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Original Research Article

Ultra-Sonographic Methods for Preoperative Assessment of the Airway for Anticipation of Difficult Endotracheal Intubation

Alok Singh[1], Akanksha Agarwal[2], Hemendra Bhardwaj[3], Saurabh Trivedi[4], Seema Gupta[5], Sudeep Phadke[1]

[1]Resident, Department of Anesthesiology, Chirayu Medical College and Hospital, Bhopal, Madhya Pradesh, India

[2]MD Anesthesiology, Professor, Department of Anesthesiology, PCMS, Bhopal, Madhya Pradesh, India

[3]MD Anesthesiology, Senior Resident, Department of Anesthesiology, Chirayu Medical College and Hospital, Bhopal, Madhya Pradesh, India

[4]DNB Anesthesiology, Assistant Professor, Department of Anesthesiology, Chirayu Medical College and Hospital, Bhopal, Madhya Pradesh, India

[5]DNB Anesthesiology, Professor and HOD, Department of Anesthesiology, Chirayu Medical College and Hospital, Bhopal, Madhya Pradesh, India

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Corresponding author: Dr. Saurabh Trivedi

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Abstract

Background: Predicting difficult intubation (DI) is a significant challenge because no single clinical predictor is sufficiently reliable to predict the result. Ultrasonography is a non-invasive and rapid bedside method for visualisation of neck anatomy and airway assessment. Therefore, this study evaluated the difficulty level during laryngoscopy and intubation using ultrasound-guided airway assessment methods.

Aims and objectives: To assess USG-guided airway assessment methods for preoperative anticipation of difficult airways, its association, and prediction with difficult laryngoscopy in patients undergoing elective surgery under general anaesthesia.

Materials and Methods: An observational & single-blinded study was conducted on 45 adult patients on whom USG parameters were studied for airway assessment. Statistical analysis using an appropriate independent t-test/non-parametric test at a P value <0.05.

Results: Out of all the USG parameters, the cross-sectional area of the tongue >3 cm (26.57 at P-value of 0.0046), AP thickness of geniohyoid > 4 mm (32.5 at P-value 0.0018), skin to hyoid >1.69 cm (5.9048 at P-value 0.0414) were statistically significant. Therefore, a strong association exists between a cross-sectional area of tongue >3 cm2, AP thickness of geniohyoid > 4 mm, skin to hyoid >1.69 cm, and occurrence of CL≥ 3 during laryngoscopy.

Conclusion: USG parameters are better predictor of difficult airway in the present study; therefore may be associated with a higher likelihood of difficult visualization during laryngoscopy, as indicated by a CL grade ≥3.

Keywords: Difficult Intubation, Endotracheal Intubation, Ultrasonography, Airway Assessment, Laryngoscopy, Elective Surgery.

Introduction

Airway assessment is a key anaesthetic concerns in airway management. The most significant challenge in everyday practice is unpredictable difficult intubation, a major contributor to death and morbidity. A difficult airway is a constellation of several features of airway care that do not have a commonly accepted conventional definition. It is divided into four categories: difficult mask or supraglottic airway (SGA) ventilation, difficult SGA positioning, difficult or unsuccessful tracheal intubation, and difficult laryngoscopy. [1]

Endotracheal intubation was established in the final quarter of the nineteenth century. It has since become one of the foundational operations on which general anaesthesia is founded, [2,3] with unexpected difficult intubation being a dreaded concern for the anaesthesiologist. The essence of safe anaesthesia is anticipating and predicting problems rather than responding to them. By thoroughly studying the airway during preoperative assessment, 98% or more difficult intubations can be predicted. [3, 4]

Ultrasonography is a non-invasive and rapid bedside method for easy visualisation view of neck anatomy and airway assessment. [5,6] Many ultrasonography-related characteristics, including tongue thickness (TT), hyoid bone invisibility (VH), mandible condylar mobility, and anterior neck soft tissue thickness from the skin to the thyrohyoid membrane (ST) and hyoid bone (SH), can indicate problematic airways. However, the present evidence is confined to small studies, which are further limited by the low incidence of DI. [7, 8]

A study that measured soft tissue thickness at three separate levels, namely the hyoid bone, the thyrohyoid membrane, and the anterior commissure, concluded that they are all independent predictors of difficult laryngoscopy and that combining all of them could improve prediction. [4] This study evaluated the difficulty during laryngoscopy and intubation using ultrasound-guided airway assessment methods.

Materials and Methods

An observational & single-blinded study was performed at the Department of Anaesthesiology and critical care, at tertiary care hospital in central India with 45 patients.

Patients aged 18-60, ASA I and II posted for elective surgery. Under general anesthesia with tracheal intubation were included in the study. However, patients with oral, head, and neck pathology and deformity, pregnancy, head injury, refusal of the patient, and patients undergoing emergency intubation were excluded from the study.

