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Imaging

Predicting difficult laryngoscopy using ultrasound measurement of distance from skin to epiglottis

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ABSTRACT

Background: Unpredicted difficult intubation can have severe consequences, and it is a significant source of morbidity and mortality. Although recent studies indicate that specific ultrasonography (US) measurements may be predictors of difficult laryngoscopy, their use is still limited, and its quantification is missing. The purpose of this prospective observational study is to evaluate the use of US-measured distance from skin to epiglottis (DSE) for difficult laryngoscopy prediction.

Methods: In a double-blind study, standard preintubation, screening tests, and DSE were obtained from 74 adult patients requiring endotracheal intubation. The relationship between difficult laryngoscopy and DSE was evaluated using a *t* test. A comparative analysis of its predictive performance with common clinical preintubation screening tests was performed using bootstrapping.

Results: We found that increasing DSE is strongly associated with difficult laryngoscopy ($P < .001$, 2-sided *t* test). We showed that a cutoff value of 27.5 mm was able to predict difficult laryngoscopy with an accuracy of 74.3%, a sensitivity of 64.7%, and a specificity of 77.1%.

Conclusions: Our work demonstrates that the DSE can be effectively used to predict difficult laryngoscopy. Moreover, combining DSE with the modified Mallampati score in a decision tree significantly improves the predictive power over either test alone.

1. Introduction

Airway management is one of the main concerns for anesthesiologists, and unpredictable difficult airway intubation remains one of the most important challenges in routine practice. Adverse outcomes and severe complications related with difficult airway are rare but may have catastrophic consequences to the patient [1].

Airway assessment can help to provide an appropriate management of an expected difficult airway. Prescreening airway evaluation can include consultation of previous medical history, physical examination, and performing additional bedside tests. Presently, bedside tests such as Mallampati test, thyromental distance (TMD), sternomental distance, neck circumference, and interincisor distance (IID), are used in daily clinical practice to predict difficult intubation. Most of these common tests, however, have limited predictive value when used on their own [2]. This is partially due to lack of standardized measurements, subjectivity, and lack of agreed-upon cutoff values. To overcome this, some multivariable risk scores have been proposed [2] to improve the predictive capability of bedside tests. However, these composite scores tend to be time consuming and difficult to use in clinical practice.

Advances in airway devices, patient monitoring, clinical protocols, and education have reduced the risks associated with an unpredicted difficult airway, but not the incidence of unexpected difficult airway [3-6]. Ultrasound (US) has recently emerged as a simple, portable, noninvasive, and safe method for rapid airway assessment and management in the operating room, emergency department, and intensive care unit [7,8].

Recent studies suggest that US-based airway assessment may be a useful adjunct to clinical methods of bedside airway assessment [9-12]. In morbidly obese patients, anterior soft neck tissue was an independent predictor of difficult laryngoscopy [9]. Another pilot study [11] analyzed three US-based measurements including the distance from skin to epiglottis (DSE) for difficult laryngoscopy prediction. The results suggested that DSE gives good predictive results, but no useful cutoff for clinical practice was validated. Although these results are promising, more systematic studies are needed before US measurements can be validated for reliable use in routine clinical practice [2].

In this regard, our main objective was to evaluate the capability of DSE in predicting difficult laryngoscopy and whether it can be used,

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alone or combined with other standard clinical preintubation screening tests, in daily clinical practice.

2. Materials and methods

This prospective double-blind study was conducted in Hospital Center Tondela-Viseu, Portugal.

2.1. Ethics statement

The data were collected after receiving approval from the Ethical Committee of the Hospital and informed consent of all 74 patients, American Society of Anesthesiologists I to III, requiring endotracheal intubation for a surgical scheduled procedure.

2.2. Experimental protocol

2.2.1. Exclusion criteria

Patients were excluded if they had any abnormalities conditioning anatomy disturbances such as facial/cervical fractures, maxillofacial abnormalities, cervical tumors, or goiter. Patients with tracheostomy tubes, morbid obesity, who were pregnant, or those unable to give consent were also excluded.

2.2.2. Standard characteristics and prescreening measurements

We collected the following information from each patient: sex, weight, height, and age. The collected clinical assessments of airway were modified Mallampati score [13,14] (see Table 1), interincisor gap [15], TMD [2], and cervical perimeter [10]. The measurements of interincisor gap (in centimeters) or intergum (in edentulous patient) were performed in the midline with the mouth fully open. The TMD (in centimeters) was measured with the patient's head fully extended and the mouth closed. Finally, the cervical perimeter (in centimeters) was measured at the level of the thyroid cartilage. An anonymized version of the data set is available upon request.

