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ORIGINAL RESEARCH

Prediction of difficult laryngoscopy using spirometry: a pilot study

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Abstract Prediction of difficult laryngoscopy is still the uncovered secret of anesthetic practice. This pilot study is aimed to assess the efficacy of spirometry measurements in predicting difficult laryngoscopy compared with conventional airway assessment techniques. We enrolled 202 adults, ages 18–40 years, with an American Society of Anaesthesiologists score of I or II, scheduled for elective surgery and undergoing general anesthesia. Spirometry was used for lung capacity measurements before the operation. The Mallampati classification, neck circumference, sternomental distance, thyromental distance, maximum mouth-opening measurement, and upper lip bite test of the subjects were measured. During intubation, the Cormack–Lehane grade was recorded. Spearman's correlation analysis was used to define the linearity between spirometry outputs and airway measurements. Receiver operating curves were drawn to discriminate the predictive features of the significant values. The thyromental distance showed a higher correlation with forced inspiratory vital capacity ($\rho = 0.420, P < 0.001$). In a multivariate linear regression model, all spirometry measurements revealed that forced inspiratory vital capacity ($\beta = -2.050$, $P = 0.022$) was the significant predictor for difficult laryngoscopy. The area under the curve for forced inspiratory vital capacity with a cut-off value of 3.1950 L while using thyromental distance as difficult laryngoscopy indicator is 0.754 and forced inspiratory vital capacity showed a sensitivity of 0.718 and specificity of 0.714 with a positive likelihood ratio of 2.5104 and negative likelihood ratio of 0.3949. Forced inspiratory vital capacity showed a close association with the prediction of difficult laryngoscopy.

Keywords Pulmonary · Airway management · Intubation · Airway-anatomy · Spirometry · Airway control

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1 Introduction

Along with technological advancement, the diversity of surgical procedures and techniques has also been rising. Apart from surgical procedure, the surgical area, patient position, and even surgical method may alter the course of the anaesthetic approach. This outcome forced anaesthesiologists to focus on a single crucial factor that is a vital part of anaesthetic practice—airway management. Since the term "airway" includes the nasal/oral cavity, pharynx, larynx, trachea and large bronchi, "difficult airway" is the

problematic establishment or maintenance of gas exchange by an artificial airway device. In recent years, various protocols and guidelines have been established to secure the airway [1]. However, the search for a satisfactory airway assessment method still continues; inevitably, that is the crucial part of airway management. Specific tests, including Mallampati, atlanto-occipital joint extension, thyromental distance (Patil's test), sternomental distance, mandibulohyoid distance, and inter-incisor distance for evaluating the airway to predict difficult ventilation or intubation have been commonly used worldwide. Furthermore, several multivariate scoring systems, such as the Wilson Score and the Simplified Airway Risk Index (SARI), have been constructed for assessment consisting of multiple items; however, none can provide a high index of sensitivity and specificity for predicting difficult airway [2–4]. A multicentre study, evaluating 11 important airway assessment features indicated by the ASA Difficult Airway Guideline did not reveal any clinically significant improvement in the detection rate of difficult laryngoscopy [5].

The ratio of neck circumference to thyromental distance is reported to be a substantial predictor for difficult laryngoscopy with a value of >5.0 [6]. Thyromental height is a newly defined anatomical dimension, which showed 83% sensitivity and 99% specificity; however, it requires further research for validation in large group series [7]. Consequently, airway assessment techniques, especially to predict the difficult laryngoscopy, remain an unsolved problem for anaesthesiologists.

