

Comparison of Three Difficult Endotracheal Intubation Predictors in Obese Individuals in an Indian Population

ABSTRACT

Context: Unanticipated difficult intubation is a challenge that no single bedside screening test can accurately predict. Independent indices or single anthropometric measurements have demonstrated lower reliability in patients with increased body mass index (BMI). Using two or three related independent indices is therefore preferred. **Aim:** The aim of the study was to assess applicability of three bedside measurements, the modified Mallampati classification (MMPC), neck circumference (NC) and thyromental distance ratio (NC/TM), and NC minus acromio-acromion distance (NEMA) in obese subset of Indian population. **Design:** Prospective observational study. **Materials and Methods:** One hundred and twenty adults with BMI >29 undergoing general anesthesia were enrolled after consenting. Pre-operative measurements and intubation details were recorded. Difficult intubation was determined using the (intubation difficulty scale ≥ 5 termed difficult). The NC/TM ratio, NEMA, and MMPC were compared with respect to sensitivity, specificity, positive, and negative predictive value (NPV) with receiver operating characteristics curve and logistic regression. **Statistical Analysis Used:** SPSS software version 25. **Results:** Incidence of difficult intubation was 12.5%. By binary univariate logistic regression, NC/TM independently predicted difficult intubation in obese ($P = 0.00$ and exponential B 29.173 [95% CI of 5.862–145.185]). NC/TM showed the highest sensitivity, NPV, and largest area under the curve. Mean NC/TM was 4.71 (SD ± 0.44) and mean NEMA was 0.83 (SD ± 2.7). **Conclusion:** The NC/TM ≥ 5 with its good sensitivity, specificity, and negative and positive predictive values, appears an independently useful, simple bedside test predicting difficult intubation in obese Indian population and superior to MMPC and NEMA.

Key words: Airway risk assessment, Difficult endotracheal intubation, Laryngoscopy, Obesity, Predictors

Key Message: Neck circumference to thyromental distance ratio (NC/TM) ≥ 5 appears an independently useful, simple bedside test superior to the modified Mallampati classification (MMPC) and the Neck circumference minus acromio-acromion distance (NEMA), to predict difficult intubation in the obese Indian population.

INTRODUCTION

Unanticipated difficult intubation is challenging even to an experienced anesthetist. Obesity is one of the risk factors of difficult intubation and single anthropometric measurements have demonstrated lower reliability at predicting the difficulty in such patients.^[1]

The most common screening test for airway evaluation is the modified Mallampati classification (MMPC).^[2] Others include the neck circumference (NC) and thyromental distance ratio (NC/TM)^[3] and the more recent NC minus the Acromio-acromion distance (NEMA).^[4] A NC/TM ≥ 5 and a NEMA parameter ≥ 5 cm most likely predict difficult intubation.

We compared the MMPC, NC/TM, and the NEMA to assess their applicability in obese individuals.

MATERIALS AND METHODS

This prospective observational study was conducted after obtaining Institutional Ethics Committee approval and enrollment with Clinical Trials Registry of India (CTRI)

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{CTRI/2018/02/011835}. Adult patients undergoing surgery involving oral intubation over 8 months between May to December 2018, with a Body mass index (BMI) >29 were enrolled after obtaining written informed consent. Children (<18 years) and those with distorted head and neck anatomy due to either malignancy and its treatment, and patients with pre-existing difficult intubation due to ankylosis, trismus were excluded from the study. Patient details such as age, sex, and

ASA grading were recorded. The patient's height in centimeters (cm) and weight in kilograms (Kg) were obtained from the electronic medical records and BMI in kg/m² calculated. A standard measuring tape was used to obtain measurements of NC, thyromental distance, and acromio-acromion distance. NC measured at the level of the cricoid cartilage. Acromion-acromion distance was measured with the patient in an upright sitting position with arms by the side of the trunk. TM distance is measured from the thyroid notch to the lower border of the mentum, with the neck in extension. The MMPC score and history of prior difficult intubation were noted.

Anesthetists with at least 2 years' experience and blind to the anthropometric measurements performed the intubations. The first intubation attempt was with a size 3 Macintosh laryngoscope blade. A swift laryngoscopy with a Macintosh direct laryngoscope to assess and record the Cormack Lehane grade was performed even if the operating room anesthetist preferred to use a video laryngoscope upfront. Laryngoscopy details such as number of attempts, number of operators, use of or change to a different blade or video laryngoscope, bougie or stylet for intubation, and alternative techniques used were noted to score the difficulty in intubation using the intubation difficulty score (IDS). The IDS is a sum of seven parameters. One of the investigators summed up the total IDS score. A score of >2 but <5 is considered mild difficulty and IDS \geq 5 is considerable difficulty.

