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THE USEFULNESS OF ULTRASOUND GUIDED AIRWAY ASSESSMENT IN PREDICTING DIFFICULT AIRWAY

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ABSTRACT

Background: Airway assessment is crucial for preanesthetic management, but unanticipated difficult airway can occur. Ultrasound has become increasingly popular for airway assessment, offering real-time imaging and aiding in various clinical scenarios. It has been included in guidelines for difficult airway management by the American Society of Anesthesiologists and European Society of Intensive Care Medicine. However, there is limited research on its effectiveness in predicting difficult airway **Aim and Objective:** The study aims to evaluate the effectiveness of ultrasound-guided airway assessment in predicting difficult airways, compare it with Cormack Lehane classification, and determine the correlation between epiglottis mobility and airway difficulty. **Material and Methods:** The Clinical Observational Cross-sectional study was conducted among 120 patients over 18 years old with ASA I, II, and III undergoing elective surgery requiring general anesthesia with direct laryngoscopy and endotracheal intubation. Patients were classified as Easy Airway (GROUP E) and Difficult Airway (GROUP D) based on the Cormack-Lehane classification of laryngoscopic view. During the preanesthetic assessment, ultrasound measurements were taken at three different levels: skin to hyoid bone thickness, skin to epiglottis level thickness at the thyrohyoid membrane, and tongue thickness. The mobility of epiglottis during inspiration and expiration was also observed with ultrasound. On the day of surgery, the Cormack-Lehane (CL) grade of laryngoscopy without any external maneuver was recorded, with Grade I and II grouped as Easy Airway (Group E) and Grade III and IV as Difficult Airway (GROUP D). **Results**: The study found that the most common age group was 50-60 years, accounting for 52.5% of the population. Males dominated (57.5%), while females (42.5%) were the least common. 93.33% of patients had mobile epiglottis, a more common condition than fixed epiglottis. Among predictors of difficult airway studied through USG, all three parameters such as Mean Anterior

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neck soft tissue thickness at hyoid level, thickness at epiglottis level and tongue thickness was higher in Group III followed by Group IV, Group II and least in Group I respectively. **Conclusion:** The study found that USG predictors of difficult airway were higher in Group III due to fewer patients in group IV. The study also revealed that anterior neck soft tissue thickness, epiglottis level, and tongue thickness were higher in Group D, indicating their usefulness in diagnosing difficult airway**.**

Key words: Ultrasound guided airway assessment, Cormack Lehane classification & Epiglottis mobility

INTRODUCTION

Airway assessment is an essential aspect of preanesthetic assessment. Using a combination of airway assessment tests like neck mobility, interincisor gap, thyromental distance, sternomental distance, neck mobility, mouth opening and mallampati classification is a common strategy to enhance the prediction of difficult laryngoscopy[1]. However, despite employing multiple clinical screening tests, there's still a notable occurrence of unanticipated difficult laryngoscopy. Despite meticulous airway assessment, instances of unexpectedly poor laryngeal views during direct laryngoscopy can occur, potentially leading to morbidity and mortality due to challenges in airway management. The use of ultrasound in airway assessment has become increasingly prevalent in recent years, offering real-time imaging that can aid in various clinical scenarios. Here are some milestones in its usage [2]. The initial exploration of ultrasound for airway assessment began in the 1990s, primarily focusing on its use in identifying the anatomical structures of the neck and airway. During this period, studies began to emerge demonstrating the utility of ultrasound in predicting difficult airways and assisting with invasive procedures such as tracheal intubation. Researchers and clinicians started to recognize its potential as a valuable tool in airway management. The 2010s saw a significant expansion in the application of ultrasound for airway assessment. Studies investigated its effectiveness in various clinical settings, including prehospital care, emergency departments, and intensive care units. Ultrasound was increasingly used to assess vocal cord function, predict difficult intubations, guide percutaneous tracheostomy procedures, and identify anatomical variations and abnormalities. In 2015 the American Society of Anesthesiologists (ASA) included ultrasound evaluation of the airway in its guidelines for difficult airway management, acknowledging its growing importance in clinical practice [3].

