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Comparison of Different Ultrasound Parameters for Airway Assessment in Patients Undergoing Surgery under General Anaesthesia

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Abstract

Aims: The aim of this study was to evaluate and correlate ultrasound measurement of airway parameters with the Cormack–Lehane (CL) grading observed under direct laryngoscopy for prediction of difficult airway.

Methods: This prospective, observational study was conducted in a tertiary care institute. Ninety-six patients were scheduled for elective surgery under general anaesthesia and tracheal intubation. They were categorised as having easy (CL grades 1, 2a, and 2b) or difficult (CL grades 3a, 3b, and 4) laryngoscopy. The sonographically measured airway parameters included anterior neck soft tissue thickness at vocal cord level (ANS-VC), hyomental distance ratio (HMDr), and tongue volume (TV). These parameters were compared and correlated with the CL grading. The statistical analysis was done using SPSS version 21.0.

Results: Difficult laryngoscopy was observed in 17.7% patients. Significant difference was noted in ANS-VC 0.28 ± 0.09; 0.39 ± 0.12, ($P <$ .0001) and HMDr, 1.2 ± 0.09; 1.15 ± 0.13, ($P =$ .006) for easy and difficult laryngoscopy, respectively. ANS-VC had a sensitivity of 78.9% and specificity of 71.1% (AUC-0.816) followed by HMDr (AUC-0.713) and TV (AUC-0.608). Combined ultrasound parameters had significantly higher AUC value (0.867).

Conclusions: ANS-VC was the most significant parameter with a value of >0.29 cm being a sensitive predictor of difficult intubation. Combined sonographic parameters (ANS-VC, HMDr, and TV) were better predictors of difficult intubation.

Keywords: Endotracheal intubation, airway, ultrasound, Cormack–Lehane grading

Introduction

Airway assessment is a vital part of preanaesthetic evaluation. However, the incidence of unanticipated difficult laryngoscopy remains high despite the availability of several clinical airway assessment tools due to their poor reliability.[1]

Ultrasound has become versatile in perioperative practice as a rapid bedside assessment tool.

Several airway sonographic parameters were reported as possible indicators of difficult laryngoscopy in small studies.[2–5] However, no clear consensus was obtained and the quest for a simple and accurate measure continues. Therefore, we planned this study to assess the most widely recommended parameters—anterior neck soft tissue thickness at vocal cord level (ANS-VC), hyomental distance ratio (HMDr), and tongue volume (TV) and observe correlation with modified Cormack–Lehane (CL) grading for prediction of difficult laryngoscopy.[6]

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Figure 1. Ultrasound measurement of anterior neck soft tissue thickness: Ultrasound probe in trasverse position. Distance skin to thyroid cartilage.

Methods

The prospective observational study was conducted in a rural tertiary care institute in operation theatre complex for a period of 12 months after approval from Ethics Committee of BPS GMC (W), Khanpur kalan, sonipat, Haryana, India (ref no.: BPSGMCW/RC 286/IEC/18), and written informed consent was taken from each patient.

Ninety-six adult patients between 18 and 70 years of age, any gender, American Society of Anesthesiologist (ASA) class I to III, scheduled for elective surgery under general anaesthesia were enrolled in the study. Patients who refused to participate in the study, pregnant women, patients with airway pathology, cervical spine injury, history of previous head and neck surgery, and history of arthritis were excluded.

Preanaesthetic evaluation and routine clinical assessment of airway were done by observer 1, and ultrasonic parameters were assessed by observer 2, who was adequately experienced in ultrasound and was blinded to clinical parameters. USG machine was used Sonosite® Micromaxx® ultrasound system (Sonosite Inc, Bothell, WA, USA). With the patient in the supine sniffing position, the anterior neck soft tissue thickness was measured at the level of anterior commissure of vocal cords by using a linear transducer (5-13 MHz) in the transverse section (Figure 1). The distance from the hyoid to the anterior most part of mentum was measured and defined as the hyomental distance in aneutral position by using curvilinear transducer (3-5 MHz) in the midsagittal plane. The patients were instructed to extend the head maximally, taking care the shoulders were not lifted while extending the head. The hyomental distance was measured again in this position, and the ratio of HMDn (in neutral) and HMDe (in the extended position of neck) was calculated (Figure 2). The TV was obtained by product of multiplication of midsagittal cross-sectional area and width in transverse plane with the help of curvilinear and linear transducer respectively as described by Wojtczak et al.[3] (Figure 3).

