12]	2020	100	ANS-VC≥0.51 cm	78.3%	74%	
Singh *et al*.[13]	2021	100	ANS-VC>0.29 cm	78.9%	71.1%	0.816
Sotoodehnia *et al*.[14]	2021	371 article (meta-analysis)	ANS-VC, ANS-Hyoid	ANS-VC- 53% ANS-Hyoid- 68%, 48%	ANS-VC- 66% ANS-hyoid 69%, 82%	-
Present study	2021	100	ANS-VC>0.32 cm	93.3%	84.7%	0.847

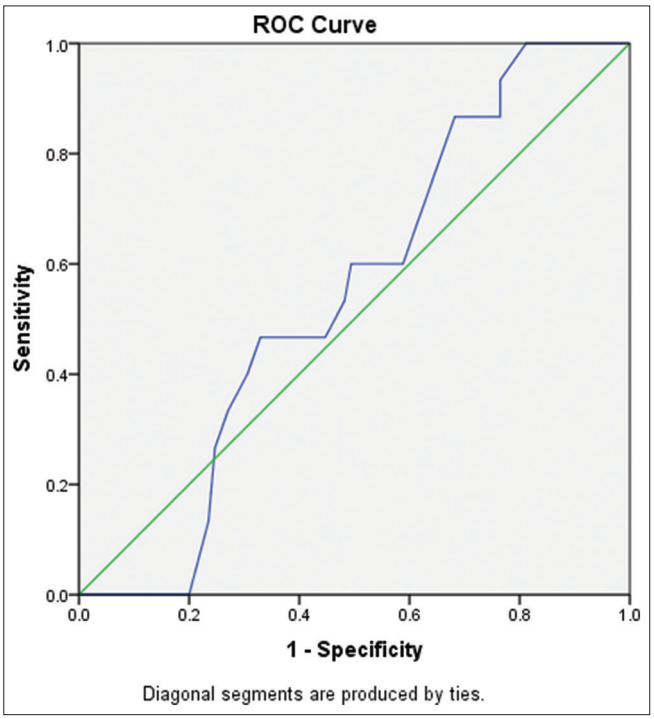

Figure 7: ROC curve for ANS-Hyoid

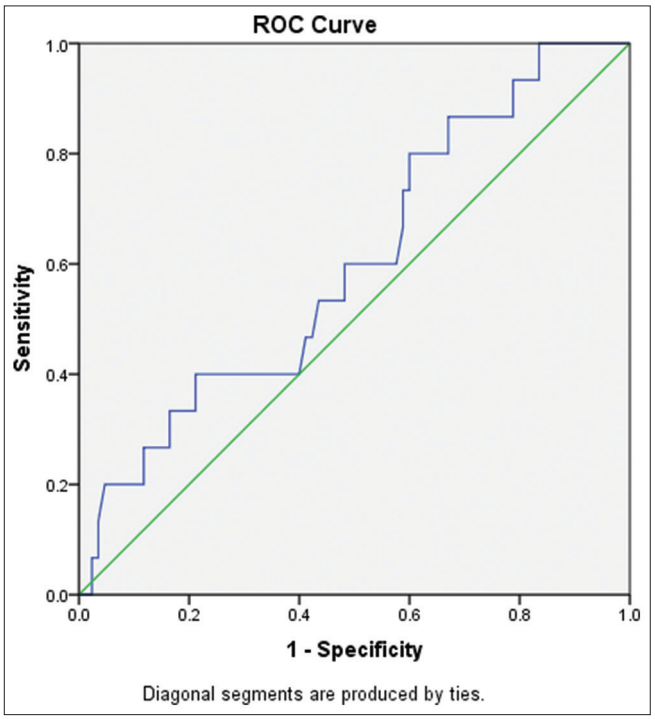

Figure 8: ROC for PES/EVL

a study in patients aged 20–65 years with the aim of determining whether ultrasound measurements of anterior neck soft-tissue thickness at hyoid bone, at the level of thyroid membrane, and at anterior commissure levels can be used to predict difficult laryngoscopy. They found that anterior neck soft-tissue thicknesses measured by ultrasound at hyoid bone, thyroid membrane, and anterior commissure levels are independent predictors of difficult laryngoscopy. The authors[8] proposed that combinations of those screening tests or risk factors with ultrasound measurements might increase the ability to predict difficult laryngoscopy. However, in another study, Mohammadi et al.,[9] found a weak correlation between PE/E-VC and CL grade, with 87% sensitivity and 30% specificity and the authors concluded that sonographic measurement criteria are not accurate in airway evaluations before anesthesia.