The use of ultrasound for airway assessment gained further traction with the publication of guidelines by the European Society of Intensive Care Medicine (ESICM) and European Society of Anesthesiology (ESA) which recommended its use in various aspects of airway management, including the assessment of anatomical structures and confirmation of endotracheal tube placement. Continuing advancements in ultrasound technology and increasing expertise among clinicians have led to broader integration of ultrasound into airway assessment protocols. There's been limited research globally on the effectiveness of ultrasound measurements of soft tissue in the anterior neck region and the airway in predicting difficult laryngoscopy [4, 5]. Recently, ultrasound-based airway assessment has emerged as a promising adjunct to clinical methods, offering a simple, noninvasive bedside tool. However, there's a scarcity of studies investigating the potential role of ultrasound in evaluating difficult airways. Whereas one of the best method to assess airway clinically is Cormack- Lehane classification of laryngoscopic view. But it is invasive and cannot be done during airway assessment. Cormack Lehane class 1 and 2 are considered easy airway while class 3 and 4 are considered difficult airway [6, 7]. The present study compares the efficacy of ultrasonogram parameters with

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clinical Cormack-lehane classification classes to gain knowledge about the credibility of these USG based parameters for its future use in routine airway assessment.

AIM

- To assess the usefulness of ultrasound guided airway assessment in predicting difficult airway.

OBJECTIVES

- To compare and correlate the ultrasound evaluation of the airway with Cormack Lehane classification.
- To assess correlation between epiglottis mobility assessed by ultrasound and its correlation with easy and difficult airway.

MATERIAL AND METHODS

The Clinical Observational Cross-sectional study was conducted in Department of Anesthesia, Santosh Medical College Hospital Ghaziabad. Around 120 patients, who satisfied the inclusion criteria will be included in the study. At the end of the study the patients will be classified as GROUP E and GROUP D based on the Cormack-Lehane classification of laryngoscopic view. GROUP E: Easy Airway group GROUP D: Difficult Airway group.

Sample Size calculation: Assuming the incidence of difficult intubation to be 12.5% among patients scheduled for elective surgery requiring general anesthesia and tracheal intubation according to a study by Koundal V, Rana S *et al.*(1), and a population size of 400, the study would require a sample size of 119 for estimating the expected incidence with 5% absolute precision and 95% confidence.The formula used in the calculation is below mentioned

Sample size n = [DEFF*Np(1-p)]/ [(d2/Z21-α/2*(N-1)+p*(1-p)]

(Where DEFF=1, P=12.5%, d=5%).

Inclusion Criteria

- Both male and female patients more than 18 yrs old
- Patients belonging to ASA I, II, III undergoing elective surgery requiring general anaesthesia with direct laryngoscopy and endotracheal intubation.

Exclusion Criteria

- The patients with mouth opening less than 3 centimeters.
- Edentulous patients.
- The patients with head and neck anatomical pathologies that might have unpredictable effect on the ultrasound assessment of the airway.
- The patients who were not able to extend their neck >30 degree.
- ASA grade IV patients.

Methodology

During preanesthetic assessment ultrasound measurement of thickness of anterior neck soft tissues [ANST] from the skin, was measured at three different levels.

Level 1: Skin to hyoid bone thickness.

Following the patient's supine positioning with the neck and head maintained in a neutral alignment, the distance from the hyoid bone to skin was measured by positioning the linear high-frequency ultrasound probe transversely over the hyoid bone. This distance was recorded.

Level 2: Skin to epiglottis level thickness at the thyrohyoid membrane.

The distance from the thyrohyoid membrane to skin was measured at a midpoint between the thyroid and hyoid cartilage, precisely at epiglottis level. This distance is also recorded.

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Level 3: Thickness of tongue.

Tongue thickness was determined by recording the thickness of the geniohyoid muscle using a curvilinear probe positioned along the midline sagittal plane. Thickness of tongue was recorded.

Mobility of epiglottis during inspiration and expiration was observed with ultrasound [mobile or fixed epiglottis]. This data was recorded.

On day of surgery CL grading of laryngoscopy without any external maneuver was recorded. The Cormack Lehane (CL) grade without any external laryngeal manipulation was documented-Grade I full view of the glottis, Grade II a partial view of the arytenoids or glottis, Grade III only the epiglottis visible, Grade IV indicating neither the glottis nor the epiglottis seen. [Patients with CL I and CL II was grouped as Easy airway [Group E]. Patients with CL III and CL IV was grouped as Difficult Airway [GROUP D].

Materials required

Ultrasound machine with high frequency (6-12MHz) linear probe transducer and curvilinear probe (5–2 MHz) and Ultrasound gel are the materials needed in addition for this study.

