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Comparison of six methods for predicting difficult intubation in obstetric patients

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Abstract

Background: Although the use of general anesthesia has been declining in obstetric patients, it may still be required in selected cases. Maintenance of the airway during obstetric anesthesia is difficult to achieve, and still remains the single most important cause of anesthetic related maternal morbidity and mortality. The purpose of this study was to determine the capability of the following preoperative airway predictive tests, in isolation and combination, to predict difficult visualization of larynx (DVL) in obstetric patients: upper lip bite test (ULBT), modified Mallampati test (MMT), sterno-mental distance (SMD), thyro-mental distance (TMD), horizontal length of the mandible (HLM), and inter incisor gap (IIG).

Methods: 203 consecutive obstetric patients with ASA grade 1 and 2 undergoing general anesthesia for cesarean delivery were evaluated preoperatively using the ULBT, MMT, SMD, TMD, HLM, and IIG tests. The cut-off points for the airway predictors were ULBT III, Mallampati III and IV, ≤ 13.5 cm, ≤ 6.5 cm, ≤ 9 cm and ≤ 4cm, respectively. During direct laryngoscopy by a blinded expert anesthesiologist, the laryngeal view was graded, using the Cormack and Lehane classification. Laryngoscopic grades III and IV were considered difficult laryngoscopy. The sensitivity, specificity and positive predictive value for each test in isolation and in combination were determined.

Results: The difficulty to visualize the larynx was found in 37 (18.2%) parturients. The sensitivity, specifity and positive predictive value for these tests were: ULBT (94.6%, 97.6%, 89.7%), MMT (29.7%, 74.7%, 20.8%), SMD (13.5%, 86.7%, 18.5%), TMD (10%, 99.4%, 10%), HLM (62.2%, 43.4%, 19.7%), and IIG (0%, 98.8%, 0%).

Conclusion: The best single predictor was ULBT and the best combination of the tests was ULBT and MMT. Data analysis showed that demographic data, MMT and IIG were independent predictors of DVL. Thus, the ULBT is a useful predictor of difficult intubation in obstetric patients and also the combination of ULBT and MMT is a valuable airway predictor in parturients.

Keywords: Methods; Intubation; Obstetrics; Patients

Introduction

Anatomic and physiologic changes during pregnancy place the parturient at an increased risk for airway management problems. Because difficult intubation in obstetric anesthesia practice is frequently unexpected, careful and timely preanesthetic evaluation of patients with difficult airway should be carried out to avoid unexpected difficult airway management. To aid the anesthetist in identifying these patients, several preoperative airway assessment tests have been proposed.[1-9] Although the use of these tests, singly or in various combinations, has been advocated by several authors,[2,3,9] studies show that these tests have a low confidence of predicting the difficult airway.[10-13] Ideally, any preoperative assessment of difficult tracheal intubation should have high sensitivity and specificity to result in minimal false positive or negative values. Upper Lip Bite test (ULBT) is a newly designed method for preoperative assessment of difficult laryngoscopy introduced by Khan ZH.[14] The purpose of our study was to determine the ability to predict difficult or easy visualization of the larynx (DVL and EVL) in a parturient population from the following preoperative airway predictors, in isolation and

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combination: upper lip bite test (ULBT), modified Mallampati test (MMT), sterno-mental distance (SMD), thyro-mental distance (TMD), horizontal length of mandible (HLM) and inter-incisors gap (IIG).

Materials and Methods

Approval for the study was obtained from the Institutional Research and Ethics Board. Two hundred and three consecutive obstetric patients, ASA physical status I to II, which required general anesthesia for elective cesarean deliveries were included in this study. Exclusion criteria were gross anatomical abnormality or recent surgery of the head and neck, preeclampsia, severe cardiorespiratory disorders, inability to sit and edentulous patients. Demographic data collected included age, sex, weight, height, and body mass index (BMI). A single anesthesiologist investigator with 4 years of experience in anesthesia carried out the following six predictive test measurements in all patients preoperatively:

Upper Lip Bite Test (ULBT)

This test which has been introduced by Khan et al. was performed according to the following criteria[14]:
Lower incisors can bite the upper lip above the vermilion line; lower incisors can bite the upper lip below the vermilion line and lower incisors can not bite the upper lip.
A classification of III was considered a potentially difficult intubation.

