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*RESEARCH ARTICLE*

# USE OF ULTRASOUND PARAMETERS FOR PREDICTION OF DIFFICULT INTUBATION AND IT'S RELATION WITH THE CORMACK AND LEHANE GRADE OF LARYNGOSCOPY

**Satyapal Dhaka[1], Sunita Meena[2], Gopal Bansal[3], Bheru Dan Charan[4], Meenu Bagarhatta[5] and Vandana Mangal[6]**

1. Senior Resident, Pandit Deendayal Upadhyay Medical College Churu.
2. Associate Professor, Department of Anaesthesia, SMS Medical College Jaipur.
3. Assistant Professor, Department of Anaesthesia, SMS Medical College Jaipur.
4. Resident, Department of Radiodiagnosis, SMS Medical College Jaipur.
5. Senior Professor Department of Radiodiagnosis, SMS Medical College Jaipur.
6. Senior Professor, Department of Anaesthesia, SMS Medical College Jaipur.

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## *Abstract*

**Background and AIMS:** Airway ultrasound is novel,safe and noninvasive modality that help in predicting difficult airway.This study aimed todetermine the usefulness of airway ultrasound in order to predict difficult intubation.

**Method:-** This was a hospital based prospective observational study on 100 patients aged 18-60 years of either sex undergoing elective surgery under general anaesthesia with endotracheal intubation.Preoperatively physical airway evaluation was performed byusing six parameters including Modified Mallampati class(MMC), thyromental distance(TMD), sternomental distance(SMD) , inter-incisor (IID)distance , hyomental distance(HMD)and neck circumference(NC). In preoperatively, Airway Ultrasoundwas performed andnoted the ratio of the depth of the pre-epiglottic space (PES) to the distance from the epiglottis to the mid-point of the distance between the vocal cords (E-VC). CL grade was also noted during laryngoscopy. Compared ultrasound parameters with Cormack–Lehane grade. Specificity,Sensitivity, positive predictive value (PPV), negative predictive value (NPV) and accuracywere calculated.Airway ultrasound measurements were compared with physical parametersin predicting Cormack –Lehane grade.

**Results**: The incidence of difficult intubation was 7%. Sensitivity of PES/E-VC ratio was higher than NC, TMD, HMD, IID and SMD but less than Mallampati class. Specificity, PPV was lower than physical parameters.NPV was comparable.

**Conclusion**: Percutaneous airway ultrasound is useful and promising technique for predicting Cormack and Lehane grading but a combination of all these is definitely helpful for better prediction.



**Corresponding Author:- Sunita Meena**
Address:- Associate Professor, Department of Anaesthesia, SMS Medical College Jaipur.

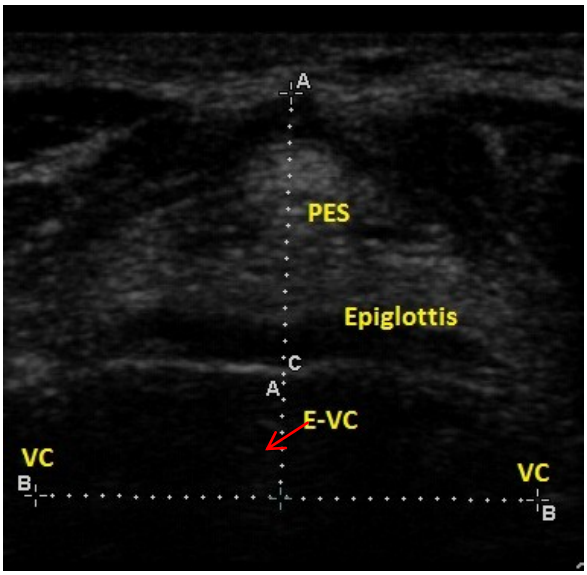
## Introduction:-

Airway- related morbidity,as the result of an inability to anticipate difficult airway,remains the primary concern for anesthesiologist[1].Over the years various measurements of the airway have been done both physically and radiologically in anticipation to correctly predict the laryngoscopic view. Various indices used are Mallampati grade(MPG),thyromental(TM),hyomental(HM),sternomental (SM) distance to name a few which have beenused to predict a difficult airway[2].Ultrasound of upper airway can provide some additional anatomic information that would not be evident onclinical examination.Ultrasound has been used to assess the size of tongue[3] , floor of the mouth musculature[3], epiglottis[4] , depth of pre-epiglottic space[5], distance from epiglottic to mid-point of vocal cord[5] , anterior neck soft tissue thickness[6] predict the difficulty in laryngoscopy and intubation.These measurements have been used to correlate with findings of physical assessment. The Cormack-Lehane grading is widely used for laryngoscopic view during intubation. In our study we, tried using the versatile ultrasonography to preoperatively assess the upper airway to predict the Cormack and Lehane grade of laryngoscopy.

