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Research Article

Evaluation of Ultrasound Guided Measurement of Tongue Thickness in Predicting Difficult Tracheal Intubation in Patients Undergoing Elective Surgery: A Cross Sectional Study

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ABSTRACT

Background: Preoperative airway assessment is necessary to identify airway difficulties to the earliest, ensure adequate preparation to airway management before induction and to avoid airway related complications. Various Imaging techniques have been studied for prediction of the difficult airway. the ultrasound is a quick and simple technique. Aim of the study was to evaluate ultrasound guided measurement of tongue thickness in predicting difficult tracheal intubation in patients undergoing elective surgery.

Methods: Sixty-one patients American Society of Anesthesiologist class I and II,18-65 years of age, either sex, were included. Tongue thickness was measured by ultrasound as the distance from the surface of tongue to the submental skin. Modified mallampatti score was also recorded.

Results: Receiver operating characteristic (ROC) curve of tongue thickness showed an AUC of 0.879 for a cut off value of >6 cm. This shows it has an excellent predictive value. Tongue thickness (>6cm) was found to have 90.16% combined diagnostic accuracy with 75% sensitivity and 94.74% specificity for prediction of difficult intubation. No correlation between tongue thickness and modified mallampatti score. (Correlation coefficient was 0.013, p value 0.920).

Conclusion: We conclude that ultrasound guided measurement of tongue thickness> 6 cm can reliably predict difficult tracheal intubation in patients undergoing elective surgery.

Maintaining a patent airway in an anaesthetised or a critically ill patient is the fundamental responsibility of the attending doctor and failure to preserve it, even for a short period of time can endanger the life of the patient. Accurate assessment of airway can prevent catastrophic perioperative events like hypoxia, arrhythmias, hypercapnia and cardiac arrest. This implies the importance of preoperative evaluation of airway. The anaesthetist should have adequate expertise and be well prepared to deal with any difficulties arising during securing of the airway. Thus, the aim of preoperative airway assessment is to identify any airway difficulties at the earliest, ensure adequate preparation to manage it prior to induction, and develop safe strategies for difficult airway management [1-3].

Difficult airway is defined as a clinical situation where a conventionally trained anaesthetist finds difficulty with facemask ventilation or tracheal intubation or both [4]. Difficult laryngoscopy is defined as a laryngoscope view of Cormack Lehane grade (CL grade) III & IV.5 Difficult tracheal intubation, which is still lacking a generally acceptable definition, is considered as insertion of

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endotracheal tube requiring more than multiple attempts of conventional laryngoscopy or requiring multiple operators or requiring more than 10 minutes or requiring use of an alternate device or technique [5-7].

Standard preanaesthetic airway assessment includes inter-incisor gap measurement to evaluate mouth opening, modified Mallampatti classification to assess oropharyngeal cavity, thyromental distance, sternomental distance, neck circumference, temporo-mandibular joint function assessment using jaw protrusion and upper lip bite test, neck movement etc [4]. Though these indices are easy to perform and can be assessed at the bedside, they have low sensitivity, low predictive value and their reproducibility can be difficult. Hence, there is 1-8% chance of facing an unanticipated difficult airway situation [8]. An uncooperative and confused patient can make these even more difficult to apply. Further, direct laryngoscope visualisation of the vocal cords requires a deep plane of anaesthesia to avoid sympathetic stimulation. An unanticipated difficult intubation during that time can be a dreadful situation. Hence preoperative techniques that help in accurately predicting the difficult airway are necessary for patient care.

Various Imaging techniques have been studied for prediction of the difficult airway. As compared to Xray, CT scan and MRI, the ultrasound is a quick and simple technique. It is portable, non-invasive, easier imaging technique and safe with no exposure to radiation [9]. Anatomical structures involved in airway assessment are mostly within 5 cm from skin surface [10]. Hence, a conventional ultrasonography (USG) can help in assessing these structures and is being increasingly used for airway evaluation.

