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Diagnostic Value of Neck Circumference and Sternomental Distance for Difficult Intubation in Patients Undergoing Cesarean Section

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ABSTRACT

Introduction: Airway safety for difficult intubation or failure to intubate is important during anesthesia. This study assessed the airway before anesthesia, and the diagnostic value of neck circumference (NC) and sternomental distance (SMD) tests was investigated in predicting difficult tracheal intubation during cesarean section.
Methods: In a cross-sectional study, 101 women who were candidates for cesarean section were selected through the convenience and non-random sampling method. The modified Mallampati test (MMT), upper lip bite (ULBT), thyromental distance (TMD), neck circumference (NC), and sternomental distance (SMD) tests were performed to estimate the laryngoscopy problem. The success rate of airway assessment by SMD and NC was evaluated using the Cormack-Lehane score. Data analysis was performed using the software SPSS version 16.0.
Results: TMD (p=0.034) and NC (p<0.001) indicated substantial association with laryngoscopy grades. The sensitivity was 35.29% and 58.82%, and the specificity was 93.93% and 59.09% for NC and SMD. The accuracy, NPV, and PPV of NC was higher than the SMD test (74% vs. 59%, 73.80% vs. 73.58, and 75% vs. 42.55%). The PPV and NPV were 43.63% and 77.77% for TMD. MMT, with high sensitivity (73.52%) and specificity (90.90%), increased the risk of difficult laryngoscopy up to 24-fold when adjusted for TMD, SMD, and NC [p<0.001; OR=24.38 (6.31-94.25)]. Although NC indicated low sensitivity, it had maximum specificity (93.93%) in predicting difficult intubation.
Conclusion: High Mallampati grades increase the risk of difficult laryngoscopy. NC presented low predictive values, and SMD and TMD lack predictive values for difficult intubation.

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Introduction

Maintaining the safety of the patient's airway during anesthesia is a critical principle that must be managed with the least complications and best performance (1). Incomplete or unsuccessful performance of airway control is associated with perioperative morbidity and mortality. Identifying situations and patients at risk for airway management problems is key to optimal care (2, 3). Tracheal intubation is one of the methods for airway control (4). One of the risk factors and a major concern for anesthetists in airway management during surgery, such as cesarean

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birth, is difficult intubation or failure to perform tracheal intubation. Hypoxia, cardiorespiratory arrest, and pulmonary aspiration are dangerous complications during tracheal intubation, sometimes leading to death (5).

Anatomical and physiological changes such as a larger tongue and airway edema in pregnant women cause more problems during intubation than in other patients (6). Anesthesiology trainees are responsible for 2.5% of women's deaths during cesarean section, mostly related to airway control problems and failed tracheal intubation (7). Accurate recognition with laryngoscopy and the diagnosis of specific intubation conditions before anesthesia is very important because it can help the medical staff choose the appropriate equipment and safer techniques for intubation and avoid the complications of unsuccessful performance (8). Preoperative evaluation includes the modified Mallampati test (MMT), measurement of thyromental distance (TMD), sternomental distance (SMD), and neck circumference (NC). Measurement of NC and SMD are high-sensitivity tests that cannot be performed in some cases despite the recommendation to perform them simultaneously (9). In previous studies, the accuracy of these tests was evaluated. Researchers reported the sensitivity and specificity of the NC test to be more than 70%. However, others, like in the present study, showed a 30% sensitivity (10, 11). In addition, the TMD test in some studies showed 100% sensitivity in non-obese people and 80% in obese people (11). The present study also reported this scale at about 70%. The PPV scale in all studies was calculated to be around 30-40%, similar to our results. These results were also true for the SMD test. A previous study found a lower specificity (26%) and NPV (50%) for SMD. However, PPV was higher (59%) in the obese population than in the present study (11). Furthermore, in some studies, its use alone without the need for other tests has been suggested (12). However, the success of this test in obese patients has not yet been determined, and it is recommended not to use this test alone in obese subjects. In this study, in addition to the modified Mallampati test, upper lip bite, and TMD tests, assessment of the airway before anesthesia was performed by two methods, SMD and NC, and the success rate of these tests in predicting difficult tracheal intubation or failure in intubation during cesarean section was investigated.

Materials and Method

Study population

In a cross-sectional study, women candidates for cesarean section who referred to Mashhad teaching hospitals in 2022 were selected using a non-random sampling method.

Inclusion and exclusion criteria

Women over 18-years who had the conditions necessary for general anesthesia for elective surgery were included. Likewise, subjects could sit properly and did not have a history of psychological and neurological diseases and head or neck trauma. Patients were excluded if their diagnosis changed. All patients provided written informed consent before the start of the study.