The need for additional lifting force at laryngoscopy, external laryngeal manipulation (ELM), vocal cord position at intubation (adducted/abducted), and abandoning of procedure was recorded.

Statistical analysis was performed using SPSS software version 25. The specificity, sensitivity, positive, and negative predictive values (NPV) of each parameter were individually measured. Accuracy of the predictors was evaluated using the area under receiver operator characteristics (ROC) curve and $P < 0.05$ by logistic regression was considered significant.

Sample size calculation

A sample size of 104 was identified to detect the difference between Area under the curve (AUC) from 0.74 to 0.89 with 90% power and a Type I error probability associated with this test of the null hypothesis was 0.05. We arrived at a sample size of 120 patients taking into account the loss to follow-up and dropouts due to change in anesthesia plan or cancellation of surgery. Since the three parameters, NC, acromio-acromion distance, and TM distance are simple measurements measured with a standard tape, all the three parameters were recorded in each patient, and hence 120 patients were enrolled in the study.

RESULTS

Over the 8 months, 185 obese patients posted for surgery under general anesthesia were screened and 120 patients who

fit the inclusion criteria, and consented were recruited into the study ($n = 120$). Ninety-five (79.2%) were female and 25 (20.8%) male. The mean age was 49.48 years (SD \pm 10.93), mean weight was 79.3 kg (SD \pm 9.8), mean height 156.13 cm (SD \pm 7.8), and the mean BMI was 32.5 (SD \pm 3.13).

The mean NC was 37.74 (SD \pm 2.89), mean TM distance 8.03 (SD \pm 0.70), mean acromio-acromion distance 36.88 (SD \pm 3.15), the mean NC/TM was 4.71 (SD \pm 0.44) and, mean NEMA was 0.83 (SD \pm 2.7). Eighty-five (70.8%) patients had an MPC of 1, 25 (20.8%) patients of 2 and 10 (8.3%) patients had an MPC of three. No patient had an MPC 0 or 4 in the study.

The majority of intubations (45%) were by postgraduate trainees with at least 2 years of experience and 93 (77.5%) were performed in a single attempt. There were no failed intubations. 106 (88.3%) intubations required only a single operator. One hundred and one (84.2%) intubations did not require the use of an alternative technique. At laryngoscopy, the Cormack and Lehane (CL) grade was 1 in 68 (57%) patients, Grade 2 in 47 (39%) patients, and Grade 3 in 5 (4.1%) patients. ELM was required in 54 (45%) patients [Table 1].

As calculated from the IDS score (\geq 5), intubation was found to be difficult in 15 (12.5%) patients. Six (5%) patients had IDS of five, 7 (5.8%) an IDS of six; 1 (0.8%) patient each had scores of 7 and 8. Eight (53.3%) were male and 7 (47.7%) female. Seven (46.7%) of these intubations were in the hands of consultants, 5 (33.3%) were by senior residents, and 3 (20%) by postgraduate trainees.

As per the anthropometric measurements used in our study, in two patients, intubation difficulty was not anticipated, but in reality, intubation in these two patients was difficult and subsequently correlated with IDS \geq 5. Therefore, the incidence of anticipated difficult intubation in our study was found to be 10.8% (13/120) and of unanticipated difficult intubation was 1.66% (2/120).

The ROC analysis was performed to compare the three parameters.

MMPC was found to have a sensitivity of 6.66% and a specificity of 91% as derived from the ROC curve and as shown in Figure 1.

The test was found to have a positive predictive value of 10% and a negative predictive value of 87.27% [as derived from the contingency table shown in Table 2]. From the logistic regression, $P > 0.05$ and exponential B 0.054 (with a 95% CI of 0.054–6.533) implied that MMPC is not a good predictor of difficult intubation in obese individuals.

The sensitivity of NC/TM as per the ROC curve was found to be 86.7% and specificity 87.6% [Figure 2].

The test was found to have a positive predictive value of 50% and a negative predictive value of 97% [as derived from the contingency table shown in Table 3]. As per logistic regression, P -value is 0.0001 and exponential B 29.173 (with a 95% CI of 5.862–145.185). Hence, in our study, NC/TM appeared to be a better predictor of difficult intubation in obese individuals.

