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Original Article

Perioperative Assessment of Difficult Airway Using Ultrasound—A Prospective Study

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ABSTRACT

Background: The study was conducted with the aim of determining the usefulness of ultrasonography in assessment of difficult airway preoperatively to compare and correlate airway assessment done clinically and airway viewed ultra sonographically with Cormack–Lehane classification of the direct laryngoscopy.

Methodology: This prospective, observational trial consists of total 150 patients undergoing elective surgeries under general anesthesia. The measurements recorded were interincisor gap, modified Mallampati's classification, and thyromental distance and the airway assessment of ultrasound done. Based on the Cormack–Lehane classification of laryngoscopic view, patients were classified into different groups: group A—easy intubation and group B—difficult intubation, at the end of the study.

Results: In both the groups, demographic data were similar except weight, which was significant in group B. Ultrasound measurements of airway done at four levels—hyoid bone, suprasternal-notch, thyroid isthmus, and thyroid—were increased in group B compared with group A, with *p*-values 0.0002, 0.0001, 0.001, and 0.0001, respectively, showing significant results.

Conclusion: On the basis of our study, we conclude that by measuring the thickness of soft tissues in the anterior part of neck with ultrasound difficult airway can be predicted, thus ultrasound can be used for assessing difficult airway preoperatively.

Keywords: Ultrasound, Airway assessment, Difficult airway, Cormack–Lehane classification

INTRODUCTION

It is the primary responsibility of the anesthesiologist to manage the airway during induction of anesthesia. Many analyses have found that most of airway-related events involve brain damage and one-third of mortality was attributable solely to anesthesia; this was mainly due to inability to maintain airway in such patients.[1]

Although enormous data are available on difficult airway predictors, broadly they can be categorized as clinical, radiological, and invasive tests. Measurement of the airway dimensions using caliper and tapes is cumbersome and is inconvenient to carry out routinely even in elective situations, especially when none have a high positive predictive value.[2,3] To overcome these problems, several methods have been introduced to identify the patients who can face difficult intubation, preoperative assessment of the airway in the patients posted for surgery being important among them.

Initially the airway assessment was performed by single factors such as Mallampati's oropharyngeal classification, thyromental distance (TMD), and head and neck movement.[4–6] Multivariate factor analysis came into existence when it was realized that many factors affect the visualization of larynx during intubation. There are examples when a patient predicted to have difficult intubation had easy intubation and vice versa, even after using of multivariate factors.

Nowadays ultrasound (US) has gained widespread popularity in several areas of perioperative and intensive care management. Also, there is growing evidence that it is a useful tool in the assessment and management of potentially difficult airway.[7] There have been many studies using US to assess the airway of patients and to predict difficult intubation.[6–9]

This study was conducted with the aim of assessing the use of US in predicting difficult airway intubation by measuring the thickness of anterior neck soft tissues at four different levels: skin to hyoid bone, skin to trachea at jugular notch, skin to thyroid isthmus, and soft tissue thickness at the level of thyroid. The objective of the study is to find out whether US can be used as a tool to predict difficult airway or not and also to find the parameters that predict difficult airway.

MATERIALS AND METHODS

This prospective and observational study was undertaken after obtaining Institutional Ethical Committee clearance and written informed consent from the patients. One-hundred fifty patients belonging to American Society of Anesthesiologists I and II of both sexes between 18 and 60 years and requiring elective surgery under general anesthesia were included in the study. Patients with facial, cervical, pharyngeal, and epiglottic cancer or trauma, history of previous thyroid surgery or tracheostomy, mouth opening less than 3 cm, pregnancy; patients requiring rapid sequence intubation; patients not able to extend their head more than 30 degrees; and uncooperative patients were excluded from the study.

On the previous day of surgery, patients were shifted to the examination room in the anesthesia department. Following parameters were recorded by the single investigator—height, weight, modified Mallampati's test (grade I: soft palate, fauces, uvula, and pillars seen; grade II: soft palate, fauces, and uvula seen, grade III: soft palate and base of uvula seen), interincisor gap (IIG), TMD, and US measurement of thickness of soft tissue in anterior neck measured (in centimeters) at four different levels: skin to hyoid bone, skin to trachea at jugular notch, skin to thyroid isthmus, and soft tissue thickness at the level of thyroid. For US measurement, we used a small-footprint, high-frequency curved-array probe of US machine (GE LOGIQ—C2) and the patients were made to lie down supine with head in neutral position without a pillow under head. Patients were instructed to keep the mouth closed and to take slow breaths during measurements to minimize errors in recordings due to movements during respiration.

