Original Article

Different 2D ultrasound calculation methods to evaluate tongue volume for prediction of difficult laryngoscopy

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ABSTRACT

Background and Aims: The aim of the study was to evaluate and compare three different ultrasonographic calculation methods for tongue volume in a real time 2D ultrasonography and correlate with Modified Cormack–Lehane grading observed under direct laryngoscopy. **Methods:** This prospective observational study was conducted in a tertiary care institute. Tongue volume was assessed ultrasonically in 50 adult patients using three techniques in all the patients undergoing surgery under general anesthesia and correlated with Modified Cormack–Lehane grading. In METHOD A, the tongue volume was calculated as multiplication of mid sagittal cross-sectional area and width in transverse plane**;** METHOD B, Cross-sectional area obtained in vertical plane was multiplied with the maximum width of tongue in transverse plane; METHOD C. the volume was calculated by multiplying length, width, and height in vertical, transverse, and mid-sagittal/oblique plane, respectively. The analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0. Receiver operating characteristic (ROC) curve was used to find out cutoff point of different methods for predicting difficult laryngoscopy. **Results:** The specificity and sensitivity of three different methods were statistically compared and area under the receiver operating characteristic (ROC) curve for method A, B, and C was 0.562, 0.502, and 0.548, respectively. **Conclusion:** In our study, we found all three methods to calculate tongue volume to be equally good to assess difficult laryngoscopy.

Key words: Cormack-Lehane grade, direct laryngoscopy, general anaesthesia, tongue, ultrasound

INTRODUCTION

Airway assessment is one of the most important skills for an anaesthesiologist in anticipating difficult intubation, however the possibility of unforeseen difficult laryngoscopy or intubation is relatively high due to poor compliance of clinical airway assessment techniques.[1] During the induction of general anesthesia, difficulty in achieving adequate ventilation or inability to perform tracheal intubation may result in the dreaded "cannot intubate/cannot ventilate" life-threatening catastrophe.[2]

Several bedside physical airway assessment tests are available, but they often fail to address the many factors associated with a difficult laryngoscopy.[3]

Real-time ultrasound is a very useful tool for the assessment of upper airway by visualising the complex anatomy and critical structure of the airway. It is a fast, safe, portable, painless, non-invasive tool of airway assessment, gives real time dynamic images and has no claustrophobic effects. Ultrasound-guided airway can help anticipate difficult airway; and assist management by optimal patient preparation, proper selection of equipment and technique, as well as participation of personnel experienced in the difficult airway management. Determining all these factors

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avoids time consuming, invasive, and potentially more traumatic methods of securing the airway, in addition to ensuring the patient safety.

Anaesthesiologists, in general assume that increased tongue thickness is associated with increased risk of difficult laryngoscopy.[4,5] There are no convenient and accurate methods to measure tongue volume clinically.

The aim of the study was to evaluate and compare three different ultrasonographic calculation methods for tongue volume assessment and find out optimum method to evaluate tongue volume in a real time 2D ultrasonography and correlate with Modified Cormack–Lehane grading[6] observed under direct laryngoscopy during general anesthesia. By using Null hypothesis, the predictive value of all the three calculation methods (Method A, B, and C) are comparable.

METHODS

This prospective observational study was conducted in a tertiary care institute in the operation theatre complex after approval from ethics committee. The study was registered with the Clinical Trial Registry of India (CTRI - 2018/05/013685).

Fifty adult patients of 18-70 years of age, any gender, American Society of Anaesthesiologists (ASA) physical status I to III, posted for elective surgery under general anaesthesia were enrolled for the study. Patients who refused to participate in the study, pregnant woman, associated airway pathology, cervical spine injury, history of previous head and neck surgery and history of arthritis were excluded.

Preanesthetic evaluation and routine clinical assessment of airway, for example, Mallampati grading, thyromental distance, hyomental distance, neck mobility, and mouth opening were done by observer 1 and ultrasonographic parameters was assessed by observer 2, who was adequately experienced in ultrasound and was blinded to clinical parameters. USG machine used was Sonosite® Micromaxx® ultrasound system (Sonosite INC, Bothell, WA, USA). We did not divide 50 patients in different groups. We evaluated tongue volume in every patient with all the three calculation methods with the patient in the supine sniffing position. The tongue volume was obtained as product of multiplication of mid-sagittal cross-sectional area and width in transverse plane with the help of curvilinear and linear transducer respectively as described by Wojtczak *et al*.[7] **(METHOD A).** In second method of calculation of volume, the cross-sectional area was obtained with probe in vertical plane and was multiplied with the maximum width of tongue with probe orientation in transverse plane **(METHOD B).** The third method used for calculation was multiplication of length × width × height with probe in vertical, transverse, and mid-sagittal/oblique plane **(METHOD C)** [Figure 1].

