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ARAŞTIRMA / RESEARCH

Ultrasound measurements of anterior neck soft tissue thickness to predict difficult laryngoscopy in pregnant patients

Gebelerde zor laringoskopinin belirlenmesinde ön boyun yumuşak doku kalınlığının ultrasonografi ile ölçümü

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Abstract

Purpose: The aim of this study is to examine the relationship between the measurement of anterior neck soft tissue thickness and the difficult laryngoscopy in which cesarean section under general anesthesia. Our secondary aim is to determine the efficacy of the other predictive tests and post-induction indicators to detect difficult laryngoscopy in pregnant women.

Materials and Methods: One hundred fiftytwo pregnant women (18-45 years old, American Society of Anesthesiologists Physical Status Class II) were included. According to Cormack and Lehane's scale (Grade I-II: easy laryngoscopy, Grade III-IV: difficult laryngoscopy) patients were divided into two groups. The distance from the skin to the anterior aspect of the trachea was measured at five different levels (hyoid bone, thyrohyoid membrane, vocal cords, thyroid isthmus, and suprasternal notch) with ultrasound. In addition, the other predictive tests and post-induction indicators for predetermining difficult laryngoscopy were recorded.

Results: There was no significant difference in the anterior neck soft tissue ultrasound measurements between the groups. Having limited mouth opening (4.80±0.51cm), buck teeth (20%), high Wilson's Risk Score (0.73±0.82), large neck circumference (41.40±2.96cm), inability to bite the upper lip (43%), and high Modified Mallampati Score (33%) were seen statistically significantly more common in the difficult laryngoscopy group. In addition, "Backward, Upward, Rightward Pressure"

Öz

Amaç: Bu çalışmanın birincil amacı, zor laringoskopi ile boyun ön yumuşak doku kalınlığı ölçümü arasındaki ilişkiyi genel anestezi altındaki sezaryenlerde incelemektir. İkincil amacımız, gebe kadınlarda zor laringoskopiyi saptamak için diğer prediktif testlerin ve indüksiyon sonrası göstergelerin etkinliğini belirlemektir.

Gereç ve Yöntem: Yüz elli iki gebe hasta (18-45 yaş, Amerikan Anesteziyologlar Derneği Fiziksel Durum Sınıf II) dahil edildi. Cormack ve Lehane skalası skoruna (I-II: kolay laringoskopi, III-IV: zor laringoskopi) göre hastalar iki gruba ayrıldı. Deriden trakeanın ön yüzüne kadar olan mesafe ultrasonografi ile 5 farklı seviyede (hyoid kemik, tirohyoid membran, vokal kord, tiroid istmus ve suprasternal çentik) ölçüldü. Zor laringoskopiyi önceden belirlemek için diğer öngörücü testler ve indüksiyon sonrası belirteçler kaydedildi.

Bulgular: Gruplar arasında boyun ön yumuşak dokusunun ultrasonografi ölçümlerinde anlamlı fark yoktu. Ağız açıklığının kısıtlı olması (4.80±0.51cm), sek dişleri (%20), Wilson Risk Skoru yüksek (0.73±0.82), boyun çevresi geniş (41.40±2.96cm), üst dudağı ısıramama (%43), ve yüksek Modifiye Mallampati Skoru (%33), zor laringoskopi grubunda istatistiksel olarak anlamlı derecede daha yaygın görüldü. Ayrıca "Geri, Yukarı, Sağa Basınç" manevrası, sakız elastik buji kullanımı, yüksek Entübasyon Zorluk Skoru ve >2 entübasyon girişimi zor laringoskopi grubunda daha sık bulundu.

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maneuver, use of gum elastic bougie, high Intubation Difficulty Score, and >2 intubation attempts were more frequently found in the difficult laryngoscopy group.
Conclusion: Measuring the anterior neck soft tissue with ultrasound is ineffective for determining difficult laryngoscopy in pregnant women. On the other hand, Mallampati Score, upper lip bite test, mouth opening, neck circumference, buck teeth, and Wilson's Risk Score can be helpful in the determination of difficult laryngoscopy in pregnancies.
Keywords:. Airway management; laryngoscopy; ultrasound; obstetrical anesthesia; cesarean section.

Sonuç: Gebelerde boyun ön yumuşak dokusunun ultrasonografi ile ölçülmesi zor laringoskopiyi belirlemede etkili bir yöntem değildir. Ancak Mallampati Skoru, üst dudak ısırma testi, ağız açma, boyun çevresi, çıkık ön diş ve Wilson Risk Skoru gebelerde zor laringoskopinin belirlenmesinde faydalı olabilir.

Anahtar kelimeler: Hava yolu yönetimi; laringoskopi; ultrason; obstetrik anestezi; sezaryen

INTRODUCTION

Although neuraxial anesthesia techniques are frequently used for cesarean section, general anesthesia can be applied when regional anesthesia is contraindicated or in accordance with the patient's preference. The possibility of a frequent encounter with airway problems due to anatomical and physiological changes in the obstetric population makes airway management more critical in cesarean sections. Increased vascularity and airway mucosa edema due to elevated progesterone levels, large breasts because of weight gain, short neck, and limitation in neck movements can cause difficult laryngoscopy in pregnancy. In addition to these factors, rapid weight gain during pregnancy causes thickening in the neck leading to difficult laryngoscopy. In pregnancy, the incidence of the difficult airway and the difficult-airway related mortality is 8-13 times higher than in the general population, respectively [1,2].