Modified Mallampati test (MMT)

The patients were in a sitting posture with the head in the natural position and were asked to open the mouth fully and protrude the tongue maximally while the observer looked from the front at the patient's eye, inspecting pharyngeal structure with a pen torch without the patients phonating. The view was graded as follows:[15]

Soft palate, uvula, fauces and pillars visible; soft palate, uvula, fauces visible and pillars invisible; soft palate and base of uvula visible and soft palate invisible.

Grades III and IV were predicted to represent difficult intubation.

Sterno-Mental Distance (SMD)

The distance was measured in the sitting position with the head fully extended on the neck and the mouth closed. Straight distance between the upper border of the manubrium-sterni and bony point of the mentum was measured. SMD less than 13.5 cm was considered as difficult intubation.[12]

Thryo-Mental Distance (TMD)

The patient was seated upright and asked to extend her head and neck as far as possible with mouth closed. The straight distance on the exterior surface from the inside of the mentum to thyroid notch was measured. If distance was equal or less than 6.5 cm, laryngoscopy was predicted to be difficult.[3]

Horizontal Length of the Mandible (HLM)

The patient was seated with the head in the neutral position and the straight distance from the angle of the mandible to the symphysis-menti was measured. HLM less than 9 cm was predicted as difficult intubation.[13]

Inter-Incisors Gap (IIG)

The patient was asked to open the mouth as wide as possible and the distance between the upper and lower incisors was measured with a pair of calipers. If IIG was less than 4 cm, laryngoscopy was predicted to be difficult.[5] After preoperative assessment the patient, having consulted the anesthetist, decided whether to receive general or regional anesthesia. Because of cultural considerations, the majority of the patients preferred general anesthesia. The patients were transferred to the operating room in the left lateral position and all the equipment for management of difficult airway was available. 30 cc of sodium citrate 0.3 mol/liter was administrated orally before their transfer to the operating table. After 3 minutes of preoxygenation, anesthesia was induced with 5 mg/kg sodium thiopental and suxamethonium l.5 mg/kg intravenously as a rapid sequence induction. Before induction, the cricoid cartilage was palpated and lightly held between the thumb and second finger. As consciousness was lost, pressure was exerted on the cricoid cartilage mainly by the index finger. Cricoid pressure was applied by a fixed assistant who had been appropriately instructed in the technique. After disappearance of fasciculation or in case of no fasciculation when the anesthetists considered jaw relaxation to be adequate, the patient's head was placed in the sniffing position and laryngoscopy was preformed, using a Macintosh # 3 or 4 blade to visualize the larynx by an expert anesthesiologist (with 3 years experience) blinded to preoperative airway assessment. The view of laryngoscopy was classified, using the Cormack and Lehane (CL) classification:[16]

I: Vocal cords visible; II: Only posterior commisure or arytenoids visible; III: Only epiglottis visible; and IV: None of the foregoing visible (not even the epiglottis).

The cricoid pressure was maintained until the trachea was intubated, the cuff of endotracheal tube was inflated and correct tube placement verified. For analysis, laryngoscopic grades III and IV were grouped as difficult visualization of the larynx (DVL) and easy visualization of the larynx (EVL) was categorized for grades I and II. The sensitivity, specificity, positive and negative predictive values of each test was calculated as follows, using Cormack and Lehane Score as the constant variable.

Sensitivity: the percentage of correctly predicted difficult intubation as a proportion of all intubations which were truly difficult.

$$\frac{True\ Positives}{True\ Positives + False\ Negatives}$$

Specificity: the percentage of correctly predicted easy intubations as a proportion of intubations which were truly easy.

$$\frac{True\ Negatives}{True\ Negatives + False\ Positives}$$

Positive predictive value: The percentage of correctly predicted difficult intubations as a proportion of all predicted difficult intubations.

$$\frac{True\ positive}{True\ Positives + false\ positives}$$

Negative predictive valve: The percentage of correctly predicted easy intubations as a proportion of all predicted easy intubations.

$$\frac{True\ \ Negative}{True\ Negative's + false\ Negative}$$

The obtained data were analyzed, using Statistical Package for Social Sciences (SPSS software, Version 15.0; Chicago, IL, USA). The association between different variables and difficulty in intubation was evaluated, using the chi-square test for qualitative data and the student's t test for quantitative data. P value < 0.05 was regarded as significant.

Results

203 obstetric patients were studied. Mean age of the patients was 27 (range 16-45) years, while the mean (±SD) for weight, height and BMI were 83.5 (±10.1) kg, 167 (±8.5) cm and 30.7 (±3.9) kg/m^2 respectively. There was no statistically significant association between laryngoscopic grade and demographic data (Table 1).

