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COMPARISON OF CONVENTIONAL AND ULTRASOUND GUIDED PREOPERATIVE ASSESSMENT OF AIRWAY TO PREDICT DIFFICULT LARYNGOSCOPY AND INTUBATION

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ABSTRACT

BACKGROUND: Advance prediction of difficult airway provides us ample time for optimal preparation and participation of experienced anesthesiologist. The present study was designed to evaluate the efficacy of clinical and ultrasound guided parameters to predict difficult intubation.

MATERIAL AND METHOD: This prospective, observational, double blind study was conducted on 100 patients, aged 18-65 years of ASA grade I, II and III scheduled for elective surgery under general anesthesia. Airway assesment was done preoperatively using clinical parameters (Mallampati score, Thyromental distance (TMD), Hyomental distance ratio (HMDR), Upper Lip BiteTest (ULBT) and ultrasound guided parameters (skin to anterior commissure distance (ANC-VC), tongue volume (TV), Hyomental distance ratio (HMDR), skin to epiglottis distance (DSE) to predict difficult intubation. Findings of the screening tests were corelated with the findings of cormack lehane grading on laryngoscopy and their sensitivity, specificity, positive predictive value, negative predictive value and area under ROC curve was calculated to predict difficult airway. Number of attempts taken for intubation, time taken for intubation and failed intubation was noted.

RESULTS: The incidence of difficult intubation was 20%. Among clinical parameters HMDR has sensitivity of 81.82%, specificity of 97.44% with positive predictive value (PPV) of 95% and negative predictive value (NPV) of 90% with AUC of 0.888. however, ULBT has highest NPV of 96.25%. Among USG guided parameters DSE has sensitivity of 97.50% and specificity of 98.73% with PPV of 97.50% and NPV of 95% with AUC of 0.992.

CONCLUSION: Hyomental distance ratio as a clinical parameter was a good predictor of difficult airway with high area under ROC curve with good sensitivity and specificity. However, Ultrasound guided parameters have an edge over clinical parameters as ultrasound guided skin to epiglottis distance was more accurate for predicting difficult airway.

KEYWORDS: difficult intubation (DI), mallampati grade (MMG), thyromental distance (TMD), hyomental distance ratio (HMDR), upper lip bite test (ULBT), anterior neck tissue thickness at the level of vocal cord (ANC-VC), tongue volume (TV), distance from skin to epiglottis (DSE).

INTRODUCTION

Airway assessment is a vital part of preanesthetic evaluation which aims at identifying patients with difficult airways and mandating planning of various approaches to adequately manage airway. Unanticipated difficult airways are hazardous for an anesthesiologist and increases morbidity and mortality among patients. So preoperative assessment of various anatomical and clinical features helps us to identify potentially difficult airways. Various screening tests has been formulated for predicting difficult airway. Ideal screening test should have certain prerequisites i.e. easy to perform, reliable, cost effective and with minimum errors. In the past many clinical bedside tests have been formulated to detect difficult airway. Recently sonographic assessment of airway has grown a long way in providing useful information to the anesthesiologist. Airway assessment using ultrasound has been proposed to be simple and noninvasive bedside tool and used as an adjunct to conventional clinical parameters in predicting difficult airway.

The present study was designed with an aim to predict difficult airways in Indian population using both conventional clinical parameters i.e. Mallampati score (MMG), Thyromental distance (TMD), ratio of hyomental distance in neutral and extended positions (HMDR), Upper lip bite test (ULBT) and USG guided parameters, i.e. skin to anterior commissure distance (ANC-VC), tongue volume (TV), ratio of Hyomental distance (HMDR), skin to epiglottis distance (DSE).