Since rapid sequence intubation is administered in cesarean sections, the prediction of the difficult airway is of great importance. Therefore, several preoperative bedside tests are performed to predict difficult airways. However, none of these tests alone is sufficient to foresee difficult laryngoscopy or difficult intubation[3]. Since there are no specific tests for obstetric patients in the preoperative evaluation of difficult airway, standardized tests are routinely used to determine airway difficulty.

Nowadays, Ultrasound (US) has become a versatile tool for obstetric anesthetists to provide the best balanced anesthesia possible. The US enables to identify important sonoanatomy of the upper airway, such as thyroid cartilage, epiglottis, cricoid cartilage, and cricothyroid membrane. Understanding airway sonoanatomy facilitates clinician works to determine difficult laryngoscopy/intubation or placement of an endotracheal tube/laryngeal mask airway. Usage of upper airway US can be helpful in airway management because of its portability, non-invasiveness, cost-effectiveness, and reproducibility. There is a potential for incorporating upper airway US into the airway assessment and imaging modalities. For example, the different levels of the anterior neck tissue may be measured as thicker in patients with difficult laryngoscopy, and the degree of anterior neck tissue thickness may be a predictive factor for difficult laryngoscopy. In recent years, anesthesiologists have begun to image the upper airways with US[4,5]. Suppose any life-threatening situation occurs in the management of a difficult airway because of airway and tissue edema in pregnant women. In that case, the US can be used to urgently locate the cricothyroid membrane in cases of a difficult airway[6].

Our hypothesis is that thick anterior neck soft tissue is associated with difficult laryngoscopy in which a cesarean section is under general anesthesia. The primary aim of this study is to examine the relationship between the measurement of the anterior distance between skin and trachea and the difficult laryngoscopy. Our secondary aim is to determine the efficacy of the other difficult airway predictive tests and post-induction difficult airway indicators in difficult laryngoscopy.

MATERIALS AND METHODS:

Study design

The study protocol was approved by Health Sciences University Bursa Yüksek Ihtisas Training and Research Hospital ethics committee (2014/08-01) and Clinical Trial Registry (ACTRN12617000482369). The study was

conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from each patient. This study was a single-center, prospective, and observational study in operating room of Bursa Yüksek Ihtisas Training and Research Hospital Women's Pregnancy Center. When regional anesthesia was not requested by the pregnant women or was contraindicated, any anesthesiologist in our clinic preferred general anesthesia in cesarean section as usual. A total of 152 pregnant women aged 18-45 and the American Society of Anesthesiologists Physical Status Class II (ASA II) who were to undergo elective cesarean section under general anesthesia were included in the study. Expectant mothers with difficult airway history, recent neck surgery, airway problems, emergency patients experiencing such disorders as acute fetal distress, umbilical prolapse, and ablatio placentae, and patients undergoing regional anesthesia were excluded from the study (Figure 1).

