Research Article

TEHRAN UNIVERSITY OF MEDICAL SCIENCES

Archives of Anesthesiology and Critical Care (Summer 2024); 10(3): 260-265.

Available online at http://aacc.tums.ac.ir

Hip to Neck Circumference Ratio as an Independent Predictor of Difficult Intubation in Obese Patients

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ARTICLE INFO

Article history:
Received 18 June 2023
Revised 11 July 2023
Accepted 26 July 2023

Keywords:
Difficult intubation;
Difficult mask ventilation;
Hip circumference;
Neck circumference;
Waist circumference;
Obesity

ABSTRACT

Background: Anaesthesiologists face difficult intubation (DI) more frequently in obese patients. Thus, we aimed to test if central obesity indices including hip circumference (HC), neck circumference (NC) or waist circumference (WC) can effectively predict DI and difficult mask ventilation (DMV) in them.
Methods: HC, NC, WC, mask ventilation grade, intubation difficulty scale (IDS), history of snoring and obstructive sleep apnoea (OSA) were measured in 300 patients with BMI ≥ 30 kg/m2. Receiver operating characteristic curve (ROC) and multivariate, logistic regression were employed to identify predictors of DI (IDS ≥5) and DMV define as mask ventilation grade of 3 or 4.
Results: DI and DMV were, respectively, detected in 14.7% and 12.7% of subjects. According to Multiple logistic regression analysis BMI (Odds ratio (OR):1.17, 95% confidence interval (CI): 1.08-1.28, p<0.001), NC (OR: 1.26, 95% CI: 1.04-1.52, p=0.01), HC (OR:1.06, 95% CI: 1.03-1.10) and HC/NC ratio (OR: 4.9, 95% CI: 1.64-14.92, p= 0.004) considered as independent predictors of DI. The same analysis recognized BMI (OR:1.13, 95% CI: 1.03-1.24, p=0.006), WC (OR: 1.06, 95% CI:1.01-1.11, p=0.01), and HC/BMI ratio (OR=0.18, 95% CI:0.06-0.53, p=0.002) as DMV predictors. Sensitivity of BMI >35.8 kg/m2, NC >39.9 centimetres (cm), HC>118cm and HC/NC ratio >2.9 were determined as 70.5%, 68.2%, and 69.3% respectively for prediction of DI. Sensitivity of BMI >36.6 kg/m2 and WC >118 cm for predicting DMV were identified as 71.0% and 73.6%.
Conclusion: This study proposes to simultaneously consider the HC/NC ratio and WC as a predictor of difficult airway in the obese.

Introduction

Difficult airway constitutes a continuous challenge for anaesthesiologists despite developments in airway management techniques and routine use of video laryngoscopes. Preoperative difficult airway prediction is a crucial element for the preanaesthetic assessment. Identifying patients suffering from difficult endotracheal intubation may increase physicians' awareness of the need for clinician support in airway training and access to advanced airway management devices such as Ultrasound, alternative techniques and equipment [1]. As the previous studies showed the airway management difficulties occurs 2-4 times more in obese patients than the non-obese [2] and unanticipated difficult airway remains three times more common in obese surgical patients compared to non-obese patients [3].

The authors declare no conflicts of interest.
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Thirty-seven percent of all airway-related conditions occur in induction of anesthesia in obese patients based on the reports of American Society of Anaesthesiologists (ASA) closed claims database [4] However, there are mixed inconsistent findings from previous studies about the relation between obesity, BMI, and obesity indicators like neck circumference (NC) and difficult mask ventilation (DMV) and/or difficult intubation (DI) [5-11].

Waist circumference (WC) and hip circumference (HC) as indicators of central obesity have been investigated in a study and their role in predicting difficult airway is not clear [9]. Considering association between central obesity pattern and obstructive sleep apnea (OSA) from one hand [12] and association between OSA and difficult airway (DI and DMV) from the other hand [13-14], we hypothesized that WC and HC can be employed for the prediction of difficult airway in obese patients. The study was performed to test this hypothesis. To prevent harmful consequences of unpredicted difficult airway management, this study attempts to evaluate probable new predictors of difficult airway and introduce practical indices to be used routinely in preanaesthesia evaluation of the obese patients.