Spirometry is a physiological test that measures inhalation and exhalation volumes of air as a function of time. It is the most beneficial tool commonly used for assessment of the pulmonary function, and can detect the air flow abnormalities after establishing close cooperation between the subject and the examiner. Although the flow-volume measurements of the lungs are obtained by spirometry, it provides remarkable outcomes in the extrathoracic airway. Many studies have used spirometry in individuals with obstructive sleep apnea syndrome (OSAS) in the preoperative period to estimate the occurrence of possible complications in the peri/postoperative period [8, 9]. It is well known that patients with OSAS show upper airway obstruction and have a higher rate of difficult laryngoscopy compared to the general population [10, 11]. As mentioned previously, the studies suggested that the outcomes of spirometry may be related to the airway evaluation tests used to predict difficult laryngoscopy.

It has been hypothesised that spirometric outputs can be used as a diagnostic tool to predict difficult laryngoscopy. Therefore, the overall aim of the present study was to elucidate the relationship between pulmonary function tests and airway assessment tests routinely performed in the preoperative period of anaesthetic examination.

2 Methods

After approval from the Gaziosmanpasa University Clinical Research Ethical Committee (13-KAEK-215) and registration with ClinicalTrials.gov (Ref: NCT02325076), this prospective study was conducted from December 2013 to February 2015. Adult patients admitted to the outpatient unit of the Department of Anaesthesiology at Medical Training and Research Centre, Medical Faculty, Gaziosmanpasa University for preoperative assessment to undergo elective surgery requiring general anaesthesia were invited to participate in the study. Additional inclusion criteria included being between the ages 18 and 40 and having an American Society of Anaesthesiologists score of I or II. We excluded patients undergoing an operation without tracheal intubation and those scheduled for ear-nose-throat surgery, cardiovascular surgery, or plastic-reconstructive surgery, as well as those with an upper airway pathology (e.g., maxillofacial fractures and tumours), a history of head/neck surgery or maxillofacial surgery, cervical spine fracture, obstructive or restrictive pulmonary disease, or a history of smoking (tobacco and tobacco products), and women with pregnancy. After obtaining written informed consents, spirometry was performed using the Spirodoc® (MIR—Medical International Research—Srl, Roma, Italy). Using a standardised data sheet, we recorded age, sex, weight, height, body-mass index (BMI), the American Society of Anaesthesiologists score, and the spirometry measurements (FVC [Forced Vital Capacity], FEV_1 [Forced Expiratory Volume in 1 s], FEV_3 [Forced Expiratory Volume in 3 s], FEV_6 [Forced Expiratory Volume in 6 s], FEV_1/FVC, FEV_3/FVC, PEF [Peak Expiratory Flow], FEF_{25} [Forced Expiratory Flow 25%], FEF_{50} [Forced Expiratory Flow 50%], FEF_{75} [Forced Expiratory Flow 75%], $FEF_{25/75}$, FET [Forced Expiratory Time], FIVC [Forced Inspiratory Vital Capacity], FIV_1 [Forced Inspiratory Volume in 1st second], FIV_1/FVC, PIF [Peak Inspiratory Flow], and MVV [Maximum Voluntary Ventilation]; volumes and capacities are presented in liters).

In the operating room, we measured the Mallampati classification (MPC) without phonation in sitting position (Class 1: clear visibility of soft palate, fauces, uvula, and pillars; Class 2: visibility of soft palate, fauces, and uvula; Class 3: visibility of soft palate, and the base of the uvula; Class 4: no visibility of soft palate), neck circumference (NC, cm; the neck circumference at the level of cricothyroid cartilage), sternomental distance (SMD, cm; the distance from the upper border of the manubrium sterni to the inside of the mentum, with the head extended as far as possible while keeping the mouth closed), thyromental distance (TMD, cm; the distance from the thyroid notch to the inside of the mentum, with the head extended as far as

possible while keeping the mouth closed), maximum mouth opening measurement (MMO, cm; the distance between the upper and the lower incisors in the midline, while the mouth is opened as wide as possible), and upper lip bite test (ULBT; Class 1: lower incisors can bite the upper lip above the vermilion line; Class 2: lower incisors can bite the upper lip below the vermilion line; Class 3: lower incisors cannot bite the upper lip). The difficult laryngoscopy value for Mallampati [1, 14] was accepted as Mallampati III or IV, TMD [1, 17] was <6.5 cm, a value for MMO [2] as ≤4.5 cm, and ≥5 for NC/TMD [6].