## Methods:-

After approval from Institutional Ethics Committee (No.2378/MC/EC/2016) and obtaining informed consent, hospital based prospective observational study was conducted on 100 patients aged between 18-60 years of either sex posted for elective orthopaedic surgery under general anaesthesia with laryngoscopic endotracheal intubation. Patients posted for emergency surgery, facial trauma, beard, lack of teeth or any anatomical deformity of head, neckand cervical spine, pregnant patients and those not willing to participate were excluded from study. The pre-anaesthetic airway assessment was carried out in two stages, physical assessment and ultrasound assessment of the airway before surgery. In physical assessment neck movement, mouth opening, upper lip bite test [7], Modified Mallampati class [8](MMC), Thyromental distance(TMD),Sternomental distance(SMD ),Hyomental distance(HMD), Interincisor distance(IID), Neck circumference( NC)were noted and recorded of all patients prior day of surgery. Ultrasonographic airway assessment of all patientsdone by the same anaesthetic who was experienced in airway ultrasound in the preoperative holding area. Airway ultrasound assessmentwas performed in supine position with fully extendedneck. The high frequency linear probe of SonoSite® MicroMaxx® ultrasound system (SonoSite INC, Bothell, WA) HFL38/6-13 MHz transducer) was used for the ultrasonographic measurements. The probe was placed in submandibular area in the coronal plane as shown in picture (A) which shows the base of tongue, the probe was gradually slide down in the mid-line in caudad direction till we could visualize hyoid as ´C` shaped hypo-echoic area as shown in picture (B). The movement in caudad direction was continued till the hyoid just disappears and epiglottis appeared as ´V` shape hypo-echoic image (in picture 'C'). Image was optimized to visualize the vocal cords at this point. The epiglottis was confirmed by asking them to swallow. Phonation was used for identification of the vocal cords; as shown in picture 'D' at this point using calipers measurements were done. First caliper (vertical-A) was used to measure the distance from skin to epiglottis, and labeled as a pre-epiglottic space (PES). Distance between epiglottises to mid-point of the vocal cords was measured by drawing two lines. Second caliper (horizontal-B) was used to join the two vocal cords; finely third caliper (vertical-C) was used to join the mid-point of line B to the center of epiglottis which was taken as distance of epiglottis to mid-point of the vocal cords (E-VC). Distance measured by caliper 'A' is the PES (Depth of the pre-epiglottic space) and E-VC is the distance from the epiglottis to the midpoint of the distance between the vocal cords as measured by caliper 'C'.

**Picture 'A'** **Picture 'B'** **Picture 'C'**




**Picture:-** D Ultrasound image of parameters.

Figure1-PictureA, B, C shows position of USG probe,PictureDshowsUSG calipers for measurements.
After that patients were shifted to operation-theater and general anaesthesia was performed as per institutional protocol with baseline monitoring.Thepatientswere induced and intubated by experienced senior anaesthesiologist (not involved in preoperative airway assessment).Direct laryngoscopy was performed using a Macintosh size 4 blade and the Cormack-Lehane grade [9]notedin sniffing position without external laryngeal pressure. Airway was secured by using appropriate size cuffed endotracheal tube and anaesthesia was maintained.

The minimum sample size required was 89 at 95% coefficient limit and 80% power to verify the expected 67% sensitivity of ultrasonography for prediction of difficult intubation so 100 patients were required to participate in thisstudy. Statisticalanalysis was performed with the SPSS,version21for windows statistical software package (SPSS Inc., Chicago, IL, USA).Continuous data was presented as mean and standard deviation. Qualitative data in the form of proportions and difference in proportions were analyzed by chi-square test.Level of significance were kept 95% for all statistical analysis.

## Results:-

Total 100 patients were participated in the study. Demographic data shows in table 1.

| Patient characteristics | Mean ±SD | Confidence interval (at 95%) |
|---|---|---|
| Age | 34.88±13 | 32.33-37.43 |
| Weight(kg) | 64.55±11.42 | 62.31-66.79 |
| Height(cm) | 167.31±8.37 | 165.67-168.95 |
| BMI($Kg/m^2$ | 22.84±2.91 | 22.27-23.41 |
| Neck circumference(cm) | 34.18±3.52 | 27.14-42.22 |
| Thyromental distance (cm) | 8.64±0.93 | 8.46-8.82 |
| Sternomental distance(cm) | 18.64±1.60 | 18.33-1896 |
| Hyomental distance(cm) | 5.97±0.80 | 5.81-613 |
| Interincisor (cm) | 5.40±0.97 | 5.21-5.59 |

Incidence of difficult laryngoscopy in our study was only 7%. It was observed that 57% patients had CL Grade 1, 36% had CL Grade 2, 5% had CL Grade 3 and 2% had CL Grade 4.