On the day of surgery, the patients were shifted to operating rooms and the institutional standard general anesthesia protocol was followed. A smooth, swift, and gentle laryngoscopy was attempted using standard technique using Macintosh blade by another experienced anesthesiologist who was blinded from US studies and Cormack–Lehane classification (class 1—visualization of the entire laryngeal aperture, class 2a—visualization of partial glottis, class 2b—visualization of arytenoids or posterior part of vocal cords, class 3—visualization of only the epiglottis, class 4—visualization of only the soft palate or neither glottis nor epiglottis visible) was considered with the best view of laryngoscopy in first attempt without any application of external maneuver.

Total 150 patients were selected for study; patients were divided into two groups based on the Cormack–Lehane—Group A: (class 1 and 2) easy laryngoscopy group, which includes 140 and Group B: (class 3 and 4) difficult laryngoscopy group, which included10 and were compared with clinical parameters (modified Mallampati's score [MMS], IIG, TMD, and US airway assessment).

Statistical analysis

All data were analyzed with SPSS version 21.0 software (IBM Corp. released 2015. IBM SPSS Statistics for Windows, Version 23.0; Armonk, New York, United States). Qualitative data was presented as frequencies and percentages. Chi-squared test or Fischer's exact test was used to find out the difference between two groups for variables such as age, gender, and MMS. Quantitative data will be expressed as mean or median based on distribution of data. Student "t" test was applied to find the difference between two groups for variables such as height, weight, TMD, IIG, soft tissue thickness from skin to hyoid bone, skin to trachea at jugular notch, skin to thyroid isthmus, and soft tissue thickness at the level of thyroid. *p*-Value of less than 0.05 was considered significant.

RESULTS

One-hundred and fifty patients who have consented for the study were enrolled. Demographic variables were comparable, except weight that was statistically significant, $70.57 \pm 14.7\ kg/m^2$ in group A and $84.2 \pm 14.2\ kg/m^2$ in group B [Table 1]. No significant correlation was found between MMS, TMD, and IIG among two groups [Table 2]. The sonographic soft tissue thickness measurements at levels from skin to hyoid bone,

Table 1: Demographic parameters.

Parameters	Group A ($n=140$)	Group B ($n=10$)	p-Value	Remarks
Age (y)	48 ± 17	49 ± 15	0.84	Not significant
Gender (M/F)	86/54	6/4	0.805	Not significant
Height (cm)	161.67 ± 6.21	159.89 ± 9.48	0.56	Not significant
Weight (kg)	70.57 ± 14.7	84.2 ± 14.2	0.005	Significant

Table 2: Airway assessment parameters.

Parameters	Group A ($n=140$)	Group B ($n=10$)	p-Value	Remarks
MMS	35 (25%)	1 (10%)	0.19	Not
I	61 (43.6%)	4 (40%)		significant
II	44 (31.4%)	4 (40%)		
III	0 (0.0%)	1 (10%)		
IV				
TMD	6.73 ± 0.56	6.70 ± 0.68	0.89	Not significant
IIG	3.76 ± 0.65	3.71 ± 0.53	0.77	Not significant

Abbreviations: IIG, interincisor gap; MMS, modified Mallampati's score; TMD, thyromental distance.

skin to trachea at jugular notch, skin to thyroid isthmus, and soft tissue thickness at the level of thyroid were found increased in group B compared with group A, which was found statistically significant [Table 3].

DISCUSSION

The most important responsibility of an anesthesiologist is airway management. Seventeen percent of the respiratory-related injuries are accounted by difficult tracheal intubation and are associated with significant morbidity and mortality. Inadequate ventilation, esophageal intubation, and difficult tracheal intubation are three main causes of respiratory related injuries to the patient. Thorough assessment of airway preoperatively has become an important necessity as unanticipated difficult airway and the consequences associated with it are potentially life-threatening to the patient.

Preoperative airway assessment was initiated by anesthesiologists to avoid situations of facing unanticipated difficult airway. Patil *et al.*[6] first started the assessment technique in the year 1980s, which put forward that the incidence of difficult airway can be suspected by measuring anatomical structures of head and neck. During the same period, a hypothesis was made by Mallampati *et al.*,[4] which says depending on the structures seen in oropharynx when mouth is wide open with tongue protruded out, difficult airway can be predicted.

