Introduction

Endotracheal intubation is the safest way for establishing a safe upper respiratory tract patency and thus achieving the maintenance of anaesthesia in the operating room. Endotracheal intubation can also help the patient's breathing or help make the breathing controlled for patients who stop breathing in the intensive care or emergency unit (1, 2). A successful intubation is not always possible because of difficult anatomical traits or existing systemic diseases of the patient (1, 3). Difficulty in intubation occurs at a rate of 1%-13% and serious intubation difficulty occurs in 2%-3% of these cases (1).

Inadequacies in establishing respiratory patency constitute an important proportion of deaths involving anaesthesia (4, 5). It is reported that approximately 30% of the deaths related to anaesthesia in the United States of America are due to failure of the difficult airway management (6). The reason for failed or inadequate airway management is reported to be due to bad or inadequate evaluation (7). The degree of difficulty in establishing respiratory patency and hypoxic brain damage progresses with the risk of death. Given that such dangers can develop when intubation cannot be performed, it is important to determine the objective tests for deciding the difficulty of difficult intubation. Predicting the difficult intubation makes it possible to change the method of anaesthesia, prepare assistive devices and find an experienced individual, and it may reduce the risk of complications. Many tests are available to direct the prediction of difficult intubation. For this purpose, measurements such as Mallampati, Cormack-Lehane tests (CL), sternomental distance, mandibular distance, neck length, neck circumference and head circumference were measured during the anthropometric measurements.

However, in studies that have been conducted, no single test has been proven to be superior. The joint use of multiple tests increases the likelihood of predicting the difficult intubation. Our aim in this study is to select combinations with
the highest selectivity value of thyromental and sternomental distances, length of mandible and neck and width of neck measurements that are combined with the Mallampati test in determining the difficult intubation. Furthermore, upon observing in our clinic that intubation is more difficult in cases where the head circumference is large, we included head circumference and (thinking that airway oedema in patients with malignancies other than head-neck malignancies may cause difficult intubation) malignancy among the predictive tests for difficult intubation.

Methods

Permission for this study was granted by the local ethics committee. After taking consent from the patients, patients aged 18–70 and falling into groups 1–2 according to American Society of Anesthesiologists’ (ASA) criteria were included in the study. Patients with head–neck tumours and head–neck anomalies that would require surgical intervention in the head-neck region were excluded from the study.

In the preoperative evaluation of the patients, age, sex, height, body weight and prior difficult intubation experiences were recorded. Oropharyngeal structures were observed and recorded in a sitting position with the mouth wide open and tongue out, according to the modified Mallampati classification. Thyromental and sternomental distances, length of the mandible, length and width of the neck and circumference of the head were anthropometrically measured. For sternomental distance, the distance between the highest tip of the sternum and the tip of the chin was measured and recorded while the head is in full extension; for thyromental distance, the distance between the thyroid cartilage and the tip of the chin was measured and recorded while the head is in full extension. The mandibular length was measured as the distance between the gonion and the tip of the chin. The mastoid process and the highest upper tip of the sternum and the medial point were taken as reference points and were measured for the length of the neck. For these measurements, a 15.0 cm long calliper with a source of error of 0.01 was used. The head circumference was measured by wrapping the head with the soft measuring tape crossing the occipital protuberance and the forehead, and the neck circumference was measured by wrapping the neck with the soft measuring tape crossing from under prominentia laryngea. All these tests were applied and evaluated to all the patients by the same anaesthesiologist researcher who had an experience of 3 years.

Before being admitted to the operation room, antecubital vascular access was established in all the patients, and 0.03 mg kg⁻¹ intravenous midazolam was registered as a premedication. Pulmonary (SpO₂, ETCO₂) and cardiovascular (blood pressure, EKG) monitoring of the patients were performed in the operating room. After a 5-min preoxygenation, the anaesthesia was induced by applying fentanyl (1 µg kg⁻¹), thiopental (5 mg kg⁻¹) and rocuronium (0.1 mg kg⁻¹). The patient’s head was in extension from the atlanto-occipital joint and the upper cervical spinal cord, and the neck was in flexion from the lower cervical spinal cord. Laryngoscopy was performed by anaesthesiologist researchers or experts with at least 1 year experience via a Macintosh 3 or 4 blade, and the view was evaluated according to the CL classification. The patients with a laryngoscopic view of CL 3–4 were considered as difficult intubation.

Statistical analysis

For the variable of patients’ intubation difficulty, a number (n) and percentage were assigned. Malignancy comparison and intubation difficulty in patient groups were performed by a Chi-squared test.