Study procedure

One-hundred and one women were evaluated to be enrolled in the study, and demographic information such as age, height, weight, and BMI were collected. An expert anesthesiologist measured the sternomental and cervical distance before anesthesia for all subjects.

The SMD (the distance between the upper edge of the sternum and the chin) was measured using a non-flexible ruler with an accuracy of 0.5 cm while the patient's mouth was closed and the head was completely fixed. The SMD size of 12.5 cm was considered the standard for predicting difficult intubation (8). The NC was measured from a point just below the larynx (Adam's apple) and perpendicular to the long axis of the neck in a sitting position. The TMD was measured as the distance between the thyroid notch and the tip of the chin protrusion using a non-flexible ruler.

After receiving propofol (2 mg/kg) and succinylcholine (neuromuscular relaxant, 1 mg/kg), the patients were intubated by another specialist who was not aware of the study. The level of intubation difficulty was evaluated using the Cormack-Lehane (CL) classification system, ULBT, and MMT. CL classification is a gold standard for predicting difficult laryngoscopy and tracheal intubation. CL grades 1 (full view of glottis) and 2 (partial view of glottis or only posterior extremity of glottis seen or only arytenoid cartilages) were considered easy, and grades 3 (only epiglottis seen, none of glottis seen) and 4 (neither glottis nor epiglottis seen) were considered difficult laryngoscopies from the inability to visualize the vocal cords. The ULBT three classes comprise: class I, where a patient can raise the lower incisors above the vermilion line; class II, where a patient can bite the upper lip below the vermilion line; and class III, where a patient cannot bite the upper lip. A difficult airway was defined by grade III in the ULBT. The MMT has five classes: class 0: any part of the epiglottis is visible; class I: soft palate, uvula, and pillars are visible; class II: soft palate and uvula are visible; class III: only the soft

palate and base of the uvula are visible; class IV: only the hard palate is visible. A difficult airway was defined by grades III and IV in the MMT.

Sample size

A sample size of 101 patients was calculated according to the odds ratio of difficult laryngoscopy in patients with big NC [odds ratio (OR): 5.17, 95% CI: (1.05-25.5)] in the Riad study (11) using α=0.05 and β=0.2 and 10% drop out.

Statistical analysis

Data was analyzed using the software SPSS version 16.0 (SPSS Inc., Chicago, Illinois, United States). The sample size was calculated according to the data from the study by Riad et al. (13) and based on OR=6. Data was described by mean± standard deviation (SD), frequency, and percentage for continuous and categorical variables. The Kolmogorov-Smirnov test evaluated the normal distribution. Fisher's exact test or chi-square test tested the association of qualitative variables. Quantitative variables were compared using the independent sample t test. The predictive role of parameters was evaluated using a logistic regression test. Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy were evaluated for all considered measures. A P-value less than 0.05 was considered significant. Diagnostic values of sensitivity, specificity, PPV, NPV, and accuracy were calculated according to the following formulas:

Sensitivity=true positive (TP)/TP+ false negative (FN); Specificity=true negative (TN)/TN+false positive (FP); PPV (positive predictive value)=TP/TP+FP; NPV (negative predictive value)=TN/TN+FN; accuracy=TP+TN/TP+TN+FP+FN.

Ethical approval

Ethical clearance and approval were obtained from the ethics committee of the Mashhad University of Medical Sciences (MUMS) under the number IR.MUMS.MEDICAL.REC.1400.803.

Results

The age range and mean were 17-43 and 31.12 years, respectively. Twenty-six (25.7%) and thirty (15.8%) women had a BMI of less than 30 and more than 35, respectively. Also, NC and SMD mean were measured at 32.63±2.15 mm and 12.68±0.54 mm, respectively. Hypothyroidism or hyperthyroidism was observed in about 10% of subjects. Moreover, the prevalence of cardiovascular diseases and gestational diabetes among patients was 17.8%, and preeclampsia was observed in 12 women. The demographic data of the subjects have been listed in Tables 1 and 2.

Patients were divided into two groups based on the laryngoscopy grade difficulty. Although NC (p=0.585) and SMD (***p***=0.383) means did not show any association between the two groups, the height (p=0.029) and weight (p=0.008) showed significant differences between the difficult and easy groups. The Mallampati (p<0.001) and upper lip bite (p=0.004) grades showed significant differences between the two groups. Moreover, likely laryngoscopy scores, TMD, NC, and SMD were divided into difficult and easy groups. The results showed a substantial association between TMD (p=0.034) and NC (p<0.001) groups with laryngoscopy categorical grades. The results are presented in Table 3.