2.2.3. Ultrasonography: DSE

To obtain the US-measured DSE at the thyrohyoid membrane level, patients were placed supine with their head and neck in a neutral position without a pillow. Distance from skin to epiglottis measurements were always performed by the same sonographer using a Sonosite M-Turbo with a 10-13-MHz linear transducer. The airway was systematically imaged along its course from the floor of the mouth to the level of the suprasternal notch using the linear transducer oriented transversely across the anterior surface of the neck. The epiglottis was visible through the thyrohyoid membrane, in the transverse plane (with varying degrees of cephalad/caudal angulation) as a curvilinear hypoechoic structure. The posterior border of the epiglottis is delineated by a brighter linear air-mucosa (A-M) interface and its anterior border is delineated by the hyperechoic pre-epiglottic space. Swallowing facilitated identification of the epiglottis, during which it was visible as a discrete mobile structure. For each patient three measurements (central axis and the left and right extremities of the epiglottis) were taken and averaged (see Fig. 1). These measurements were performed before intubation and thus were blind to the status of laryngoscopy difficulty.

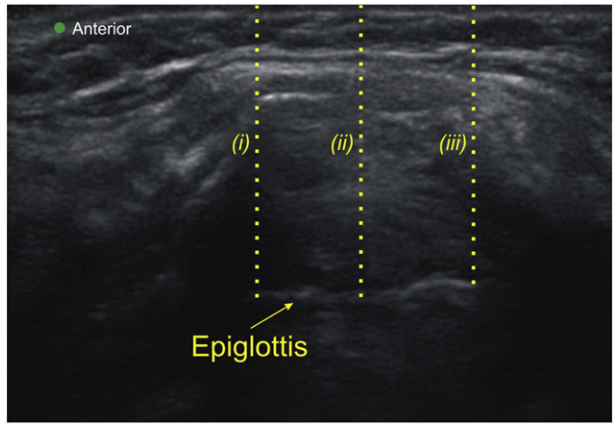

Fig. 1. Ultrasound-measured DSE. Distance from skin to epiglottis is computed as the average value of 3 measurements taken at the central axis, (ii) in figure, left (i) and right (iii) extremities.

2.2.4. Cormack-Lehane grades for classifying difficult laryngoscopy

To classify the grade of laryngoscopy difficulty, that is, to obtain the ground truth used to measure the performance of each predictive test, we used the Cormack-Lehane classification system [16]. Specifically, the first view with external laryngeal maneuvers of Cormack-Lehane grade of laryngoscopy was recorded as part of routine documentation by the anesthesiologist who performed the endotracheal intubation. Cormack-Lehane grade 1 or 2 was categorized as easy laryngoscopy; and grade 3 or 4, as difficult laryngoscopy [16].

2.3. Data analysis

2.3.1. Statistical analysis

First, we wanted to know which variables show significant differences across groups (easy and difficult laryngoscopy). In particular, we wanted to test the null hypotheses that there is no association between difficult laryngoscopy and DSE. For each variable, we compared the difference between the difficult and easy laryngoscopy groups. For numerical variables, we performed a comparison between the means of the 2 groups using the Student *t* test. For categorical variables, the χ^2 test and Fisher exact test were used when appropriate (see Table 3).

2.3.2. Standard prescreening tests

2.3.2.1. Univariate. We used the currently accepted cutoff points for each of the 3 standard predictive tests analyzed: modified Mallampati score [17], IID, and TMD (see Table 2). There is not an agreed-upon cutoff for TMD, ranging from 4 cm [10] to 7 cm [13]. For that test, we adopted a cutoff point of 6 cm [18].

2.3.2.2. Multivariate. We also analyzed the performance of a widely used difficult laryngoscopy assessment score called the Naguib score [19]:

$$l = 0.2262 - 0.421 \times TMD + 2.5516 \times Mallampati\ score - 1.1461 \times IID + 0.0433 \times height. \quad (1)$$

Table 1
Modified Mallampati score

Class 1	Soft palate, fauces, uvula, and pillars are visible
Class 2	Soft palate, fauces, and uvula are visible
Class 3	Soft palate and base of uvula are visible
Class 4	Soft palate not visible

Classes of the modified Mallampati score as described by Samsoon and Young [13]. Colors indicate the difficulty of laryngoscopy predicted by the modified Mallampati test (see Table 2): blue for easy and red for difficult.

Table 2
Standard clinical screening tests

Clinical screening test	Easy	Difficult
Modified Mallampati score	1 or 2	3 or 4
IID	≥4 cm	<4 cm
TMD	>6 cm	≤6 cm

Cutoffs for the different standard clinical tests for predicting for predicting difficulty of laryngoscopy.