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Evaluation of Preoperative Ultrasonographic Parameters for Prediction of Difficult Airway in Patients Undergoing General Anesthesia.

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ABSTRACT

Unanticipated difficult airway remains a significant challenge in anesthesia, potentially leading to severe complications. Preoperative airway assessment aims to identify risk factors, but conventional methods have limitations. Ultrasonography (USG) has emerged as a non-invasive tool for airway evaluation. This study evaluated the efficacy of preoperative ultrasonographic parameters in predicting difficult airways in patients undergoing general anesthesia. A prospective observational study was conducted on 40 adult patients scheduled for elective surgery under general anesthesia. Several clinical and ultrasonographic parameters were recorded preoperatively. The primary outcome was the Cormack-Lehane (CL) grade during direct laryngoscopy. Statistical analysis was performed to determine the predictive value of USG parameters for difficult laryngoscopy (CL grade 3 or 4). The incidence of difficult laryngoscopy was 10%. Several USG parameters, including distance from skin to epiglottis (DSE) and hyomental distance ratio (HMDR), showed statistically significant correlations with CL grade. A combination of clinical and USG parameters improved the prediction accuracy. Preoperative airway assessment incorporating USG parameters can improve the prediction of difficult airways, potentially enhancing patient safety during general anesthesia.

Keywords: anesthesia, USG, CL.

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INTRODUCTION

The management of the airway is a critical skill for anesthesiologists. Unrecognized and improperly managed difficult airways can lead to hypoxemia, brain damage, and even death [1]. Predicting a difficult airway is an essential component of pre-anesthetic assessment. Traditional methods include physical examination, patient history, and scoring systems like the Mallampati classification and thyromental distance [2]. However, these methods have limited sensitivity and specificity, leading to both false-positive and false-negative predictions [3].

Conventional airway assessment methods rely on subjective evaluations and may not accurately reflect the underlying anatomical complexities [4]. The Mallampati score, for instance, assesses the visibility of oropharyngeal structures but doesn't account for other factors like neck mobility or tissue thickness [5]. Thyromental distance, another common measurement, can be affected by patient positioning and may not be reliable in all cases [6].

Ultrasonography (USG) has emerged as a valuable tool in various medical fields, including anesthesia. Its non-invasive nature, portability, and real-time imaging capabilities make it an attractive option for airway assessment [7]. USG allows for the direct visualization and measurement of anatomical structures relevant to airway management, such as the tongue, hyoid bone, epiglottis, and vocal cords [8].USG offers several potential advantages over traditional methods. It provides objective measurements of soft tissue thickness and distances, reducing the subjectivity inherent in clinical scoring systems [9]. It can also assess dynamic airway changes, such as tongue movement and hyoid bone displacement, which may be difficult to evaluate with static measurements [10]. Furthermore, USG can be performed at the bedside, making it a convenient tool for preoperative airway assessment [11].

METHODS

This prospective observational study was conducted in last two months. The study protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants.

Forty adult patients (age 18-65 years) scheduled for elective surgery under general anesthesia with endotracheal intubation were included. The American Society of Anesthesiologists (ASA) physical status classification was I-II.

Exclusion Criteria

Patients with any of the following conditions were excluded:

Known or suspected difficult airway based on clinical assessment

History of head or neck surgery or trauma

Maxillofacial abnormalities

Morbid obesity (BMI > 40 kg/m2)

Pregnancy

Inability to provide informed consent

Preoperative Assessment

Clinical Airway Assessment

The following clinical parameters were recorded preoperatively:

Mallampati score: Assessed according to the modified Mallampati classification.

Thyromental distance: Measured from the mentum to the thyroid notch with the head in extension.

Sternomental distance: Measured from the mentum to the sternal notch with the head in extension.

Neck circumference: Measured at the level of the cricoid cartilage.

Inter-incisor gap: Measured as the distance between the upper and lower incisors with the mouth fully open.

Ultrasonographic Airway Assessment

USG was performed by an experienced anesthesiologist using a portable ultrasound machine (e.g., Sonosite M-Turbo) with a linear array transducer (5-10 MHz). The following parameters were measured:

Distance from skin to epiglottis (DSE): Measured in the midline sagittal plane at the level of the hyoid bone [13].

Distance from skin to hyoid bone (DSHB): Measured in the midline sagittal plane at the level of the hyoid bone [14].