Gestational diabetes and cardiovascular disease were the most common diseases among

Table 1. Demographic features in the study subjects

Characteristics	Mean±SD	Standard Deviation (SD)	Minimum	Maximum
Age (years)	31.12	6.41	17	43
Height (cm)	161.20	3.67	150	174
Weight (kg)	83.02	9.16	65	110
BMI (kg/m^2)	31.93	3.15	26.45	41.91
Thyromental distance (cm)	6.64	0.40	6.00	7.50
Neck circumference (cm)	32.81	0.86	30.00	34.50
Sternomental distance (cm)	12.68	0.54	12.00	14.00

Table 2. Clinical features in the study subjects

Characteristics	Number	Percent
Diabetes mellitus	2	2.0%
Gestational diabetes	18	17.8%
Cardiovascular disease	18	17.8%
Thalassemia	1	1.0%
Preeclampsia	12	11.9%
Asthma	1	1.0%
Skeletal diseases	1	1.0%
Thyroid disorder	10	%9.9
AIDS	1	1.0%
Hypertension	14	13.9%
Addiction	2	2.0%

Table 3. Association between demographic and clinical characteristics and laryngoscopy classification

Characteristics		Easy (N=66) Mean±SD	Difficult (N=34) Mean±SD	P-value
BMI (kg/m²)		31.23±2.63	33.35±3.63	0.530
Age (years)		31.00±6.13	31.71±6.76	0.430
Thyromental distance (cm)		6.73±0.35	6.47±0.44	0.246
Neck circumference (cm)		32.36±2.53	33.15±0.92	0.585
Sternomental distance (cm)		12.79±0.52	12.46±0.51	0.383
Characteristics		Number (%)	Number (%)	P-value
Modified Mallampati score	0	0 (0.0%)	0 (0.0%)	<0.001
	1	19 (100.0%)	0 (0.0%)	
	2	41 (82.0%)	9 (18.0%)	
	3	6 (21.4.0%)	22 (%78.6)	
	4	0 (0.0%)	3 (100.0%)	
Upper lip bite grade	1	49 (%76.6)	15 (%23.4)	0.004
	2	17 (%47.2)	19 (%52.8)	
	3	0 (0.0%)	0 (0.0%)	
Thyromental distance	Easy	35 (%77.8)	10 (%22.2)	0.034
	Difficult	31 (%56.4)	24 (%43.6)	
Neck circumference	Easy	62 (%73.8)	22 (2%6.2)	<0.001
	Difficult	4 (25.0%)	12 (75.0%)	
Sternomental distance	Easy	39 (%73.6)	14 (%26.4)	0.097
	Difficult	27 (%57.4)	20 (%42.6)	

patients. Data are presented in Table 4. Multivariate logistic regression showed that a higher Mallampati grade significantly increased the risk of difficult laryngoscopy [OR=24.38, 95% CI: (6.31-94.25), p-value <0.001], where it was adjusted for SMD, TMD, and NC. Results are shown in Table 5. Finally, Mallampati indicated maximum sensitivity (73.52%) and specificity (90.90%), with high positive predictive value (80.64%), negative predictive value (86.95%), and accuracy (85.00%). TMD also had a sensitivity of 70.58% and an NPV of 77.77%. However, other values were low. The results are shown in Table 6.

The ROC plot for considered tests is shown in Fig. 1. Area under the curve was 0.33, 0.69, and 0.33 for TMD, NC, and SMD, respectively. The ROC

Table 4. Comparison of underlying diseases in patients with easy and difficult laryngoscopy

Underlying diseases	Easy (N=66) Number (%)	Difficult (N=34) Number (%)	P-value
Diabetes mellitus	1 (50.0%)	1 (50.0%)	0.999
Gestational diabetes	10 (%55.6)	8 (%44.4)	0.410
Cardiovascular disease	10 (55.6)	8 (%44.4)	0.410
Thalassemia	1 (100.0%)	0 (0.0%)	0.999
Preeclampsia	7 (%58.3)	5 (%41.7)	0.536
Asthma	1 (100.0%)	0 (0.0%)	0.999
Skeletal diseases	1 (100.0%)	0 (0.0%)	0.999
Thyroid disorder	7 (70.0%)	3 (30.0%)	0.999
AIDS	1 (100.0%)	0 (0.0%)	0.999
Hypertension	7 (50.0%)	7 (50.0%)	0.225
Addiction	2 (100.0%)	0 (0.0%)	0.547