A total of 45 patients were selected on whom USG parameters were studied. Linear USG probe was used to evaluate the distance from skin to hyoid in transverse section. The hyoid bone was identified as a curved echogenic structure with posterior acoustic shadow. It also assessed distance from skin to epiglottis at the level of the thyrohyoid membrane, midway between hyoid and thyroid. Epiglottis was identified as a curvilinear hypoechoic structure with a bright posterior air mucosal interface and hyperechoic pre-epiglottic space, which was evaluated by the linear probe in transverse view. The thickness of the geniohyoid was measured by a linear probe in the transverse view. Parameters measured by USG are width of tongue, CS area of tongue, MHD, AP thickness of geniohyoid, skin to hyoid and skin to epiglottis.

On the day of surgery, laryngoscopy was performed by experienced anesthesiologist who was associated with this study. The glottic view obtained on first attempt of direct laryngoscopy was graded according to the Cormack–Lehane classification.

- *Grade I*: If most of the glottis is visible, then there is no difficulty.

- *Grade II:* If only the posterior extremity of the glottis is visible, then there may be slight difficulty.
- *Grade III:* If no part of the glottis can be seen but only the epiglottis, then there may be fairly severe difficulty.
- *Grade IV*: If not even the epiglottis can be exposed, then intubation is impossible except by special methods.

Statistical analysis plan

Data were categorized first using frequencies and tables. The odd ratio was calculated in the association between CL grade and USG parameters. The association of categorical variables, such as patient groups, was analyzed using an independent t-test after checking normality. Otherwise, non-parametric tests was used. P value <0.05 were considered statistically significant.

Results

Demographic parameters are shown in Table1.

Table 1: Demographic data and duration of surgery

Parameters	USG group (n=45)
Age (years)	43.75 ± 9.9
Weight (kg)	68.21 ± 9.9
Gender (Male: Female)	24:21
ASA I/II/III	26.6%/ 51.1%/ 22.2%

Data are expressed as Mean ± SD, ratio, and percentage.

Distribution of frequency in patients undergoing USG was performed based on CML, the width of the tongue (mm), CS area of the tongue, MHD, AP geniohyoid, skin-to-hyoid distance, and skin-to-epiglottis distance as shown in Table2.

Table 2: Frequency distribution in patients undergoing USG based on different parameters.

Parameters	Frequency	Percentage
CML		
Grade 1	29	64.44
Grade 2	9	20.0
Grade 3	6	13.33
Grade 4	1	2.222
Width of the tongue (mm)		
Male <=41.3 mm	22	48.88
Male>41.3 mm	5	11.11
Female <=39.3 mm	2	4.444
Female >39.3 mm	16	35.55
CS area of the tongue		
<=3 cm	32	71.11
>3 cm	13	28.88
MHD		
<3.5 cm	32	71.11
>=3.5cm	13	28.88
AP thickness of geniohyoid		
<=4 mm	38	84.44
>4 mm	7	
Skin to hyoid distance		
<=1.69cm	34	75.55

>1.69cm	11	24.44
Skin to epiglottis distance		
<=2.8cm	42	93.33
>2.8cm	3	6.666

Data are expressed as numbers and percentage

In this present study, CL grade was compared with USG parameters such as the width of the tongue, CS area of the tongue, MHD, AP thickness of geniohyoid, skin-to-hyoid distance, skin-to-epiglottis distance for prediction of the difficult airway as shown in **Table 3.**

Table 3: USG parameters for prediction of difficult airways

USG parameters	ODDS RATIO	95% CL	Z-Statistic	Significance level (P-value)
Width of tongue	8.400	0.9139 to 77.2111	1.88	0.0601
Cs area ofthe tongue	26.5714	2.7441 to 257.2912	2.831	0.0046
MHD	2.7692	0.2993 to 25.6200	0.897	0.3695
AP thickness of geniohyoid	32.5	3.6694 to 287.8528	3.128	0.0018
Skin to hyoid distance	5.9048	1.0712 to 32.5476	2.039	0.0414
Skin to epiglottis distance	3.000	0.2339 to 38.4731	0.844	0.3987

Data are expressed as ratios and percentages.

On comparison of CL grade with USG parameters for prediction of difficult airway, the odds of having CL grade ≥3 in patients with a width of tongue <41.3 mm in males or <39.3 mm in females was 8.40 (P-value 0.0601), the cross-sectional area of tongue >3 cm was 26.57 (P-value of 0.0046; statistically significant), MHD <3.5 cm was 2.7692 (P-value 0.3695), AP thickness of geniohyoid > 4 mm was 32.5 (P-value 0.0018) (statistically significant), skin to hyoid >1.69 cm was 5.9048 (P-value 0.0414; statistically significant), skin to epiglottis >2.8 cm was 3.0 (P-value 0.3987).