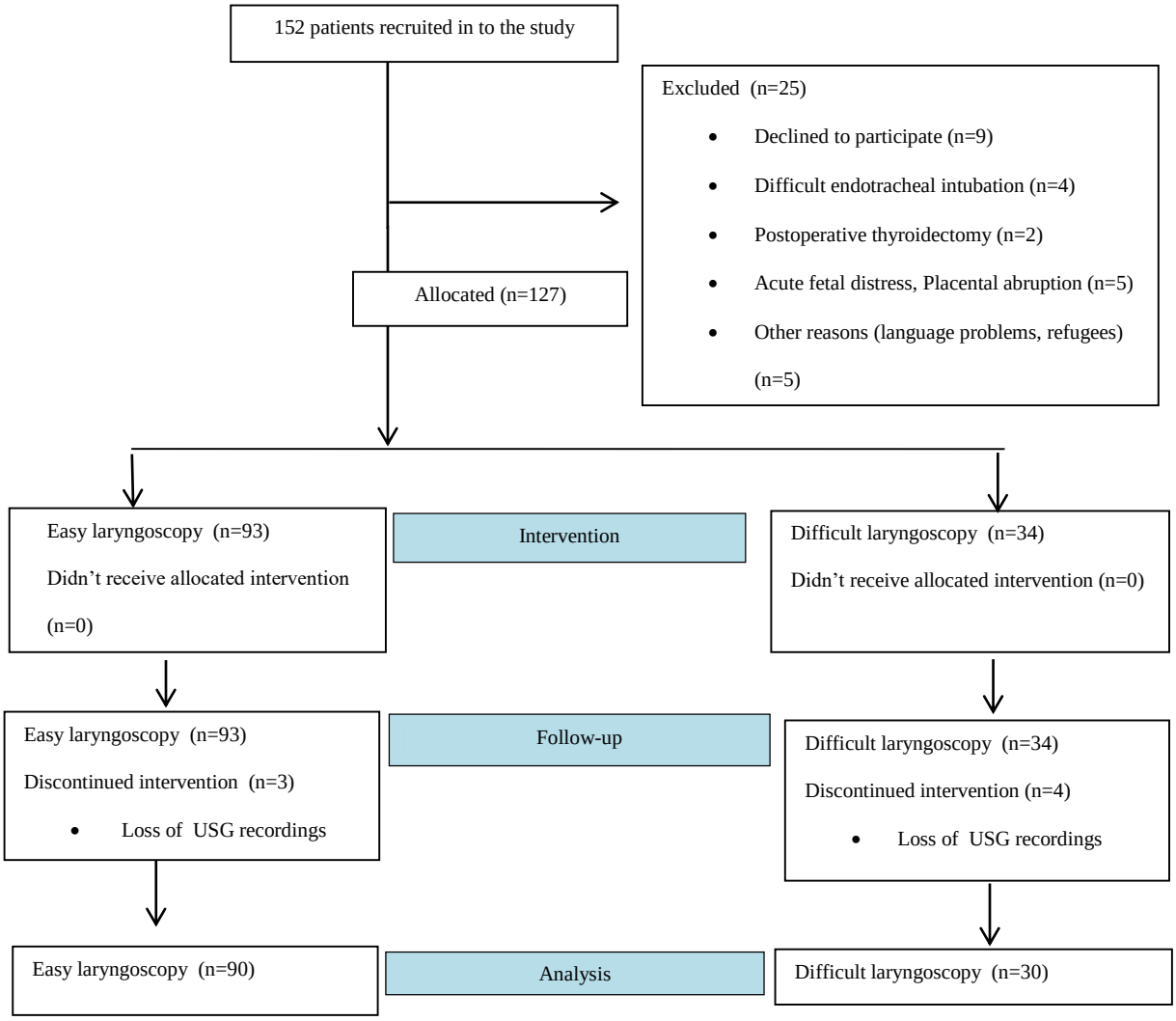

Figure 1: Flow chart

Procedure

According to Cormack and Lehane's scale, patients were divided into two groups: Grade I or II was accepted as easy laryngoscopy, whereas Grade III or IV was considered difficult laryngoscopy.

In order to determine the difficult airway in advance, Modified Mallampati Score (MMS), mouth opening, sternomental distance (SMD), thyromental distance (TMD), and neck circumference measurements, upper lip bite test which was done to assess the range of motion of the mandibular and architecture of the teeth, and Wilson Risk Score (WRS) were performed by an anesthesiologist.

MMS is the classification of oropharyngeal visualization (Class I: Soft palate, fauces, pillars, and uvula are visible, Class II: Soft palate, fauces, and uvula are visible, Class III: Soft palate and base of uvula are visible, and Class IV: Soft palate is not visible at all) Each patient was asked to bite their upper lip with lower incisor, and then the upper lip bite test was categorized as Class I (Lower incisor can hide mucosa of the upper lip), Class II (Lower incisor can partially hide mucosa of the upper lip) and, Class III (Lower incisor unable to touch mucosa of the upper lip). The WRS is based upon five risk factors with three possible scores (0,1,2) for each one, and a total score is between 0 and 10. These factors are head-neck movement, weight, jaw movement, mandibular recession, and buck teeth (large front teeth protruding over the other teeth).

Another anesthesiologist who was experienced in neck ultrasonography performed anterior neck soft tissue thickness measurements with US (EsaoteMyLab 30®, Florence, Italy) in the operating room. At the same time, the patient was slightly extended in the supine position. Neck measurements were made with a linear probe (12 MHz frequency) at five different levels, which were defined as hyoid bone (zone I), thyrohyoid membrane (zone II), vocal cords (zone III), thyroid isthmus (zone IV), and suprasternal notch (zone V) in real-time (Figure 2).

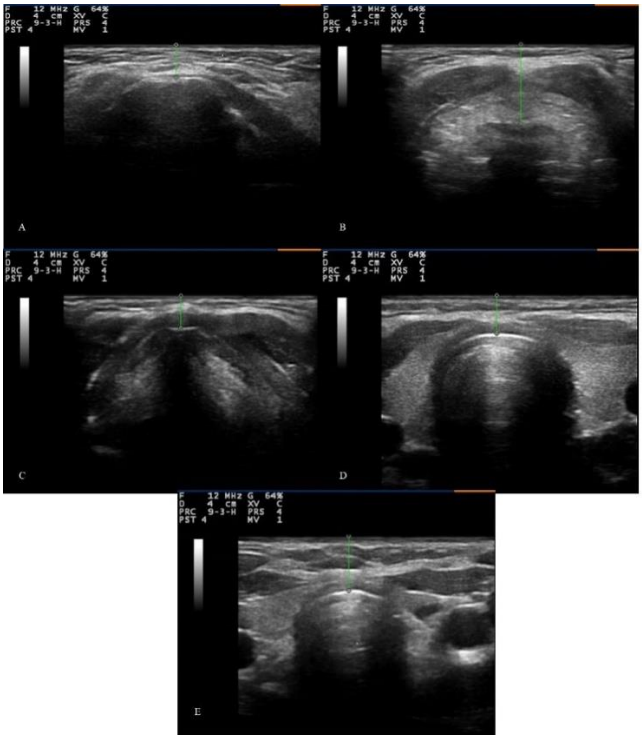

Figure 2: Neck ultrasonography, performed anterior neck soft tissue thickness measurements with US. A: hyoid bone (zone I), B: thyrohyoid membrane (zone II), C: vocal cords (zone III), D: thyroid isthmus (zone IV), E: suprasternal notch (zone V)