Difficult airway can also be predicted and analyzed by other various clinical methods such as extent of neck mobility, sternomental distance, and IIG, these tests are considered as an single test and analysis is made. The predicted value when these are used alone is less. Therefore use of indices such as Wilson's score, Lemon assessment, Arne's simplified score, Benumof's 11 parameter analysis, Rocket *et al.*, score, help when assessed preoperatively.[10,11]

For predicting difficult airway, many advanced indices have developed in the recent past years, such as US airway assessment, flexible bronchoscope, acoustic response measurement, and flow volume loop. US is gaining eyesight of anesthesiologists in past few years. For airway assessment the reliability of using US was studied by Prasad *et al.*[12]

Demographic parameters were similar in both the groups, except weight which was increased in group A compared with group B and was found significant. Therefore, there was association of increased weight of patient in difficult intubation. The study result can be compared with the prospective observational study of assessment of difficult intubation using neck circumference to TMD ratio as a predictor by

Table 3: Ultrasound airway assessment.

Parameters	Group A ($n=140$) in cm (Mean ± SD)	Group B ($n=10$) in cm (Mean ± SD)	p-Value	Remarks
Soft tissue thickness from skin to hyoid bone	0.73 ± 0.1156	0.88 ± 0.086	0.0002	Significant
Skin to trachea at jugular notch	0.73 ± 0.131	0.88 ± 0.117	0.0001	Significant
Skin to thyroid isthmus	0.274 ± 0.11	0.48 ± 0.64	0.001	Significant
Soft tissue thickness at the level of thyroid	1.034 ± 0.22	1.5 ± 0.101	0.0001	Significant

Abbreviation: SD, standard deviation.

Kim *et al*.[13] They found that difficult intubation was more frequent in obese patients than in nonobese patients (13.8 vs. 4.8%; *p*-value = 0.016). Ezri *et al*.[8] in their study demonstrated that difficult laryngoscopy could be predicted in obese patients by quantifying the neck soft tissue at the level of the vocal cords and suprasternal notch using US. Gonzalez *et al*.[14] did a study on importance of increased neck circumference to intubation difficulties in obese patients. They concluded obese patients have more chances of difficult intubation compared with thin patients (14.3 vs. 3%; $p = 0.03$).

Clinical measurements such as MMS, TMD, and IIG were found comparable in two groups in our study. In Shiga *et al*.[15] meta-analysis study of predicting difficult intubation in apparently normal patients, it was concluded that available screening tests such as MMS and TMD for difficult intubation have only poor-to-moderate discriminative power when used alone. Combinations of individual tests add some incremental diagnostic value in comparison to the value of each test alone. However, the clinical value of these bedside screening tests for predicting difficult intubation remains limited. The study by Randell[16] showed the sensitivities of the commonly used bedside tests; that is, the Mallampati classification and the TMD are from 42 to 81% and from 62 to 91%, respectively. Specificity has varied from 66 to 84% and from 25 to 82%, respectively for the above tests. They concluded that the positive predictive value is improved, if combinations of tests are used. The Mallampati's score is not reliably assessed because of different gradings by independent observers. It cannot be evaluated in many young children and in patients who cannot cooperate because of their underlying medical condition. The Mallampati's score lacks the accuracy, reliability, and feasibility required to supplement a standard airway evaluation.[17]

In our study, results showed difficulty in intubation when there was increase in soft tissue thickness in anterior neck at the level of hyoid, jugular notch, thyroid isthmus, and thyroid. Results of study by Adhikari *et al*.[18] were similar to our study. In their study, which was performed on 50 patients, they experienced difficulty in intubation when there was increase in thickness of soft tissue in anterior neck at the level of hyoid bone, epiglottis at thyrohyoid membrane, which was performed on 50 patients. In the study by Reddy *et al*.,[19] among all the parameters that they assessed, the anterior neck soft tissue at vocal cord had the highest sensitivity in predicting difficult intubation, which was higher than that of the MP class, TMD, and sternomental distance.

CONCLUSION

US measurement of airway is a good tool in predicting the difficult airway and difficult airway was more associated with increase in weight and increased thickness of neck. The limitation of the study was that we were not able to give the "cut of value" for soft tissue thickness of anterior neck for predicting difficult airway by US.

Authors' contributions

All the authors have contributed to conceptualization, designing, definition of intellectual content, literature search, clinical and experimental studies, data acquisition, data analysis, statistical analysis, manuscript preparation, review, and editing.

Conflict of interest

Nil

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