J Anesth (2011) 25:457–461
DOI 10.1007/s00540-011-1126-3

SHORT COMMUNICATION

Using temporomandibular joint mobility to predict difficult tracheal intubation

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Received: 22 October 2010 / Accepted: 7 March 2011 / Published online: 31 March 2011

Abstract The aim of this prospective study was to determine the reliability of temporomandibular joint (TMJ) mobility measurements for predicting difficult intubation. To evaluate the accuracy in predicting difficult intubation by TMJ mobility measurement, 762 patients requiring general anesthesia with tracheal intubation for elective surgery were enrolled in this prospective, observational, single-blind study. Maximum mouth opening, right–left jaw excursion, and degrees of protraction were determined with a digital inclinometer. Incisor gap was measured using a vernier caliper during full mouth opening. After induction of anesthesia using a standard protocol, the patient's grade of laryngeal view by Cormack–Lehane classification was documented by an anesthesiologist. We found that the degrees of protraction and incisor gap in the easy intubation group were significantly higher than those in the difficult intubation group. The incisor gap was found to be more sensitive (88.37%) and more specific (95.71%) than protraction degrees (58.14% and 59.76%, respectively). The results revealed that measurements of the incisor gap and degrees of protraction may be useful routine screening tests for preoperative prediction of difficult intubation.

Keywords General anesthesia · Laryngoscopy · Airway assessment tests · Tracheal intubation

Introduction

Difficult tracheal intubation is the most common cause of respiratory-related adverse outcomes, including brain damage and death, in anesthetic practice [1, 2]. Preoperative evaluation is important to identify patients at risk for difficult airway management. However, a standardized evaluation method is still unclear, as published studies have indicated variable estimates of diagnostic test accuracy. The evaluation of difficult intubation for measurement of temporomandibular joint (TMJ) movement has not been found in the literature.

The aim of this prospective study is to investigate TMJ mobility to determine the correlation with the prediction of difficult tracheal intubation.

After obtaining approval of the Local Ethics Committee and written informed consent, 762 ASA I–III physical status patients scheduled for elective surgery and requiring endotracheal intubation were enrolled in the study prospectively over a 1-year period. The exclusion criteria included patients aged less than 18 years, obstetrical patients, patients with anatomic abnormality or recent surgery of the head/neck, burns or trauma to the airways or to the cranial, cervical, and facial regions, patients with tumors or a mass in the aforementioned regions, patients with restricted mobility of the neck and mandible, and patients who do not have incisor teeth.

The measurements were performed with an Electronic Digital Inclinometer (Lumex, New York, NY, USA) by the same anatomist during the preoperative visit of each patient. Range of motion was recorded for maximum

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mouth opening, right–left excursion, and protraction (Fig. 1a,b). The incisor gap was measured using a vernier caliper during full mouth opening.

Maximum mouth opening

The angle between the transverse plane and corpus mandible (between upper and lower incisors) at the maximum mouth opening was measured while the patient was sitting erect, with neck hyperextended (Fig. 2a).

Right–left excursion of mandible

The recordings were performed by placing the probe parallel to the right or left ramus of the mandible with the patient moving the mandible first to the left, then to the right, without opening his/her mouth while sitting erect and facing forward (Fig. 2b,c).

Protraction

The inclinometer's probe was placed between the upper lip and mental protuberance, and then the patient was required to protract the mandible instead of biting the upper lip without opening the mouth (Fig. 2d).

Incisor gap

Distance between the upper and lower incisors was measured using a ruler during full mouth opening (Fig. 2e).

