Original Article

Does neck circumference help to predict difficult intubation in obstetric patients? A prospective observational study

ABSTRACT

Background: Failed intubation in obstetrics remains the most common cause of death directly related to anesthesia. Neck circumference has been shown to be a predictor for difficult intubation in morbidly obese patients. The aim of this study was to determine an optimal cutoff point of neck circumference for prediction of difficult intubation in obstetric patients.

Methods: Ninety-four parturients scheduled for cesarean section under general anesthesia were included in the study. Preoperative airway assessment and neck circumference were measured. Difficult intubation was the primary outcome according to the intubation difficulty scale (IDS), intubation reported difficult if the IDS score was ≥5.

Results: Univariate analysis showed that Mallampati score and neck circumference were positive predictors for difficult intubation (P = 0.005 and P = 0.011, respectively). Mouth opening, thyromental distance, sternomental distance, and the hyomental distance ratio were not useful predictors (P = 0.68, P = 0.87, P = 0.48, and P = 0.27, respectively). Logistic regression for the Mallampati score and neck circumference negative results as independent predictors of difficult intubation in obstetric (P = 0.53). Sensitivity analysis showed that neck circumference of 33.5 cm is the cutoff point to detect difficult intubation with 100% sensitivity (95% confidence interval [CI]: 69.2–100) and 50% specificity (95% CI: 38.9–61.1). The area under the curve for neck circumference was 0.746 (95% CI: 0.646–0.830) with a positive predictive value of 19.2 (95% CI: 9.6–32.5), a negative predicative value of 100 (95% CI: 91.6–100), and a P < 0.0001.

Conclusions: In obstetric patients, a neck circumference ≥33.5 cm is a sensitive predictor for difficult intubation.

Key words: Difficult intubation; neck circumference; obstetrics

Introduction

Failed intubation and ventilation in obstetrics remains the most common cause of death directly related to anesthesia.[1,2] At present, general anesthesia is used mainly for emergency situations in obstetrics, which leaves limited time for adequate airway assessment.[1] Further, most patients undergoing an emergency obstetric procedure are attended by junior anesthesiologists with limited experience in dealing with these situations. It has been documented that the risk of failed intubation is less if anesthetic management is performed by a senior anesthesiologist.[3,4] The higher incidence of difficult intubation in obstetrics could be attributed to edema in the upper airways caused by the increased maternal blood volume and the effects of estrogen.[5]

Researchers are continuously seeking signs or clinical parameters with high sensitivity and specificity to

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help predict a difficult airway. The Mallampati score, which is commonly used for this purpose during airway assessment, has poor sensitivity and specificity. A Mallampati score of 3 or 4 was reported to have a specificity of 62% and a positive predictive value of 29% in obese patients.[6] Further, this test was considered neither sensitive nor specific enough as a single predictor of difficult intubation in obstetric patients.[7]

It has been reported that the risk of difficulty in airway management increases with a thyromental distance >6.5 cm in obese patients.[8] However, a leading investigator in this area failed to demonstrate that a short thyromental distance or sternomental distance is an independent risk factor for difficult intubation in morbidly obese patients.[9] Similarly, investigators from our institution reported that the sternomental distance may not be an adequate sole predictor of difficult laryngoscopy in obstetric patients.[10] The thyromental distance ratio had a sensitivity of 88% and a specificity of 60% in detecting normal visualization of the larynx in a normal population;[11] however, there are no data available for patients who are pregnant.

A small number of publications have identified increasing neck circumference as a single predictor of problematic intubation.[8,9,12] It has been documented that a neck circumference >43 cm has higher sensitivity and specificity as a predictor of difficult intubation in obese patients.[8] In addition, another study reported problematic intubation at a neck circumference of 40 cm, which increased markedly at 60 cm.[9] More recently, one of the authors (WR) demonstrated that neck circumference can be used as a sole predictor of difficult ventilation and intubation in morbidly obese patients.[12] However, the exact neck circumference that is predictive of problems with airway management or that justifies additional intervention such as awake intubation in obstetric is not known.

The primary aim of this observational study was to determine an optimal cutoff point of neck circumference to predict difficult intubation in obstetric patients.