Thereafter, patients were monitored through electrocardiogram (ECG), peripheral oxygen saturation (spO_2), and non-invasive arterial blood pressure. Additionally, to visualise the neuromuscular blocking agent, train-of-four (TOF) was performed using a TOF-Watch®SX (Organon Ltd., Drynam Road, Swords, Co. Dublin, Ireland). After pre-oxygenation, anaesthesia induction was provided by thiopental sodium 5 mg/kg intravenous (iv) and rocuronium bromide 0.6 mg/kg iv. Orotracheal intubation was initiated after complete suppression of TOF was seen with the aid of a neuromuscular monitor. Patients were intubated with a Macintosh laryngoscope and direct laryngoscopy was achieved using a regular Macintosh blade size 3 or 4. The laryngoscopical view was assessed using the Cormack–Lehane grade (CLG) without any maneuver to optimize the view [12]. The intubation and the evaluation process of the laryngoscopical view were completed by an experienced anaesthesiologist (5 years of experience in anaesthesiology) blinded to the study and the previous measurements.

A linear backward stepwise multivariate regression modelling method was used in which all spirometry outcomes were considered in the multivariable analysis. The backward stepwise method was used to confine the suppressor effects, in which a predictor has a significant effect only when another variable is held constant, and to limit the risk of making a type II error, thereby missing a substantial predictor. The variable with the highest p value, which has no significance at the 0.05 level, was excluded at each step.

A receiver operating characteristics (ROC) curve, which is useful in assessing the performance of a diagnostic test in the classification of subjects into two categories as either positive and negative, was used to determine the sensitivity and specificity. Sensitivity refers to the proportion of actual positives, whereas specificity is the actual negatives correctly identified. Likelihood ratios are calculated as follows: positive likelihood ratio = sensitivity/(1 − specificity); negative likelihood ratio = (1 − sensitivity)/specificity. Likelihood ratios greater than 10 and less than 0.1 are accepted to have strong evidence for ruling in or ruling out diagnoses, respectively. The ROC curve was used to evaluate the efficiency by area under the curve (AUC). If the AUC is near 1, it has a higher chance of correct classification; however, when it is close to 0, it has a higher chance of being incorrectly classified in the opposite group [13].

Previous studies showed that the sensitivity of TMD (≤7.3 cm) was 0.58 [6]. Assuming a 10% sensitivity difference between TMD and spirometry outcomes, with a two-sided type I error of 0.05, and a power of 0.80, 195 subjects were required to find a significant difference in the sensitivity of TMD and spirometry outputs. Normality and variance were tested using the one-Sample Kolmogorov–Smirnov test, skewness and kurtosis, and histograms for each variable. Quantitative data are presented as means and standard deviation, and qualitative data as frequency and percentage. Associations between spirometry measurements and difficult laryngoscopy indicators were performed by using the Spearman rho correlation coefficient (ρ). The comparisons between spirometry outcomes among to the cut-off values of TMD, MMO, and NC/TMD were carried out by using the Mann–Whitney *U* test. Analyses were completed by using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA) version 20.0 program. The statistical significance for all analyses was set at $P < 0.05$.

3 Results

A total of 202 patients were enrolled in the study. The demographic data of the patients is presented in Table 1. Significantly moderate correlations were found between TMD and MMO, and NC/TMD and SMD ($P < 0.001$, $P < 0.001$, respectively, Table 2). Table 3 shows the correlation matrix of airway assessment tests and spirometry measurements. There was an evident association yielded between TMD and FIVC ($\beta = 0.420$, $P < 0.001$). The mean spirometry measurements are presented in Table 4, since the cut-off value for TMD was accepted as <6.5 cm, a value for MMO as ≤4.5 cm, and ≥5 for NC/TMD. The mean FIVC value was significantly lower in TMD <6.5 cm group (3.02 ± 0.62, $P < 0.001$).