Methods

Ethics code (protocol number: IR.MUI.MED.REC.1398.479) was obtained on December 25, 2019, from the Ethical Committee of Isfahan University of medical sciences. Before enrolling in this study, all the patients signed a written informed consent. A prospective observational research study was conducted on 300 obese patients recruiting surgery from February to December 2020 at AL-Zahra University Hospital in Isfahan, Iran. Obesity was defined as having at least 30 kg/m2 BMI [15]. In this study, patients with BMI ≥ 30 kg/m2, ASA I to II, age of 18 - 65 years, undergoing elective surgery needing tracheal intubation participated in the study. The exclusion criteria were cervical spine abnormalities, head and neck tumors, temporomandibular joint abnormalities, facial anomalies, edentulous or loss of numbers of tooth which caused to abnormal mouth occlusion, need to instantaneous awake intubation or sequence induction, pregnancy and emergency procedures. In the pre-anaesthesia care unit, a complete medical history including sex, ASA physical status, smoking, snoring, OSA and using continuous positive airway pressure (CPAP) was obtained by an anaesthesia assistant. Patients were asked questions about if they know or have they been told that they have night snoring; or do they share their bedroom with their husband/wife or some other person cohabitating with? Yes answers were assumed as evidence of snoring. The same person also measured anatomical indices. The height was measured in centimetres with the patient barefoot on a flat surface against a solid wall. BMI was estimated based on height and weight measurements. Furthermore, NC at the level of the thyroid cartilage, HC at the level of maximum circumference over the buttocks, and WC in a horizontal plane at the middle of the lowest rib margin and the iliac crest were also measured in centimetres by a flexible measurement tape by the same anaesthesia assistant [9].

Modified mallampati classification (MMC) was used to classify the oropharyngeal view and it was determined by two professors of anaesthesiologist with more than 15 years of experience. MMC defined as class I to IV that from them grades of I and II are assumed as “Easy” laryngoscopy prediction, while III and IV grades are the difficult laryngoscopy predictors [16].

The same anesthesiologist did mask ventilation (MV) and tracheal intubation. Before induction, the patients were put in a ramp state by some blankets and head cradle allowing suprasternal notch aligns with the external auditory meatus for obese patients to specifically ease the tracheal intubation [17]. They patients were monitored by pulse oximetry, electrocardiogram, and non-invasive arterial blood pressure measurement. Preoxygenation ran for at least 3 min. Afterwards, propofol 2-3 mg/kg and fentanyl 3 μg/kg were used for Anaesthesia induction. Atracurium 0.6 mg/kg was administered for neuromuscular relaxation induction after mask ventilation. Mask ventilation was done by a facemask with an appropriate size determined by the attending anaesthesiologist. Regarding the method demonstrated by Han et al., MV grading was done before administering atracurium as follow: Grade 0; no ventilation, Grade 1; normal effective MV, Grade 2; MV with an oral airway or use of other adjuvant, Grade 3; difficult MV, where there were unstable mask ventilation or insufficient lungs ventilation to keep oxygenation, or MV needed two providers, and Grade 4; impossible MV, after which supraglottic airway or other device have to be used to maintain oxygenation and ventilation. DMV was considered as mask ventilation grades 3 and 4 in this study [18].

Direct laryngoscopy with a Macintosh number 4 laryngoscope blade was employed for tracheal intubation after achieving adequate relaxation. The Intubation Difficulty Scale (IDS) was utilized for defining DI. The IDS scale that previously validated and considers as a multiple factors resulted to DI determining according to seven factors: the number of additional intubation attempts or operators, alternative techniques to intubation, Cormack and Lehane’s definition of laryngoscopy view (grade 1-4; scored 0-3) lifting force in laryngoscopy (0 if inconsiderable; 1 if considerable), applying required external laryngeal pressure to improve glottis pressure (0 no external pressure/ only Sellick manoeuvre; 1 applying external pressure), the position of vocal cord at intubation (0 abducted vocal cords or not visible; 1 vocal cords abducted). The anaesthesiologists have assessed all the seven variables and the IDS was estimated using the sum of them 19. With at least 5, DI was defined as IDS and easy intubation (EI) was shown with any value of less than 5 [19-20].