Statistical Analysis

Descriptive and comparative analysis will be performed with the IBM SPSS Statistics version 16 (IBM, Armonk, NY, USA) software. Quantitative variables will be described using mean (±standard deviation (SD)) and qualitative variables as number (%). Univariate comparisons between the groups will be done using Student’s t- tests or Mann–Whitney tests, as appropriate, for quantitative variables and Pearson’s $\chi 2$ tests was used. P value of < 0.05 will be considered as significant with 95% confidence interval.

Ethical consideration:

Ethical principles such as respect to the patient, beneficence and justice were strictly adhered. The approval to conduct the present study was obtained from the “Institutional Ethics Committee “(IEC). Informed written consent was obtained from all the study participants before administering questionnaire, after explaining the risks and benefits in a language comfortable to them. All the intervention was done under the supervision of a trained and experienced guide. Confidentiality of the study participants was maintained throughout the study.

RESULTS

The present study recruited 120 patients posted for surgery and routine airway assessment was made for these patients using Cormack Lehane classification. All these patients underwent airway assessment through Ultrasonogram. Parameters like Anterior neck tissue thickness at epiglottis level, tongue thickness, Anterior neck tissue thickness at hyoid bone level, mobility of epiglottis was assessed and calculated through Ultrasonogram and documented. According to Cormack- Lehane classification of laryngoscopic view, patients were divided as Group E (Cormack -Lehane class I & II), and Group D (Cormack -Lehane class III & IV). USG parameters are compared within this group and between these groups and statistical analysis of importance was analysed as secondary objective.

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 11, 2024

Table 1: Age and gender distribution among our study group

	No of cases (n)	Percentage (%)
Age		
20-29	8	6.67%
30-39	12	10.00%
40-49	13	10.83%
50-60	63	52.50%
>60	24	20.00%
Gender		
Male	69	57.50%
Female	51	42.50%
Grand Total	**120**	**100.00%**

Table 1 shows the age group distribution among study participants, most common age group was 50-60 years of age accounting for 52.5% of population. Second common age group was >60 years of age which constitutes 20% of study population followed by 40-49 years of age (10.83%) and 30-39 years of age (10%). Least prevalent age group was 20-29 years of age which accounts for 6.67% of the study population. In gender distribution males predominate (57.5%) when compared to females (42.5%).

Table 2: Distribution of anterior neck soft tissue thickness at hyoid level, Epiglottis level and tongue thickness among various Cormack –Lehane (CL) grades.

Mean thickness	CL grading				Total
	Group I	Group II	Group III	Group IV	
Mean anterior neck soft tissue thickness at Hyoid level ± SD	0.48 ± 0.06	0.60 ± 0.07	0.79 ± 0.04	0.79 ± 0.05	0.60 ± 0.13
Mean anterior neck soft tissue thickness at Epiglottis level ± SD	1.48 ± 0.06	1.62 ± 0.06	1.84 ± 0.04	1.82 ± 0.06	1.62 ± 0.14
Mean tongue thickness ± SD	5.41 ± 0.15	5.62 ± 0.07	6.07 ± 0.11	6.05 ± 0.12	5.64 ± 0.26

Mean of Anterior neck soft tissue thickness at hyoid level was greatest at Group IV (0.79) and III (0.79 ± 0.05) than Group II (0.60 ± 0.07) which is in turn greater than Group I (0.48 ± 0.06). Hence, Anterior neck soft tissue thickness at hyoid level was clearly greater in GROUP D (Group IV and III) when compared to GROUP E (group I & II). The mean anterior neck soft tissue thickness at Epiglottis level was greater in Group III (1.84 ± 0.04) than Group IV (1.82 ± 0.06). This may be probably due to lesser number of patients being prevalent in Group IV when compared to Group III. Group II (1.62 ± 0.06) have lesser mean Anterior neck soft tissue thickness at epiglottis level than Group III & IV. Group I has least (1.48 ± 0.06) mean anterior neck soft tissue thickness at epiglottis level when compared to Group II, III & IV. Among the study group, Group D (Group IV & III) has clearly greater anterior neck soft thickness at

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 11, 2024

epiglottis level than Group E (Group I & II). The mean tongue thickness was greatest in Group III (6.07 ± 0.11) than Group IV (6.05 ± 0.12). This can also be explained due to lesser number of patients belonging to Group IV when compared to Group III. Mean Tongue thickness was lesser in Group II (5.62 ± 0.07) when compared to Group III & IV. Group I (5.41 ± 0.15) has least Mean tongue thickness than Group II, III and IV. Apparently, Mean Tongue thickness was greater in Group D (Group IV & III) when compared to Group E (Group I & II).

