Predicting Difficult Laryngoscopy Using Ultrasound Measurement of Distance from Skin to Epiglottis

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Abstract

Introduction: Management of the difficult airway poses a challenge and identification of difficult airway poses even greater challenges. Conventional methods are used for identifying difficult airway but with little sensitivity and specificity. Use of ultrasound in the assessment of the airway is an emerging technique with increased sensitivity and specificity as compared to conventional techniques. This study aimed to predict difficult airway using ultrasound.

Methods: A prospective observational was study was conducted among 138 patients, who were divided into two groups: easy laryngoscopy and difficult group based on the Cormack-Lehane grade (CL grade). Airway assessment of each patient was done with measurement of thyromental distance (TMD), Mallampati grading (MPG), inter-incisor distance (IID) and ultrasonographic measurement of the distance between skin to epiglottis (DSE).

Results: Among total of 138 patients, 82% fell in easy laryngoscopy and 18% in difficult group. Mallampati and thyromental distance were statistically significant whereas IID showing no difference. The mean DSE in easy group verses difficult group was 1.43 ± 0.27 cm and 2.1 ± 0.22 cm respectively. The accuracy, sensitivity, specificity, PPV and NPV remained higher with DSE measurement techniques as compared to with group as compared to TMD, MPG, IID assessment. The sensitivity and specificity of DSE measurement for prediction of difficult airway was 96% and 97.3%.

Conclusions: Ultrasonographic measurement of DSE was better in predicting difficult airway in comparison to other conventional airway assessment methods.

INTRODUCTION

Airway management poses a significant concern for anaesthesiologists, and dealing with unpredictable difficult airway remains a primary challenge in routine medical practice. Although adverse outcomes and severe complications associated with difficult airway are infrequent, they can lead to catastrophic consequences for the patient.[1] Conducting an airway assessment plays a crucial role in facilitating the appropriate management of an anticipated difficult airway. Currently, the prescreening airway evaluation encompasses consulting the patient's past medical history, conducting a physical examination, and performing additional bedside tests such as Mallampati test, thyromental distance (TMD), sternomental distance, neck circumference, and inter-incisor distance (IID). However, they exhibit significant interobserver variability and moderate to fair sensitivity and

specificity.[2,3] Furthermore, these tests may also be difficult to implement in emergency and critical care settings, where patients are frequently confused, uncooperative and unable to follow directions.[4]

Recently ultrasonography has emerged as a promising tool for airway assessment, as it is safe, quick, repeatable, portable, widely available, and gives real-time dynamic images.[5,6] In ultrasonographic measurements, distance from skin to epiglottis (DSE) is the most studied index test in literature to predict difficult direct laryngoscopy.[7] Numerous studies have been published in this field, yet there remains uncertainty regarding which sonographic parameters and their respective cutoff values serve as clinically useful predictors of difficult laryngoscopy and intubation.[8-10]

The current parameters to assess the difficult airway by using ultrasound were validated mainly in Caucasian population and the data in Nepalese population are lacking. The purpose of this study is to evaluate the capability of DSE in predicting difficult laryngoscopy and whether it can be used in daily clinical practice or not. This study has been conceptualized to evaluate ultrasonography measured distance from skin to epiglottis (DSE) for predicting difficult laryngoscopy.