After complete evaluation of tongue volume by 2D method (A, B, C), patient was made to lie supine with a head elevation of 8–10 cm and optimum sniffing position was obtained. Standard monitors were applied and difficult airway cart was prepared in all the cases. For induction of anesthesia, a standard anaesthesia protocol was followed in all patients. Direct laryngoscopy was performed by observer 1 who was blinded to USG findings and the assessment of difficult visualisation of the larynx and difficult intubation was made by applying the modified Cormack–Lehane classification.[6] Laryngoscopy is classified as easy view (CL Grade 1 and 2a, laryngoscopy time <10 s and no adjuvants required)), restricted view (2b and 3a, laryngoscopy time >10 s and external manipulation, e.g., BURP was required) and difficult visualisation (CL Grade 3b and 4, laryngoscopy time >30 s and adjuvant like stylet/bougie was required and more than one attempt was needed).

The number of attempts at intubation, need for alternative difficult intubation approaches, and invasive airway access or cancellation of the procedure due to inability to secure the airway was also noted.

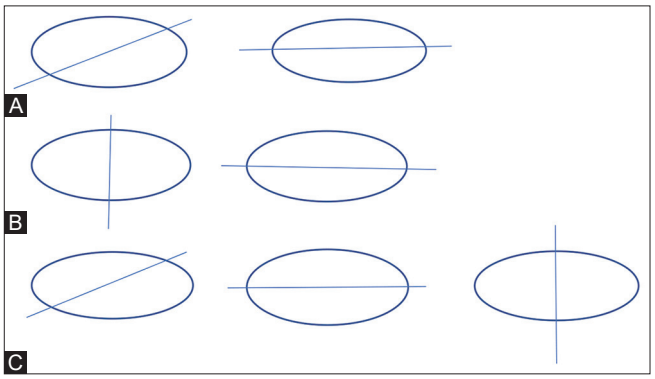

Figure 1: Graphical representation of USG guided 2D methods (A-C) to evaluate tongue volume. METHOD A - multiplication of mid sagittal cross-sectional area and width in transverse plane (* Straight line represents the USG probe orientation). METHOD B - multiplication of vertical plane and transverse plane. METHOD C - multiplication of length × width × height

The sample size was calculated by a study of Parameswari, *et al.*[8] who observed that sensitivity and specificity of tongue volume for predicting difficult laryngoscopy was 66.7% and 62.7%, respectively. Taking these values as reference, the minimum required sample size with desired precision of 20%, 80% power of study, and 5% level of significance was 41 patients. To reduce margin of error, total sample size taken was 50.

Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean ± standard deviation (SD). Receiver operating characteristic curve (ROC) was used to find out cutoff point of different methods for predicting difficult laryngoscopy. Comparison of ROC was performed to find out any significant difference in area under the curve (AUC) between different methods. A *P* value of <0.05 was considered statistically significant. The data was entered in MS EXCEL spreadsheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0.

RESULTS

Fifty patients were recruited into the study, which included 17 male (34%) and 33 females (66%), with age ranging from 18 to 70 years, mean ± SD (42.9 ± 12.25). Body mass index (BMI) of the patient's ranged from 16.1 to 36.8. The incidence of difficult laryngoscopy in our study was 4% (2 patients). 27 patients had an easy visualisation of glottis (CL grade 1 and 2a) (54%), 21 patients had a restricted visualisation of glottis (CL grade 2b and 3a) (%), 2 patients had a difficult visualisation of glottis (CL grade 3b and 4) (4%). Table 1 shows the sensitivity, specificity, PPV, and NPV values of USG-guided tongue volume estimation by methods A, B, and C to predict difficult laryngoscopy. The AUC for method A was 0.562 (*P* value-0.4596), method B was 0.502 (*P* value-0.9773) and method C was 0.548 (*P* value-0.5772). The sensitivity of method A was 95.65 and specificity was 33.33, method B was 86.95 and specificity was 33.33 and method C was 4.35 and specificity was 70.35. Table 2 shows the comparison of methods (A, B, and C) for tongue volume assessment. AUC of methods A, B , and C was compared [Figure 2].