MATERIAL AND METHODS: This prospective, observational, double blind study was conducted in 100 patients of either sex, aged 18-65 years, of ASA grade I, II and III scheduled to undergo elective surgeries under general anaesthesia after obtaining approval from institutional ethics and thesis committee (BFUHS/2K24p-TH/1178) along with written and informed consent of the patients enrolled in the study. This study was registered prospectively with Clinical Trial Registry of India (www.ctri.nic.in) with registration number CTRI/2023/07/054926. Exclusion criteria was patients of ASA grade IV, limited head and neck flexion or extension, previous history of head and neck surgery, any growth or scar in head and neck region, previous history of difficult intubation, pregnancy, obstructive sleep apnea and BMI >40. Primary aim of the study was to evaluate and recognize difficult airway by using clinical and ultrasound guided parameters and to assess their correlation with Cormack lehane grading findings during direct laryngoscopy by calculating sensitivity, specificity, positive predictive value, negative predictive value and Area under ROC curve. Secondary aim of the study was to determine timetaken for intubation, number of attempts and any failed intubation.

A day before the surgery, preanesthetic checkup was done in all patients. Detailed clinical history regarding obstructive sleep apnea, history of snoring, history of hoarsness of voice, any respiratory tract infection, previous knowledge of difficult intubation was noted. General physical examination and systemic examination which includes cardiovascular system, respiratory system and central nervous system was done. Clinical examination of head and neck region for any scar mark, growth, burns and abscess was done. Built of the patient, posture and facial asymmetry was also noted. Baseline hemodynamic parameters and body mass index was noted. Routine investigations were done and if needed, special investigations were ordered.

Airway examination was done in all patients by observer 1 (trained anesthesiologist who was not involved in direct layngoscopy), using clinical parameters and USG guided parameters.

Among clinical parameter, Modified mallampati grading was noted and class 3 and 4 was taken as difficult airway. Thyromental distance was measured from thyroid notch to mental prominence with head fully extended and value of < 6.5cm was taken as cut off value for difficult airway. Hyomental distance ratio in neutral and extended head position was noted with cutoff value of < 1.2 taken as difficult airway. ULBT was performed and class 3 was taken as difficult airway.

Ultrasound guided parameters were noted.

- In Anterior neck soft tissue thickness at the level of anterior commissure of vocal cords (ANC-VC), linear USG probe (6-13 MHZ) was used in midline of the submandibular region in patients lying supine in sniffing position. Probe was rotated from cephalad to cauded until vocal cords appear as triangular, hypoechoic form with medial border surrounded by hyperechoic vocal ligaments. Distance from skin to anterior commissure of vocal cord was measured and ANS-VC >0.23cm was taken as cut-off for difficult intubation.
- HMDR was measured using curvilinear probe (3-5MHZ) kept in mid sagittal plane and distance from hyoid to anterior-most portion of mentum was measured by keeping head in neutral (HMDn) position and then in extended position (HMDe). HMDR (HMDe/HMDn) <1.2 was taken cut-off value for difficult airway.
- Tongue volume was measured with patient in supine sniffing position by multiplying mid sagittal cross-sectional area and width in transverse plane using curvilinear probe and linear probe respectively. TV >100 cm^3 was taken as cut-off and indicates difficult airway.
- Distance from skin to epiglottis (DSE) was measured with linear USG probe (10-13MHZ) with head and neck of the patient in neutral position and epiglottis appeared as hypoechoic curvilinear structure through thyrohyoid membrane in transverse plane with varying degree of cephalad and caudad angulation of probe. DSE > 2 cm was taken as difficult intubation.

