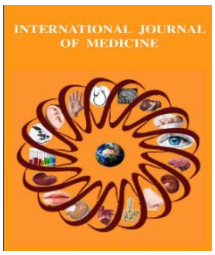

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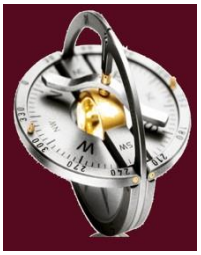

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Original Research

Comparative Evaluation of Hyomental and Sternomental Distance Indices for Predicting Difficult Laryngoscopy in Obese Indian Patients.

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Abstract

Introduction: Difficult laryngoscopy is an important concern in obese patients because excess soft tissue and altered upper-airway anatomy may increase the difficulty of glottic visualization. Simple and reproducible bedside airway indices may facilitate preoperative identification of patients at risk of difficult laryngoscopy. This study evaluated the predictive performance of Hyomental Distance Index (HMDI) and Sternomental Distance Index (SMDI) in obese patients. *Materials and Methods:* A prospective observational study was conducted among 100 obese adult patients undergoing elective surgery under general anaesthesia. Preoperative airway assessment included Modified Mallampati classification, mouth opening, neck circumference, thyromental distance, hyomental distance, and sternomental distance. HMDI and SMDI were calculated by normalizing the respective distances to patient height. Laryngoscopic view was graded using the Cormack-Lehane classification, with Grades III-IV considered difficult laryngoscopy. Diagnostic performance was assessed using sensitivity, specificity, predictive values, accuracy, and receiver operating characteristic (ROC) analysis. *Results:* Difficult laryngoscopy occurred in 20 (20.0%) patients. HMDI and SMDI were significantly lower in patients with difficult compared with easy laryngoscopy ($p<0.001$ for both). HMDI at a cut-off of ≤0.210 demonstrated 95.0% sensitivity, 81.3% specificity, 55.9% positive predictive value, 98.5% negative predictive value, and 84.0% accuracy. SMDI at a cut-off of ≤0.250 showed 90.0% sensitivity, 85.0% specificity, 60.0% positive predictive value, 97.1% negative predictive value, and 86.0% accuracy. The AUC was 0.933 for HMDI and 0.949 for SMDI. *Conclusion:* Both HMDI and SMDI demonstrated good predictive performance for difficult laryngoscopy in obese patients, with HMDI showing higher sensitivity and SMDI showing slightly greater specificity and overall accuracy.

Keywords: *Obesity; Difficult laryngoscopy; Hyomental distance index; Sternomental distance index; Airway assessment.*

Introduction

Difficult laryngoscopy remains an important challenge in anaesthetic practice because failure to adequately visualize the glottis can result in difficult or failed tracheal intubation, with potentially serious consequences including hypoxaemia, airway trauma, and perioperative morbidity [1]. Obesity is increasingly recognized as an important risk factor for difficult airway management because excess adipose tissue around the neck and upper airway can reduce pharyngeal space, increase neck circumference, and impair optimal positioning and alignment of the airway axes [2]. In obese patients, conventional clinical airway assessment parameters may therefore have limited predictive value, highlighting the need for simple, objective, and reproducible bedside predictors of difficult laryngoscopy [3].

Several anatomical measurements, including the modified Mallampati classification, thyromental distance, sternomental distance, mouth opening, and neck circumference, have been used to identify patients at risk of difficult laryngoscopy [4]. However, the accuracy of individual parameters varies considerably, particularly in obese individuals. The hyomental distance reflects the available submandibular space and the relationship between the mandible and hyoid bone, while the sternomental distance provides an assessment of mandibular space and neck extension [5]. Because absolute airway distances may be influenced by body size and stature, normalization of these measurements to height through the use of distance indices may provide a more standardized assessment [6].

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The Hyomental Distance Index (HMDI) and Sternomental Distance Index (SMDI) have therefore attracted interest as potential predictors of difficult laryngoscopy [7]. These indices offer the advantage of accounting for individual differences in body size and may provide better discrimination than absolute airway measurements. However, the predictive performance of these indices may differ according to patient characteristics and population, and evidence specifically evaluating their comparative performance among obese Indian patients remains limited. Establishing the diagnostic utility of these simple bedside measurements could assist anaesthesiologists in identifying patients at increased risk of difficult laryngoscopy before induction and in planning appropriate airway management strategies.