In our observations 32 patients had MMC 3/4 (7 patients CL grade 3/4 and 25 patient CL 1/2) and 68 patients had MMC 1/2 (68 patients CL grade 1/2).Most commonly and reliably used indicator MMC had 100% sensitivity and negative predictive value (NPV), specificity 73.1% and positive predictive value (PPV) 21.9% with accuracy of 75%.

The cut-off value [10] of NC 35.5cm for predictor of difficult laryngoscopy.We were observed that 50 patients NC ≥ 35.5cm(46 patients CL grade 1/2 and 4 patients CL grade 3/4) and 50patients NC< 35.5cm (47 patients CL grade 1/2 and 3 patients CL grade 3/4).

The cut-off value of TMD ≤ 6.5cm for predictor of difficult intubation [11]. In our observations 3 patients had values ≤ 6.5cm (2 patients CL grade 1/2 and 1 patients CL grade ¾ and 97 patients TMD > 6.5cm (91 patients CL grade 1/2 and 6 patients CL grad3/4).

HMD ≤5cm is considered to predict difficult laryngoscopy[12].In our observations 95patients had HMD ≥ 5cm (89 patients CL grade 1/2 and 6 patients CL grade 3/4) and 5 patients HMD < 5cm (1 patient CL grade 3 and 4 patients CL grade 2.

Inter-incisor distance cut off value is≤4cmto predict difficult laryngoscopy[13]. We observed that majority patients 95 had IID ≥ 4cm (89 patients CL grade 1/2 and 6 patients CL grade 3/4 and 5patients IID< 4cm (4 patients CL grade 1/2 and 1 patient CL grade 3.

SMD cut off value is ≤12 cm to predict difficult laryngoscopy[14].We were observed that all the patients had SMD >12.0cm (7 patients CL grade 3/4 and 93 patients CL grade 1/2).

For ultrasonographic assessment using the measured parameter, the ratio of PES/E-VC distance was calculated and cut-off value [15]was taken as >2 as suggested in previous studies. In our observations 52 patients had a ratio >2 (6 patients CL grade 3/4 &46 patients CL grade 1/2) and 48 patients ratio <2 (1 patient CL grade 3 & 47patients CL grade 1/2).The comparison of ultrasonographic measurements with physical parameters in predicting the Cormark - Lehane grade- sensitivity, specificity, PPV, NPV and accuracy of the parameters were calculated and represented in (table 3)

**Table 2:-** Shows the distribution of the CL grade in comparison with ultrasound parameters.

| **CL grade** (n) | 1 (57) | 2 (36) | 3 (5) | 4 (2) |
|---|---|---|---|---|
| **PES** (mean in cm.) | 1.50 | 1.46 | 1.72 | 1.86 |
| **E-VC** (mean in cm.) | 0.73 | 0.79 | 0.75 | 0.66 |
| **PES/E-VC** | 2.10 | 2.00 | 2.46 | 2.82 |

**Table 3:-** Shows comparison of ultrasonographic measurements with physical parameters in predicting the Cormark–
Lehane grade- sensitivity, specificity, PPV, NPV and accuracy of the parameters.

| Parameters | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) | Accuracy (%) |
|---|---|---|---|---|---|
| PES/E-VC | 85.7 | 50.5 | 11.5 | 97.9 | 53 |
| MMC | 100 | 73.1 | 21.9 | 100 | 75 |
| NC (cm) | 57.1 | 50.5 | 8 | 94 | 51 |
| TMD (cm) | 14.3 | 97.8 | 33 | 93.8 | 91 |
| HMD (cm) | 14.3 | 95.7 | 20 | 93.7 | 90 |
| IID (cm) | 14.3 | 95.7 | 20 | 93.7 | 90 |
| SMD (cm) | 0 | 100 | 0 | 93 | 93 |

PES/E‐VC ‐ ratio of the depth of the pre‐epiglottic space to the distance from the epiglottis to the mid‐point of the distance between the vocal cords; MMC – Modified Mallampati class; TMD – Thyromental distance; SMD – Sternomental distance; PPV – Positive predictive value; NPV – Negative predictive value, NC-neck circumference, IID-Inter-incisor distance