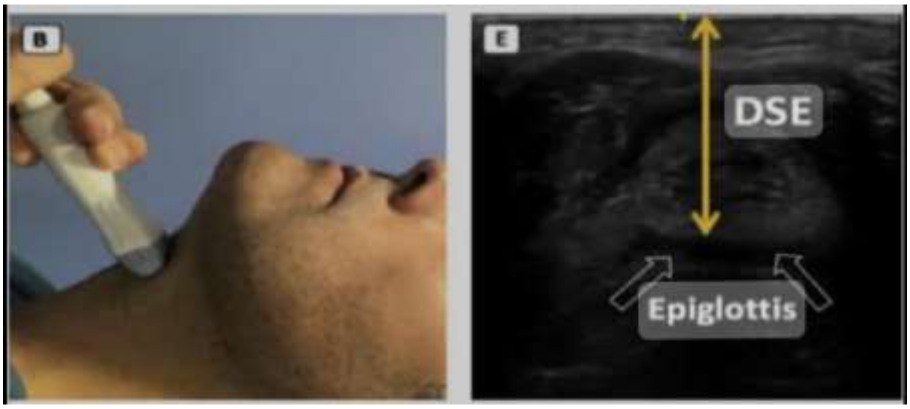


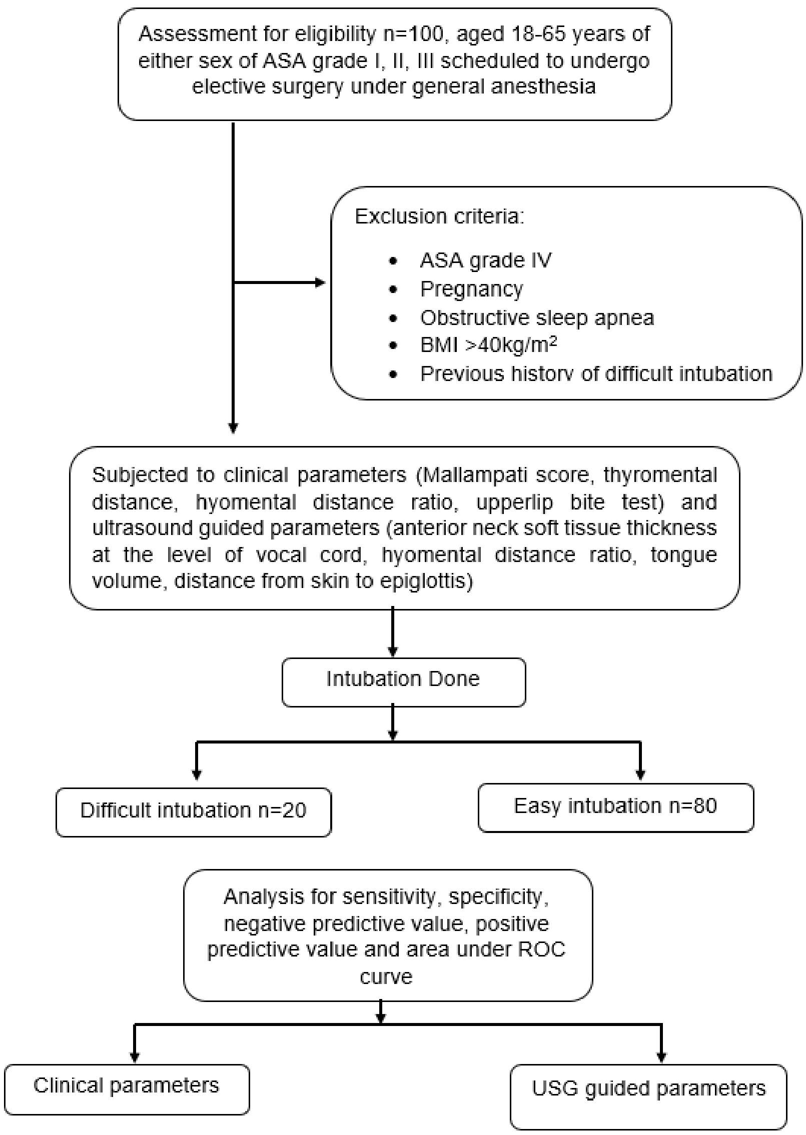
FIGURE 1 – measurement of skin to epiglottis distance using linear probe