Table 1: Comparison of different 2D USG methods to predict difficult laryngoscopy

	Area under the ROC curve (AUC)	Standard Error	95% Confidence interval	*P*	Cut off	Sensitivity	95% CI	Specificity	95% CI	+PV	95% CI	-PV	95% CI
Method A	0.562	0.0838	0.414-0.702	0.4596	≤104.12	95.65	78.1-99.9	33.33	16.5-54.0	55	38.5-70.7	90	55.5-99.7
Method C	0.502	0.0849	0.358-0.647	0.9773	≤103.207	86.96	66.4-97.2	33.33	16.5-54.0	52.6	35.8-69.0	75	42.8-94.5
Method C	0.548	0.0852	0.400-0.689	0.5772	>123.23	4.35	0.1-21.9	70.37	49.8-86.2	11.1	0.3-48.2	46.3	30.7-62.6

DISCUSSION

Calculation of tongue volume by ultrasound is a non-invasive and safe procedure. The three different methods for calculation of tongue volume (Method A,

Table 2: Comparison of calculation methods (A, B and C) for Tongue Volume assessment			
	Method A~Method B	Method A~Method C	Method B~Method C
Difference between areas	0.0596	0.0145	0.0451
Standard Error	0.053	0.16	0.161
95% Confidence Interval	-0.0444-0.164	-0.299-0.328	-0.270-0.360
Z statistic	1.123	0.0906	0.281
P	0.2612	0.9278	0.7789

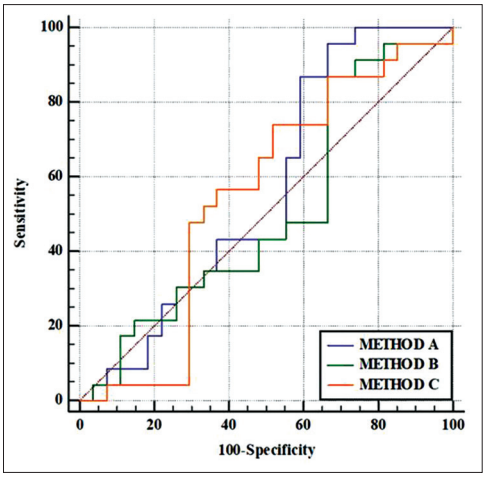

Figure 2: Comparison of AUC of method A, B and C

B, and C) proposed in this study seem to be effective and easy to perform. For correct volume measurement we followed different studies for USG-guided volume assessment.[7-10]

Wojtczak *et al.* have used 3D software method and 2D manual method for tongue volume assessment in their case series and concluded that 2D method overestimates the tongue volume in comparison to 3D; and tongue volume doesn't differ much in patients with difficult or easy intubation.[7] In comparison with study done by Wojtczak *et al.* we measured tongue volume by three different calculation methods via using 2D manual method. Our sample size is larger than previous study. On the other hand, our findings are commensurate to two recent studies using 2D method which found that larger the tongue volume, more difficult the intubation, coinciding with the clinical assumption that size and volume of tongue affects laryngoscopy and view of glottis because of insufficient room in submandibular space.[8,10] The difference of our study from the study done by Andruszkiewiez *et al.* is that they classified difficult laryngoscopy in easy and difficult groups and have taken nine airway sonographic parameters in an anaesthetised person.[10] In our study we classified laryngoscopy in easy, restricted, and difficult groups and we took only one airway parameter, that is, tongue volume and assessed with three different calculation methods to find our more accurate results. We concluded that all the three methods of calculation were equally good to assess the difficult laryngoscopy. Yadav N K *et al.* measured tongue thickness by recording the geniohyoid muscle using a curvilinear probe in the midsagittal plane, with head and neck in neutral and in sniffing position to rule out any difference with change in position. In comparison with study done by Yadav NK *et al.*, we measure tongue volume by three different calculation methods in sniffing position.[11]

The current study may have some limitations as the sample size was small and a single race were included. Only 2D methods were used in the study as ultrasound machines with 3D software are not readily available in our setup. The ultrasonic measurements are vulnerable to variations depending on degree of pressure on the ultrasound probe. Moreover, mobile nature of tongue can also lead to variation in measurement. We excluded patients with cervical spine injury, difficult mouth opening, head and neck carcinoma, previous history of head and neck surgery and with restricted neck movements. In future, research may be conducted in large number of populations with different ethnicity to evaluate different USG parameters in patients with clinically anticipated difficult intubation to further validate these results.

CONCLUSION

USG-guided tongue volume assessment is an easy and safe method to evaluate difficult laryngoscopy. In our study we found that all the three calculation methods for tongue volume measurement are equally good to assess the difficult laryngoscopy.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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