Table 1: Means and SD of demographic data compared by laryngoscopy grade.

	Laryngoscopy grade		P-value
	EVL (n=166)	DVL (n=37)	
Age (year)	26.9±6.1	27.5±4.7	0.604
Height (cm)	167±8.9	167±6.6	0.893
Weight (kg)	85.1±9.9	86.2±11.2	0.551
BMI (kg/m^2)	30.7±4.0	30.9±3.9	0.766

EVL: Easy visualization of the larynx, DVL: Difficult visualization of the larynx; *P-value<0.05 is significant

Out of the 203 patients who had been intubated, 81 (39.9%), 85 (41.9%), 35 (17.2%) and 2 (1%) had laryngoscopic grade I, II, III, IV, respectively. 37 (18.2%) patients were DVL and 166 (81.8%), EVL. All the patients were successfully intubated. According to modified Mallampati test 43 (21.2%), 107 (52.7%) and 53 (26.1%) had score I, II and III, respectively. There was no Mallampati IV in this study; therefore, according to this test 150 (73.9 %) and 53 cases (26.1%) were predicted to be EVL and DVL, respectively. Based on the upper lip bite test, 78 (38.4%) patients had score I, 86 (42.8%) score II, thus 164 (80.8%) cases were predicted to be EVL and 39 (19.2%) had score III (DVL). Table 2 shows the laryngoscopic grade of the patients related to grades of MMT and ULBT.

Table 3 represents the means of the other four predictive tests in both EVL and DVL categories. There were significant differences between SMD, TMD and HLM between EVL and DVL patients (PV<0.001). This relationship was not observed for IIG. The measure of agreement (Kappa) between laryngoscopic grade and upper lip bite test was 0.903 with a significant difference (P<0.001) while it was 0.038 without a significant difference (P=0.579) for Mallampati test (Table 4). Table 5 shows the sensitivity, specificity, positive and negative predictive values for all of the six mentioned preoperative tests and Table 6 represents those criteria for various combinations of predictors.

Single Predictors

The ULBT has high sensitivity (94.6%) and specificity (97.6%) as a single test. However, SMD and

TMD were more specific than ULBT but their sensitivities were very low.

Combined predictive tests of EVL and DVL

The combination of the six tests increased the sensitivity and negative predictive value to 100% but decreased the specificity and the positive predictive value to 26.5% and 23.3%, respectively (Table 6).

Table 2: Laryngoscopic grade of obstetric patients related to modified Mallampati and upper lip bite test score.

			Laryngoscopy grade				Total
			I	II	III	IV	
Upper Lip Bite Test	I	No.	66	12	0	0	78
		%	84.6	15.4	.0	.0	100.0
	II	No.	14	70	1	1	86
		%	16.3	81.4	1.2	1.2	100.0
	III	No.	1	3	34	1	39
		%	2.6	7.7	87.2	2.6	100.0
Mallampati score	I	No.	20	11	12	0	43
		%	46.5	25.6	27.9	.0	100.0
	II	No.	36	57	13	1	107
		%	33.6	53.3	12.1	.9	100.0
	III	No.	25	17	10	1	53
		%	47.2	32.1	18.9	1.9	100.0
	IV	No.	0	0	0	0	0
		%	0	0	0	0	0

Table 3: Means of predictive tests in obstetric patients compared by Laryngoscopy grade

	Laryngoscopy grade		P-value
	EVL (n=166)	DVL (n=37)	
Sterno-Mental Distance	15.1±1.1	14.1±0.8	<0.001*
Thryo-Mental Distance	7.6±0.7	7.0±0.6	<0.001*
Inter-Incisor Gap	4.1±0.4	4.1±0.3	0.563
Horizontal Length of the Mandible	9.4±0.9	8.9±0.5	<0.001*

EVL: Easy visualization of the larynx, DVL: Difficult visualization of the larynx, *P-value < 0.05 is significant

Table 4: Measure of agreement between laryngoscopy grade and Upper Lip Bite Test and modified Mallampati score

			Laryngoscopy grade		Measure of Agreement (Kappa)	P-value
			EVL	DVL		
Upper Lip Bite Test	EVL	No.	162	2	0.903	<0.001*
		%	98.8	1.2		
	DVL	No.	4	35		
		%	10.3	89.7		
Modified Mallampati score	EVL	No.	124	26	0.038	0.579
		%	82.7	17.3		
	DVL	No.	42	11		
		%	79.2	20.8%		

EVL: Easy visualization of the larynx, DVL: Difficult visualization of the larynx; *P-value <0.05 is significant

Table 5: Sensitivity, specificity, positive and negative predictive values of Upper Lip Bite test, Modified Mallampati score, Sterno-Mental Distance, Thryo-Mental Distance, Inter-Incisor Gap and Horizontal Length of the Mandible.