Considering the four grades classification, the same anaesthesiologist reported the Cormack-Lehane (C-L) grade. Views 3 and 4 were assumed as difficult laryngoscopy (DL). This classification consists of: grade 1; full glottis viewing, grade 2; only posterior commissure and arytenoids viewing, grade 3; epiglottis visibility only, grade 4; neither glottis nor epiglottis [21-22].

Head, weight, and neck motion range, jaw motion (inter-incisory gap estimated by mouth fully openned and lower incisors' subluxation), receding protruding and mandible maxillary anterior teeth, were applied to estimate Wilson score. Every factor was scored from 0 to 2 and to calculate Wilson score, all these scores need to be summed [23].

In the previous studies, the DMV incidences in the obese have been reported 1.4-24% [24-26] and the prevalence of DI and morbidly among them was between 9% and 15% [27]. The lowest sample size was found 288 if d=0.04, P=0.11, and Z= 2.17 (for confidence interval 97%).

Statistical Analysis

Mean ± standard deviation (SD) for continuous variables and categorical variables, frequency and percentage data were showed. Variable analysis was carried out applying Chi square and independent sample T-test. Multiple logistic regression was utilized to analyze statistically significant variables between DI and EI or DMV and EMV groups to find the DI and DMV independent predictors. A receiver operating characteristic curve (ROC) analysis was carried out for every independent predictor to indicate decent cut-off points by SPSS 26.

A P-value of lower than 0.05 was assumed as significant.

Results

Difficult intubation, difficult laryngoscopy (DL) and difficult mask ventilation (DMV) were observed in 14.7 %, 24.7% and 12.7% of the study population, respectively and no case of Intubation failure was occurred.

Positive history of OSA (15.7% vs 4.5%, p=0.01) and snoring (57.9% vs 35.8%, p=0.01) were frequently observed in the DMV group compared to the EMV group; only in DI group positive snoring evidence was higher than the EI group significantly (54.5% and 35.9% respectively, p=0.02). No significant difference was detected between EMV and DMV study groups in the presence of facial hair (19.4% vs 10.5%, P=0.26).

(Table 1 and Table 2) have demonstrated whether significant differences were observed between difficult intubation(DI) and easy intubation (EI) groups or between difficult mask ventilation (DMV) and easy mask ventilation (EMV) groups regarding mean BMI, NC, WC, HC, HC to NC ratio, HC to WC ratio, WC to NC ratio, HC to BMI ratio, WC to BMI ratio and NC to BMI ratio, frequency of MMC grades of 3 or 4, C-L grades 3 or 4 and Wilson score ≥2.

Multiple logistic regression analysis demonstrated, adjusting all significant anatomical indices for difficult intubation (IDS≥5) in the univariate analysis, that BMI (Odds ratio (OR):1.17, 95% confidence interval (CI): 1.08-1.28, p<0.001), NC (OR: 1.26, 95% CI: 1.04-1.52, p=0.01), HC (OR:1.06, 95% CI: 1.03-1.10), HC/NC ratio (OR:4.9, 95% CI:1.64-14.92, p=0.004) were independent DI predictors in obese patients. WC (OR:0.98, 95% CI: 0.94-1.02, p=0.41) did not act as independent predictor of DI however.

Moreover, adjusting for all significant anatomical indices for difficult mask ventilation in the univariate analysis, multiple logistic regression analysis illustrated that BMI (OR:1.13, 95% CI: 1.03-1.24, p=0.006), WC (OR: 1.06, 95% CI: 1.01-1.11, p= 0.01) and HC/BMI ratio (OR=0.18, 95% CI:0.06-0.53, p=0.002) were also independent DMV predictors in obese patients.

Using ROC analysis, the specificity and sensitivity of independent predictors for predicting DI and DMV in obese patients were determined and reported in (Table 3). Tests including BMI>35.8 kg/m2, NC>39.9cm, HC>118 cm and HC/NC ratio>2.93 had area under curve (AUC) of 0.73, 0.65, 0.67 and 0.68 respectively for predicting DI with significant p-values.

BMI>36.6 kg/m2, WC>118cm, HC/BMI ratio<3.12 were predictors of DMV with AUC of 0.78, 0.74 and 0.61 respectively and significant p-values.

Table 1- Variables associated with difficult intubation (IDS≥5) in obese patients.