Receiver operating characteristic (ROC) analysis was performed, and ROC graphs were drawn for variables of thyromental and sternomental distances, neck length, neck circumference and head circumference that were clinically predicted to be effective in determining the risk group, and the area under curve (AUC) and this area’s 95% confidence intervals were determined. After the analysis, variables with AUC>0.500 were concluded as having a specific sensitivity/selectivity in determining the risk group. In addition to calculating the sensitivity and selectivity values for determining the risk group for these variables, positive and negative predictive values were also calculated.

After ROC analysis, high selectivity values were determined as the breakpoint. Sensitivity and selectivity of the breakpoints determined for the variables that were effective for determining the risk group were calculated in the groups that were determined as risky and riskless after performing the Mallampati test.

For statistical analysis, MS-Excel 2007 and Statistical Package for the Social Sciences (SPSS, Inc., Chicago, IL, USA) Windows version 15.0 were used. Statistical level of significance was accepted as p<0.05.

Results

No statistically significant difference was found in the patient groups with difficult and easy intubation when compared for age, weight, height and body mass index (BMI). In total, 23 of the 290 patients in the study (7.9%) were accepted as difficult intubation (Table 1).

No statistically significant difference was found between malignancy of patients and easy and difficult intubation groups (χ²=0.101; p=0.751). Of the 206 patients with malignancies, 189 (91.7%) were determined as easy intubation, and 17 (8.3%) were determined as difficult intubation (Table 2).

After ROC analysis of the variables was performed by taking the easy and difficult intubation group as a reference, it was found to be statistically significant (p<0.05) for thyromental and sternomental distances, neck length, neck circumference and head circumference (Table 3).
For these variables, high selectivity values were taken as the cut-off value and their sensitivities, selectivities and positive and negative predictive values were calculated (Table 4). For the high selective value of the thyromental distance (≤6.40 cm), sensitivity was calculated as 26.09%, selectivity as 97.38%, positive predictive value as 46.15% and negative predictive value as 93.86%. For the sternomental distance of ≤12.45, sensitivity was calculated as 13.04%, selectivity as 96.25%, positive predictive value as 23.08% and negative predictive value as 92.78%. For the neck length of ≤16.65, sensitivity was calculated as 21.74%, selectivity as 91.76%, positive predictive value as 18.52% and negative predictive value as 93.16%.

For the neck circumference of ≥40.75, sensitivity was calculated as 39.13%, selectivity as 83.15%, positive predictive value as 16.67% and negative predictive value as 94.07%. For the head circumference of ≥57.35, sensitivity was calculated as 26.09%, selectivity as 85.39%, positive predictive value as 13.33% and negative predictive value as 93.06%.

Sensitivities and selectivities of the variables with regards to breakpoints with high selectivity, along with patients with Mallampati 3-4 are illustrated in Table 5. For the thyromental distance of ≤6.40 cm, sensitivity was calculated as 37.50% and selectivity as 100.00%. For the sternomental distance of ≤12.45, sensitivity was calculated as 18.75% and selectivity as 90.48%, and for the neck length of ≤16.65, sensitivity was calculated as 31.25% and selectivity as 90.48%. For the neck circumference of ≥40.75, sensitivity was calculated as 43.75% and selectivity as 66.67%. For the head circumference of ≥57.35, sensitivity was calculated as 25.00% and selectivity as 85.71%.

Predicting difficult intubation requires safe tests and careful investigation of the airway. Many predictive tests are available for predetermining intubation difficulty. However, it is reported that because no single test is sufficient to establish intubation difficulty on its own, most correct results can be achieved through combinations of tests (9-11).

The likelihood for anaesthesiologists to encounter difficult intubation is reported as 1%–18%. Related failed intubation rate, however, varies between 0.05%–0.35% (1). In their study of 350 cases, Sava et al. (12) determined 4.9% difficult intubations. In their meta-analysis that consisted of 35 studies and that compared intubation tests with the CL test, Shiga et al. (13) encountered 5.8% difficult intubations. In their study that consisted of 212 cases and that compared intubation tests with the CL test, Iohom et al. (14) found the difficult intubation rate to be 9%, and Butler et al. (15), in their study of 250 cases, found the difficult intubation rate to be 11.5%.

In our study where we considered CL 3-4 patients as the intubation criterion, we found difficult intubation incidence to be 7.9%. This is similar to Iohom et al (14) where they accepted CL 3 and 4 as the difficult intubation criterion. In their study involving 778 adult male patients, Wilson et al. (16) found the difficult intubation rate to be 1.5%, much lower than what we found in our study. We maintain that the reason for this rate being low was that they accepted difficult intubation only as the complete absence of epiglottis. Were we to also accept CL 4 as the criterion for difficult intubation, our rate would be 0.7%.