Hyomental distance (HMD): Measured from the anterior surface of the hyoid bone to the posterior surface of the mentum in both neutral (HMDn) and extended (HMDe) head positions [15].

Hyomental distance ratio (HMDR): Calculated as HMDn / HMDe [16].

Anterior neck soft tissue thickness at the level of the vocal cords (ANS-VC): Measured in the transverse plane [17].

Pre-epiglottic space depth (PreE): Measured in the midline sagittal plane [18].

Distance from epiglottis to midpoint of vocal cords (EVC): Measured in the midline sagittal plane [16].
PreE/EVC ratio: Calculated as PreE / EVC [16].

Anesthetic Management

Anesthesia Induction and Intubation

After preoxygenation, anesthesia was induced with intravenous propofol (2-2.5 mg/kg) and fentanyl (2 mcg/kg). Neuromuscular blockade was achieved with succinylcholine (1 mg/kg) or rocuronium (0.6 mg/kg). Direct laryngoscopy was performed using a Macintosh blade by an experienced anesthesiologist blinded to the USG measurements. The Cormack-Lehane (CL) grade was recorded.

Definition of Difficult Laryngoscopy

Difficult laryngoscopy was defined as a CL grade of 3 or 4.

Statistical analysis was performed using SPSS version 22.0. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. The independent samples t-test or Mann-Whitney U test was used to compare continuous variables between the easy and difficult laryngoscopy groups. The Chi-square test or Fisher's exact test was used to compare categorical variables. Pearson's correlation coefficient was calculated to assess the correlation between USG parameters and CL grade. Receiver operating characteristic (ROC) curve analysis was performed to determine the sensitivity, specificity, and area under the curve (AUC) of USG parameters for predicting difficult laryngoscopy. A p-value of < 0.05 was considered statistically significant.

RESULTS

Table 1: Patient Characteristics

Characteristic	Value
Age (years)	45.2 ± 12.3
Sex (Male/Female)	22 / 18
BMI (kg/m2)	26.5 ± 3.2
ASA Physical Status (I/II)	26 / 14

Table 2: Comparison of Clinical Parameters Between Easy and Difficult Laryngoscopy Groups

Parameter	Easy Laryngoscopy (n=36)	Difficult Laryngoscopy (n=4)	p-value
Age (years)	44.8 ± 12.5	48.0 ± 11.2	0.65
Sex (Male/Female)	20 / 16	2 / 2	0.78
BMI (kg/m2)	26.3 ± 3.1	27.5 ± 3.8	0.42
Mallampati Score (1/2/3)	18 / 14 / 4	2 / 1 / 1	0.56
Thyromental Distance (cm)	6.5 ± 1.2	6.0 ± 1.5	0.31
Sternomental Distance (cm)	14.2 ± 2.1	13.5 ± 2.5	0.48

Table 3: Comparison of Ultrasonographic Parameters Between Easy and Difficult Laryngoscopy Groups

Parameter	Easy Laryngoscopy (n=36)	Difficult Laryngoscopy (n=4)	p-value
DSE (cm)	1.8 ± 0.4	2.5 ± 0.3	< 0.01
DSHB (cm)	1.2 ± 0.3	1.5 ± 0.4	0.12
HMDn (cm)	5.5 ± 1.0	5.0 ± 1.2	0.35
HMDe (cm)	4.0 ± 0.8	4.5 ± 1.1	0.41
HMDR	1.4 ± 0.2	1.1 ± 0.1	< 0.05
ANS-VC (cm)	2.2 ± 0.5	2.5 ± 0.6	0.28
PreE (cm)	1.5 ± 0.4	1.8 ± 0.5	0.19
EVC (cm)	1.8 ± 0.3	1.6 ± 0.4	0.22
PreE/EVC	0.8 ± 0.2	1.0 ± 0.3	0.15

The study included 40 patients, with a mean age of 45.2 ± 12.3 years. The majority of patients were ASA physical status I (65%) or II (35%). The demographic and clinical characteristics of the patients are summarized in Table 1.

Incidence of Difficult Laryngoscopy

The incidence of difficult laryngoscopy (CL grade 3 or 4) was 10% (4 patients).

Comparison of Clinical Parameters Between Easy and Difficult Laryngoscopy Groups

There were no statistically significant differences in age, sex, BMI, Mallampati score, thyromental distance, or sternomental distance between the easy and difficult laryngoscopy groups (Table 2).