Anesthesia management

The patients' heads were raised 4-6 cm with 1-2 folded towels which were soft and easily malleable. They were placed in the sniffing position. Propofol (Propofol %2 Fresenius®, Fresenius Kabi, BadHamborg, Germany) 2-2.5 mg/kg iv and rocuronium (Curon®, Mustafa Nevzat, Istanbul, Turkey) 0.9 mg/kg iv were administered for anesthesia induction. Patients were intubated by another anesthesiologist with at least four years of experience who had not evaluated the difficult airway predictive tests and US measurements preoperatively. Cricoid pressure was not applied because of affecting the laryngeal view. The Cormack and Lehane's scale (CLS) is a grading system commonly used to describe laryngeal views during direct laryngoscopy with a Macintosh blade (size 3-4). During the intraoperative direct laryngoscopy, the anesthesiologists were asked to fill out the CLS as per following: CLS I: visualization of the entire vocal cords, CLS II: visualization of parts of vocal cords or the arytenoids, CLS III: visualization of only the epiglottis, CLS IV: visualization of only the soft palate. While CLS I and II were classified as easy, CLS III and IV were accepted as difficult laryngoscopy. The 'Backward, Upward, Rightward Pressure' (BURP) maneuver was not used for cricoid pressure during all intubation, but it was applied to patients with difficult laryngoscopy. In case of a second intubation attempt failed, another experienced anesthesiologist tried intubation with a gum elastic bougie. If the third attempt had failed to intubate, Intubating Laryngeal Mask Airway (ILMA) or video laryngoscope would have been used. Another anesthesiologist recorded the number of laryngoscopy attempts, practitioners, and alternative techniques. The Intubation Difficulty Scale (IDS) was recorded. IDS contains seven parameters that are known to be associated with difficult intubation. They are a number of supplementary attempts, a number of supplementary operators, a number and type of alternative techniques used, laryngoscopic grade, subjective lifting force, external laryngeal manipulation, and mobility or position of the vocal cords. Airway traumas such as mucosal injury, bleeding, tooth fracture, and sore throat were recorded as airway complications.

Outcomes

In this study, our primary outcome was to evaluate the effectiveness of the distance between the skin and the trachea anterior in predicting difficult laryngoscopy in pregnant women undergoing cesarean section with general anesthesia. Our secondary outcomes were to investigate the relationship between the incidence of difficult laryngoscopy and tests for difficult airway (predictive and post-induction).

Statistical analysis

SPSS 21 Windows (Statistical Package for Social Sciences, Armonk, NY, USA) was used for statistical evaluation. In the descriptive statistics of the data, average and standard deviation were used for qualitative data; frequency and percentage values were used for quantitative data. The Kolmogorov - Smirnov test measured the distribution of the variables. Mann-Whitney U test or independent samples t-test was used to compare variables in order to analyze quantitative data. The Chi-square test or Fischer exact test was used to compare variables in order to analyze qualitative data. The level of impact was measured with univariate logistic regression. A significance level of $p<0.05$ was accepted as significant statistically in the assessment. The expected effect size regarding the t-test in the independent groups was calculated as $d = 0.57$, and α and power were taken as $\alpha = 0.05$, power = 0.85, and the required minimum number of samples was determined as 120. The relevant calculation was made in the G Power 3.1.9.2 (Franz Foul, Edgar Erdfelder, Albert Georg Land and Axel Buchner. 2006, 2009) package program. Significant values in Table 2 were included in the logistic regression model according to collinearity analysis (tolerance >4). Difficult airway predictive tests were estimated according to OR (Odds Ratio) and respective 95% CI (Confidential Interval) obtained using logistic regression analysis.

RESULTS

Of the 152 patients undergoing general anesthesia, 127 were included in study. 90 patients in the easy laryngoscopy group and 30 patients in the difficult laryngoscopy group were evaluated statistically. Demographic data were given in Table 1. The average age of the patients was 30.55 ± 5.26 years of age in the easy laryngoscopy group and 30.53 ± 4.13 years of age in the difficult laryngoscopy group ($p = 0.903$). The body mass index (BMI) was 30.92 ± 4.39 in the easy laryngoscopy group and 32.68 ± 5.10 in the difficult laryngoscopy group ($p = 0.090$).

Table 1. Demographic data [mean ± standard deviation, n (%)]

Variable	n=120
Age (Years)	30.55±4.99
Body Mass Index (kg/m2)	31.36±4.62
ASA† II	120(100)

†**ASA**: American Society of Anesthesiology

Table 2. Predictive tests of difficult airway [mean ± standard deviation, n (%)]

	Easy laryngoscopy (n=90)	Difficult laryngoscopy (n=30)	p
Limitation of neck mobility	1(1.1)	0(0)	1.000
Big tongue	0(0)	0(0)	-
Buck teeth	6(6.7)	6(20)	**0.035***
Mandibular recession	0(0)	0(0)	-
Thyromental distance(cm)	7.89±1.01	7.73±1.23	0.565
Sternomental distance(cm)	16.91±1.41	16.17±1.95	0.128
Mouth opening(cm)	5.04±0.47	4.80±0.51	**0.017***
Neck circumference(cm)	40.16±2.37	41.40±2.96	**0.005***
Ultrasound (mm)			
Zone I	10.57±0.51	10.66±0.65	0.181
Zone II	10.50±0.48	10.54±0.73	0.173
Zone III	10.18±0.93	10.27±0.85	0.151
Zone IV	10.15±0.76	10.28±0.86	0.125
Zone V	10.14±0.75	10.28±0.84	0.102
Wilson Risk Score	0.26±0.57	0.73±0.82	**<0.001****
Modified Mallampati Score			
I	52(58)	15(53)	
II	30(32)	4(13)	**<0.001****
III	8(9)	9(30)	
IV	0(0)	2(3)	
Upper lip bite test			
1	20(22)	4(13)	**0.007***
2	56(62)	13(43)	
3	14(16)	13(43)	

*p< 0.05 **p<0.001

There was no significant difference in our primary outcome regarding US anterior neck soft tissue measurements between the two groups (p>0.05, Table 2).