Table 5. Risk of difficult laryngoscopy in relation to anthropometric indicators

Characteristics	OR	P-value	95% CI	
			Lower	Upper
Mallampati (grade 3 and 4)	24.38	**<0.001**	6.31	94.25
SMD (≤12.5 cm)	0.46	0.265	0.12	1.80
TMD (≤6.5 cm)	2.02	0.271	0.5	7.04
NC (≥33.5 cm)	1.92	0.443	0.361	10.2

TMD: thyromental distance, NC: neck circumference, SMD: sternomental distance, OR: odds ratio, CI: confidence interval, cm: centimeter

Table 6. Diagnostic value of the Mallampati, SMD, TMD, and NC scores for difficult laryngoscopy

Characteristics	Sensitivity	Specificity	PPV	NPV	ACC
Mallampati (grade 3 and 4)	73.52%	90.90%	80.64%	86.95%	85.00%
SMD (≤12.5 cm)	58.82%	59.09%	42.55%	73.58%	59.00%
TMD (≤6.5 cm)	70.58%	53.03%	43.63%	77.77%	59.00%
NC (≥33.5 cm)	35.29%	93.93%	75.00%	73.80%	74.00%

PPV: Positive predictive value, NPV: Negative predictive value, ACC: Accuracy, TMD: Thyromental distance, NC: Neck circumference, SMD: Sternomental distance

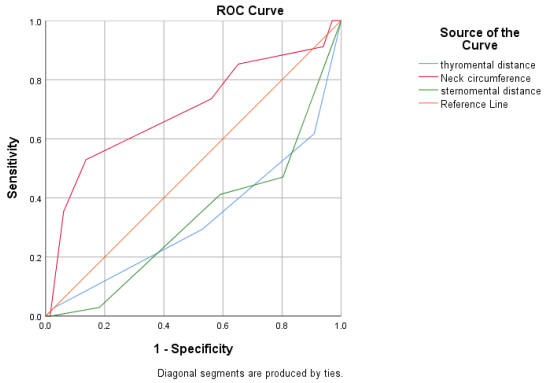

Figure 1. ROC plot for TMD, NC, and SMD measures

plot is shown in Fig. 1.

Discussion

A cross-sectional study investigated the association of anthropometric indicators and difficult laryngoscopy in patients undergoing caesarian section. Results showed that the higher grades of Mallampati increased the risk of difficult laryngoscopy. The specificity, PPV, and NPV of Mallampati in grade 3 and 4 was 90.90%, 80.64%, and 86.95%, respectively.

The effect of anatomical and physiological changes in the airway on the difficulty of intubation is clear. Mallampati et al. predicted difficult intubation in 28 out of 210 cases of direct laryngoscopy (13). These changes during pregnancy place the parturient at increased risk for airway management problems. So, performing a thorough pre-anesthetic evaluation and identifying the factors predictive of difficult intubation is essential. This study found that short height and heavy weight is more common in difficult laryngoscopy groups, and all indicators except SMD had significant differences between difficult and easy groups. Also, due to the high accuracy, specificity, and sensitivity of the Mallampati score, which has a standard limit above 80%, it can be considered the first tool to evaluate intubation status. While the NC test indicated low sensitivity, it could diagnose 93% of true negatives out of all subjects and had significant accuracy. Therefore, like the results of previous studies, this test can effectively predict difficult intubation. Moreover, the SMD and TMD tests indicated low sensitivity and specificity.

Previous studies showed that using a single assessment score decreased the effects of screening tests for difficult intubation (14). Therefore, combinations of tests may add some incremental diagnostic value. Researchers in past studies combined several factors, which is a multivariate system. However, the main problem is the existence of several variables and spending much time. So, using two scores may increase the diagnostic value while not significantly increasing the test limitation16 ,15)). Airway characteristics and changes in pregnant women, such as edema or tongue enlargement, are similar to those in obese patients. According to past studies, NC, TMD, and SMD indicators were selected among the predictors of difficult intubation (2, 17). Our results showed that neck circumference was a better indicator than TMD and SMD. However, multivariate analysis showed no association between NC/SMD/TMD and difficult intubation.