Main Points

- Ultrasound can be used as a bedside tool for airway assessment in the perioperative prediction of difficult laryngoscopy.
- Combined sonographic parameters (ANS-VC, HMDr, and TV) correlate well with CL grading.
- Combined ultrasound parameters are better predictors of difficult laryngoscopy as compared to an individual parameter.

After complete evaluation of the airway, the 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 kept ready in all the cases. For induction of anaesthesia, 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 CL classification.[6] Intubation is classified as easy (CL grades 1, 2a, and 2b) or difficult (CL grades 3a, 3b, and 4).

The number of attempts at intubation, the need for alternative difficult intubation approaches, and invasive airway access or cancellation of the procedure due to inability to secure the airway was also be noted. The sample size was calculated based on previous studies done by Reddy et al.[7,8] and Adamus et al. The sensitivity of the test is 85.7% with the power of study being 80% and alpha error at 5%, the sample size was calculated to be 96 patients.

Figure 2. Ultrasound measurement of hyomental distance: Ultrasound probe in parasagittal position. Distance measured in neutral and extended neck position.

Figure 3. Ultrasound measurement of tongue volume. Value obtained by multiplication of surface area obtained in midsagittal and transverse plane.

The data were entered into a Microsoft Excel spreadsheet and analysed using statistical software SPSS 21 for quantification data mean ±SD was calculated and for qualitative data percentage and proportion was calculated. Categorical variables were analysed using chi-square test, Fisher exact test, and independent t-test. Sensitivity and specificity were calculated. *P* value < .05 was considered as statistically significant. Receiver operating characteristic curve analysis was made for all three parameters for obtaining cut-off values (Figure 4).

Results

Ninety-six adult patients posted for elective surgery who required endotracheal intubation were presented. The study population included patients of age group 18-70 years with 36.46% males and 63.54% females. As shown in Table 1, the mean age and body mass index were statically higher in patients with difficult intubation. The association with difficult intubation found to be most strong predictor with anterior neck soft tissue thickness at the level of anterior commissure of vocal cords (ANS-VC) > 0.29 cm at *P* value < .0001 followed by HMDr < 1.14 cm ($P = .001$) and TV > 81.8 cm^3 ($P = .006$) (Table 2).

When chi-square test was used, the increase in HMDr values was found to be favourable for easy laryngoscopy (CL grades 1, 2a, and 2b) at *P* value of .004. As an exception to the HMDr trend, it was observed that one patient with favourable HMDr (>1.14 cm) posed difficult intubation with CL grade 3a.

17.70% of our patients with difficult intubation required more than 1 attempt of intubation and required time more