When mouth opening, neck circumference measurement, WRS value, buck teeth, MMS, and upper lip bite test were compared, a significant difference was found between the two groups (p<0.05, Table 2). There were statistically significant differences between two groups in the cases with mask ventilation difficulties, a high score of IDS, more than two intubation attempts, the cases that required BURP maneuvers, and the use of gum elastic bougie for intubation (p<0.05, Table 3). There were shown positive and negative predictive values, sensitivity, and specificity of difficult airway predictive tests in Table 4. The Logistic regression analysis was given in the distinction between difficult and easy laryngoscopy in Table 5. Difficult intubation and hypoxia were found in none of the patients. Therefore, there was no need to use intubation laryngeal mask airway or video laryngoscopy during intubation. None of the patients developed complications due to laryngoscopy or intubation.

Table 3. Difficult airway indicators after anesthesia induction [mean ± standard deviation, n (%)]

	Easy laryngoscopy (n=90)	Difficult laryngoscopy (n=30)	p
Difficulty ventilation with mask	0(0)	9(30)	< 0.001
Intubation Difficulty Scale	3.94±0.85	8.10±4.01	< 0.001
>2 Tracheal Intubation Attempts	0(0)	11(36.6)	< 0.001
BURP† maneuver	0(0)	11(36.6)	< 0.001
Use of Gum Elastik Bougie	0(0)	6(20)	< 0.001

†**BURP:** Backward, Upward, Rightward Pressure

Table 4. Sensitivity, specificity, positive and negative predictive values of difficult airway predictive tests

	Sensitivity (%)	Specificity (%)	(+) Predictive Value (%)	(-) Predictive Value (%)
Modified Mallampati Score	33.3	91.1	55.6	80.4
Mouth opening	50.0	75.6	40.5	81.9
Neck circumference	40.0	84.4	46.2	80.9
Upper lip bite test	43.3	84.4	48.1	81.7
Wilson Risk Score	50.0	80.0	45.5	82.8
Buck teeth	20.0	93.3	50.0	77.8

Table 5. Logistic regression analysis for difficult airway predictive tests

	Wald	OR	CI (95%)	p
Buck Teeth	0.221	2.239	0.078 – 64.281	0.638
Mouth Opening	1.332	1.348	0.812 – 2.238	0.248
Modified Mallampati Score	2.789	0.611	0.343 – 1.089	0.095
Wilson Risk Score	6.358	0.527	0.320 – 0.867	0.012*
UpperLip Bite Test	1.107	0.680	0.332 – 1.394	0.293
Neck Circumference	0.185	0.959	0.792 – 1.161	0.667

OR: Odds Ratio, **CI:** Confidential interval *p<0.05

DISCUSSION

Four hundred cesarean operations are performed on average per month in our hospital. Although most cesarean sections are performed under neuraxial anesthesia, the rate of our general anesthesia is approximately 10-15%. In our prospective observational study, pregnant women who were planned to undergo elective cesarean section with general anesthesia were divided into two groups according to CLS. There was no significant difference in the two groups' anterior neck soft tissue thickness measurements. However, the increased values of the preoperative screening tests such as mouth opening restriction, buck teeth, neck circumference, WRS, MMS, and upper lip bite test were frequently seen in the difficult laryngoscopy group. In addition, the number of patients developing mask ventilation difficulty, IDS, the number of patients on whom more than two intubation attempts were performed, BURP maneuver, and the use of gum elastic bougie were also significantly high in the difficult laryngoscopy group.

In our study, we used CLS to determine the difficult laryngoscopy. The difficult airway guide published by the Difficult Airway Society in 2015 established definitions of difficult airway, such as difficult mask or supraglottic airway ventilation, difficult supraglottic airway placement, difficult laryngoscopy, difficult tracheal intubation, and failed intubation[7]. CLS III-IV is defined as difficult laryngoscopy and associated with intubation difficulty. Yentis et al.[8] reported an approximate 90% chance of difficult intubation in patients with the laryngoscopic appearance of CLS III.