METHODS

This is a prospective, observational study conducted in Shree Birendra Hospital (SBH), Department of Anaesthesiology and Critical Care, Chhauni, Kathmandu, Nepal. The study was conducted after ethical clearance from Institutional Review Committee of NAIHS (Reg. No: 940) from December 2023 to February 2024 for the period of three months. The sample size "n" was calculated based on the study by Pinto et al where the prevalence of the difficult airway was reported to be 23%. Hence, with the confidence interval of 95%, permissible error 'd" of 7% and expected proportion of the population the total sample size calculated was found to be 138. Patients undergoing elective surgery under general anesthesia with ASA status I - III, aged between 18 - 65 years were included in the study. Whereas, patients not willing to take part in the study, patients with cervical spine injury, head and neck tumors or goiter, history of neck surgery, pregnant patients, ASA-PS Grade IV and above were excluded from the study. During the pre-anesthetic evaluation detailed airway examination was done, during which Modified Mallampati Score (MMC), TMD, and IID were recorded. On the day of surgery, the principal investigator performed ultrasound measurement of the airway before induction of the general anaesthesia. Patients were placed supine with their head and neck in a neutral position. DSE measurement was using a portable ultrasound machine (Samsung O-HS30) with 5-12 Hz linear transducer. DSE was measured at the thyrohyoid membrane level by placing the probe in transverse plane and identifying epiglottis as curvilinear hypoechoic structure. The posterior border of the epiglottis was identified as a brighter linear air-mucosa (A-M) interface. Similarly, the anterior border was taken as hyperechoic pre-epiglottic space. After recording DSE, patients were anesthetized using standard anesthetic techniques. Direct laryngoscopy and intubation were performed by consultant anaesthesiologist, not a part of the study. He was asked to mention the Cormack-Lehane grading during each intubation. Cormack-Lehane grading 1 and 2 were categorized as easy laryngoscopy and grades 3 and 4 were considered as difficult laryngoscopy. The data were collected using a proforma which included patient's demographic details, and measurements such as TMD, IID, MMC score and DSE. The statistical analysis was performed by using the IBM SPSS ver. 24.0. Categorical data were analysed by using chi-square test. Similarly, the accuracy, sensitivity and specificity of each test for measurement of the airway parameters were done.

RESULTS

Total 138 participants were enrolled in the study and divided into two groups namely- Easy laryngoscopy and difficult laryngoscopy by an anaesthesiologist performing the intubation based on Cormack-Lehane grade (CL grade) at the time of intubation. The patients with CL grading I and II were labelled as easy laryngoscopy group whereas patients with CL grading III and IV were labelled as difficultlaryngoscopy group. The incidence of easy laryngoscopy (CL grade I and II) was 82% whereas, difficult laryngoscopy (CL grade III and IV) was 18%. The intubating anaesthesiologist did not encounter any CL grade IV. Using the two groups, we analyzed which variables were associated with difficult laryngoscopy.

Among the predictive variables, MMC score (P = 0.00) and TMD (P = 0.00) were significantly different between two groups but IID did not show significant difference. The ultrasound parameter, DSE was significantly different the two groups (P = 0.00). Mean of DSE from skin to epiglottis in difficult laryngoscopy was (2.1 ± 0.22) compared with (1.43 ± 0.27) in easy laryngoscopy. We also compared the performance of DSE with standard clinical test. We found that the DSE has the highest average values for accuracy, sensitivity, specificity and negative predictive value (NPV).

Table 1: Descriptive statistics and predictive variables

			Easy Laryngoscopy (CL grade I and II)	Difficult Laryngoscopy (CL grade III and IV)	P - value
Descriptive variables	Sex	M	50	14	0.286
		F	63	11	
	Age (47.12 ± 13.97 years)	15-30	24	0	0.001
		30 - 45	26	3	
		45 - 60	36	18	
		60 +	27	4	
	Weight	50 <	9	2	0.99
		50 >	104	23	
	ASA-PS	I	53	5	0.04
		II	48	17	
		III	12	3	
Predictive variables	Modified Mallampati score	I	35	2	0.00
		II	61	9	
		III	17	14	
	Inter-incisor distance (cm)	≥ 4cm	67	11	0.163
		< 4 cm	46	14	
	Thyromental distance (cm)	> 6 cm	95	6	0.00
		≤ 6 cm	18	19	
	Distance from skin to epiglottis *	Mean ± SD (cm)	(1.43 ± 0.27)	(2.1 ± 0.22)	0.00

(* Independent t test)

Table 2: Predictive value of USG and clinical test (%)

Predictive variables	Accuracy (%)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
MMC	79.7%	56.0%	85.0%	45.2%	89.7%
IID	58.5%	56.0%	59.3%	23.3%	85.9%
TMD	82.6%	76.0%	84.1%	51.4%	94.1%
DSE	97.1%	96.0%	97.3%	88.9%	99.1%

The cutoffs for the DSE in each of the proposed decision trees are determined by maximizing the Youden's index: sensitivity + specificity − 1. (1.8750)