Materials and Methods

Ethical approval for this study was provided by the Research Ethics Committee at Corniche Hospital, Abu Dhabi, United Arab Emirates (Chairperson Dr. P. Bosio) on October 9, 2014, reference number Ch09101401. The study was registered with a clinical trials registry (ClinicalTrials.gov identifier: NCT02366182). After obtaining the approval and informed written patient consent, 94 obstetric patients scheduled for cesarean section under general anesthesia at Corniche Hospital were prospectively recruited. Patients with upper airway pathology or cervical spine abnormality, those undergoing emergency procedures, and those with a history of difficult intubation were excluded from the study. The patients were assessed by the anesthesiologist preoperatively and asked about their medical history, with a specific enquiry for obstructive sleep apnea and snoring. The physical examination included measurement of weight and height for calculation of the body mass index (BMI). Airway assessment included (a) maximum mouth opening, measured as the interincisor gap (mm);[13] (b) sternomental distance, measured as the straight distance between the upper border of the manubrium sterni and the bony point of the mentum with the head in full extension and the mouth closed (cm);[13] (c) hyomental distance, measured from just above the hyoid bone to the tip of the most anterior part of the mentum in both the neutral position and with maximum head extension (cm) for calculation of the hyomental distance ratio (HMDR); (d) thyromental distance, measured as the distance from the thyroid notch to the inner margin of the mental prominence when the head was fully extended (cm);[13] (e) extended Mallampati Score in the sitting position with full extension of the craniocervical junction with phonation (Class I, entire uvula is clearly visible; Class II, upper half of the uvula is visible; Class III, soft and hard palate clearly visible; and Class IV, only the hard palate is visible);[13] (f) neck circumference at the level of the thyroid cartilage (cm);[12] (j) condition of the teeth (protrusion, loose, and missing); and (h) a mandibular protrusion test to detect temporomandibular joint mobility, measured as ability to move the lower teeth in front of the upper teeth.

Preoperative investigations, preparations, and monitoring followed the standard practice of our hospital. Before induction of anesthesia, patients were positioned with a small pillow under the head to maintain the standard sniffing position for direct laryngoscopy. Preoxygenation was carried out for a minimum of 3 min to ensure adequate denitrogenation. Anesthesia was induced by a sleeping dose of thiopentone (4–5 mg/kg), followed by succinylcholine 1.5 mg/kg to facilitate intubation. When adequate relaxation was achieved, the attending anesthesiologist, using the correctly sized Macintosh laryngoscope, attempted endotracheal intubation. A number of intubation attempts, additional operators required, alternative intubation techniques, position of the vocal cords, and Cormack and Lehane's classification for laryngoscopic view were recorded. The need for

external laryngeal pressure and use of lifting force with the laryngoscope to obtain a better view of the vocal cords were also recorded. All the above-mentioned items were used to determine the intubation difficulty scale (IDS) score.[14] Intubation was reported to be difficult if the IDS score was ≥5.

Statistical analysis

Sample size calculation showed that 94 patients would need to be enrolled in this study. This was calculated based on the formula used for descriptive studies as follows:

$$N = 4\, z_{\alpha}^{2}\, S^2/W^2$$

Where,
S is the standard deviation of neck circumference in obese patients,
W is the width of the 95% confidence interval (CI),
z_{α} is a value for the normal distribution related to the confidence level.

The results were analyzed using Statistical Package for the Social Sciences for Windows version 20 software (IBM SPSS Statistics for Macintosh, Armonk, NY, USA). All comparisons were conducted at the significance level with a $P < 0.05$. The Student's *t*-test was used to make comparisons between parametric variables.

Univariate analysis was performed to determine clinical predictors of difficult intubation. For positive clinical predictors, the sensitivity analysis was performed using the receiver operating characteristic (ROC) curve between sensitivity and 1-specificity and the Youden index to define the best discriminating point.[15] Logistic regression was used to identify independent predictors.

Results

Ninety-four pregnant female patients receiving general anesthesia for cesarean section were enrolled in this observational study. Patient age, BMI, American Society of Anesthesiologist classification, and associated medical problems are shown in Table 1. Ten patients were considered to be difficult to intubate based on the IDS criterion (IDS ≥5).[13] Morphological airway morphological measurements and characteristics of the airways and characteristics of all for all patients are shown in Table 2. Mallampatti score, neck circumference, as well as IDS were significantly different between patients who were and were not difficult and nondifficult to intubate patients ($P = 0.02$, $P = 0.01$, and $P = 0.00$, respectively).