The observation of the present study is in line with the study findings of Reddy et al.,[10] who observed the ANS-VC >0.23 cm to be a potential predictor of difficult intubation. However, they observed that ANS-Hyoid is not indicative of difficult intubation and the ratio PreE/EVC has a low-to-moderate predictive value.

In another study, Nazir and Mehta[11] observed that the increase in anterior neck soft-tissue distance at epiglottis (DSEM) is strongly associated with difficult laryngoscopy. They observed that a cutoff value of 17.7 mm of DSEM was able to predict difficult laryngoscopy with high

accuracy, sensitivity, and specificity (77.2%, 78.9%, and 76.3%, respectively).

In a recent study, Shah et al.,[12] observed that the ultrasound distance from skin surface to anterior commissure of vocal cord (DSVC) cutoff value of 0.51 cm can appear as the best predictor of CL grade more than 2 at direct laryngoscopy and of difficult intubation (sensitivity 78.3% and specificity 74%).

Singh et al.,[13] observed ANS-VC as the most significant parameter with a value of >0.29 cm being a sensitive predictor of difficult intubation with a sensitivity of 78.9% and specificity of 71.1% with an area under ROC curve 0.816. They commented that combined sonographic parameters can be better predictor of difficult intubation.

In a meta-analysis (data from 26 articles that had examined a total of 45 ultrasonography (US) indicators for predicting difficult intubation), Sotoodehnia et al.,[14] found that the most common ultrasonography parameter was the "thickness of anterior neck soft tissue at the vocal cords level." Furthermore, "skin to epiglottis" and "anterior neck soft tissue at the hyoid bone level" were among the most common indicators examined in this area. A glimpse of similar type of the previous studies evaluating different ultrasonographic parameters is presented in Table 4.

The area under ROC curve for ANS-VC was 0.847 which falls under the category of "good" diagnostic ability, while other ultrasonographic parameters were not found statistically significant. The ROC analysis is an important tool to compare the accuracy between tests and predictive models. The AUC is an overall summary of diagnostic accuracy. AUC equals 0.5 when the ROC curve corresponds to random chance and 1.0 for perfect accuracy.[15]

Limitations of the study

The present study has some limitations sample size was small, pediatric patients and patients with obvious difficult airway were excluded from study.

CONCLUSION

It can be concluded that ultrasound can be used as a useful tool in the prediction of difficult intubation. The ultrasonographic parameter measuring the anterior neck soft-tissue thickness at the level of vocal cords (ANS-VC) with a cutoff value more than 0.32 cm can be used as good predictive tool with high sensitivity and specificity. No other ultrasonographic parameter was found to be useful in the prediction of difficult intubation in this study.

