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Respiration and the Airway

Can tongue thickness measured by ultrasonography predict difficult tracheal intubation?

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Abstract

Background. Increased tongue thickness is likely to be associated with difficult airways. However, no methods to evaluate tongue thickness were available. Currently, tongue thickness can be measured by ultrasonography. The present study investigated the predictive value of tongue thickness to predict difficult tracheal intubation.

Methods. Adult patients undergoing tracheal intubation and general anaesthesia were enrolled in the study. Tongue thickness was assessed using submental ultrasonography in the median sagittal plane before anaesthesia. Airway assessments were conducted. Ratios of tongue thickness to thyromental distance were calculated to investigate the potential predictive value of their combination. The primary outcome was difficult tracheal intubation. A multivariable logistic regression and receiver operating characteristic curve analysis were used.

Results. In total, 2254 patients were analysed. One hundred and forty-two (6.3%) patients experienced difficult laryngoscopy, and 51 (2.3%) patients experienced difficult tracheal intubation. Increased tongue thickness (>6.1 cm) was an independent predictor for difficult tracheal intubation [sensitivity 0.75, 95% confidence interval (CI) 0.60–0.86; specificity 0.72, 95% CI 0.70–0.74]. An area under the curve of 0.78 (95% CI 0.77–0.80) for predicting difficult tracheal intubation was calculated. Increased ratios of tongue thickness to thyromental distance (>0.87) presented a considerable area under the curve (0.86, 95% CI 0.84–0.87), sensitivity (0.84, 95% CI 0.71–0.93), and specificity (0.79, 95% CI 0.77–0.81).

Conclusions. Tongue thickness measured by ultrasonography and its ratio to thyromental distance present significant capacities to predict difficult tracheal intubation.

Clinical trial registration. ChiCTR-RCS-14004539.

Key words: airway management; intubation, intratracheal; laryngoscopy; tongue; ultrasonography

Difficult airway remains a potential risk for patients undergoing general anaesthesia and a challenge for anaesthetists.[1 2] There have been no effective methods to predict difficult airway accurately.[3–7] Seeking a more accurate method is still necessary for anaesthetists.

Anaesthetists know that increased tongue thickness affects the performance of laryngoscopy and tracheal intubation and increases the risk of difficult airway.[8 9] However, there are no convenient and accurate recommended measurements to evaluate tongue thickness. Imaging techniques, such as three-dimensional computed tomography, X-ray, and magnetic resonance imaging, display the anatomical features of the upper airways well and have been recommended for evaluation of difficult airway.[10–12] However, it is difficult to use these techniques in airway research and clinical applications because of their high cost and potential harm to the body. The low incidence of difficult airways and the large sample demands for research further exacerbate the difficulty in applicatio of these traditional imaging methods in clinical practice and research. The modified Mallampati test reflects tongue volume to some

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Editor's key points

- Ultrasonography may be useful in predicting difficult tracheal intubation, by measuring the thickness of the tongue.
- Increased tongue thickness (>6.1 cm) indicates an increased risk of difficult tracheal intubation.

extent, but its limited predictive power[4] and requirement that patients perform mandatory actions decrease the application value for predicting difficult airway, especially in unconscious patients.[13] Until now, the tongue thickness has not been well explored in predicting difficult airway.

Ultrasonography may bring a new change in difficult airway research because it is non-invasive, convenient, and inexpensive. Previous clinical practice and observations[14–16] have found that ultrasonography can image a patient's tongue and accurately measure tongue thickness in the 'sniffing' position. This variable may reflect the internal characteristics of a patient's upper airway anatomy while requiring less patient collaboration than traditional techniques. However, whether tongue thickness assessed by ultrasonography is a useful predictor of difficult airway is not known. Therefore, this study was designed to evaluate the predictive value of accurately measured tongue thickness using ultrasonography for predicting difficult tracheal intubation and difficult laryngoscopy.

Methods

The Ethics Committee of Yijishan Hospital of Wannan Medical College approved the research protocol, and written informed consent forms were obtained from the patients before enrolment in the study.