Univariate analysis performed to determine clinical predictors of difficult intubation showed that the Mallampati score and neck circumference were positive predictors for difficult intubation in obstetric patients ($P = 0.005$ and $P = 0.011$, respectively). Negative predictors for difficult intubation were mouth opening ($P = 0.863$), thyromental distance ($P = 0.876$), sternomental distance ($P = 0.481$), and HMDR ($P = 0.276$). On the other hand, when logistic regression analysis was performed to detect independent predictors for Mallampati score and neck circumference, the result was negative ($P = 0.53$).

Sensitivity analysis for positive clinical predictors was performed using the area under the ROC curve to assess the predictive value of the model. A neck circumference of 33.5 cm was the cutoff point to detect difficult intubation, with 100% sensitivity (95% CI: 69.2–100) and 50% specificity (95% CI: 38.9–61.1) [Figure 1]. The area under the ROC curve for neck circumference was 0.746 (95% CI: 0.646–0.830) with a positive predictive value of 19.2 (95% CI: 9.6–32.5) and a negative predictive value of 100 (95% CI 91.6–100), with a $P < 0.0001$. In contrast, the area under the ROC curve for Mallampati classification was 0.643 (95% CI: 0.53–0.73), with a *P* value of 0.109.

Table 1: Patient demographic data

Variables	Data
Age (years)	32.3 (5.9)
BMI	32.9 (6.3)
ASA:	
I	48 (51.1%)
II	43 (45.7%)
III	3. (3.2%)
Medical problems	
Diabetes mellitus	5 (5.3%)
Hypertension	3 (3.2%)

Data expressed as Mean (Standard deviation) or number and percentage. BMI: Body mass index; ASA: American society of anesthesiologists physical status

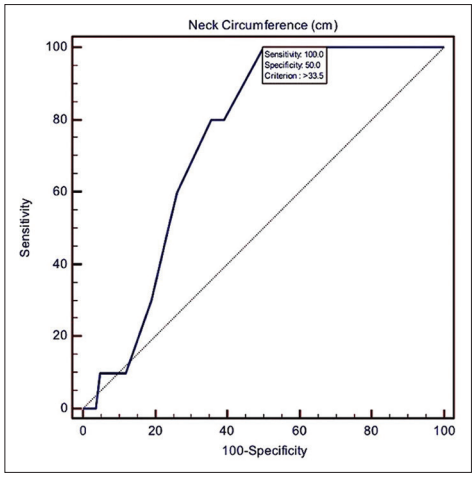

Figure 1: Receiver operating characteristic analysis of neck circumference

Table 2: Airway and intubation characteristics

	Total sample ($n=94$)	Intubation		P
		Not difficult ($n=84$)	Difficult ($n=10$)	
Mallampati classification, *n* (%)				
I	33 (35.1)	31 (36.9)	2 (20.0)	0.002
II	58 (61.7)	52 (61.9)	6 (60.0)	
III	3 (3.2)	1 (1.2)	2 (20.0)	
Mouth opening (cm)	4.50 (4.375-5.000)	4.50 (4.125-5.000)	4.5 (4.375-5.000)	0.863
Thyromental distance (cm)	8.00 (7.50-9.00)	8.00 (7.50-9.00)	8.25 (7.875-8.750)	0.876
Sternomental distance (cm)	13 (12.5-14.0)	13 (12.5-14.0)	14 (12.375-14.000)	0.481
Hyomental distance (cm)				
Neutral position	3.50 (3.00-4.00)	3.50 (3.00-4.00)	3.10 (2.500-3.775)	0.206
Extension	4.75 (4.50-5.00)	5.00 (4.50-5.00)	4.50 (4.375-5.500)	0.444
Hyomental distance ratio	1.37 (1.25-1.50)	1.365 (1.25-1.50)	1.45 (1.257-1.50)	0.276
Neck circumference	34.00 (32.375-36.000)	33.75 (32.00-35.50)	35.75 (34.75-36.625)	0.011
IDS, *n* (%)				
Negative (IDS 0)	68 (72.3)	68 (81.0)	0	0.000
Positive (IDS ≥1)	26 (27.7)	16 (19.0)	10 (100)	
IDS	0.00 (0.00-1.00)	0.00 (0.00-0.00)	6.00 (5.00-6.00)	0.000
Difficult intubation, *n* (%)	10 (10.6) 95% CI (4.29-16.99)			

Data expressed as the median (interquartile range) or number and percentage. CI: Confidence interval; IDS: Intubation difficulty scale

Discussion

The results of this study show that neck circumference and the Mallampati score are positive predictors of difficult intubation in obstetric patients. A neck circumference ≥33.5 cm was a sensitive predictor for difficult intubation. However, the current study failed to demonstrate that neck circumference can be used as a sole predictor. We also found that mouth opening, thyromental and sternomental distances, and HMDR were negative predictors of difficult intubation in our parturient population.