Table 1 Characteristics of the patients

	Mean ± SD	Median (range)
Age (years)	29.58 ± 6.72	29 (18–40)
Height (cm)	168.73 ± 9.88	170 (106–193)
Weight (kg)	73.24 ± 14.30	73 (40–115)
BMI (kg/m^2)	26.81 ± 5.35	25.17 (13.27–56.07)
Gender (n)		
Female	96	–
Male	106	–

BMI body mass index

Table 2 Correlation matrix of airway assessment tests

	MPC	ULBT	MMO	NC	SMD	TMD	CLG
MPC	–						
ULBT	0.047	–					
MMO	0.034	−0.039	–				
NC	0.165[a]	−0.015	0.344[c]	–			
SMD	−0.088	−0.034	0.193[d]	0.043	–		
TMD	−0.043	−0.039	0.346[e]	0.211[f]	0.505[h]	–	
CLG	0.144[b]	−0.094	−0.094	0.015	−0.135	−0.031	–
NC/TMD	0.126	−0.014	−0.164[m]	0.293[g]	−0.454[i]	−0.852[k]	−0.037

MPC Mallampati classification, *UPLBT* upper lip bite test, *MMO* maximal mouth opening, *NC* neck circumference, *SMD* sternomental distance, *TMD* thyromental distance, *CLG* Cormack–Lehane grading, *NC/TMD* the ratio of neck circumference to thyromental distance

[a] $P = 0.019$; [b] $P = 0.048$; [c] $P < 0.001$; [d] $P = 0.006$; [e] $P < 0.001$; [f] $P = 0.03$; [g] $P < 0.001$; [h] $P < 0.001$; [i] $P < 0.001$; [k] $P < 0.001$; [m] $P = 0.020$

Table 3 Correlation matrix between airway assessment tests and spirometry outcomes

	MMO	TMD	SMD	NC	MPC	NC/TMD	CLG
FVC	0.306[a]	0.266[n]	0.244[w]	0.293[gg]			
FEV_1	0.308[b]	0.173[o]	0.184[z]	0.295[hh]			
FEV_3	0.317[c]	0.267[p]	0.248[aa]	0.300[ii]			
FEV_6	0.309[d]	0.267[q]	0.267[bb]	0.295[ij]			
FEV_3/FVC				−0.158[kk]			−0.166[ww]
PEF	0.263[e]		0.139[cc]	0.289[ll]			
FEF_{25}	0.269[f]			0.291[mm]			
FEF_{50}	0.277[g]			0.264[nn]			
FEF_{75}							
$FEF_{25/75}$	0.259[h]			0.240[oo]			
FET	0.156[i]	0.164[r]					0.150[yy]
FIVC	0.308[j]	0.420[s]	0.262[dd]	0.274[pp]		−0.269[uu]	
FIV_1	0.269[k]	0.301[t]	0.223[ee]	0.207[qq]	−0.195[ss]	−0.202[vv]	
PIF	0.294[l]	0.225[u]			−0.288[tt]		
MVV	0.308[m]	0.173[v]	0.184[ff]	0.295[rr]			

MPC Mallampati classification, *UPLBT* upper lip bite test, *MMO* maximal mouth opening, *NC* neck circumference, *SMD* sternomental distance, *TMD* thyromental distance, *CLG* Cormack–Lehane grading, *NC/TMD* the ratio of neck circumference to thyromental distance, *FVC* forced vital capacity, FEV_1 forced expiratory volume in 1 s, FEV_3 forced expiratory volume in 3 s, FEV_6 forced expiratory flow in 6 s, *PEF* peak expiratory flow, FEF_{25} forced expiratory flow 25%, FEF_{50} forced expiratory flow 50%, FEF_{75} forced expiratory flow 75%, *FET* forced expiratory time, *FIVC* forced inspiratory vital capacity, FIV_1 forced inspiratory volume in 1 s, *PIF* peak inspiratory flow, *MVV* maximum voluntary ventilation