A large tongue is a known predictor of difficult airway. Although modified Mallampatti test reflects tongue size, its predictive value is low and it cannot be used as an independent and accurate tool for airway assessment. Poor inter observer reliability is another issue related with the modified Mallampatti class [4,11-12]. Measurement of anterior neck soft tissue thickness, tongue thickness, distance from skin to epiglottis and epiglottis to mid-vocal cord by ultrasonography predicts difficult intubation [13-15]. USG is a tool which measures tongue thickness accurately and can aid in prediction of difficult intubation in the operation theatre, ICU, or emergency room. Also, the tongue can be easily located submental with ultrasonography. Thus, we hypothesize that USG guided measurement of tongue thickness can be used to predict difficult tracheal intubation in patients undergoing elective surgery. Aim of the study was to evaluate ultrasound guided measurement of tongue thickness in predicting difficult tracheal intubation in patients undergoing elective surgery.

Methods

This Cross sectional observational study was conducted after approval from institutional ethics committee between 1st November 2019 to 31st March, 2021 and clinical trial registry of India (CTRI/2020/04/024558). Sixty-one Patients of either sex, age between 18 to 65 years belonging to American Society of Anaesthesiologists (ASA) Grade I and II, posted for elective surgeries and requiring general anesthesia with endo-tracheal intubation were included in this study. Patients with thyroid or neck swelling, cervical spine fracture, facial fracture, maxillofacial abnormality, tumour of upper airway, inter-incisor distance <3 cm, pregnant patients and previous history of difficult intubation were excluded from the study.

Sample size was calculated based on a past study by Yao W et al, this study observed that sensitivity and specificity of increased tongue thickness for predicting difficult tracheal intubation was 75% and 72% respectively.7 Taking these values as reference, the minimum required sample size with desired precision of 15%, 80% power of study and 5% level of significance is 61 patients.

After obtaining written informed consent from the patients, a thorough pre anaesthetic airway evaluation was done, during which modified Mallampatti grading was noted. Then these enrolled patients underwent an ultrasonography assessment of tongue thickness in the preoperative area. All the USG assessments were done by the same anesthesiologist. Patients were positioned without a pillow in supine position with full neck extension. They were asked to keep their mouth closed. The tip of the tongue was touching the back of incisors and no phonation was allowed during examination. USG jelly was applied, linear USG probe (6-13 MHZ) was placed under the chin of the patient in the median sagittal plane. The probe was adjusted till the entire tongue outline was clearly seen on the screen and the image was frozen. The maximal vertical dimension from the surface of tongue to the submental skin was taken as tongue thickness and measured (Figure 1).

Figure 1- Tongue thickness under the chin

In operation theatre, baseline values of heart rate, systolic and diastolic blood pressure, SpO2 were noted. In all patients, general anaesthesia was given as per the following protocol: Premedication with Inj. midazolam 1mg I.V. and Inj. fentanyl 2mcg/kg I.V followed by anaesthetic induction using Inj. propofol 2mg/kg I.V. After checking adequate mask ventilation, neuromuscular blockade was achieved by giving Inj. Vecuronium 0.1 mg/kg I.V. Patient was ventilated for 3 minutes. Direct laryngoscopy and intubation using appropriate sized endotracheal tube was performed by an anaesthesiologist who was unaware of the ultrasound-based assessment. Cormack & Lehane (CL) grade was noted. Number of attempts for intubation, time taken for intubation and use of any alternate device or technique were noted. Throughout the procedure, adequate ventilation and oxygenation was maintained using bag and mask ventilation to maintain the oxygen saturation above 98%. The study concludes at this point. Anaesthesia was maintained using 1 MAC Sevoflurane with 50:50 O2 and N2O. At the end of surgery, neuromuscular blockade was reversed with Inj. Neostigmine 0.05 mg/kg and Inj. Glycopyrrolate 0.01 mg/kg. Primary outcome measure of this study was to predict difficult intubation using USG measurement of tongue thickness.

In statistical analysis Categorical variables was done in the form of number and percentage (%). On the other hand, the quantitative data were presented as the means ± SD. Receiver operating characteristic curve was used to find out cut off point of tongue thickness(cm) for predicting difficult intubation. Sensitivity, specificity, positive predictive value and negative predictive value was calculated of tongue thickness(cm) for predicting difficult intubation. The association of tongue thickness(cm) was analysed using ANOVA for more than two groups. Spearman rank correlation coefficient was used to find correlation of tongue thickness(cm) with Mallampatti grading. The final analysis was done with the use of Statistical Package for Social Sciences (SPSS) software, version 21.0. For statistical significance, p value of less than 0.05 was considered statistically significant.