After detailed preanesthetic checkup, patients were kept fasting and Tablet Alprazolam 0.25 mg was given night before surgery, On the day of surgery, on arrival in the operating room, multipara monitor was attached, baseline vital parameters noted and continuous monitoring was started. Intravenous line was secured with ringer lactate and premedication was given as injection glycopyrrolate 0.2mg, Injection midazolam 2mg and injection butorphanol 1mg. After preoxygenation with 100% oxygen for 3 minutes injection propofol 2 mg/kg I/V was given. After ensuring successful ventilation, Injection succinyl choline 1.5 mg/kg was given followed by intermittent positive pressure ventilation. Direct laryngoscopy was performed by observer 2 (trained anesthesiologist who was not involved in airway assessment during PAC) with a Macintosh blade and Cormack-lehane grading of laryngoscopic view without any external laryngeal manouver was done. CL Grade I and 2a was taken as easy intubation and CL grade 2b, 3 and 4 was taken as difficult intubation. Trachea was intubated with tracheal tube of appropriate size. Time taken for intubation was noted. In case of difficult intubation, number of attempts and change of equipment (stylet, bougie, video laryngoscope) or change of person for intubation was noted. General Anesthesia was maintained with 50% oxygen in 50 % nitrous oxide, isoflurane 1.2 MAC and Injection vecuronium 0.01 — 0.015mg/kg. At the end of the surgery, suction was done, neuromuscular block was reversed with Intravenous injection of neostigmine 50µg/kg and glycopyrrolate 10µg/kg and patient was extubated. Patients were assessed for any complications like cough, hoarseness, dry mouth, nausea and vomiting in postoperative period.

At the end of study, the correlation between findings of clinical parameters and ultrasound guided parameters was done with Cormack-Lehane grading findings on laryngoscopy.

STATISTICAL ANALYSIS: Data was recorded in Microsoft excel spread sheet and analysed using Statistical Package for the IBM SPSS windows, version 23.0. Armonk, NY: IBM Corp.,Chicago. The association between different independent variables and outcome variables were evaluated using the chi square test for qualitative data and student's t test for quantitative data. For continuous data, each parameter's results were averaged (mean ± standard deviation [SD]). Chi-square test was used to ascertain if any significant difference existed between patients having easy and difficult intubation. Sensitivity, specificity, negative and positive predictive value calculations were used to evaluate the predictive value of the tests. The area under the Receiver Operator Characteristics (ROC) curve was computed to evaluate the prognosis, accuracy and to determine the ideal cut-off scores. Sample size was calculated in consultation with statistician taking success rate and intubation time in consideration of findings of previous studies to get the power of study more than 80%.

OBSERVATIONS AND RESULTS
CONSORT FLOW DIAGRAM



In the present study, among 100 patients, 80 (80%) patients had easy intubation and 20 (20%) patients had difficult intubation. Ninety five (95%) patients were intubated in first attempt whereas five (5%) patients were intubated at second attempt either with change of equipment (use of stylet, bougie or video laryngoscope) or change of person. Mean time taken to intubate in first attempt was 22.43±21.52 seconds and time taken to intubate in second attempt was 174.00±31.30 seconds. There was no failed intubation. Distribution of patients having easy intubation or difficult intubation based on demographic profile of the patients i.e. age, sex, ASA grade and BMI is shown in Table no .1. It was observed that incidence of difficult intubation was more in patients above 40 years of age and in patients having BMI> 25 kg/m^{2}.

Table 1: DISTRIBUTION OF PATIENTS HAVING EASY AND DIFFICULT INTUBATION DEPENDING UPON THE DEMOGRAPHIC PROFILE OF THE PATIENTS

PARAMETERS	TOTAL NUMBER OF PATIENTS (%)	NO. OF PATIENTS (%) HAVING EASY INTUBATION (CL G1, 2a)	NO. OF PATIENTS (%) HAVING DIFFICULT INTUBATION (CL G 2b, 3 and 4)
Age In years			
18-40	41 (41%)	37(90.24%)	4 (9.76%)
41-65	59 (59%)	43(72.88%)	16 (27.12%)
Sex			
Males	40 (40%)	32 (80%)	8 (20%)
Females	60 (60%)	48 (80%)	12 (20%)
ASA GRADE			
GRADE1	27 (27%)	24 (88.89%)	3 (11.11%)
GRADE 2	67 (67%)	50 (74.63)	17 (25.37%)
GRADE 3	6 (6%)	6 (100%)	0 (0%)
BMI			
<25 kg/m^2	12 (12%)	13 (92.85%)	1 (7.14%)
>25 kg/m^2	86 (86%)	67 (77.90%)	19 (22.09%)