The US can help determine the position of the endotracheal tube and the laryngeal mask airway. Also, it is suggested that the measurement of anterior neck soft tissue thickness can be evaluated as a

predictor of difficult laryngoscopy in the literature[9]. While preoperative bedside tests have low predictive values alone, they yield more accurate results in predicting difficult laryngoscopy or difficult intubation when used together [10,11]. This problem prompted researchers to combine tests used in predicting difficult airway or seeking advanced methods such as anterior neck tissue thickness measurement of US, computed tomography, or magnetic resonance. The US has the same efficacy as computed tomography in imaging all airway structures, and the cricoid lumen is as reliable as magnetic resonance imaging in the measurement of airway diameter[12,13]. In a study conducted by Ezri et al.[14] to evaluate difficult laryngoscopy in obese patients. They measured the thickness of the anterior neck soft tissue by using the US at three different levels: vocal cords, thyroid isthmus, and suprasternal notch. They found that the thickening at the vocal cords and suprasternal notch level increased statistically. However, they decided that thickening at the level of the vocal cords may be a better predictor. Adhikari et al.[15] found that only hyoid bone and thyrohyoid membrane level thickness out of five levels (hyoid bone, thyroid membrane, vocal cords, thyroid isthmus, and suprasternal notch) was statistically more significant in the determining the difficult laryngoscopy. Wu et al.[16] suggested that the increase in neck tissue thickness at a hyoid bone, thyrohyoid membrane, and vocal cord anterior commissural levels were an independent predictive factor for the difficult laryngoscopy. In recent studies, it has been reported that the increase in the distance between the skin and the epiglottis is a strong indicator in predicting difficult laryngoscopy[17-19]. Some research results have shown that the US is ineffective in difficult airway prediction[20-22]. In our study, we could not also find any statistically significant difference between the easy and difficult laryngoscopy groups in terms of the anterior neck tissue thickness at five different levels. When the results were evaluated, the thickening of the hyoid bone (zone I) and thyrohyoid membrane (zone II) levels was higher than the other three levels in the difficult laryngoscopy group. However, this increase was insufficient to predict difficult laryngoscopy in pregnant women. The reason why the measurement of anterior neck tissue thickness at five different levels was insufficient to predict the difficult laryngoscopy could be that our study was conducted in a young female population. When the studies investigating the relationship between difficult laryngoscopy and US measurements were considered, it was seen that while the measurements were made, head and neck positions were different in each study[16,20,21]. In a systematic review and meta-analysis, hyomental distance with the head and neck in a neutral position was the most reliable parameter for airway US assessment. This systematic review and meta-analysis have limitations: the small sample size, heterogeneity of studies, and absence of a standardized ultrasonographic evaluation method [23]. We performed our US measurements in the supine position with a pillow under the head. At the same time, the patient's neck was in the sniffing position, which is the closest position to the one given during intubation.

Different threshold levels were found in US measurements in many studies where the measurement was performed at thyrohyoid membrane level to predict difficult laryngoscopy. Adhikari et al.[15] determined that the threshold values at the level of the thyrohyoid membrane be 28 mm for difficult laryngoscopy and 23.7 mm for easy laryngoscopy. In other studies, the threshold values for difficult laryngoscopy were found to be 23.9 mm and 27.5 mm[16,17]. In our study, the thickness at the thyrohyoid membrane (zone II) level was 10.5 mm in the difficult laryngoscopy group. In our study, the threshold of thyrohyoid membrane thickness for difficult laryngoscopy was found to be lower than in other studies. The reason for this may be due to the fact that other studies were conducted in a population with a high BMI. In addition, the demographic characteristics of the groups also affect the threshold values of US measurements. In studies measuring the efficiency of US, difficult laryngoscopy cases are predominantly apparent in the male population. In addition, patient populations of different ethnic origins were examined in these studies[14-17]. It is known that fat distributions are different among various ethnic groups[20,24,25]. Fulkerson et al.[26] also drew attention to this issue; gender and ethnic differences could make a difference of approximately 10 mm between the groups. In our study, we concluded that the lower threshold of the thyrohyoid membrane thickness in the difficult laryngoscopy group compared to the other studies is because our patients were young, female, or Caucasian race, and their average BMI was low.

Harmer et al.[27] emphasized that care must be taken when the gap between the incisors is <5 cm for obstetric patients. On the other hand, in a meta-

analysis, it was reported that limited mouth opening was not a sufficient indicator as a predictor of difficult intubation[3]. When mouth opening restriction was examined among preoperative screening tests, a statistically significant difference was found between the two groups in our study. The mouth opening restriction for determination to difficult laryngoscopy has a sensitivity of 50%, a specificity of 75.6%, a positive predictive value of 40.5%, and a negative predictive value of 81.9%. Some studies support the fact that the neck circumference measured from the thyroid cartilage level is over 43 cm and does not predict difficult airway[28-30]. In our study, the neck circumference measured from the thyroid cartilage level remained at a significant level in the difficult laryngoscopy group. We found that the sensitivity of the neck circumference was 40%, the specificity was 84.4%, the positive predictive value was 46.2%, and the negative predictive value was 80.9%.WRS≥2, which is evaluated with five variables, is used for difficult airway identification. Gonzalez et al.[31] found in their studies on obese patients that the sensitivity of WRS≥2 was 75%, the specificity was 60%, and the positive predictive value was 16%. The incidence of difficult tracheal intubation was prospectively compared according to IDS in 70 obese (BMI ≥30 kg/m2) and 61 lean patients (BMI <30 kg/m2). In our study, WRS was statistically and significantly high in difficult laryngoscopy, and the sensitivity of the test was 50%, the specificity was 80%, and the positive predictive value was 45.5%. The reason why the positive predictive value of WRS was so different between this and our study is that study protocols were established on the incidence of difficult intubation in their study and on the incidence of difficult laryngoscopy in our study. In their study, Hester et al.[32] argued that the upper lip bite test is superior to MMS. In the prediction of difficult intubation in pregnancy, Alıc et al.[28] found the upper lip bite test class III to be the most useful test among the studies performed on obstetric patients with 63.6% sensitivity, 99.1% specificity, and 77.7% positive predictive ratio. Comparing the upper lip bite test with MMS, Honarmand et al.[33] stated that the upper lip bite test had low sensitivity (17%) and was less useful in evaluating difficult airway. We found that the sensitivity of MMS was 33.3%, the specificity was 91.1%, the positive predictive value was 55.6%, the negative predictive value was 80.4%, and the difficult laryngoscopy ratio increased in parallel with MMS. In our study, we found that the upper lip bite test class III was statistically and significantly high in the difficult laryngoscopy group, and the test sensitivity was 43.3%. Alıc et al.[28] found in a study on pregnant women that IDS> 5 was statistically and significantly higher in the obese than in the non-obese. We also found that in accordance with the literature, IDS increased apparently in the difficult laryngoscopy group.