[a] $p < 0.001$; [b] $p < 0.001$; [c] $p < 0.001$; [d] $p < 0.001$; $p < 0.001$; [e] $p < 0.001$; [f] $p < 0.001$; [g] $p < 0.001$; [h] $p < 0.001$; [i] $p = 0.027$; [j] $p = 0.001$; [k] $p = 0.004$; [l] $p = 0.001$; [m] $p < 0.001$; [n] $p < 0.001$; [o] $p = 0.014$; [p] $p < 0.001$; [q] $p < 0.001$; [r] 0.020; [s] $p < 0.001$; [t] $p = 0.001$; [u] $p = 0.015$; [v] $p = 0.014$; [w] $p < 0.001$; [z] $p = 0.009$; [aa] $p < 0.001$; [bb] $p < 0.001$; $p = 0.048$; [dd] $p = 0.004$; [ee] $p = 0.017$; [ff] $p = 0.009$; [gg] $p < 0.001$; [hh] $p < 0.001$; [ii] $p < 0.001$; [jj] $p < 0.001$; [kk] $p = 0.026$; [ll] $p < 0.001$; [mm] $p < 0.001$; [nn] $p < 0.001$; [oo] $p = 0.001$; [pp] $p = 0.003$; [qq] $p = 0.027$; [rr] $p < 0.001$; [ss] $p = 0.037$; [tt] $p = 0.002$; [uu] $p = 0.003$; [vv] $p = 0.032$; [ww] $p = 0.023$; [yy] $p = 0.039$

A multivariate linear regression analysis using the backward stepwise elimination method of all spirometry measurements as candidate–independent variables and the TMD as a dependent variable revealed that FIVC ($\beta = -2.050$, $P = 0.022$) was a significant predictor for difficult laryngoscopy.

The AUC values of FVC, FEV_1, FEV_3, FEV_6, FIVC, and MVV according to MMO were 0.637, 0.612, 0.626, 0.636, 0.589, and 0.612, respectively. The ROC curve for FIVC is presented in Fig. 1. The AUC for FIVC with a cut-off value of 3.1950 L while using TMD as difficult laryngoscopy indicator is 0.754 (95% CI 0.646–0.862), and

Table 4 The mean spirometric measurements according to TMD, MMO, and NC/TMD

		FVC	FEV_1	FEV_3	FEV_6	FIVC	MVV
TMD	<6.5 cm					3.02 ± 0.62	107.80 ± 22.12
	≥6.5 cm					3.90 ± 1.06	117.30 ± 29.46
	p					<0.001*	0.128
MMO	≤4.5 cm	3.80 ± 0.97	3.08 ± 0.83	3.73 ± 0.94	3.80 ± 0.97	3.56 ± 1.11	108.03 ± 29.34
	>4.5 cm	4.21 ± 1.00	3.38 ± 0.82	4.08 ± 0.96	4.20 ± 1.00	3.91 ± 1.05	118.42 ± 28.95
	p	0.003*	0.014*	0.003*	0.003*	0.127	0.014*
NC/TMD	≥5			3.90 ± 0.91			
	<5			4.08 ± 0.98			
	p			0.019*			

* $p < 0.05$; Mann–Whitney *U* test. Only, the significant values with a Spearman correlation coefficient over 0.300 were presented

MMO maximal mouth opening, *TMD* thyromental distance, *NC/TMD* the ratio of neck circumference to thyromental distance, *FVC* forced vital capacity, FEV_1 forced expiratory volume in 1 s, FEV_3 forced expiratory volume in 3 s, FEV_6 forced expiratory flow in 6 s, *PEF* peak expiratory flow, FEF_{25} forced expiratory flow 25%, FEF_{50} forced expiratory flow 50%, *FIVC* forced inspiratory vital capacity, FIV_1 forced inspiratory volume in 1 s, *PIF* peak inspiratory flow, *MVV* maximum voluntary ventilation. All comparisons performed by using Mann–Whitney *U* test