Results

Mean ± SD age of the study population was 41.39 ±12.6. 29.51%(18) male and 70.49%(43) of the patients enrolled in the study were females. Mean ± SD body mass index(kg/m²) was 23.88 ± 1.76. Mean ± SD weight (kg) was 61.84 ± 7.38. Mean ± SD height (cm) was 160.7 ± 7.05. Airway assessment of the patients showed 27 (44.26%) patients had Modified Mallampati class I, 11 patients had Modified Mallampati class II, 23 (37.7%) patients had Modified Mallampati class III and None of the patients belonged to Modified Mallampati class. Mean ± SD tongue thickness(cm) was 5.59 ± 0.37 (Table 1).

Table 1- Demographic details

Age in Years (Mean ± SD)	41.39 ± 12.6
Weight(kg) (Mean ± SD)	61.84 ± 7.38
Height(cm) (Mean ± SD)	160.7 ± 7.05
Body mass index(kg/m²) (Mean ± SD)	23.88 ± 1.76
Sex (Male/Female), N	18/43
Mallampatti Score:1/2/3/4	27/11/23/0
Tongue thickness(cm) (Mean ± SD)	5.59 ± 0.37

Intubation was easy in 57 (93.44%) patients and was difficult for 4 patients. 3 patients were intubated in the 2nd attempt and a stylet was used for intubation. 1 patient got intubated in the 3rd attempt with the help of a bougie. Mean time taken for easy intubation was 33.35 ± 9.51 seconds and for difficult intubation was 116 ±15.06 seconds (Table 2).

Table 2- Easy/Difficult intubation, Number of attempts for intubation, Use of adjuncts for intubation, Time taken for intubation(seconds)

Easy/Difficult intubation	**Frequency**	**Percentage**
Easy intubation	57	93.44%
Difficult intubation	4	6.56%
Number of attempts		
1	57	93.44%
2	3	4.9%
3	1	1.63%
Use of adjunct		
Not required	57	93.44%
Bougie	1	1.64%
Stylet	3	4.92%
Time taken for intubation(seconds)	Easy intubation (n=57)	Difficult intubation (n=4)
Mean ± SD	33.35 ± 9.51	116 ± 15.06

The cut off value of tongue thickness for prediction of difficult intubation using tongue was found to be 6 cm. ROC curve of tongue thickness showed an AUC of 0.879 (SE: 0.0975; 95% CI: 0.771 – 0.949) for a cut off value of >6 cm. This shows it has an excellent predictive value.

Tongue thickness was found to have 90.16% combined diagnostic accuracy with 75% (19.4 - 99.4%) sensitivity, 94.74% (85.4 - 98.9%) specificity, positive predictive value of 50% (11.8 - 88.2%) and a negative predictive value of 98.2% (90.3 - 100.0%) for prediction of difficult intubation. (Table 3, Figure 2).

Table 3- Receiver operating characteristic curve of tongue thickness for predicting difficult intubation

Area under the ROC curve(AUC)	0.879
Standard Error	0.0975
95% Confidence Interval	0.771- 0.949
P value	0.0001
Cut off	>6

Sensitivity (95% CI)	75% (19.4 - 99.4%)
Specificity (95% CI)	94.74% (85.4 - 98.9%)
PPV (95% CI)	50% (11.8 - 88.2%)
NPV (95% CI)	98.2% (90.3 - 100.0%)

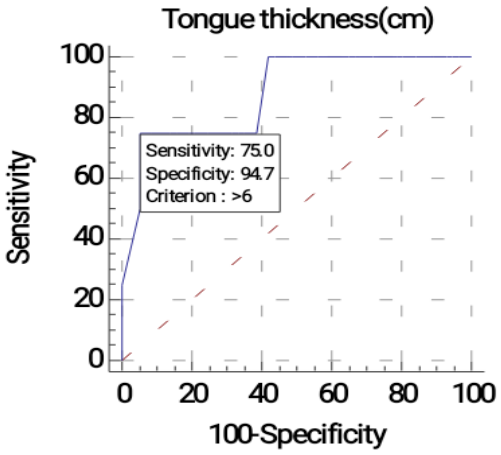

Figure 2- Receiver operating characteristic curve of tongue thickness for predicting difficult intubation

Mean tongue thickness for MMP grade 1 was 5.58 ± 0.34 cm, for MMP grade II was 5.54 ± 0.23 cm and for MMP grade III was 5.59 ± 0.37 cm. To identify the association of tongue thickness with MMP grade, ANOVA test was done and it was found to be not significant (p value 0.920). Spearman rank correlation coefficient was then done to find out the correlation between tongue thickness values and MMP grade of the patient. Correlation coefficient was 0.013 which is close to 0, showing that there is no correlation between tongue thickness and modified mallampatti score.