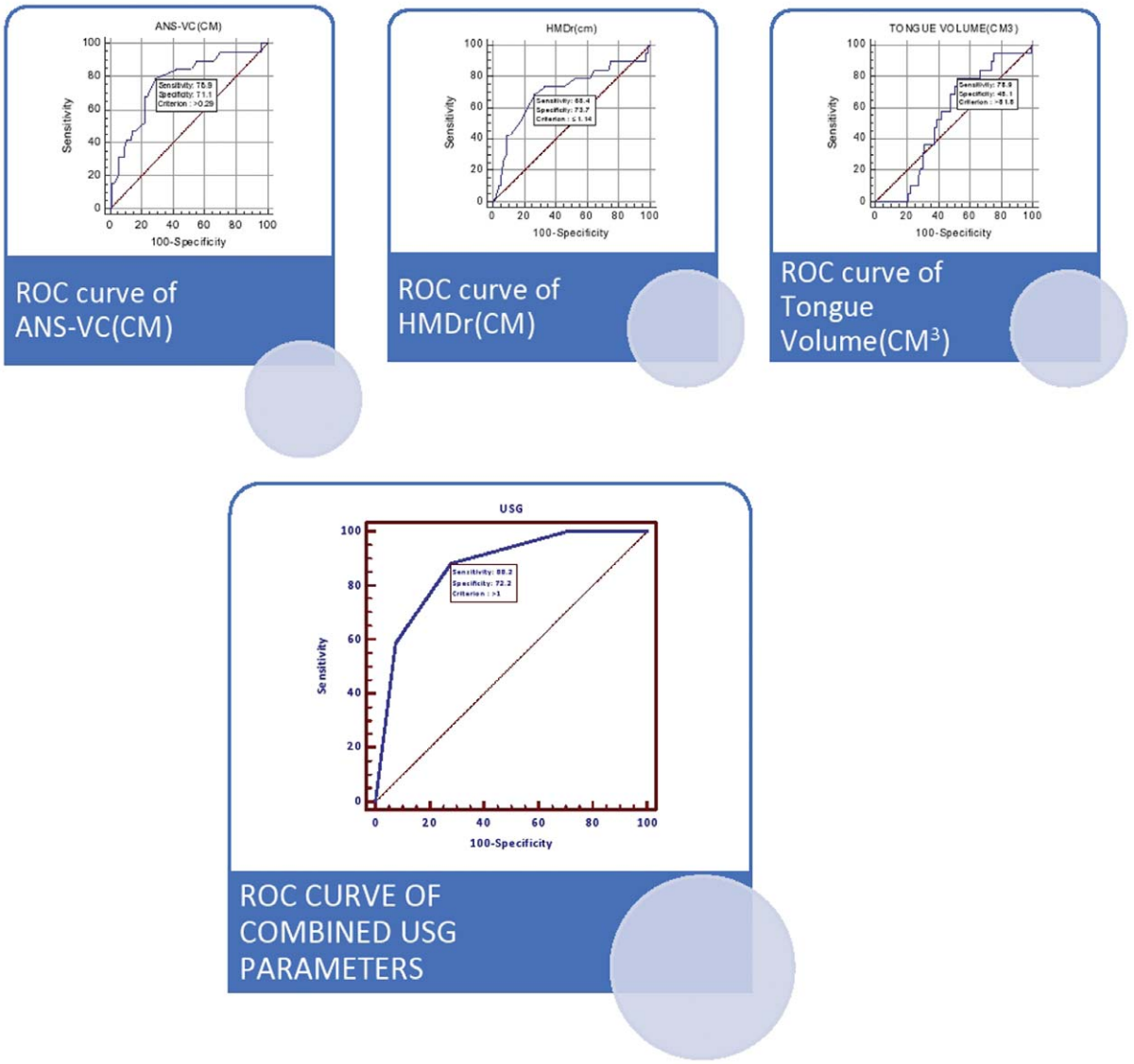

Figure 4. Receiver operating characteristics curve distribution for different parameters.

Table 1. Demographic Characteristics Comparison Based on Ease of Intubation

Demographic characteristics	Difficult (n = 17)	Easy (n = 79)	Total (n = 96)	*P*
1 Age Mean ± SD	49.24 ± 9.56	39.3 ± 13.6	41.06 ± 13.48	.001*
2 BMI (kg/m^2) Mean ± SD	28.34 ± 5.9	24.5 ± 5.03	25.18 ± 5.37	.007*

Abbreviation: BMI, body mass index.
*Independent T test.

Table 2. USG Parameters Comparison Based on Ease of Intubation at Different Levels According to Modified CL Grade

Ultrasonographic parameter at different levels	Modified CL grade		Total	*P*
	Difficult	Easy		
ANS-VC (cm)				<.0001*
≤0.29	2 (11.76%)	57 (72.15%)	59 (61.46%)	
>0.29	15 (88.24%)	22 (27.85%)	37 (38.54%)	
HMDr (cm)				.001#
>1.14	5 (29.41%)	57 (72.15%)	62 (64.58%)	
≤1.14	12 (70.59%)	22 (27.85%)	34 (35.42%)	
Tongue volume (cm^3)				.006*
≤81.8	2 (11.76%)	39 (49.37%)	41 (42.71%)	
>81.8	15 (88.24%)	40 (50.63%)	55 (57.29%)	

Abbreviations: ANS-VC, Anterior neck soft tissue thickness at the level of vocal cords; HMDr, Hyomental distance ratio.
*Fisher's exact test.

than 30 seconds. Among them, 76.47% had ANS-VC > 0.29 cm, 58.8% of patients had HMDr <1.14 cm, and 58.8% of patients had TV > 81.8 cm^3.

ANS-VC was found to be the most significant factor for comparison and assessment of laryngoscopy with sensitivity of 78.9% and specificity of 71.1% (AUC-0.816) followed by HMDr (AUC-0.713) and TV (AUC-0.608), respectively (Figure 4). Combined USG parameters (ANS-VC, HMDr, and TV) is the best predictor of difficult intubation (AUC-0.867) with the sensitivity of 88.2% and specificity of 72.2% (Figure 4).