Thus, a strong association exists between a cross-sectional area of tongue >3 cm^2, AP thickness of geniohyoid > 4 mm, skin to hyoid >1.69 cm, and occurrence of CL≥ 3 during laryngoscopy. Moreover, the statistically significant associations between tongue cross-sectional area >3 cm^2, AP thickness of geniohyoid >4 mm, and skin-to-hyoid distance >1.69 cm.

The study suggests that USG parameters may be associated with a higher likelihood of difficult visualization during laryngoscopy, as indicated by a CL grade ≥3. However, it is essential to note that these associations may not necessarily be causative.

Discussion

Airway assessment is an important step in managing patients undergoing general anesthesia. Difficulty in intubation can lead to serious complications and even death. [1] Various clinical and ultrasonographic (USG) parameters can be used to predict difficult intubation.

On comparison with USG parameters, the odds of having CL grade ≥3 were significantly higher in patients with a cross-sectional area of the tongue >3 cm^2, AP thickness of geniohyoid > 4 mm, skin-to-hyoid distance >1.69 cm, and skin-to-epiglottis distance >2.8 cm. However, the odds were not significantly different in patients with a width of the tongue <41.3 mm in males or <39.3 mm in females, or MHD <3.5 cm. Overall, the results of this study suggest that USG parameters, particularly the cross-sectional area of the tongue and AP thickness of the geniohyoid, maybe more reliable predictors of difficult intubation than clinical parameters such as MPC and TMD. Similar to the results of our study, Ambesh SP et al.,2013 [9] showed

that the anterior neck soft tissue thickness at the level of the vocal cord (ANS-VC), hyomental distance ratio (HMDr), and tongue volume (TV) were all useful parameters in predicting difficult airway. However, in particular, ANS-VC was the most significant parameter, with a sensitivity of 78.9% and a specificity of 71.1% (AUC of 0.816) in predicting difficult airways.

Inconsistent with previous findings, Abdelhady et al., 2020 [10] also showed consistent results with the present study's findings. The study reported that ultrasound parameters are associated with a higher likelihood of having a difficult airway during laryngoscopy, as indicated by a CL grade of 3 or higher, and ultrasonography may be a useful tool for predicting difficult airways in certain populations. The study by Parameswari A et al., 2017 [11] found that combining the modified Mallampati classification and the skin-to-epiglottis distance measured by ultrasonography was the most sensitive predictor of difficult laryngoscopy.

In contrast, Parameswari A et al., 2017 [11] also reported that the skin-to-epiglottis distance had the maximum sensitivity and specificity in sonographic parameters. Similarly, Yadav U et al., 2020 [12] found that the diagnostic validity profile of the different predictors varied, with the anterior neck soft tissue thickness at the level of the vocal cord (ANS-VC) having the highest sensitivity (87.50%) and area under the curve (AUC) value (0.887). In comparison, the hymeneal distance ratio (HMDR) had the highest specificity (94.2%) and accuracy (89.60%), indicating a low rate of false positive predictions. Moreover, results reported by Gomes SH et al., 2021 [13] were different from the results of the present study, which reported that ultrasonography, specifically the measurement of the hymeneal distance in a neutral position, may help predict difficult laryngoscopy. [14] Whereas, our findings of the study showed that several other ultrasonography parameters (such as the width of the tongue, cross-sectional area of the tongue, AP thickness of geniohyoid, and skin-to-hyoid distance) were significantly associated with a difficult airway as indicated by a Cormack-Lehane (CL) grade of 3 or higher.

Limitations and strengths of the study

One of the most important limitations of this study is the small sample size. Also, a single investigator obtained ultrasonographic USG measurements, which could have caused some bias. Another limitation is optimal sniffing position and external laryngeal manipulation, which were not considered in our study protocol, could have affected glottis exposure and CL as the components of the best performance of laryngoscopy consisted of the optimal sniff position, complete muscle relaxation, skilled laryngoscopist, and external laryngeal manipulation if needed.

Moreover, we could not control factors such as the experience of anaesthesia providers, equipment used for laryngoscopy, and the number of intubation attempts. The anterior neck soft tissue varied greatly between males and females and depended on their age and comorbidities. Also, pregnant patients were not included for the same reason.

The assessment of the sonographic parameters was performed uniformly; however, in view of the minute distances measured, it would be an error if we failed to acknowledge the fact that maintaining uniform probe pressure in each patient is difficult, and this might lead to inadvertent measuring errors – some distances might be measured as less than their actual value.

The analysis was performed based on the consent proforma, and the standard protocol was strictly followed for the USG method.

Conclusion

We conclude that USG parameters are a better predictor of difficult airways; we suggest that USG parameters may be associated with a higher likelihood of difficult visualization during laryngoscopy, as indicated by a CL grade ≥3. The associations between tongue cross-sectional area >3 cm2, AP thickness of geniohyoid >4 mm, and skin-to-hyoid distance >1.69 cm were statistically significant. However, it is important to note that these associations may not necessarily be causative. Further research would be needed to determine the exact relationships between these parameters and difficult airways.

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