Table 3: Distribution of epiglottis mobility among our study group

Epiglottis -F/M	No of cases (n)	Percentage (%)
Mobile	112	93.33%
Fixed	8	6.67%
Grand Total	**120**	**100.00%**

Among 120 patients, 93.33% of patients had mobile epiglottis which is more common than fixed epiglottis which is prevalent only in 6.67% of our study patients.

Table 4: Comparison of Ultrasonagram parameters among Group E vs Group D

	Group E	Group D	p value
Mean anterior neck soft tissue thickness at Hyoid level ± SD	0.5462 ± 0.0857	0.7948 ± 0.0377	<0.001
Mean anterior neck soft tissue thickness at Epiglottis level ± SD	1.5575 ± 0.0923	1.8352 ± 0.0477	<0.001
Mean tongue thickness ± SD	5.5295 ± 0.15801	6.0592 ± 0.1109	<0.001

The Mean thickness of anterior neck soft tissue at hyoid level was greater in Group D (0.79) when compared to Group E (0.54). And this association of higher mean anterior neck soft tissue thickness at hyoid level with Group D than Group E had strong statistical significance (p value < 0.001). The Mean thickness of anterior neck soft tissue at epiglottis level was greater apparently in Group D (1.835) when compared to Group E (1.5575). And this association of higher mean anterior neck soft tissue thickness at epiglottis level with Group D when compared to Group E had strong significance with statistical correlation (p value < 0.001). The mean Tongue thickness was greater in Group D (6.05) when compared to Group E (5.52). And this association of higher mean tongue thickness with Group D when compared to Group E had strong statistical correlation with significant p value < 0.001. Epiglottis is more mobile in Group E when compared to Group D in our study group. Group D when compared to Group E had strong statistical correlation with significant p value < 0.001.

DISCUSSION

The present Study shows the usefulness of ultrasound guided airway assessment in predicting difficult airway, in which 120 patients posted for surgery under general Anaesthesia were recruited after written informed consent. During preanesthetic evaluation ultrasound guided assessment of airway was performed and following parameters were recorded - Anterior neck soft tissue thickness at hyoid level, Anterior neck soft tissue thickness at epiglottis level, Tongue thickness and Epiglottis mobility. On day of surgery while performing direct laryngoscopy patients were classified according to Cormack-Lehane classification into

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 11, 2024

Cormack- Lehane class I, II, III and IV. Patients in Cormack- Lehane class I and II were labelled as group E (easy intubation group) while patients belonging to Cormack-Lehane class III and IV were labelled as group D (Difficult intubation group). Among our study population, when all patients are grouped according to Cormack-Lehane classification, 42 patients belong to Grade I group, 53 patients belong to Grade II, 17 patients belong to Grade III and 8 patients are in Grade IV group. Collectively, Group E had 95 patients and Group D had 25 patients respectively.

The most common age group in this study was 50-60 years, comprising 52.5% of participants. This aligns with findings from a study by Gupta *et al.* (5), which reported a significant prevalence of difficult airways in older populations, particularly those aged over 50 years. The male-to-female ratio in this study was approximately 1.35:1, which is consistent with other studies such as that by Singh *et al.*, who found a similar ratio in their analysis of airway difficulties. This suggests that males may be more prone to anatomical variations leading to difficult intubation (6).

Following parameters are measured through ultrasonogram and compared between Cormack- Lehane classification groups of our study population.Mean anterior soft tissue thickness at hyoid level in CL grade I, II, III and IV were respectively. 0.478 cm, 0.600 cm, 0.795 cm and 0.793 cm. Mean value of Anterior neck soft tissue at hyoid level in group E was 0.54 cm and in group D was 0.79 cm. Mean value of Anterior neck soft tissue thickness at hyoid level were greatest in Group III followed by Group IV which in turn is greater than Group II and least in Group I. Median value also follows same pattern in all groups, whereas Standard deviation and range does not correlate among various groups of C-L grading in our study population. Mean value of thickness at hyoid level is greater in Group D when compared to Group E with statistical significance with p value of <0.0001. Mean Anterior neck soft tissue thickness at hyoid level was 0.25 cm higher in Group D than Group E in our study group. Our finding of Group D being 0.25 cm higher thickness at hyoid level than group E was similar to study by Alessandri *et al.* (9) (0.22 cm), Adhikari *et al.* (36) (0.32 cm). In study by Wu *et al.* (11), difference of thickness at hyoid level between Group D & E was higher (0.53 cm) than our study and in study by Martinez *et al.* (10) (0.05 cm) and Yadav *et al.* (12) (0.18 cm), the difference of thickness at hyoid level between Group D & E was much lower than our study.