Findings for difficult airways, such as ultrasound-guided anatomical measurements of the neck and physical examinations of the face, jaw, and neck had been shown to have very high predictive and comparative variability, with sensitivity, specificity, and significance values ranging from low to very high across all patient measures (Category B2-E evidence)[34]. No single characteristic had been identified as consistently being more predictive than another, and measurements intended to predict difficult airways had been diverse among the studies to determine a common set of predictors. Among the recommendations of "2022 American Society of Anesthesiologists Practice Guidelines for Management of the Difficult Airway" include the following items: Before the initiation of anesthetic care or airway management, an airway risk assessment is done to identify patient, medical, surgical, environmental, and anesthetic factors (e.g., risk of aspiration) that may show the potential for a difficult airway. The physical examination to further identify physical characteristics that may show the potential for a difficult airway may include the assessment of anatomical measurements and landmarks. The multiple features to determine a patient's potential for a difficult airway must be assessed in the physical examination[34]. In this study, we have shown that various predictive parameters (MMS, upper lip bite test, mouth opening, neck circumference, buck teeth, WRS, and IDS) are helpful in predicting difficult airway in obstetrical anesthesia. Also, our study demonstrated that BURP maneuver and use of gum elastic bougie increase the success rate of endotracheal intubation in pregnant women with difficult laryngoscopy.

The fact that only the young population and female gender were included in the study can be considered among the limitations of the study. Our results cannot be generalized because we only do this study on pregnant women. Neck sonoanatomy may change depending on sex, age, or pregnancy. In addition, we could only include elective cesarean cases in our study. Another limitation may be that emergency cesarean section cases were not included in our study.

Emergency cases were not included in the study because there was not enough time for preoperative neck ultrasound in emergency cesarean sections. In addition, the compression due to probe pressure on the anterior neck was not checked. Thickness measurements may have been affected because the probe pressure was not be controlled. However, measurements were always made by the same anesthesiologist. Another limitation of this study is excluding patients with difficult airway histories and airway problems.

In conclusion, data obtained from measurements and scores of MMS, upper lip bite test, mouth opening, neck circumference, buck teeth, WRS, and IDS are helpful in determining difficult laryngoscopy in obstetric anesthesia. Furthermore, BURP maneuver and use of gum elastic bougie in difficult laryngoscopy increase the success of endotracheal intubation for pregnant women. However, in our study, we do not find a significant relationship between US-guided anterior neck soft tissue thickness measurement and difficult laryngoscopy before cesarean section. Until now, no single feature or measurement intended to predict difficult airway has been identified in the literature as being consistently more predictive than the others in identifying more prominent predictors. Further studies that include different races and larger numbers of pregnant women are needed to investigate the relationship between US-guided anterior neck tissue thickness measurement and difficult laryngoscopy in obstetric anesthesia.