Airway assessment was done in 100 patients using clinical parameters [modified mallampati classification (MMG), thyromental distance (TMD), hyomental distance ratio in neutral and extended position (HMDR), upper lip bite test (ULBT)] and ultrasound guided parameters [anterior neck soft tissue thickness at the level of anterior commissure (ANC-VC), hyomental distance ratio (HMDR), tongue volume (TV), skin to epiglottis distance (DSE)]. Distribution of patients based on various grades of above parameters are shown in table no.2

TABLE 2- DISTRIBUTION OF PATIENTS ACCORDING TO GRADING OF CLINICAL AND ULTRASOUNDED GUIDED PARAMETERS

PARAMETERS	GRADING	TOTAL NUMBER OF PATIENTS (%)
MMG	**CLASS1 (easy intubation)**	39 (39%)
	CLASS 2 (easy intubation)	46 (46%)
	CLASS 3 (difficult intubation)	12 (12%)
	CLASS 4 (difficult intubation)	3 (3%)
TMD	**< 6.5 cm (difficult intubation)**	15 (15%)
	>6.5 cm (easy intubation)	85 (85%)
HMDR	**< 1.2 (difficult intubation)**	22 (22%)
	>1.2 (easy intubation)	78 (78%)
ULBT	**CLASS 1 (easy intubation)**	78 (78%)
	CLASS 2 (easy intubation)	10 (10%)
	CLASS 3 (difficult intubation)	12 (12%)
ANC-VC	**<0.23 cm (easy intubation)**	84 (84%)
	>0.23 cm (difficult intubation)	16 (16%)
USG GUIDED HMDR	**<1.2 (difficult intubation)**	20 (20%)
	>1.2 (easy intubation)	80 (80%)
TONGUE VOLUME	**<100 cm^3 (easy intubation)**	82 (82%)
	>100 cm^3(difficult intubation)	18 (18%)
SKIN TO EPIGLOTTIS DISTANCE	**< 2 cm (easy intubation)**	79 (79%)
	>2cm (difficult intubation)	21 (21%)