Table 1: Demographics (n=120)

Demographics	n=120 (%)
Sex	
Female	95 (79.2)
Male	25 (20.8)
Mallampati class	
I	85 (70.8)
II	25 (20.8)
III	10 (8.3)
Intubations performed	
Consultant	22 (18.3)
Senior Registrar	44 (36.7)
Postgraduate trainees (> 2yrs experience)	54 (45)
Intubation attempts	
Single	93 (77.5)
Two	23 (19.2)
Three	4 (3.3)
Operators	
Single	106 (88.3)
Two	13 (10.8)
Three	1 (0.8)
Alternative adjuncts for intubation	
None	101 (84.16)
Blade changed	2 (1.7)
Stylet	4 (3.3)
Bougie	6 (5)
Videolaryngoscope	7 (5.8)
Cormack Lehane grading	
Grade I	68 (56.7)
Grade II	47 (39.2)
Grade III	5 (4.1)
Additional manipulations	
Additional lifting force	14 (11.7)
External laryngeal manipulation	54 (45)

Table 2: Contingency table for MMPC.

	IDS ≥5	IDS <5
MMPC ≥3	1	9
MMPC <3	14	96

n=120

Table 3: Contingency table for NC/TM.

	IDS ≥5	IDS <5
NC/TM ≥5	13	13
NC/TM <5	2	92

(N=120)

Table 4. Contingency table for NEMA.

	IDS ≥5	IDS <5
NEMA ≥5	3	6
NEMA <5	12	99

(N=120)

Table 5: Comparison of the three predictors

Parameter	Sn	Sp	PPV	NPV
NC/TM	86.66	87.6	50	97.87
MPC	6.66	91	10	87.27
NEMA	20	94.2	33.33	89.18

Sn: Sensitivity, Sp: Specificity, PPV: Positive predictive value, NPV: Negative predictive value

NEMA was found to have a sensitivity of 20% and specificity of 94.2% as derived from the ROC curve [Figure 3].

The test was found to have a positive predictive value of 33% and a negative predictive value of 89.1% [as derived from the contingency table shown in Table 4]. By logistic regression, $P > 0.05$ and exponential B 1.117 (with a 95% CI of 0.208–5.922). In this study, we found that NEMA is not a good predictor of difficult intubation in obese individuals in the Indian population.

The sensitivity, specificity, and positive and NPV of the parameters are shown in Table 5.

DISCUSSION

In the study where we applied the three difficult intubation predictors or screening tests, namely, the MMPC, NC/TM, and NEMA, to an obese Indian population, we found that the NC/TM had the highest sensitivity to predict difficult intubation.

An overall 13% incidence of difficult intubation in Indians has been reported in the literature.^[5,6] We found a 12.5% incidence in this study involving obese population, which is lower than the 14–15% incidence mentioned in international studies^[3,7,8] involving a similar population. We chose a BMI ≥29 as the cut-off for patient selection based on the WHO expert consultation^[9] and Consensus statement on obesity in Indians^[10] which proposed that in the Asian population a BMI cut-off, lower than the WHO standards of BMI grading of obesity should be accepted.^[10,11]

When faced with intubation difficulty, a video-laryngoscope (5.8%) was the most preferred alternative technique than a change of blade (1.7%), stylet (3.3%), or a bougie (5%), probably due to the easy availability of a videolaryngoscope in our hospital setting.

Fifty-four (45%) patients required an ELM and it was observed that all patients in whom intubation was difficult required ELM to assist intubation as opposed to the BURP (backward, upward, rightward pressure) technique used by Torres *et al.*^[4] in their study which helped in 22.7% of intubations. The ELM is superior, as it involves immediate feedback from the person performing the intubation, which