Discussion

Optimal preoperative patient evaluation and preparation for airway intervention is important for safer anaesthetic management. The application of ultrasound for airway assessment is to bridge the gap between preoperative airway assessment and difficult airway. Various ultrasonography aided upper airway measurements are under evaluation to predict difficult intubation with an acceptable accuracy. One of the parameters under evaluation is tongue thickness. Our results showed that tongue thickness is a predictor difficult intubation. No correlation could be made between tongue thickness and MMP classification in our study.

Our primary outcome was to determine if tongue thickness could be used as a predictor of difficult intubation. The cut off value for tongue thickness to predict difficult intubation in our results was found to be >6.0 cm. Above that value, tongue thickness had a sensitivity of 75%, specificity of 94.74%, positive predictive value of 50% and a negative predictive value of 98.2% with an AUC of 0.868. The combined diagnostic accuracy for the same was 90.16%. Various studies have classified it on the basis of number of attempts taken, number of operators, time taken for intubation and requirement for alternate devices or techniques [5-7,16]. In our study, 4 patients were classified as difficult intubation because of the use of adjuvants. For 3 patients, stylet was used, while for 1 patient, a bougie was used for securing the airway.

Similar results were found by Yao W et al They found that tongue thickness has a statistically significant predictive value for difficult laryngoscopy and difficult intubation.7 Their study showed that an increased tongue thickness of > 6.1 cm is an independent predictor of difficult intubation with sensitivity of 75% and specificity of 72% with an AUC of 0.78. The positive predictive value and negative predictive value in their study was 6% and 99% respectively.

Another study done by Agarwal R et al. [17] in 2021 also found a statistically significant relation between tongue thickness and difficult intubation with an AUC of 0.880 at a cut off value of 5.8 cm. The sensitivity and specificity were found to be 84.5% and 78.1% respectively. These results in these studies were similar to our study.

A study done by Yadav NK et al. [14] in 2019 also concluded that USG guided measurement of tongue thickness can predict difficult intubation. Since the values of tongue thickness in their study were not normally distributed, they derived the median value of tongue thickness for difficult intubation prediction. The median value in that study was found to be 6.1 cm. The AUC of USG guided tongue thickness assessment for predicting difficult intubation was 0.72 & sensitivity and specificity were 69.6% and 77% respectively. The results were also found to be statistically significant with a p value of 0.0001. Our study also revealed a similar result.

Another study done by Kumar AN et al. [18] in 2020 on 60 patients focussed on the depth of posterior 1/3rd of the tongue for airway prediction and derived similar predictive values for difficult intubation. Their study found a sensitivity and specificity of 75% and 88.89% respectively for the predictive value of USG guided tongue thickness for difficult intubation. Yao W et al7, found that tongue thickness >6 cm could predict difficult intubation with a sensitivity of 63%, specificity 66%, positive predictive value of 11% and negative predictive value 96% with an AUC of 0.69.

Our study could not find any statistically significant relationship between tongue thickness and MMP grade. There was no correlation between the tongue thickness values and MMP grade in our study population (Spearman rank corelation coefficient 0.013).

In the study done by Yao W et al7, the corelation coefficient between tongue thickness and modified Mallampati classification was 0.14 which shows they are not corelated. This finding was similar to our study. Adhikari S et al11 also couldn't corelate MMP with tongue thickness using sonography

Our study has certain limitations, the smaller sample size with lesser difficult airway cases. Also, since the study was conducted in a single hospital, the results cannot be extrapolated to the whole population.

Conclusion

We conclude that ultrasound guided measurement of tongue thickness> 6 cm can reliably predict difficult tracheal intubation in patients undergoing elective surgery.

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