Mean anterior soft tissue thickness at epiglottis level in CL grade 1, II, III, and IV were respectively 1.48cm, 1.61cm, 1.84 cm and 1.820 cm. Mean value of Anterior neck soft tissue thickness at epiglottis level was 1.55 cm in group E and 1.83 cm in group D. Mean anterior neck soft tissue thickness at epiglottis is greater in Group D when compared to Group E with strong statistical correlation and a p value < 0.001. Importantly, Mean Anterior neck soft tissue thickness at epiglottis level was 0.28 cm higher in Group D when compared to Group E. Similar to our study, in which the difference in thickness at epiglottis level between Group D & E was 0.28, other study like Yadav *et al.* (12) (0.35 cm), Abdelkady *et al.* (14) (0.3 cm), Daggupati *et al.* (13) (0.49 cm), Martinez-Garcia *et al.* (10) (0.58 cm) also show identical results in differences in thickness at epiglottis level. In contrast to our study, difference of thickness at epiglottis level between Group D & E was very low in Alessandri *et al.* (9) (0.13 cm) and very high in Wu *et al.* (11) (0.9 cm).

Mean and Median value of Anterior neck soft tissue thickness at epiglottis level was greatest among Group III when compared to Grade IV. Grade II thickness was lower than Grade III & IV and least in Group I. Standard deviation and Range does not correlate with different grades of C- L groups. Mean tongue thickness in CL grade I, II, III and IV where respectively 5.4 cm, 5.6 cm,6.06 cm and 6.045 cm. Mean tongue thickness was 6.059 cm in

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group D and 5.529 cm in group E. This is similar to study by Yadav *et al.* [12] in which Median Tongue thickness in Group E (CL group 1 & 2) was 5.3 cm and Group D (CL Group 3 & 4) was 6.1 cm. Mean Tongue thickness in Group D is greater when compared to Group E, that too with strong statistical correlation with a p value of < 0.0001. Also, Mean Tongue thickness was 0.53 cm higher in Group D than Group E of our study group. Similar to other two parameters, Mean Tongue thickness also greatest among Group III than Group IV. Group II tongue thickness was lesser than Group III & IV and least among Group I. Standard deviation and Range does not correlate among these grades of C-L grouping of the study population.

Predictors of difficult airway was greater in Grade III compared Grade IV probably due to small size of population in Grade IV group. Epiglottis was fixed only in Grade IV of C-L group and mobile in all other grades (Grade I, II, III) of our study group. Fixed epiglottis was seen in 32% of patients in Group D whereas it is seen in none of the patients in Group E. However, this with strong statistical correlation with a p value of < 0.001. There are not enough studies available on epiglottis mobility as a predictor for difficult airway.

CONCLUSION

The study 50 -60 years was the most common age group among our study group and < 20 years was the least common age group. Male: female ratio among our study group was 1.35 :1, being males more common than females. Among predictors of difficult airway studied through USG, all three parameters such as Mean Anterior neck soft tissue thickness at hyoid level, thickness at epiglottis level and tongue thickness was higher in Group III followed by Group IV, Group II and least in Group I respectively. Standard deviation and Range of these parameters does not correlate with these group patterns significantly. These higher mean values in Group III when compared to Group IV was probably due to the lesser number of patients in Group IV. Among comparison of these predictors between Group D and Group E, anterior neck soft tissue thickness at hyoid level was 0.25 cm greater in Group D than Group E. Also, Anterior neck soft tissue thickness at epiglottis level was 0.28 cm higher in Group D when compared to Group E. And, Tongue thickness was apparently 0.53 cm higher in Group D than Group E respectively. All these correlations of USG predictors being greater in Group D when compared to Group E had strong statistical significance. Epiglottis fixation was only seen in Grade IV of Group D patients. Hence, our study confirms the usefulness of these predictors in diagnosing the difficult airway which is shown as statistical significance in our study. Knowledge of these predictors and application in real- time will help us to identify the high-risk patients and can help us in arranging early alternative airway techniques during anesthesia and hence will prevent morbidity and mortality in many patients undergoing surgery.

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