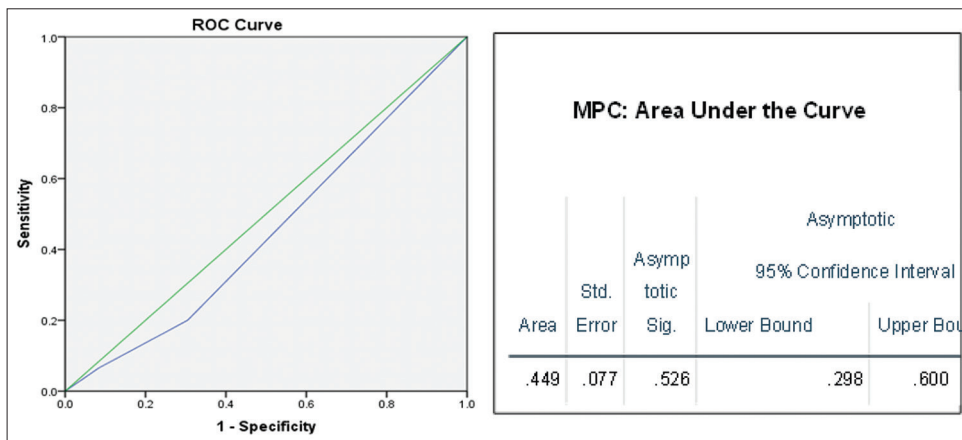


Figure 1: ROC curve of MPC

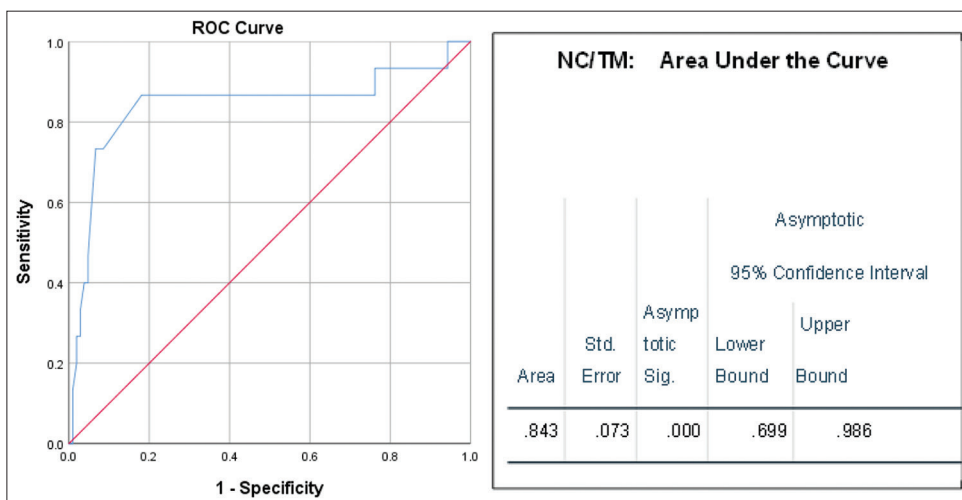


Figure 2: ROC curve of NC/TM

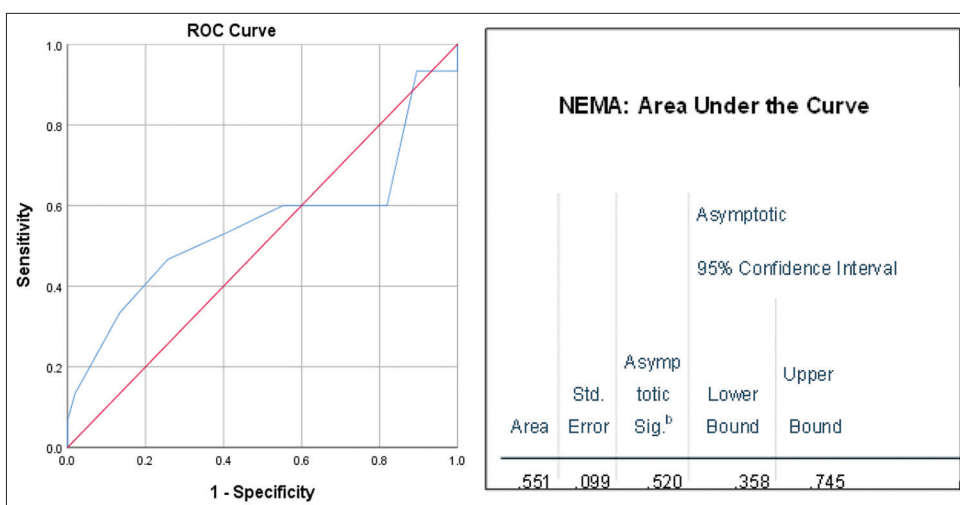


Figure 3: ROC curve of NEMA

helps in adjusting the force and direction of the manipulation as opposed to the BURP.