	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)
Upper Lip Bite Test	94.6	97.6	89.7	98.8
Modified Mallampati score	29.7	74.7	20.8	82.7
Sterno-Mental Distance	13.5	86.7	18.5	81.8
Thryo-Mental Distance	10.0	99.4	10.0	81.7
Inter-Incisor Gap	0	98.8	0	82
Horizontal Length of the Mandible	62.2	43.4	19.7	83.7

Table 6: Sensitivity, specificity, positive and negative predictive value of airway predictors combinations.

	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)
ULBT+MMT	97.0	100.0	100.0	86.0
ULBT+SMD	94.6	85.5	59.3	98.6
ULBT+TMD	94.6	97.0	87.5	98.8
ULBT+IIG	94.6	96.4	85.4	98.8
ULBT+HLM	100.0	42.8	28.0	100.0
ULBT+MMT+SMD	97.3	62.7	36.7	99.0
ULBT+MMT+TMD	97.3	72.3	43.9	99.2
ULBT+MMT+SMD+TMD	97.3	62.0	48.8	99.0
ULBT+MMT+SMD+TMD+IIG+HLM	100.0	26.5	23.3	100.0

ULBT: Upper Lip Bite test, MMT: Modified Mallampati test, SMD: Sterno-Mental Distance, TMD: Thryo-Mental Distance, IIG: Inter-Incisor Gap and HLM: Horizontal Length of the Mandible

The combination with the best results was the ULBT and MMT with sensitivity, specificity, positive and negative predictive values of 97.0, 100, 100 and 86.0, respectively. The various other combinations resulted in an increased sensitivity at the expense of lowering the positive predictive value.

Discussion

Obstetric anesthesia is considered to be a high risk practice exposing the anesthesiologist to increased medicolegal liability because it involves simultaneous care of both mother and baby.

The failure of the anesthesiologist to maintain a patent airway after the induction of general anesthesia is one of the most significant causes of anesthesia-related maternal morbidity and mortality.[17-19] Anesthesia is the seventh leading cause of maternal mortality in the United States.[20] Because of the potentially serious consequences of failed tracheal intubation such as hypoxemic cardiopulmonary arrest, considerable attention has been focused on attempts to predict, preoperatively, patients in whom laryngoscopy and intubation will be difficult. A screening test for the prediction of difficult laryngoscopy must be urgent, providing reliable results. No single screening test is 100% sensitive and 100% specific. A test to predict difficult laryngoscopy should have a high positive predictive value to detect most susceptible cases.[16] Although many predictions of difficult intubation have been developed, they all have low positive predictive value. Thus the anticipated difficult laryngoscopic intubation would continue to occur in our day to day practice for the foreseeable future. There are numerous methods for assessing, which may help predict a difficult airway. There are only a few studies which have specifically dealt with obstetric patients in whom the risk of difficult intubation is reported to be eight times greater than that in the general surgical population.[21] Anatomical factors that place the pregnant women at increased risk for airway management complications and difficult intubation include pregnancy-iduced generalized weight gain and, particularly, increase in breast size, respiratory mucosal edema, and an increased risk of pulmonary aspiration. Also, increased abdominal contents raise the diaphragm and alter the normal alignment of the

upper airway.[22] Pilkington et al. reported a 34% increase in the number of Mallampati grade IV at 38 weeks' gestation as compared to 12 weeks' gestation.[23] The six tests used in this study include upper lip bite tests, modified Mallampati test, sterno-mental distance, thyro-mental distance, the horizontal length of the mandible and the inter-incisor gap. The actual incidence of difficult intubation is difficult to estimate. The reported incidence varies from 1.3% to 13% in the general surgical population.[24-28] We found an 18.2% incidence of difficult intubation in parturients in this study and there was no failure to intubate the trachea. Wide variations in the incidence of DVL have been ascribed to various factors, such as lack of uniformity in describing or grading the laryngeal view, cricoid pressure, head position, degree of muscle relaxation, type or size of laryngoscopic blade and skill of performer. For achieving a uniform intubating condition, all direct laryngoscopies were done by a fixed expert anesthesiologist, using a Macintosh blade size 3 or 4 while the cricoid pressure was applied by a third fixed assistant appropriately instructed in the technique. Also, all the parturients were anesthetized and fully relaxed with maximum allowable doses of induction drugs.