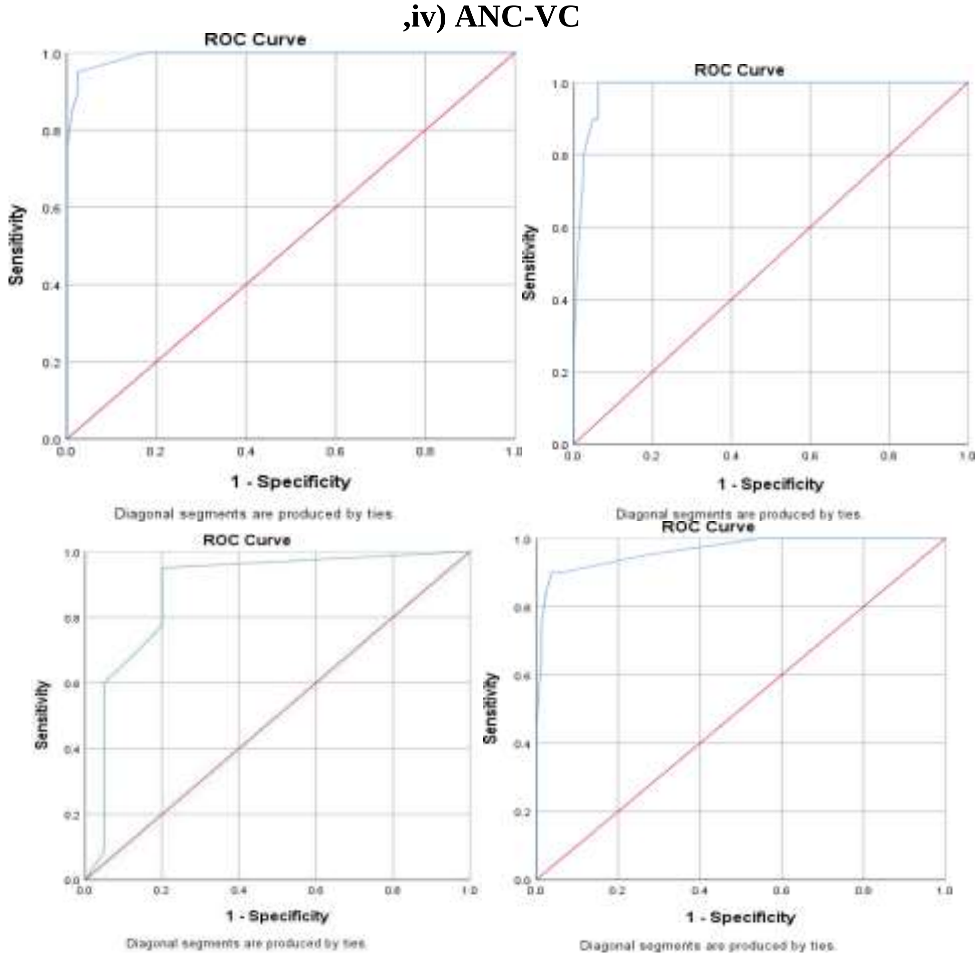
Findings of clinical and ultrasound guided parameters were correlated with the findings of Cormack-lehane grading during direct larnygoscopy and sensitivity, specificity, positive predictive value and negative predictive value were calculated. Graphic representation of sensitivity and specificity of each parameter was done by ROC curve for evaluating the tests intrinsic validity by measuring area under curve (AUC).0.9≤ AUC represent excellent accuracy, AUC ≤ 0.6 represents poor accuracy and AUC ≤ 0.5 represent failure of screening test. Table no. 3 shows the comparison of clinical and ultrasound guided parameters for their sensitivity, specificity, PPV, NPV and AUC in predicting difficult airway.

Table 3: COMPARISON OF CLINICAL PARAMETERS AND ULTRASOUND GUIDED PARAMETERS IN PREDICTING DIFFICULT INTUBATION

Parameters	Sensitivity (true positive/true positive +false negative)	Specificity (true negative/true negative+ false positive)	Negative predictive value (true negative/true negative+ false negative)	Positive predictive value (true positive/false positive+true positive)	Area under curve
Mallampati class	66.67%	88.24%	93.75%	50.00%	0.841
HMD Ratio	81.82%	97.44%	95.00%	90.00%	0.888
Thyromental distance	60.00%	87.06%	92.50%	45.00%	0.335
Upper lip bite test	75.00%	87.50%	96.25%	45.00%	0.775
ANC-VC	81.25%	91.67%	96.25%	65.00%	0.966
HMD Ratio USG guided	80.00%	95.00%	80.00%	95.00%	0.885
Tongue volume	88.89%	95.12%	97.50%	80.00%	0.983
Skin to epiglottis distance	90.48%	98.73%	97.50%	95.00%	0.992

Among clinical and ultrasound guided parameters , skin to epiglottis (DSE) has highest area under ROC curve ie 0.992 as shown in figure no. 2.

Figure 2:PREDICTION OF DIFFICULT INTUBATION USING i) DSE , ii) TV, iii) HMDR ,iv) ANC-VC



X-axis – 1-specificity, Y-axis – sensitivity

DISCUSSION

Prediction of difficult airway in advance gives an ample time for optimal preparation of the patient, proper selection of equipment and participation of experienced anesthesiologist to handle difficult airway. The most common cause of morbidity in difficult airway is unprepared or inexperienced anesthesiologist, inadequate preoperative assessment and poor equipment preparation. Other factors that might contribute to difficult intubation could be type of laryngoscope blade used and application of external laryngeal pressure. In the present study, incidence of difficult intubation was 20%. In a study conducted by Ni H et al[1] incidence of difficult intubation was reported as 20.85% while it was high (25%) in critically ill patients in ICU as reported by Hrithima D et al[2]. Harjai M et al[3], in 150 patients and Koundal V et al[4], in 200 patients reported low incidence of difficult intubation as 13.3% and 12.5% respectively. In the present study, incidence of difficult intubation was high as compared to the study conducted by Harjai M et al[3] and Koundal V et al[4] which can be due to more number of patients above 40 years and with more patients of BMI >25 kg/m.^{2}. Incidence of difficult intubation increases with increasing age due to morphological and pathophysiological changes in elderly population, that impact various aspects of airway care including ventilation, difficulty in visualizing vocal cords, intubation and increased risk of aspiration. Increased BMI alters anatomy and physiology of airway as excessive fat deposition in the anterior region of neck leads to difficult airway.