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REFERENCES

1. Krage R, van Rijn C, van Groeningen D, Loer SA, Schwarte LA and Schober P. Cormack-lehane classification revisited. Br J Anaesth. 2010;105(2):220-227.
   https://doi.org/10.1093/bja/aeq136
2. Vannucci A and Cavallone LF. Bedside predictors of difficult intubation: A systematic review. Minerva Anestesiol. 2016;82(1):69-83.
3. Shiga T, Wajima Z, Inoue T and Sakamoto A. Predicting difficult intubation in apparently normal patients: A meta-analysis of bedside screening test performance. Anesthesiology. 2005;103(2):429-437.
   https://doi.org/10.1097/00000542-200508000-00027
4. Abraham S, Himarani J, Nancy SM, Shanmugasundaram S and Raja VB. Ultrasound as an assessment method in predicting difficult intubation: A prospective clinical study. J Maxillofac Oral Surg. 2018;17(4):563-569.
   https://doi.org/10.1007/s12663-018-1088-1
5. Ji C, Ni Q and Chen W. Diagnostic accuracy of radiology (CT, X-ray, US) for predicting difficult intubation in adults: A meta-analysis. J Clin Anesth. 2018;45:79-87.
   https://doi.org/10.1016/j.jclinane.2017.12.023
6. Kundra P, Mishra SK and Ramesh A. Ultrasound of the airway. Indian J Anaesth. 2011;55(5):456-462.
   https://doi.org/10.4103/0019-5049.89868
7. Gupta D, Srirajakalidindi A, Ittiara B, Apple L, Toshniwal G and Haber H. Ultrasonographic modification of cormack lehane classification for pre-anesthetic airway assessment. Middle East J Anaesthesiol. 2012;21(6):835-842.
8. Wu J, Dong J, Ding Y and Zheng J. Role of anterior neck soft tissue quantifications by ultrasound in predicting difficult laryngoscopy. Med Sci Monit. 2014;20:2343-2350.
   https://doi.org/10.12659/MSM.891037
9. Mohammadi SS, Saliminia A, Nejatifard N and Azma R. Usefulness of ultrasound view of larynx in pre-anesthetic airway assessment: A comparison with cormack-lehane classification during direct laryngoscopy. Anesth Pain Med. 2016;6(6):e39566.
   https://doi.org/10.5812/aapm.39566
10. Reddy PB, Punetha P and Chalam KS. Ultrasonography-a viable tool for airway assessment. Indian J Anaesth. 2016;60(11):807-813.
    https://doi.org/10.4103/0019-5049.193660
11. Nazir I and Mehta N. A comparative correlation of pre-anaesthetic airway assessment using ultrasound with cormack lehane classification of direct laryngoscopy. IOSR J Dent Med Sci (IOSR-JDMS). 2018;17(4):43-51.
    https://doi.org/10.9790/0853-1704104351
12. Shah A, Kanzariya H and Bose N. A correlation of preoperative ultrasound parameter to cormack-lehane classification in predicting difficult laryngoscopy. Indian J Anesth Analg. 2020;7(1)(Part-I):9-14.
    https://doi.org/10.21088/ijaa.2349.8471.7120.1
13. Singh S, Ohri R, Singh K, Singh M and Bansal P. Comparison of different ultrasound parameters for airway assessment in

patients undergoing surgery under general anaesthesia. Turk J Anaesthesiol Reanim. 2021;49(5):394-399.
https://doi.org/10.5152/TJAR.2021.1370

14. Sotoodehnia M, Rafiemanesh H, Mirfazaelian H, Safaie A and Baratloo A. Ultrasonography indicators for predicting difficult intubation: A systematic review and meta-analysis. BMC Emerg Med. 2021;21(1):76.
https://doi.org/10.1186/s12873-021-00472-w
15. Zou KH, O'Malley AJ and Mauri L. Receiver-operating characteristic analysis for evaluating diagnostic tests and predictive models. Circulation. 2007;115(5):654-657.
https://doi.org/10.1161/CIRCULATIONAHA.105.594929

Authors Contribution:
SJ- Concept and design of the study, Prepared first draft of manuscript, Data collection, Statistical analysis, Interpreted the results, Review of literature; **JA-** Concept and design of the study, Manuscript preparation; **AR-** Coordination, Statistical analysis, Review of literature; **SD-** Review of literature, Concept, Coordination, Review of literature

Work attributed to:
Shyam Shah Medical College, Rewa - 486 001, Madhya Pradesh, India.

Orcid ID:
Dr. Sakshi Jain - https://orcid.org/0000-0002-2240-7341
Dr. Jayendra Arya - https://orcid.org/0000-0001-5094-8551
Dr. Arvind Rathiya - https://orcid.org/0000-0003-4421-605X
Dr. Sudhakar Dwivedi - https://orcid.org/0000-0002-5299-3505

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