Discussion

This study represents data of 96 patients of Asian population scheduled for elective surgery under general anaesthesia. Amongst all the three parameters assessed, we found that the anterior neck soft tissue thickness at the level of anterior commissure of vocal cords had the highest sensitivity in predicting difficult intubation followed by HMDr and TV.

Patients of all age groups were selected for our study population. The ossification of cartilages in older patients may cause difficulty in identifying the level of vocal cords. We also encountered this in few of our patients, which was managed by instructing the patient to phonate 'ee' to identify the arytenoid cartilage. Moreover, we had to apply a large amount of jelly or use saline-filled gloves for male patients with prominent thyroid cartilage, which poses a challenge of poor transducer contact with the skin.

Modified CL was used in our study to assess the degree of difficult intubation when assessed under direct laryngoscopy. By increasing CL system grading, sensitivity for studying difficult intubation under direct laryngoscopy is improved.[9]

Anterior neck soft tissue thickness has been studied previously by different researchers at various levels, ie, hyoid bone, thyrohyoid membrane, suprasternal notch, thyroid isthmus as well as vocal cords in different studies.[4,5,10,11] Although the results of all these studies show conflicting results, anterior neck soft tissue thickness at the level of anterior commissure of vocal cords (ANS-VC) has been found to be a better predictor of difficult intubation among other levels of soft tissue thickness in the majority of the studies.[7,10–12] Therefore, we opted anterior neck soft tissue thickness at the level of vocal cords to predict difficult intubation.

A study done on adult Asian population found similar results with cut-off values ANS-VC >0.23 cm being associated with difficult intubation.[7] In our study, ANS-VC >0.29 cm was found to be a good predictor of difficult intubation. The difference in cut-off values between our study and previous ones may relate to ultrasound technique, head positions (extension vs neutral), and variable body mass index in different ethnic population.[5,10] Also, in our study, we took rural Asian population in contrast to previous studies done on middle eastern population and African American population.[4,10]

HMDr is measured from mentum to hyoid bone in a neutral and extended position of head, and it is the predictor of reduced occipitoatlantoaxial extension capacity. First introduced by Takenaka et al.,[13] HMDr was studied in patients with rheumatoid arthritis in the sitting position. He concluded HMDr < 1.2 cm is associated with difficult intubation. In another study conducted in obese patients, HMDr range of 1.0-1.03 was found to be associated with difficult intubation and 1.12-1.16 with easy intubation.[3] These results have been further confirmed by two different researchers with almost similar results.[14,15] In this study, HMDr was evaluated by comparing hyomental distance in extended neck position (HMDe) and in neutral neck position (HMDn).

Wozetck et al.[3] has used both 2D and 3D methods to measure TV and concluded that 2D method overestimates the TV in comparison to 3D method. In view of recent two studies, using 2D method postulated that the larger the TV, the more difficult the intubation.[16,17] However, in our study, we found a moderate significant correlation between TV and difficult intubation.

In addition, few of the patients of our study who had favourable ultrasonic parameters presented with difficult intubation with CL grades of 3a, 3b, and 4. One of these patients in our study had CL grade 3a which may be due to floppy epiglottis. The other contributing factors of difficult intubation may be an increase in age, body mass index, prominent thyroid cartilage, and neck circumference.

This study may have some limitations. The ultrasonic measurements are vulnerable to variations depending on the degree of pressure on the ultrasound probe. Moreover, mobile nature of tongue can also lead to variation in the measurement. In future, research may be conducted to study the USG parameters in patients with clinically anticipated difficult intubation to further validate these results.

Ultrasonographic parameters can predict difficult airway by measuring anterior neck soft tissue thickness. The cut-off value of 0.29 cm at the level of vocal cords delineates the group of difficult intubation and easy intubation and is a better predictor of difficult intubation as compared to HMDr and TV. Combined USG parameters (ANS-VC, HMDr, and TV) may be the best predictor for difficult individual as compared to individual parameters.

Ethics Committee Approval: The ethical clearance was obtained from the institutional ethics committee (BPS Govt. Medical College for Women, Khanpur Kalan, Haryana, India; Date: 03-02-2018; ref no.: BPSGMCW/RC 286/IEC/18).

Informed Consent: Written informed consent was taken from patients participated in the study.

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