The majority of our patient profiles consisted of patients with malignancies. Thinking that airway oedema in patients with malignancies other than head–neck malignancies may cause difficult intubation, we included malignancy among our predictive criteria (17). The difficult intubation rate in patients with malignancies other than head and neck malignancies was found to be 8.3%, and in patients with no malignancy, the difficult intubation rate was found to be 7.1%. However, a statistically significant difference was not determined. We are of the opinion that the expectation for difficult intubation in patients with malignancies other than head and neck malignancies was not different from that of the general population.

In the study by Savva et al. (12), a correlation was not determined between age, weight, height and difficult intubation.
Aşık et al. (4) also found no correlation between height and weight and difficult intubation. In contrast, Yıldız et al. (18) found difficult intubation frequency to increase with body weight. The patients in our study were within obesity limits according to their BMI, and we observed that there was no correlation between weight and difficult intubation. Furthermore, no correlation between height and difficult intubation was found in our study. Karkouti et al. (19) reported difficult intubation to be more common among advanced age, male patients, but we observed no correlation between age and difficult intubation.

Patil et al. (20) interpreted the distance between the lower edge of the chin and the prominentia laryngea being measured as less than 6 cm while the neck is in full extension in favour of difficult intubation. In their study, Frerk et al. (21) found thyromental distance being less than 7 cm to be meaningful for difficult intubation, and Karkouti et al. (19) found it being less than 7.75 cm to be meaningful for difficult intubation. Karkouti et al. (19) reported difficult intubation to be more common among advanced age, male patients, but we observed no correlation between age and difficult intubation.

Savva et al. (12) concluded that thyromental distance is neither sufficiently sensitive nor specific and that it cannot be used as the only measurement. Similar to Frerk et al. (21), we found the thyromental distance to be less than 6.40 cm in patients with difficult intubation. Iohom et al. (14) reported that measuring thyromental and sternomental distances along with the Mallampati test reduces sensitivity by 25% but that selectivity and positive predictive value reaches the maximum values of 100%. In our study, when we evaluated the Mallampati test and thyromental distance together, the difficult intubation selectivity increased. In addition to the Mallampati test, when we included the thyromental distance to the evaluation, selectivity reached 100%; furthermore, we reached 37% sensitivity and 100% positive predictive value. In our study we found Mallampati–thyromental distance combination as the test with the highest selectivity and highest positive predictive value with regard to predicting the difficult intubation.

In literature, short and thick necks are cited among the risk factors for difficult intubation (12, 23). In their study of 227 cases, Acer et al. (24) found neck circumference cut-off value

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<th>Table 3. Variables’ areas under curve</th>
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AUC: area under curve

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<th>Table 4. Sensitivity, selectivity and positive and negative predictive values of the variables</th>
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MP: Mallampati; TM: thyromental distance; SM: sternomental distance

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<th>Table 5. Evaluation of data</th>
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<td>Cormack–Lehane test</td>
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MP: Mallampati; TM: thyromental distance; SM: sternomental distance
to be 360 mm according to the CL test in the risky group, and for this value, sensitivity is calculated as 94.74% and selectivity as 42.68%. In our study, however, neck length and neck circumference were found to be statistically significant in predicting difficult intubation. In neck circumferences of 40.75 cm and over, 43.7% sensitivity, 66.6% selectivity and 50% positive predictive value were obtained; when neck lengths of 16.65 cm or lower were added as risks, 31.2% sensitivity, 90.4% selectivity and 71.4% positive predictive value were obtained.

Upon observing in our clinic that in cases where head circumference was big, intubation was more difficult, we included head circumference among the predictive tests for difficult intubation. A statistically significant correlation was found between difficult intubation and head circumference. For head circumferences of 57.35 cm or over we obtained 85.7% selectivity, 25% sensitivity and 57.1% positive predictive value in predicting the difficult intubation. We maintain that due to its shortening of the necessary extension for intubation, increased head circumference may be causing difficult intubation.

Patients with head–neck tumours and head–neck anomalies who require surgical intervention in the head–neck region were excluded from the study.

Conclusion

We found the Mallampati–thyromental distance combination as the test with the highest selectivity and highest positive predictive value with regard to predicting the difficult intubation.

In addition to the present anthropometric measurements, we maintain that measuring the head circumference and neck length may also be important in predicting the difficult intubation. Furthermore, we are of the opinion that the expectation for difficult intubation in patients with malignancies other than head and neck is not different from that of the general population.

Conflict of Interest: No conflict of interest was declared by the authors.

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