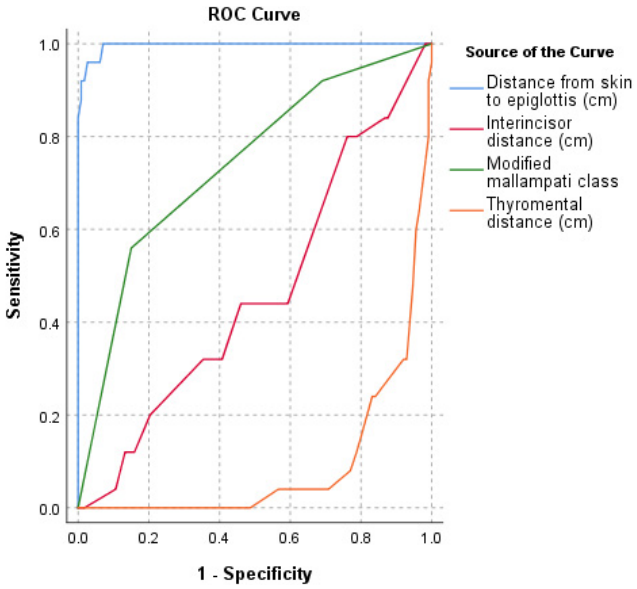

Fig 1. Relative operating characteristics (ROC) curve

DISCUSSION

Managing airway is one of the major tasks of the anaesthesiologists. However, the challenges in predicting the airwayis well-established, as conventional techniques often demonstrate low sensitivity and specificity.[12] Even though there are several conventional methods for prediction of difficult laryngoscopy, none of the methods are 100% sensitive and specific. Hence, this limitation has led to increased interest in using ultrasound scanning as a more reliable method for assessing difficult airway, prompting extensive research into various ultrasound parameters.[5,7,13] we have been extensively using ultrasonography in anaesthesia practice in our institution, we conducted this study where ultrasonographic measurement of distance from skin to epiglottis was used to predict difficult airway. We found association between DSE and difficul airway, the larger the distance more was degree of difficulty. Similarly, we found higher Mallampati score associated with greater value of CL grading indicating towards difficult airway.

In this study, we found that DSE value of greater than 18.7 mm significantly was associated with higher Cormack-Lehane (CL) grading. Similarly, DSE had an accuracy of 97.1%, sensitivity of 96%, specificity of 97.1%, and a negative predictive value (NPV) of 99.1% in predicting a difficult airway and was superior in predicting the difficult airway in comparison to other conventional methods.

Similar to our study, Pinto et al[11] found that increasing DSE is strongly associated with difficult laryngoscopy, reporting a statistically significant correlation. They identified a cutoff value of 27.5 mm for predicting difficult laryngoscopy, achieving an accuracy of 74.3%, with sensitivity of 64.7% and specificity of 77.1%. In another study conducted by Prathep et al,[14] It was found considerably lower cutoff value of 13 mm in contrast to 18.7 mm in our study and 27.5 mm in study by Pinto et al. This disparity highlights the influence of anatomical characteristics on the effectiveness of ultrasound as a predictive tool, suggesting that factors such as ethnicity and body composition could significantly affect outcomes.

In another study by Abdelhady et al,[15] greater thickness of the ultrasound measured had greater DSE value in comparison to easy laryngoscopy group (2 ± 0.3 cm versus 1.7 ± 0.3 cm; P = 0.002). This study showed the cut-off point of more than 1.85 cm for difficult laryngoscopy with sensitivity of 80 %, specificity of 70.8 % and areaunder the receiver operating characteristic curve being 0.759. Mallampati score and TMD had poor area under the curve (0.651, 0.670 respectively).

However, the study is not without its limitations. The research involved a relatively small sample size of 138 patients, drawn from a single tertiary care hospital over a short time frame of three months. This narrow focus may limit the generalizability of the findings to the broader Nepali population. Additionally, interpatient variability, the practitioner's familiarity with ultrasound technology, patient positioning during assessments, and the experience level of the anaesthesiologist performing the intubation can all introduce significant variability into the data.

To build on these findings, future research should aim to include larger cohorts and consider more diverse patient populations, particularly those with known difficulties in airway management, such as individuals who are obese or pregnant. This broader approach could enhance the robustness of ultrasound as a predictive tool and ensure its applicability across varied clinical contexts.

CONCLUSIONS

This study demonstrates that the ultrasound measured DSE can be used as a screening test to predict difficult laryngoscopy among Nepali population. It is superior to other conventional methods of assessment of difficult airway such as TMD, Mallampati score, IID and can be very reliable in technique in airway assessment and management.

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