Before the induction of anesthesia, intravenous (i.v.) access was established. The monitored parameters included electrocardiogram, noninvasive blood pressure, and pulse oximetry. After the induction of anesthesia (i.v. propofol 2–2.5 mg/kg) and administration of an intubation dose of a neuromuscular blocking agent (i.v. vecuronium 0.1 mg/kg or rocuronium 0.6 mg/kg), laryngoscopy was performed on the patient in the "sniffing" position using a number 3 or 4 Macintosh laryngoscope blade. Head extension with cervical flexion was introduced with a pillow 7 cm in height. The laryngeal view was graded according to the Cormack–Lehane's scale: grade I, all the vocal cords visible; grade II, only posterior commissure or arytenoids visible; grade III, only epiglottis visible; grade IV, none of the foregoing visible [3]. In this study, difficult laryngoscopy was defined as Cormack–Lehane grade III or IV. Initial intubation attempts were performed by anesthesiologists with at least 3 years of work experience under the supervision of a staff anesthesiologist. The intubating anesthetist was blinded to the preoperative assessment during the grading of the laryngoscopic view; the staff anesthesiologist was aware of the patient's preoperative assessment. An 8.0-mm inner-diameter endotracheal tube without a stylet was routinely used for men and a 7.0-mm inner-diameter tube was used for women. No external laryngeal manipulation was performed for classifying the laryngoscopic view. Intubation was regarded as difficult when there was a need for a stylet or more than three attempts in patients with Cormack–Lehane grade III or IV. When tube progression into the trachea may not be possible without a stylet, Cormack–Lehane grade II laryngoscopy has defined as difficult intubation.

Normality distribution of the variables was tested using the one-sample Kolmogorov–Smirnov test. Numeric variables between the easy and difficult intubation groups were compared using the Student's *t* test for normal distributed data and the Mann–Whitney *U* test for non-normal distributed data. The categorical variables were compared with a chi-square test. The area under the curve (AUC) of the receiver operating characteristic (ROC) curve was used to assess the predictive power of the variables for difficult intubation. A P value < 0.05 was considered statistically significant.

This study included a total of 762 patients. Both groups (easy intubation and difficult intubation) were found to be homogeneous in relationship to their age, gender, height,

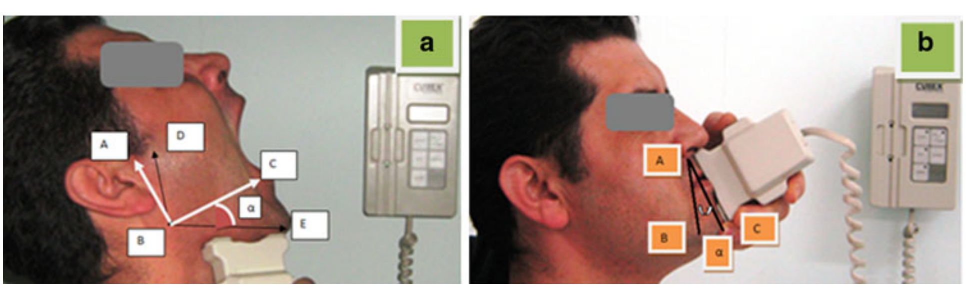

Fig. 1 Measurements were performed with an Electronic Digital Inclinometer. **a** *A–B–C*, neutral position of the mandible (*A–B*, ramus mandible; *B–C*, corpus mandible); *D–B–E*, maximum mouth opening of the mandible (*D–B*, ramus mandible; *B–E*, corpus mandible); α, maximum mouth opening. **b** *A–B*, neutral position of the mandible; *A–C*, protraction of the mandible; α, angle of protraction