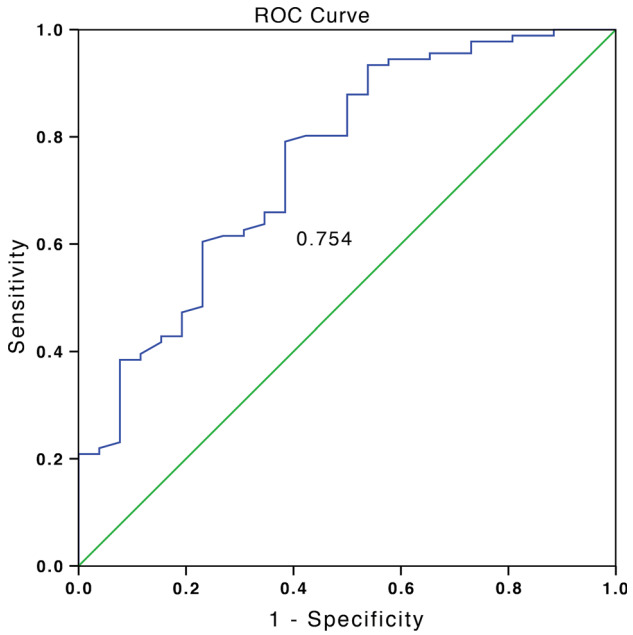


Fig. 1 The ROC curve analysis of FIVC. The ROC curve analysis revealed an AUC (area under the curve) of 0.754

FIVC showed a sensitivity of 0.718 and specificity of 0.714 with a positive likelihood ratio of 2.5104 and negative likelihood ratio of 0.3949.

4 Discussion

The present study shows a clear association between airway measurements and spirometry outputs, in which the FIVC revealed the highest value of equality with TMD to predict difficult laryngoscopy.

Several investigators have tried to find a simple bedside physical examination to estimate difficult laryngoscopy. The Mallampati classification was introduced and is currently a common and well-known screening test that categorises the visibility of the oropharyngeal structures [14]. The TMD, SMD, and MMO are widely described tools for predicting difficult laryngoscopy [15–17]. Nevertheless, the diagnostic value of these tests showed inconsistent results in consecutive trials, probably due to the differences in the incidence of difficult laryngoscopy or in patient characteristics. Various studies suggested that a single airway assessment test has limited value to anticipate difficult laryngoscopy [6, 17, 18]. Therefore, studies have focused on the combination of multiple tests to enhance diagnostic value and accuracy. The Wilson scoring system and intubation difficulty scale are the most-demonstrated risk indexes; they consist of multiple factors, which leads to confusion in evaluation and requires considerable time to use [2, 19].

Furthermore, spirometry and flow-volume curves are simple and widely performed tests used in the diagnosis or treatment of patients with obstructive or restrictive pulmonary symptoms. Obstructive sleep apnea syndrome (OSAS) is a well-known health problem mainly caused by the structural and functional abnormalities of the upper airway, which may reflect alterations on the pulmonary function tests. Several studies demonstrated a close relationship between significant spirometry outcomes, including saw-tooth sign (three or more consecutive peaks occurring on regular intervals at forced expiratory and inspiratory flow volume curves) and increased ratio of FEF_{50}/FIF_{50} (>1), and OSAS [20–22]. Moreover, it is reported that OSAS may cause difficulty in laryngoscopy related to the deformed structure of the upper airway and

increased neck circumference [10, 23, 24]. Recent research has shown that this anatomical disturbance leads to upper airway volume which might be associated with the magnitude of the air from mouth to the lungs [25]. In this context, air-flow may be influenced by the upper airway anatomy linked the spirometry to difficult laryngoscopy. Consequently, the outputs of spirometry may be a beneficial predictor for difficult laryngoscopy.