This prospective observational study was conducted from May 1, 2014 to December 31, 2014 and from January 1, 2016 to May 31, 2016 at our institution. Patients who were undergoing elective surgery with general anaesthesia were included. The following inclusion criteria were used: (i) 18- to 90-yr-old patients; (ii) ASA score of I, II, or III; (iii) undergoing general anaesthesia requiring tracheal intubation; (iv) no upper airway anatomical deformity, trauma, or tumour; (v) no identified difficult airway or difficult airway history that required the patient to be awake during tracheal intubation; and (vi) no subglottic airway stenosis. The following exclusion criteria were used: (i) patients who dropped out of the study; (ii) modified anaesthesia protocol or cancellation of tracheal intubation for a non-difficult-airway reason; and (iii) missing patient characteristics or study variables (e.g. age, sex, and modified Mallampati test score). Only the patients who were assigned to the operation rooms in a specified area were enrolled because of the large number of patients in our institution but the limit of two sonographers and two ultrasound machines.

Airway assessments

All enrolled patients underwent an ultrasonographic measurement of tongue thickness in a transitional waiting hall before transport to the operating room. A low-frequency convex array probe (S8; SonoScape Corp LP, Shenzhen, China) was used for ultrasonography. Two experienced sonographers performed the ultrasonographic measurements. The following ultrasonographic methods were used to measure tongue thickness. The patient assumed a supine position with the neck stretched. To obtain a uniform status of the tongue, all of the patients were asked to keep their mouth closed and to place the tongue tip slightly touching the incisors, with the tongue relaxed and with no phonation. The probe was placed under the chin in the median sagittal plane (Fig. 1A) and adjusted to obtain the entire tongue outline clearly on the screen. This image was frozen. The maximal vertical dimension from the tongue surface to the submental skin was measured and defined as the tongue thickness (Fig. 1B).

A special team performed preoperative classical difficult airway assessments, including the modified Mallampati test, the thyromental distance, and the inter-incisor distance for all patients, early on the preoperative day. The modified Mallampati test was measured as described previously.[17 18] The view was graded as follows: Grade 1, visible soft palate, fauces, uvula, and pillars; Grade 2, visible soft palate, fauces, and uvula; Grade 3, visible soft palate and base of the uvula; and Grade 4, soft palate not visible. Grades 3 and 4 were deemed predictors of difficult airway. Thyromental distance was measured as the straight distance between the upper border of the thyroid cartilage incisure and the bony point of the mentum with the head and neck stretched. Inter-incisor distance was obtained when the patient maximally opened his or her mouth.

A higher modified Mallampati test score, thicker tongue, and lower thyromental distance suggested a greater risk of difficult airway; therefore, the ratios of the modified Mallampati test to thyromental distance (in centimetres) and tongue thickness (in centimetres) to thyromental distance (in centimetres) were calculated. Moreover, in order to investigate the relationship between tongue thickness and other predictors, correlation coefficients were calculated.

Induction of general anaesthesia

Airway evaluations were completed, and the patients were transported to the operating room. The patients were placed in a supine position, and standard monitors were applied. Oxygen for inhalation was administered through a facemask. General anaesthesia was induced using midazolam (0.05 mg kg^{-1}), fentanyl (0.004 mg kg^{-1}), propofol (1–2 mg kg^{-1}), and vecuronium (0.1 mg kg^{-1}). Mask ventilation was administered when the patients stopped communication. Patients were placed in the sniffing position after 3 min of ventilation, and one of the attending anaesthetists, who had ≥5 yr of experience, performed the laryngoscopies. A Macintosh number 3 or number 4 laryngoscope blade was used. External laryngeal pressure or manipulation was permitted to improve the view of the glottis. The tracheal tube size was selected based on the anaesthetist's clinical experience.

Study end points

The primary end point was difficult tracheal intubation, which was evaluated based on the intubation result after every intubation. Difficult tracheal intubation was defined as an insertion of the tracheal tube using conventional laryngoscopy that required more than two attempts, lasted >10 min, or required an alternative technique.[19] No more than four intubation attempts via the application of a Macintosh laryngoscope blade were permitted in our routine clinical anaesthesia procedure to ensure patient safety, and the operating time for each attempt was no longer than 1 min. Mask ventilation was used for at least