Several studies have been conducted on the association of obesity with difficult intubation in pregnant women and other patients. For example, oropharyngeal anatomy is double in obese pregnant women, and patients have a high risk for airway management problems (6). These women are at increased risk for anesthesia-related morbidity and mortality during cesarean surgery, particularly due to failed intubation during procedures under general anesthesia. Screening the airway condition and proper management by as-

sessment and accuracy tools can greatly prevent these complications (3, 6). In a study, 250 pregnant women scheduled for cesarean section were analyzed for the efficiency of different preoperative difficult intubation tests. The MMT, SMD, and TMD revealed more difficult intubations than the actual number of cases. The results showed that the combination of the upper limb bite test and thyromental distance test is superior to other methods for predicting difficult intubation in pregnant women (8).

Laryngoscopy will be easy or difficult, which may be predicted by using the Mallampati score. Despite diagnostic limitations, it is still a convenient and practical method that can easily be applied in the clinical setting (8). Merah et al. found 87.1% sensitivity and 99.6% specificity in the Mallampati test. They concluded that the MMT could be used to predict difficult intubation18)). However, another study indicated that the Mallampati test produced many false positive results (19). In our study, the MMT had 73.52% sensitivity, 90.90% specificity, 80.64% PPV, and 86.95% NPV, and these results were similar to some previous studies (8). However, the accuracy of this test was higher compared to other indicators.

Head extension is important in predicting whether the intubation will be easy or difficult. Patel et al. indicated that the SMD had a sensitivity and specificity of 91% and 92.7%, respectively. They said that If SMD was less than 12.5 cm, it was considered a predictor of a difficult intubation (20). The results of the sensitivity and specificity of the SMD test in the present study were lower than in previous studies (21). It was proved that it was not a useful test for predicting difficult intubation. The difference in results can be related to the size of the examined samples. For example, in a study conducted by Prakash et al., they enrolled 610 patients to evaluate LD by the SMD method. Finally, they reported sensitivity and specificity of 66% and 60%, respectively (22). However, in the present study, only one-hundred patients participated.

An accurate tool for estimating overweightness and obesity in people is the neck circumference size. A neck circumference ≥32 cm in women should be considered the cutoff point for being overweight. The relationship between the NC size and intubation conditions has been investigated and it has been proven that in several studies more patients with larger NC were in the difficult intubation group. For example, Riad et al. found that neck circumference >42 cm (p=0.044) was an independent predictor of difficult intubation. Also, in the present study, NC had a significant association with the laryngoscopy easy/difficult category (22).

Although the high specificity (94%) of the TMD test was remarkable in our study, Jimson et al. reported that TMD ≤7 cm was not a good predictor of difficult intubation preoperatively, as it had a low sensitivity (32%), and high specificity (80%). On the other hand, Patel et al. reported that TMD (<6.5 CM) had a sensitivity and specificity of 100% and 75.8%, respectively (20). There is disagreement that it is the best test for predicting hardship intubation.

Since a single test is insufficient to predict difficult intubation, it was reported that a combination of tests would obtain the most accurate results. In a study, the MMT, TMD, and SMD tests in single form were weak regarding sensitivity, specificity, and PPV. When MMT was combined with TMD or SMD, the sensitivity decreased, and the NPV remained at 93%. They found that the specificity for the MMT with the TMD increased from 89% to 100% and increased from 27% to 100% with SMD (23). Furthermore, Patel et al. indicated that combining MMT, SMD, and TMD increases the assessment validity of difficult intubation in adults compared to individual tests (20). Although the safe outcome of anesthesia is an important goal for every anesthesiologist during cesarean sections, there is still no test or group of tests predicting 100% of difficult laryngoscopies. However, our findings alongside previous reports highlight the importance of the modified Mallampati test as a valuable test for the prediction of difficult laryngoscopy for the management of patients under cesarean surgery.

Like other studies, this project had some limitations that should be acknowledged. The number of patients was one of the limitations of the present study, and more studies with larger populations should be conducted to increase the power. Underlying diseases such as diabetes or gestational hypertension might affect the results, so homogenous samples concerning underlying diseases should be selected in the subsequent studies. It is also better to research male or female patients undergoing other surgeries so that the results are comprehensive.

Conclusion

Although the big NC, short TMD, and high grades of ULB and Mallampati were associated with difficult laryngoscopy, patients with grades 3 and 4 of the Mallampati score had 24 times greater risk of difficult laryngoscopy. NC indicates low predictive value and SMD and TMD lack predictive value, and the modified Mallampati is a valuable test for the prediction of difficult laryngoscopy because of its high specificity, PPV, NPV,

and accuracy. These findings could assist clinical professionals choose valuable and precise tests to predict laryngoscopy statuses, which could increase the quality of patients' safety during anesthesia.

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