The Mallampati test is a comprehensive technique to assess the size of the tongue, oral cavity, pharyngeal structures, level of mouth opening, and (indirectly) the mobility of the head and neck [14]. Despite its effectiveness, the test shows inadequate sensitivity and specificity values, leading to inconsistency in diagnosis of difficult laryngoscopy, which can be caused by improper evaluation of the test with/without phonation and/or with different head or tongue positions [26]. Unfortunately, the present study showed no association between MPC and spirometry measurements.

Maximal mouth opening is the distance between upper and lower incisors with the mouth opened as wide as possible. Multivariate analysis indicated that MMO is strongly associated with difficult laryngoscopy [27]. Only one study demonstrated unsatisfactory results for MMO, which might be due to the limited data used [17]. Moderate correlations have been found between MMO and FVC, FEV_1, FEV_3, FEV_6, FIVC and MVV in the present study; however, none yielded an adequate AUC on the ROC curve.

Recent studies, especially on obese patients, have supported the use of neck circumference measurement in the preoperative period to predict laryngoscopy difficulties, showing sensitivity of 92% and specificity of 84% [23, 28]. However, NC may not clearly show the quantity of soft tissue at regions on the neck. It was reported that a large amount of fat tissue was detected in the surrounding segments of the pharynx in obese patients, using magnetic resonance imaging, and also showed that difficult laryngoscopy could be determined by using ultrasonographic assessment on the pre-tracheal soft tissue of the neck [29, 30]. These results suggested that NC alone may not be useful and that an additional technique is required to predict difficult laryngoscopy. A current study demonstrated that NC/TMD with a cut-off value over 5 had a moderate sensitivity (88.2%), specificity (83%), and a negative predictive value (97.8%); therefore, it may be an important predictor for difficult laryngoscopy [6]. In the present study, the NC/TMD ratio yielded a negative mild correlation with FIVC, which could not be accepted as a satisfactory outcome.

Thyromental distance can be considered to be an indicator of mandibular space, which can also show information about the displacement degree of the tongue by the laryngoscope blade. Several studies reported variable results on test sensitivity; those related with the difference in cut-off points ranged between 4.0 and 7.0 cm, and had unstandardised measurement methods of TMD (the distance between thyroid notch and inside/outside of mentum). In relation, an investigator obtained a positive likelihood ratio of 4.1 when a $\leq$6.0 cm cut-off was applied, and another obtained a higher diagnostic performance with the lowest used cut-off value of $\leq$4.0 cm; the latter study reported positive and negative likelihood ratios of 9.4 and 0.03, respectively [17, 31]. The current study revealed a higher correlation coefficient between TMD and FIVC, and a higher sensitivity and specificity with moderate positive and negative likelihood ratios predicting difficult laryngoscopy. The multivariate linear regression analysis confirmed FIVC as a predictor of difficult laryngoscopy.

There are a few limitations to this study. First, all intubation processes were completed by the same anesthesiologist; however, the airway assessment measurements were not, which could have led to a minimal difference. A group consisting of experienced anaesthesiologists may decrease the measurement errors for accuracy. Second, the scale of the population is restricted and it reflects only a single institutional and regional measurement for comparison. A multicentre trial is required to limit this effect.

The current pilot study is the first study to demonstrate the relationship between spirometry outputs and airway assessment measurements. In conclusion, it seems that merely the spirometry value, FIVC, may display a close association with the prediction of difficult laryngoscopy. However, it is clearly demonstrated that neither FIVC nor any other measurements of spirometry show the clinically important value to predict difficult laryngoscopy. Therefore, further studies with large population series in obese and pregnant patients are required to confirm or elucidate the exact association between these measurements.

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Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest to disclose.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration.

Informed consent Informed consent was obtained from all individual participants included in the study.

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