## Discussion:-

Ultrasound imaging of the upper airway has emerged as safe, rapid, simple, novel, non-invasive, portable modality which can serve as a useful adjunct to clinical methods of bedside airway assessment by assessing the airway to predict difficult intubation. The Cormack-Lehane gradingcan't be used to predict difficult tracheal intubation for the first time. Direct laryngoscopy is too invasive technique to be used for assessment and predict difficult airway[5]

ReddyPBetal[16] found BMI range 14.2-39kg/$m^2$, incidence of difficult intubation14%,In our study incidence difficult intubation 7%, out of which 5 had BMI >25 kg/$m^2$ and MMC 3/4.They were found that ANS-VC>0.23 cm had highest sensitivity 85.7% in predicting a CLgrade3/4 which was higher than MPclass≥3 (71.4%), TMD<6.5 cm (28.6%), SMD≤12.5cm (28.6%) and also Pre-E/E-VC (1.2%).We observed 100% sensitivity and NPV for MMC in predicting difficult laryngoscopy.**Adamus M et al[17]** assessed the airway by Samsoon's and young's modified Mallampati test (MMT) and failed to detect 35.4% patients with difficult laryngoscopy.AdamusM et al [17]and Narang Netal[18] were found that conventionally used MMC a fairly good predictorof difficult intubation. However in another study, Agni shah et al[19]studied8% subjects of total were obese (BMI ≥ 30kg/$m^2$and incidence of difficult intubation 23%. They were found that Mallampati also a good predictor of difficult intubation but ultrasonographic measurement distance skin to anterior commissure of vocal cord (DSVC) had high sensitivity than MP class.

In our study cut off value of PEC/E-VC ratio was >2 for predicting difficult laryngoscopy whereasGupta et al[5] study cutoff value 1.49. Shelly et al[1] cutoff value>1.77 and Vishal et al[20]PEC/E-VCratio cut off value was ≥1.785.

In our study value of mean(cm) PES/E-VC were 2.10,2.00 for CL grade 1,2,and 2.46, 2.82 for CL grade 3,4 whereas Reddy et al[21] mean were 1.22,1.25,1.38 for CL grade 1, 2 ,3 not encounter patientsCLwith grade 4.

We were observed weak correlation of PES and E-VC with CL grading and almost similar sensitivity of 85.7% for the PES/E-VC ratio but observed a strong correlation between MMC and ratio of PES/E-VC as all 7 patients with difficult laryngoscopy had a MMC of 3/4 and ratio >2.46. Gupta D et al[5] found strong negative correlation between E-VC with CL grading , positive correlation of PES with the CL grading was strong and strongest correlation of ratio of PES/ E-VC distances with the CL grading (Sensitivity67-68%) .Mohammadi S et al[22] found weak correlation of PES and E-VC with CL grading but PES/E-VC ratio for correlation with CL grading had 87.5% sensitivity and 30% specificitybut no correlation Mallampati class with PES/E-VC ratio.Parameswari A et al**[23]** were found that the skin to epiglottis distance was most sensitive (75%), specific (63.6%) index in predicting difficult laryngoscopy than MMP classification sensitivity(66.7%).Vishal et al[20]evaluating many ultrasonographic measurements to predicting difficult CLgrade laryngoscopy in which one predictor was PEC/E-VC ratio with sensitivity 82.8% and specificity 83.8%.Recently airway assessment through ultrasonography increasing in use by anaesthesiologist so various studies related to it .Harith Daggupatiet al[24] developed an airway scoring system using the ultrasound measurement of skin to epiglottis distance along with clinical predictors. Another recent study Nabin et al[25] ultrasound measurement of anterior neck soft tissue thickness (at the level of hyoid and thyrohyoid membrane) and tongue thickness along with clinical parameters can be used in predicting difficult laryngoscopy.RuchiOhri et al[26] recently evaluated and compared three different 2D ultrasound methods to calculate tongue volume for prediction laryngoscopy.There are few limitations of our study, that exclude facial trauma and pregnant patients, only 5 patients had BMI>25 kg/$m^2$,compared only one ultrasonographic parameter PES/E-VC ratio with clinical parameter to predict difficult intubation.

## Conclusion:-

Percutaneous ultrasonographic assessment of the airway is useful and promising technique for predicting CL grading as it does not require much patient co-operation, so it can be done even in unconscious patients and patients with restricted mouth opening. But we need to find the appropriate measurements whether it be anterior neck soft tissue, pre-epiglottic space (PES), tongue volume, mobility of epiglottis, epiglottis to mid-point of the vocal cords distance (E-VC), ratio between PES/E-VC need to be investigated

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