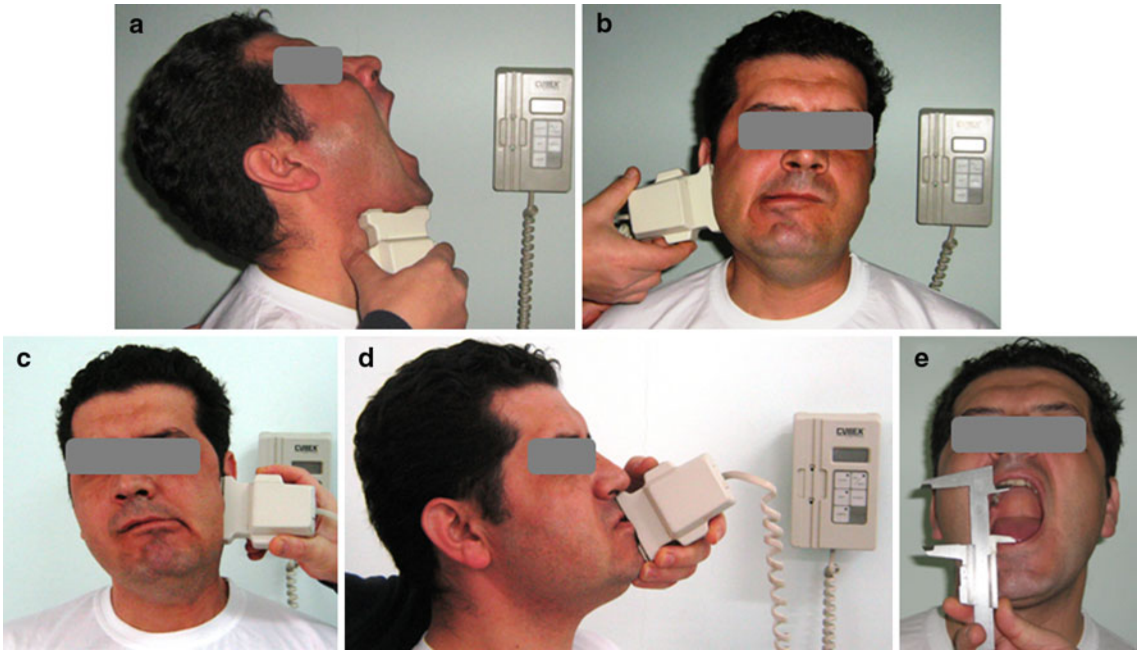

Fig. 2 Maximum mouth opening (**a**), right–left excursion (**b**, **c**), and protraction degrees (**d**) were determined with a digital inclinometer. The incisor gap was measured using a vernier caliper during full mouth opening (**e**)

Table 1 Demographic data and predictive tests with relationship to the intubation difficulty (mean ± SD)

Factor	Easy intubation group ($n = 676$)	Difficult intubation group ($n = 86$)	P
Age (years)	42.89 ± 16.68	45.29 ± 15.06	0.153
Sex (male/female)	358/318	37/49	0.082
Height (cm)	167.92 ± 6.74	167.43 ± 7.27	0.422
BMI (kg/m^2)	26.76 ± 2.98	26.53 ± 3.29	0.601
Maximum mouth opening (°)	29.75 ± 4.66	28.80 ± 4.48	0.109
Protraction (°)	12.02 ± 2.07	11.32 ± 2.19	**0.001**
Right excursion (°)	4.47 ± 1.55	4.40 ± 1.46	0.796
Left excursion (°)	4.52 ± 1.47	4.49 ± 1.36	0.914
Incisor gap (mm)	60.84 ± 6.37	42.56 ± 8.31	**<0.001**
CL grade and n (%)			
I	573 (84.8)	0 (0.0)	
II	103 (15.2)	25 (29)	
III	0 (0.0)	51 (59.3)	
IV	0 (0.0)	10 (11.6)	

No statistically significant difference was obtained in demographic parameters between groups ($P > 0.05$)Degree of protraction and incisor gap in the easy intubation group were significantly higher than in the difficult intubation group ($P < 0.05$)

BMI body mass index; *CL* Cormack–Lehane classification

weight, and body mass index (Table 1; all $P > 0.05$). The Cormack–Lehane grades of the patients are shown in Table 1. There were no failed intubations in either of these groups.

Difficult tracheal intubation was found in 86 (11%) patients. There were no significant differences between the easy intubation and difficult intubation groups regarding maximum mouth opening and right–left excursion. The degree of protraction and incisor gap in the easy intubation group were significantly higher than those in the difficult intubation group (see Table 1; $P < 0.05$). In this study, the incisor gap was found to be more sensitive (88.37%) and more specific (95.71%) than degrees of protraction (58.14% and 59.76%, respectively; Table 2).