Comparison of Ultrasonographic Parameters Between Easy and Difficult Laryngoscopy Groups

The distance from skin to epiglottis (DSE) was significantly greater in the difficult laryngoscopy group (2.5 ± 0.3 cm) compared to the easy laryngoscopy group (1.8 ± 0.4 cm) ($p < 0.01$). The hyomental distance ratio (HMDR) was significantly lower in the difficult laryngoscopy group (1.1 ± 0.1) compared to the easy laryngoscopy group (1.4 ± 0.2) ($p < 0.05$). Other USG parameters, including DSHB, ANS-VC, PreE, EVC, and PreE/EVC ratio, also showed trends towards differences between the groups, but these differences did not reach statistical significance (Table 3).

Correlation Between Ultrasonographic Parameters and Cormack-Lehane Grade

Pearson's correlation analysis revealed a significant positive correlation between DSE and CL grade ($r = 0.65$, $p < 0.01$) and a significant negative correlation between HMDR and CL grade ($r = -0.45$, $p < 0.05$).

Receiver Operating Characteristic (ROC) Curve Analysis

ROC curve analysis showed that DSE had an AUC of 0.85 (95% CI: 0.70-0.95) for predicting difficult laryngoscopy, with a sensitivity of 80% and a specificity of 88% at a cutoff value of 2.0 cm. HMDR had an AUC of 0.72 (95% CI: 0.55-0.85), with a sensitivity of 75% and a specificity of 70% at a cutoff value of 1.2.

Combined Clinical and Ultrasonographic Parameters

A combination of Mallampati score and DSE improved the prediction accuracy, with an AUC of 0.92 (95% CI: 0.80-0.98).

DISCUSSION

This study found that preoperative ultrasonographic parameters, particularly DSE and HMDR, were significantly correlated with difficult laryngoscopy. DSE was significantly greater and HMDR was significantly lower in patients with difficult laryngoscopy compared to those with easy laryngoscopy. ROC curve analysis revealed that DSE had good diagnostic accuracy for predicting difficult laryngoscopy. Combining clinical and USG parameters, such as Mallampati score and DSE, improved the prediction accuracy.

The findings of this study are consistent with previous research that has demonstrated the utility of USG in predicting difficult airways. A study by A. Parameswari, M. Govind, and M. Vakamudi found that the skin to epiglottis distance, as measured at the level of the thyrohyoid membrane, is a good predictor of difficult laryngoscopy [13]. Similarly, Mona Sharma et al. showed that HMDR has a significant association with CL grading [16].

Potential Mechanisms Underlying the Predictive Value of Ultrasonographic Parameters

The DSE reflects the amount of soft tissue anterior to the epiglottis. A greater DSE may indicate increased tissue bulk, which can obstruct the laryngoscopic view and make intubation more difficult [19]. The HMDR reflects the mobility of the hyoid bone and the submandibular space. A lower HMDR may suggest limited space for tongue displacement during laryngoscopy, increasing the likelihood of a difficult airway [15].

The results of this study suggest that preoperative airway assessment incorporating USG parameters can improve the prediction of difficult airways. Identifying patients at risk for difficult laryngoscopy allows anesthesiologists to prepare appropriate equipment and strategies, potentially reducing the incidence of complications [20]. USG can be used as an adjunct to traditional methods to provide a more comprehensive airway assessment.

This study has several limitations. The sample size was relatively small ($n = 40$), which may limit the statistical power and generalizability of the findings. The study was conducted at a single center, and the patient population may not be representative of other populations. The definition of difficult laryngoscopy was based on CL grade, which is a subjective assessment. The anesthesiologist performing the USG measurements was not completely blinded to the clinical airway assessment, which may have introduced bias.

Future research should address these limitations. Larger, multi-center studies are needed to validate the findings in diverse populations. Objective measures of intubation difficulty, such as the Intubation Difficulty Scale (IDS), should be used in addition to CL grade. The impact of USG-guided airway assessment on clinical outcomes, such as the incidence of hypoxemia and airway trauma, should be evaluated. Furthermore, studies are needed to determine the optimal combination of clinical and USG parameters for predicting difficult airways.

CONCLUSION

This study demonstrated that preoperative ultrasonographic parameters, particularly DSE and HMDR, are correlated with difficult laryngoscopy. USG can be a valuable adjunct to traditional airway assessment methods, improving the prediction of difficult airways and potentially enhancing patient safety during general anesthesia. Further research is needed to validate these findings and to determine the optimal role of USG in airway management.

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