CL grade at laryngoscopy was one in 56.7%. Incidence of CL Grade 3 was 4.1% in our study and much lower than the 6.5% incidence in the study by Torres *et al.*, where they used Cormack Lehane grading 3 and 4 as the endpoint of difficult intubation. The incidence of grade 4 view was 0.6% in their study, while we did not have a single Grade 4 view in our study. We attribute this variation to the ethnic differences between the Asian, Middle Eastern population. Hur *et al.*^[11] found that genetic factors contribute to the differences in variability of height, weight, and BMI between Caucasians and East Asians.

In our study, NC/TM had better sensitivity than MMPC and NEMA. NEMA is a relatively new parameter and in the study that proposed it,^[4] showed a sensitivity of 55% and specificity of 66% whereas, in our study, NEMA had a low sensitivity of 20% but a high specificity of 94.2%. The original study involved the European population; hence, genetic and ethnic differences between Indians and Europeans, including the distribution of body fat, type of obesity, and anthropometric measurements could be the reason for the disparity. The AUC was not significant and we presume that a larger study is required to further establish the significance of this parameter and its use in the future.

Three studies have evaluated the NC/TM^[3,12] in Korean, Portuguese, and Iranian populations, while one other study^[13] has evaluated it in the Indian population. All of these studies found NC/TM to be a better predictor of difficult intubation. We too had a sensitivity of 86.66, a specificity of 87.6, and a negative predictive value (NPV) of 97.87 for NC/TM, which indicates its use both as a screening and diagnostic test in predicting difficult intubation.

The sensitivity of MMPC was 6.66% in our study, much lower than that mentioned in the literature. While studies have found sensitivity of >40% with MMPC,^[6,14] there is some evidence for poor sensitivity.^[15,16] However, we did have a specificity of 91% justifying its use as a screening tool. To rule out the possibility of underestimation of MMPC by the investigators, the MMPC grading recorded in the case record forms was cross-checked with those recorded at preoperative assessment from the Electronic Medical records of the hospital.

The exponential B by logistic regression showed a wide range for a 95% confidence interval. This can be attributed to the lower incidence of difficult intubation and thereby a smaller subset of the sample in the current study. Other studies^[3,13] have noted similar findings.

Similar to other studies that evaluated airway prediction tools, our results derived a higher specificity and lower sensitivity for the three parameters. The Cochrane review^[17] quoted, "Standard airway examination tests do not appear to work well as screening tests. Although false negatives can result from bedside examination tests, it is important to put the risk of an unanticipated difficult airway into context." However, it was a review largely based on normal adults. When it comes to obese individuals, the screening tests need to address the neck

fat and focus on parameters that incorporate the same. There are studies using ultrasonography for quantification of anterior neck soft tissue^[18] and can be used in conjunction with other bedside tests wherever feasible.

There is no ideal airway prediction test identified so far^[19] but the effort to find one better than the existing ones or to reinforce and prove a pre-existing test continues perpetually. In our study, the NC/TM appeared to be a superior parameter to MMPC and NEMA in predicting difficult endotracheal intubation in obese patients in the Indian population.

Strengths

The study focused on the obese Indian population and provided a glimpse of the applicability of the difficult intubation predictors. There are very few studies comparing these predictors in an Indian population.

The operating room anesthetist was blinded to the anthropometric measurements.

Limitations

1. Despite being more objective, IDS may still vary with the experience of the anesthetist. If the initial intubation attempt was made by a less experienced anesthetist (in our case the senior resident and postgraduate trainees with 2 years of experience) and then taken over by a consultant anesthetist, the IDS could increase.
2. Subjective variability in the Mallampati scoring system is a possibility, to counter this, the modified Mallampati scores were crosschecked with those recorded at the pre-anesthetic checkup clinic from the electronic medical records of each patient.
3. The operating room anesthetist was free to choose to ramp and modify the intubating position. This might have affected the IDS. We allowed ramping as it is the norm while intubating obese patients at the hospital and disallowing the same would have been unethical.
4. We did not collect details of associated comorbidities such as diabetes, rheumatoid arthritis and so on, which are capable of causing difficulty in intubation.

CONCLUSION

The NC/TM \geq 5 with its good sensitivity, specificity, negative and positive predictive values, appears to be an independently useful, simple bedside test in predicting difficult intubation in the obese Indian population. It appears to be far superior to the MMPC and the NEMA, both of which had a high specificity and negative predictive

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To all our patients.

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