Table 2 AUCs and predictive value of maximum mouth opening, protraction, right and left excursion, and incisor gap

Variables	Sen	Spe	ROC curve		
	(%)	(%)	Cut-off	AUC (95% CI)	*P*
Maximum mouth opening (°)	80.23	29.73	≤32	0.553 (0.517–0.588)	0.100
Protraction (°)	58.14	59.76	≤11	0.605 (0.570–0.640)	**0.001**
Right excursion (°)	74.42	29.44	≤5	0.508 (0.472–0.544)	0.789
Left excursion (°)	76.74	28.25	≤5	0.503 (0.467–0.540)	0.910
Incisor gap (mm)	88.37	95.71	≤50	0.939 (0.919–0.954)	**<0.001**

The incisor gap was found to be more sensitive and more specific than degrees of protraction ($P < 0.05$)

We investigated the relationship between TMJ mobility and difficult tracheal intubation. The patients were evaluated using the same factors, such as stylet usage, number of attempts, and Cormack–Lehane classification. The incidence of difficult intubation was found to be 11%, within the range reported in the literature.

Difficult intubation is widely described in the literature. Cormack–Lehane grade III or IV is generally regarded as difficult [4, 5]. The ASA Task Force describes endotracheal intubation as difficult when proper insertion of the tracheal tube with conventional laryngoscopy requires more than three attempts or more than 10 min [6]. In general, endotracheal intubation is accepted as easy when immediate visualization of the glottis can be obtained and tube progression into the trachea can be achieved without the use of intubation aids, such as a rigid stylet [7, 8].

Various preoperative screening tests have been described for the prediction of difficult intubation. The main objective of a test should be a high sensitivity in the presence of high specificity. High sensitivity in the presence of high specificity values of these tests will eventually accurately categorize patients who are at risk and will mandate preoperative preparation.

The TMJ is a complex joint and demonstrates morphological differences in various patients. Therefore, it has been eagerly studied by clinicians. Although there have been several studies regarding the prediction of difficult intubation, our study is the first one that shows how to predict difficult tracheal intubation with measurements for TMJ mobility. Angular TMJ movements can be readily measured, and easy implementation distinguishes this reported method from other methods.

The measurement technique may affect the reliability of the tests. Certain factors, such as measurement error, will decrease the reliability of the test. Therefore, we used an electronic digital inclinometer as an alternate method as it allows the measurement of angular joint motion values.

Maximum mouth opening seemed to be an inadequate predictor of difficult intubation in our study. It may be discussed that mouth opening indicates movement of the TMJ and that significantly limited mouth opening prevents access to the larynx. Calder et al. [9] showed that mandibular movement and craniocervical movement are interrelated. Patients with restricted craniocervical movement may have reduced mouth opening ability. Unexpected results were obtained in our study because of the use of different measurement techniques.

Right–left excursion has not yet been examined. Significant differences were not observed regarding right–left excursion between the easy intubation and difficult intubation groups in our study.

The incisor gap was the most specific of all the five tests, with a specificity of 95.71% in this study. Wilson et al. [10] found that the mean incisor gap is 4.6 cm in the easy intubation group and 3.8 cm in the difficult intubation group, in agreement with the results obtained by Nath and Sekar [11]. However, this result is contradictory to the study conducted by Savva who reported that there was no correlation between incisor gap and difficult intubation [12].

In this study, the degrees of protraction measurement was the second most specific of all the five tests, with a specificity of 59.76%. Rosenstock et al. [13] found that the ability for jaw protrusion was an indicator for difficult intubation. Yildiz et al. [14] reported that incidence of difficult intubation was significantly higher in patients who had mandibular protrusion.

The previous studies demonstrated that the sensitivity and specificity rates of the tests used for predicting difficult tracheal intubation vary. Savva [12] found that sternomental distance was a more sensitive (82.4%) and more specific (88.6%) test than thyromental distance and the modified Mallampati test. In addition, Yildiz et al. [14] reported that incisor gap and Mallampati grade III–IV were the most sensitive measurements when used alone (43% and 35%, respectively). In our study, incisor gap and degrees of protraction were found to be more sensitive and more specific for predicting difficult intubation. Because there is still no single test that predicts difficult intubation accurately, sensitivity and specificity rates for the values of our studies are valuable.

In conclusion, TMJ mobility measured can be used for predicting difficult tracheal intubation in patients. The risk of difficult tracheal intubation may increase because of decrease in protraction degrees and incisor gap. In this study, the most sensitive tests for predicting difficult intubation were determined to be incisor gap and degree of protraction in TMJ mobility.

Acknowledgments Support was provided from institutional and departmental sources.

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