Variable	IDS<5 N=256	IDS≥5 N=44	P value
Age (years)	40.3±11.9	37.4±11.8	0.14
Male/Female (n)	99/157	12/32	0.17
ASA(I/II)	187/68	31/13	0.71
Modified mallampati class≥3	33(12.9%)	19(43.1%)	< 0.001
Wilson score≥2	220(85.9%)	43 (97.7%)	0.02
Cormack-Lehane grade ≥3	31(12.1%)	43(97.7%)	< 0.001
Body mass index (kg/m2) (BMI)	35.1±4.0	39.8±6.1	<0.001
Waist circumference (WC)	112.4±12.4	118.3±12.1	0.004
Hip circumference (HC)	112.6±12.1	120.4±10.9	<0.001
Neck circumference (NC)	39.4±1.8	40.5±1.9	<0.001
WC/HC ratio	1.0±0.09	0.9±0.07	0.14

HC/NC ratio	2.85±0.31	2.97±0.28	0.02
WC/NC ratio	2.85±0.32	2.92±0.28	0.18
HC/BMI ratio	3.22±0.36	3.06±0.32	0.007
WC/BMI ratio	3.21±0.36	3.00±0.33	<0.001
NC/BMI ratio	1.13±0.12	1.03±0.14	0.06

Data shown mean± standard deviation (SD) or n (%), IDS: intubation difficulty scale, ASA: American Society of Anaesthesiologists

Table 2- Variables associated with difficult mask ventilation (DMV) in obese patients.

Variable	**EMV N=262**	**DMV N=38**	**P value**
Age (years)	40.2±11.8	37.4±12.2	0.18
Male/Female (n)	98/164	13/25	0.85
ASA(I/II)	189/72	29/9	0.69
Modified mallampati class≥3	29(11.0%)	23(60.5%)	< 0.001
Wilson score≥2	225 (85.8%)	38 (100%)	0.007
Cormack-Lehane grade ≥3	44(16.8%)	30(78.9%)	< 0.001
Body mass index (kg/m2) (BMI)	35.2±4.1	40.2±5.5	<0.001
Waist circumference (WC)	111.9±12.1	122.8±11.4	<0.001
Hip circumference (HC)	112.6±11.9	121.7±11.8	<0.001
Neck circumference (NC)	39.5±1.8	40.2±2.2	0.02
WC/HC ratio	0.99±0.09	1.01±0.08	0.36
HC/NC ratio	2.85±0.30	3.02±0.30	<0.001
WC/NC ratio	2.83±0.30	3.05±0.32	<0.001
HC/BMI ratio	3.21±0.35	3.06±0.39	0.01
WC/BMI ratio	3.20±0.36	3.08±0.33	0.06
NC/BMI ratio	1.13±0.12	1.01±0.14	0.06

Data shown mean± standard deviation (SD) or n (%), EMV: easy mask ventilation, ASA: American Society of Anaesthesiologists.

Table 3- Predictive values of bedside tests for predicting difficult intubation and difficult mask ventilation in obese patients using receiver operating characteristic analysis.

Tests for DI	**Cut of point**	**AUC**	**Sensitivity**	**Specificity**	**P value**
BMI	>35.8	0.73	70.5	61.3	<0.001
NC	>39.9	0.65	68.2	52.3	<0.001
HC	>118	0.67	60.0	60.5	<0.001
HC/NC ratio	>2.93	0.68	69.3	62.2	0.03
Tests for DMV	Cut of point	AUC	Sensitivity	Specificity	P-value
BMI	>36.6	0.78	71.0	69.0	<0.001
WC	>118	0.74	73.7	60.3	<0.001
HC/BMI ratio	<3.12	0.61	63.1	56.1	0.01

DI: difficult intubation, DMV: difficult mask ventilation, BMI: body max index, NC: neck circumference, HC: hip circumference, WC: waist circumference, AUC: area under curve.

Discussion

BMI, NC, HC, and HC/NC ratio were identified as independent predictors of difficult intubation. According to our findings increased BMI and WC with decreased HC/BMI ratio were known as independent predictors of DMV as well.