In the present study, various clinical and ultrasound guided parameters were used preoperatively to predict difficult airway. Among USG guided parameters, DSE (skin to epiglottis distance) with cut off value of 2 cm was excellent predictor of difficult intubation with AUC of 0.992, sensitivity of 90.48% and specificity of 98.73%. Ni H et al[1] observed that DSE with cut off value taken as 2.36 cm had sensitivity of 81.8%, specificity of 85.6% with AUC of 0.8292. Abdelhady BS et al[5], observed that DSE with cut off value of 1.85 cm had sensitivity of 80%, specificity of 70.8%, positive predictive value of 38.7%, negative predictive value of 93.9% and AUC of 0.759. Koundal V et al[4] had taken the cut of value for DSE as ≥1.615 cm and reported sensitivity of 89.7%, specificity of 64.85%, PPV of 50.98%, NPV of 93.88% with AUC of 0.819. The difference in the findings of the present study from the results of above studies might be due to the fact that different cutoff value were used for labelling difficult airway using DSE. In the present study cutoff value for DSE was 2 cm, cutoff value taken by Ni H et al was 2.36 cm, Abdelhady BS et al[5] as 1.85 cm and Koundal V et al[4] had cutoff value of ≥ 1.615 cm.

In the present study, tongue volume measured sonographically was also a good predictor of difficult airway with high sensitivity of 88.89%, specificity of 95.12%, PPV of 80% and NPV of 97.50% and AUC of 0.983 with cut off value of 100 cm^2. Laryngoscopy and vision of glottis is impacted by size and volume of tongue as large tongue provides insufficient space in submandibular area for laryngoscopy. Ruchi Ohri et al[6] observed that tongue volume has sensitivity of 86.96%, specificity of 35%, PPV of 52.6% and NPV of 75% with AUC of 0.502 in predicting difficult airway. Parameswari A et al[7] reported low sensitivity (66.7%), low specificity (62.7%) and high NPV (94.6%) for tongue volume. Mobile nature of the tongue during ultrasound scanning might effect the actual readings and could be the cause of variation in findings of different studies.

It has been observed in the present study that there is strong positive correlation between anterior neck soft tissue thickness at the level of vocal cords (ANC-VC) and difficult intubation with cut off value taken as 0.23 cm with sensitivity of 81.25%, specificity of 91.67%, PPV of 65% and NPV of 96.25% with AUC of 0.966. Similar results were reported by Reddy et al[8] where they observed that ANC-VC has sensitivity of 85.7%, specificity of 57%, PPV of 24.5% and NPV of 95.6% with similar cutoff value of 0.23. Jain S et al[9] has taken cutoff value for ANC-VC as 0.32 cm for labelling difficult intubation and observed that it has sensitivity of 93.3% with low specificity, low PPV and high NPV (97.03%). The high sensitivity observed in this study might be due to higher cutoff value taken for ANC-VC as 0.23 cm.