In this study, it was found that the ULBT was the most useful single predictor with a sensitivity, specificity and positive predictive value of 94.6%, 97.6% and 89.7%, respectively. These results are similar to those of the studies done by Hester et al. and Khan.[14,29] Although in the study by Eberhart et al. it was indicated that ULBT and MMT were poor predictors as single screening tests, they reported a low sensitivity and positive predictive value for ULBT. [30] Other studies on ULBT showed a high specificity (88.7% to 99.1%) but with different ranges of sensitivity (20.5% to 76.5%) and positive predictive value (28.9% to 83%).[14,29,30,31] The ULBT has some limitations; it requires the patients' cooperation, ability to move the mouth and the presence of teeth. In our evaluation, MMT had a low sensitivity (29.7%) and positive predictive value (20.8%) with an acceptable specificity (74.7%). Hester et al. reported a relatively similar result, although other studies on MMT represented different reports on sensitivity (11% to 82.4%), specifity (61% to 98.4%) and positive predictive value (9% to 57%) of MMT.[29] Mallampati hypothesized that the degree to which oropharyngeal structures could be visualized upon examination should correlate with structures that could be on laryngoscopy and developed a scoring system that has been in use for more than 2 decades and over the years many of its limitations have been pointed out by various trials. The absence of a definite demarcation between class II and III and between class III and IV group and the effect of phonation and patient's cooperation on its classification lead to high inter-observer variability and decreased reliability.[30,32] Karkouti et al. argued that the inter-observer reliability of only two of ten preoperative airway tests (mouth opening and chin protrusion) was excellent and classic Mallampati had poor inter-observer reliability. [33] The reliability of some tests may also be improved if devices such as positioning aids, photographs, or radiographs are used. A recent study that assessed the reliability of the Mallampati test, using photographs of the oropharynx, found that the test was still only moderately reliable.[23] The SMD with a cut-off point of 13.5 cm had a low sensitivity (13.5%) and positive predictive value (18.5%) but a relatively high specifity (86.7%) in the present study. Ramadhani and colleagues failed to prove that SMD can be as a sole predictor of difficult laryngoscopy in obstetric anesthesia. According to their report, a SMD of 13.5 cm or less had a sensitivity, specificity and positive predictive value of 66.7%, 71.1% and 7.6%, respectively. [24] The difference between the means of the SMD between DVL and EVL was statistically significant. This is in agreement with the results obtained by both Nikhu et al. and Ramadhani.[24,15] The TMD had a very low sensitivity and positive predictive value of 10% in this study. Both Nikhu et al.[15] and Arne[34] reported a similarly low sensitivity of 15.4% and 16%, respectively while in the majority of reports it was reported to be above 60%.[5,12,13,28] This could possibly be due to anthropometric peculiarities in the study population, a postulate that should be validated in future studies. According to our results, the IIG was unable to predict any difficult laryngoscopies and there was no correlation between IIG and view at laryngoscopy. Savva et al. reported similar results regarding IIG, [12] unlike Nikhu and Arne et al.'s studies that both showed sensitivities of 30.8% and 42%, respectively for inter-incisor gap.[15,34] The HLM was the second most sensitive of all the six tests with a sensitivity of 62.2%, specificity of 43.4% and positive predictive value of 19.7%. Nikhu et al. found a lower sensitivity and positive predictive value (30.8% and 4.3%, respectively) and a higher specifity (76%) than that in our study for HLM.[15] The difference between the mean of the HLM between DVL and EVL was statistically significant. The combination of all the six tests

increased the sensitivity and negative predictive value to 100% at the expense of the specificity and positive predictive value (26.5% and 23.3%, respectively). The combination providing the best prediction in our study involved the ULBT and MMT with sensitivity, specifity, positive and negative predictive values of 97%, 100%, 100% and 86%, respectively. Bhat et al. showed a sensitivity of 7.7% and specifity of 99.6% with ULBT and MMT combination and concluded that a combination of ULBT and MMT in parallel was more sensitive, specific and had a higher discriminative power which is clinically more relevant than MMT or ULBT alone.[31] Logistic regression showed that ULBT, SMD, TMD and HLM were independent predictors of difficult laryngoscopy while the age, height, weight, body mass index, IIG and MMT were not independent predictors of difficult intubation.

In conclusion, it seems that the upper lip bite test is a valuable predictor of difficult laryngoscopy in isolation and in combination with modified Mallampati test in obstetric patients.

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