Firstly, we introduce HC/NC ratio ≥3 as a DI predictor in obese patients with odds ratio of 4.9, sensitivity of 70 % and specificity of 62 % indicating the practical importance of recording it within pre-anaesthesia evaluations. Additionally, BMI>36.6 kg/m2 and WC>118 centimetres (cm) had area under curve (AUC)>0.7 in ROC analysis with more than 70% sensitivity and 60% specificity for predicting DMV. With respect to significant but low odds ratio of WC in predicting DMV more research need to be done. Thus, it seems that central obesity patients are at higher risk of difficult airway. It should be stated that DI and DMV rates were 14.7% and 12.7% in the present study which were already being expected according to previous studies [6,7,25].

For all we know, no research study has taken into account the HC/NC ratio for predicting difficult intubation. In addition, Results of previous studies on predictive values of BMI, NC, WC and HC for DI and DMV are lack and conflicting [3,5-10]. Literature has shown that only one study has evaluated predictive value of HC and WC for predicting DI and DMV in the obese. Riad et al. included 104 morbidly obese patients (mean BMI:48.4±7.5) and showed that the mean WC was meaningfully larger in the DI group, compared to the patients with EI, but no significant difference was detected between EMV and DMV groups with regard to WC [9]. The authors did not find significant association between HC and DI or DMV. The authors used the same definition for DI as we used in our study but their findings were not in consistent with the present study. Considering high AUC and sensitivity by ROC analysis for WC in predicting DMV besides its significant p-value in multiple regression analysis, WC were identified as an independent predictor of DMV. Having said that, further studies need to be done to determine the clinical efficacy of it for pre anaesthesia evaluations.

Consistent with our findings, Riad et al. and Gonzalez et al. also took BMI into consideration as a DI and DMV independent predictor and NC as a DI predictor of in obese patients [8-9]. However, according to Brodsky et al., BMI and obesity were not associated with DI which was defined as C-L grade ≥3. In their study, large NC was associated with DI7. The differences might be related to disparities in definition of DI which they used in their study. The only one aspect of the process of intubation is represented by C-L grade and was not initially aimed to be utilized as an intubation difficulty indicator [22, 28]. Association between NC and DI has not been demonstrated in all studies and some authors failed to show an association between NC and DI or DL in morbidly obese patients [10]. However, the primary outcome in the latter study was association between OSA and DI, and the study might not have enough power to detect association between NC and DI.

Similar to our study findings, Aydin et al. evaluated 90 obese patients and showed that history of snoring was more frequent in individuals with DMV. While patients with DMV had a significantly larger NC, multivariate analysis did not show NC as a predictor of DMV. In their study, there was not an association between BMI and DMV as well [11] which were not similar to our findings. As mentioned earlier, available literature on predictive values of BMI, NC, WC and HC for DI and DMV are conflicting [3,5-10] and our study which is adequately powered, provides more information on predictive value of these variables for predicting DI and DMV of obese patients.

Our study has several limitations that needs to be highlighted. Definitions of DI are different and make it hard to compare the studies' results. Lack of a standard definition for DI cross anaesthesiology research is another issue. We defined DI as IDS score of at least 5 employed in various studies [3,6,8,9]. IDS ≥ 5 has been validated as predictor of DI in obese patients [20]. However, some authors considered only IDS scores of greater than 5 as an indicator of DI [8]. Furthermore, we included only elective surgical patients and put them in the ramp position that is used regularly by many anaesthesiologists [9-10]. Ramping obese patients for intubation also varies in studies evaluating DI in obese patients. There is a possibility that intubating obese patients in a different position, yield different findings.

Conclusion

We identified HC/NC ratio ≥3 as an independent predictor of difficult intubation people having BMI≥ 30 kg/m2 with high odds ratio, sensitivity and specificity. Therefore, we suggest measuring and recording it within pre-anaesthesia assessments. HC/NC ratio ≥3 and WC>118cm can let physicians to pay attention to the possibility of difficult airway management in obese patients specially whom with central obesity and suitable backup plans and equipment have to be provided. Finally, further research is recommended to investigate the association between central obesity indices specifically HC and WC with DI and DMV in obese and morbidly obese patients to reveal their relationships more precisely.

Acknowledgement

We are tanksful from Vice chancellor for research of Isfahan University of Medical sciences for financial support of the current study.

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