Over the last few years, increasing attention has been paid to neck circumference as a predictor of difficult intubation. Recent studies have shown the usefulness of neck circumference as a predictor of difficult intubation and ventilation in morbidly obese patients.[8,9,12] Gonzalez *et al*. used the IDS to compare obese and nonobese patients and reported that a neck circumference >43 cm can be used as a predictor of difficult intubation with 92% sensitivity and 84% specificity.[8] Brodsky *et al*. investigated 100 morbidly obese patients and reported that a high neck circumference and Mallampati classification are the only predictors of potentially difficult intubation; at a neck circumference of 40 cm, the probability of problematic intubation was approximately 5% and increased to approximately 35% at a neck circumference of 60 cm.[9] Riad *et al*. performed a multiple regression analysis for difficult intubation in morbidly obese patients. They found that a neck circumference >42 cm and a BMI >50 kg/m^2 were independent predictors of difficult intubation in this patient population.[12]

Airway anatomy in pregnant patients is different from that in the normal population, and the difference becomes more obvious as pregnancy advances. It has been shown that the airway is markedly narrowed in the third trimester and that this occurs mainly in the supine position secondary to fluid retention in the head and neck tissues.[16] Pilkington *et al*. observed an increase in Grade 4 Mallampati score by 34% at 38 weeks of pregnancy when compared with the examination performed at 12 weeks of pregnancy.[17] The authors correlated this increase with weight gain and fluid retention. Risk analysis showed that difficult intubation is 11 times more common in women with Mallampati class IV when compared with those who have class I scores.[4] This in agreement with the current work, which documented that the Mallampati score can be used as a positive predictor for difficult intubation in an obstetric population. On the other hand, an older study in 350 patients (322 nonobstetric and 28 obstetric; 185 women) by Savva reported that the Mallampati score is not sensitive nor specific enough for routine use as a predictor of difficult intubation.[7] This inconsistency in results could be attributed to the difference in sample size.

Neck circumference as a predictor of difficult intubation is not well studied in obstetrics. Hirmanpour *et al*. recently reported on 657 patients scheduled for elective cesarean delivery under general anesthesia.[18] They found that laryngoscopy (Grade 3 or 4) was difficult is 8.06% of their patients, which is consistent with the current work. Their study documented that neck circumference, the ratio of height to thyromental distance, and the ratio of neck circumference to thyromental distance are good predictors of difficult laryngoscopy.[18] The

area under the ROC curve for neck circumference in that study was 0.69, which is similar to the value of 0.74 reported by the current work. However, in contrast with our findings of 100% sensitivity and 50% specificity, they reported figures of 49.06% and 89.07%, respectively. They also reported that neck circumference >39.5 cm and a neck circumference over thyromental distance of >5.6 predicted a poor laryngeal view in parturient patients. On the contrary, Eiamchroenwit *et al*. reported a limited performance of neck circumference as a predictor of difficult intubation in obese parturients undergoing cesarean delivery. They reported the ROC curve for neck circumference of 0.6 in both sitting and supine position.[18] Furthermore, they reported the neck circumference to sternomental distance in the sitting position of ≥2.7 and were optimal cutoff points to identify difficult intubation.[19] Our study showed that a neck circumference of ≥33.5 cm could be a sensitive predictor of difficult intubation in an obstetric population. This difference in the incidence of difficult intubation could be attributed to the use of cricoid pressure, differences in the patient populations studied, and a difference in the intubation scoring system used. Moreover, use of a Troop Elevation Pillow can optimize the head position and decrease the incidence of difficult intubation.[20]

We acknowledge that our study has some limitations. First, we did not study how difficult our patients were to ventilate. Second, the relationship between high BMI and difficult intubation was not examined.

In summary, we found that the Mallampati score and neck circumference are positive predictors for difficult intubation in obstetric patients undergoing cesarean section under general anesthesia. A neck circumference of ≥ 33.5 cm could be used as a cutoff point to detect difficult intubation in obstetric patients with 100% sensitivity and 50% specificity. However, neck circumference cannot be used as a single predictor for difficult intubation.

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Conflicts of interest

There are no conflicts of interest.

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