In the present study, HMDR measured by ultrasound was found to be a decent predictor of decreased atlanto-occipito-axial extension required during laryngoscopy with cut off value taken as <1.2 with sensitivity of 80%, specificity of 95%, PPV of 95% and NPV of 80% with AUC 0.885. Petrisor C et al[10] conducted a study in morbid obese patients and observed sensitivity of 100% with specificity of 90.5%and AUC of 0.92 with cut off value of 1.23. It shows that HDMR is more sensitive in predicting difficult airway in morbid obese patients. High sensitivity ensures that false negative results are identified better and failed intubations are prevented. Koundal V et al[4] observed that HMDR had sensitivity of 65% with specificity of 77% and AUC 0.762 with cutoff value taken as <1.0870. As the cutoff value is lowered, the efficacy of the parameter in predicting difficult airway decreases. Differences in the results of our study from the above studies can be attributed to different cutoff values taken and increasing BMI of the patients.

In our study, clinical assessment of difficult airway using HMDR has high sensitivity of 81.82%, specificity of 97.44%, PPV 90.0%, NPV 95% with AUC 0.888. HDMR depicts the expansion capability of occipito-atlanto-axial complex. A smaller HDMR means there is less room for tongue to accomodate during laryngoscopy. Hrithima D et al[2] conducted a study in ICU patients and found that HDMR has sensitivity of 88.5% with specificity of 85.9%, PPV of 67.7% and NPV of 95.7%. Difference in the findings could be due to the study population which was critically ill ICU patients, who were attached to monitors, I/V lines and measuring HMDR might be difficult in these patients. Similar results were reported by a study done by Huh J et al[11] in 213 patients with cutoff point of HMDR taken as < 1.2 observed that sensitivity of HDMR was 88% and specificity of 60% with high NPV of 97% and AUC of 0.782.

Modified Mallampati grade (MMG) is the most common clinical screening test used in prediction of difficult airway. In the present study, MMG has specificity of 88.24%, low sensitivity and PPV of 66.6% and 50% respectively with high NPV of 93.75% with AUC of 0.841. Yadav U et al[12] found sensitivity and specificity of 74.1% and 85.4% respectively with AUC of 0.763. Another study conducted by Parameshwari A et al[7] also found that MMG has low sensitivity with AUC of 0.727. The difference in the findings of our study from the above studies might be due to higher inter observer variability and inconsistent way of performing this test.

In the present study, Upper lip bite test (ULBT) was found to be decent predictor of difficult airway with specificity and NPV of 87.50% and 96.25% respectively with AUC of 0.775. Similar finding were observed by Khan ZH et al[13], reporting high specificity and NPV of 88.7% and 98.4% respectively. Another study conducted by Dhanger S et al[14] observed high specificity of 96.25% and NPV of 98.08% respectively of ULBT. The difference in the findings of ULBT as a predictor of difficult airway could be due to the fact that the sex and ethinicity of patients impact the accuracy and dependability of ULBT as lip size varies among ethinic groups.

In the present study, patients having Thyromental distance (TMD) <6.5 cm were assumed to have difficult airway. TMD was found to have negative correlation with difficult intubation with very low AUC of 0.335 and sensitivity of 60.0% and high specificity (87.06%) and NPV (92.50%). Similar findings were observed by Abdelhady et al[5] and found thyromental distance had sensitivity of 53.3%, specificity of 80%, NPV of 88.1% with AUC of 0.670. Yadav U et al[12], reported specificity of 91.2% and NPV of 89.95% with AUC of 0.580. The findings of our study and above studies show that TMD predicts difficult airways with strong specificity and accuracy but with low sensitivity.

LIMITATIONS: In the present study more female patients were present as compared to male patients. Most of the male population in this region has beard which makes ultrasonic examination of airway in neck region more difficult. Secondly ultrasound assessment of airway was done by different anesthesiologists. Hence vulnerability to interobserver variations is possible depending upon the degree of pressure on the ultrasound probe and experience of a person. Mobile nature of the tongue can also lead to variations in the measurement which might effect the overall efficacy of a parameter in predicting difficult airway.

CONCLUSION: Among clinical parameters, Hyomental distance ratio was a good predictor of difficult airway with high area under ROC curve with good sensitivity and specificity. However, Ultrasound guided parameters have an edge over clinical parameters as ultrasound guided skin to epiglottis distance is more accurate and has highest sensitivity, specificity, positive predictive value and negative predictive value with highest area under ROC curve for predicting difficult airway.

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