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REFERENCES

1. Kuczkowski KM, Reisner LS, Benumof JI. The difficult airway: Risk, prophylaxis and management. In Chestnut's Obstetric Anesthesia: Principles and Practice (Eds Beilin Y, Chestnut DH, Ngan WD, Tsen LC, Wong CA). 3rd ed. Canada:Mosby Inc, 2004;535-62.
2. Hagberg CA. Handbook of Difficult Airway Management. Philadelphia, :Churchill Livingstone, 2000;.
3. Shiga T, Wajima Z, Inoue T, Sakamoto A. Predicting difficult intubation in apparently normal patients: a meta-analysis of bedside screening test performance. Anesthesiology. 2005;103:429-37.
4. Kristensen MS. Ultrasonography in the management of the airway. Acta Anaesthesiol Scand. 2011;55:1155-73.
5. Singh M, Chin KJ, Chan VW, Wong DT, Prasad GA, Yu E. Use of sonography for airway assessment: an observational study. J Ultrasound Med. 2010;29:79-85.
6. Apfelbaum JL, Hagberg CA, Caplan RA, Blitt CD, Connis RT, Nickinovich DG, Hagberg CA et al. American Society of Anesthesiologists Task Force on Management of the Difficult AirwayPractice guidelines for management of difficult airway: an updated report by the American society of anesthesiologists task force on management of the difficult airway. Anesthesiology. 2013;118:251-70.
7. Yentis SM, Lee DJH. Evaluation of an improved scoring system for the grading of direct laryngoscopy. Anaesthesia. 1998;53:1041-4.
8. Cook TM, MacDougall-Davis SR. Complications and failure of airway management. Br J Anaesth. 2012;109:68-85.
9. Lundstrøm LH, Vester-Andersen M, Møller AM, Charuluxananan S, L'hermite J, Wetterslev J. Poor prognostic value of the modified Mallampati score: a meta-analysis involving 177,088 patients. Br J Anaesth. 2011;107:659-67.
10. Prasad A, Yu E, Wong DT, Karkhanis R, Gullane P, Chan VW. Comparison of sonography and computed tomography as imaging tools for assessment of airway structures. J Ultrasound Med. 2011;30:965-72.
11. Lakhal K, Delplace X, Cottier JP, Tranquart F, Sauvagnac X, Mercier C et al. The feasibility of ultrasound to assess subglottic diameter. Anesth Analg. 2007;104:611-4.
12. Ezri T, Gewürtz G, Sessler DI, Medalion B, Szmuk P, Hagberg C et al. Prediction of difficult laryngoscopy in obese patients by ultrasound quantification of anterior neck soft tissue. Anaesthesia. 2003;58:1111-4.
13. Adhikari S, Zeger W, Schmier C, Crum T, Craven A, Frrokaj I et al. Pilot study to determine the utility of point-of-care ultrasound in the assessment of difficult laryngoscopy. Acad Emerg Med. 2011;18:754-8.

14. Wu J, Dong J, Ding Y, Zheng J. Role of anterior neck soft tissue quantifications by ultrasound in predicting difficult laryngoscopy. Med Sci Monit. 2014;20:2343-50.
15. Pinto J, Cordeiro L, Pereira C, Gama R, Fernandes HL, Assunc J. Predicting difficult laryngoscopy using ultrasound measurement of distance from skin to epiglottis. J Crit Care. 2016;33:26-31.
16. Parameswari A, Govind M, Vakamudi M. Correlation between preoperative ultrasonographic airway assessment and laryngoscopic view in adult patients: A prospective study. J Anaesthesiol Clin Pharmacol. 2017;33:353-8.
17. Rana S, Verma V, Bhandari S, Sharma S, Koundal V, Chaudhary SK. Point of care ultrasound in the airway assessment: A correlation of ultrasonography-guided parameters to the Cormack–Lehane Classification. Saudi J Anaesth. 2018;12:292-6.
18. Komatsu R, Sengupta P, Wadhwa A, Akça O, Sessler DI, Ezri T et al. Ultrasound quantification of anterior soft tissue thickness fails to difficult laryngoscopy in obese patients. Anaesth Intensive Care. 2007;35:32-7.
19. Aydogmus MT, Erkalp K, Sinikoglu SN, Usta TA, Ulger OG, Alagol A. Is ultrasonic investigation of transverse tracheal air shadow diameter reasonable for evaluation of difficult airway in pregnant women: a prospective comparative study. Pak J Med Sci. 2014;30:91-5.
20. Mohammadi SS, Saliminia A, Nejatifard N, Azma R. Usefulness of ultrasound view of larynx in pre-anesthetic airway assessment: a comparison with cormack-lehane classification during direct laryngoscopy. Anesth Pain Med. 2016;6:e39566.
21. Craig P, Halavatau V, Comino E, Caterson I. Differences in body composition between Tongans and Australians: time to rethink the healthy weight ranges? Int J Obes Relat Metab Disord. 2001;25:1806-14.
22. Zillikens MC, Conway JM. Anthropometry in blacks: applicability of generalized skinfold equations and differences in fat patterning between blacks and whites. Am J Clin Nutr. 1990;52:45-51.
23. Fulkerson JS, Moore HM, Anderson TS, Lowe RF Jr. Ultrasonography in the preoperative difficult airway assessment. J Clin Monit Comput. 2017;31:513-30.
24. Harmer M. Difficult and failed intubation in obstetrics. Int J Obstet Anaesth. 1997;6:25-31.
25. Alıç M, Birbiçer H, Kurku Ö. The Importance of predictive tests on determination of intubation difficulties in obese pregnants. Turk J Anaesthesiol Reanim. 2011;39:126-133.
26. Min JJ, Kim G, Kim E, Lee J. The diagnostic validity of clinical airway assessments for predicting difficult laryngoscopy using a grey zone approach. J Int Med Res. 2016;44:893-904.
27. Siriussawakul A, Rattana-arpa S, Jirachaipitak S, Chatsiriphattana A, Nimmannit A, Wong-in N. The performance of the neck circumference for a difficult laryngoscopy in obese patients. J Med Assoc Thai. 2016;99:484-90.
28. Gonzalez H, Minville V, Delanoue K, Mazerolles M, Concina D, Fourcade O. The importance of increased neck circumference to intubation difficulties in obese patients. Anesth Analg. 2008;106:1132-6.
29. Hester CE, Dietrich SA, White SW, Secrest JA, Lindgren KR, Smith T. A comparison of preoperative airway assessment techniques: the modified Mallampati and the upper lip bite test. AANA J. 2007;75:177-82.
30. Honarmand A, Safavi MR. Prediction of difficult laryngoscopy in obstetric patients scheduled for Caesarean delivery. Eur J Anaesthesiol. 2008;25:714-20.