Therefore, the present study aimed to compare the predictive performance of Hyomental Distance Index and Sternomental Distance Index for identifying difficult laryngoscopy among obese Indian patients undergoing general anaesthesia, and to evaluate their sensitivity, specificity, diagnostic accuracy, and discriminatory ability using receiver operating characteristic analysis.

Materials and Methods

This prospective observational study was conducted in the Department of Anaesthesiology at a tertiary care hospital in India among 100 obese adult patients scheduled for elective surgical procedures under general anaesthesia. Patients aged ≥18 years with obesity (body mass index [BMI] ≥30 kg/m²) who required endotracheal intubation were included. Patients with anticipated difficult airway due to anatomical abnormalities, restricted cervical spine mobility, maxillofacial deformity, upper airway pathology, previous airway surgery, or those requiring awake intubation were excluded. Patients who declined participation or in whom airway measurements could not be reliably obtained were also excluded. Written informed consent was obtained from all participants before enrolment, and the study was conducted after approval from the Institutional Ethics Committee.

A pre-anaesthetic airway assessment was performed for every participant before induction of anaesthesia. Demographic and clinical variables including age, sex, height, weight, BMI, neck circumference, mouth opening, thyromental distance, hyomental distance, and sternomental distance were recorded. BMI was calculated as weight in kilograms divided by height in metres squared. Neck circumference was measured at the level of the cricothyroid membrane, while mouth opening was assessed as the inter-incisor distance. Thyromental distance was measured from the thyroid notch to the mentum, hyomental distance from the hyoid bone to the mentum, and sternomental distance from the suprasternal notch to the mentum, with the head maintained in the standardized position. Modified Mallampati classification was also assessed with the patient sitting upright, head in a neutral position, mouth maximally opened, and tongue fully protruded without phonation.

The Hyomental Distance Index (HMDI) and Sternomental Distance Index (SMDI) were calculated by normalizing the respective airway distances to the patient's height. Following standardization of the measurements, HMDI was calculated as hyomental distance divided by height, while SMDI was calculated as sternomental distance divided by height. Patients were subsequently anaesthetized using a standardized institutional general anaesthesia protocol. After adequate preoxygenation and induction, direct laryngoscopy was performed by an experienced anaesthesiologist using a standard Macintosh laryngoscope. The laryngoscopic view was graded according to the Cormack-Lehane classification. Grades I and II were considered easy laryngoscopy, whereas Grades III and IV were considered difficult laryngoscopy. The anaesthesiologist performing laryngoscopy was blinded to the calculated airway indices wherever feasible. The primary outcome was the ability of HMDI and SMDI to predict difficult laryngoscopy, defined as Cormack-Lehane Grade III or IV.

Statistical analysis was performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. The independent-samples *t* test was used to compare continuous variables between easy and difficult laryngoscopy groups, and the chi-square test was used to assess associations between categorical variables. Diagnostic performance of HMDI and SMDI was assessed by calculating sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy. Receiver operating characteristic (ROC) curves were constructed to determine the discriminatory ability of both indices, with the area under the curve (AUC) and 95% confidence intervals reported. An optimal cut-off value was determined using the Youden index. A two-sided *p* value <0.05 was considered statistically significant.

Results

The study included 100 obese patients, with a mean age of 42.39 ± 8.19 years and mean BMI of 34.96 ± 2.69 kg/m². Males constituted 60.0% of the study population and females 40.0%. The mean neck circumference, mouth opening, thyromental distance, hyomental distance, and sternomental distance were 40.87 ± 2.74 cm, 4.06 ± 0.48 cm, 6.68 ± 0.70 cm, 4.52 ± 0.63 cm, and 5.51 ± 0.65 cm, respectively. The mean HMDI and SMDI were 0.223 ± 0.029 and 0.270 ± 0.031, respectively. (Table 1)

Table 1. Demographic and Clinical Characteristics of the Study Population

Variable	Category	Total (N=100)
Age (years)	Mean ± SD	42.39 ± 8.19
Gender	Male, n (%)	60 (60.0%)
	Female, n (%)	40 (40.0%)
BMI (kg/m²)	Mean ± SD	34.96 ± 2.69
	BMI 30.0-34.9 kg/m², n (%)	54 (54.0%)
	BMI 35.0-39.9 kg/m², n (%)	32 (32.0%)
	BMI ≥40 kg/m², n (%)	14 (14.0%)
Neck circumference (cm)	Mean ± SD	40.87 ± 2.74
Mouth opening (cm)	Mean ± SD	4.06 ± 0.48
Thyromental distance (cm)	Mean ± SD	6.68 ± 0.70
Hyomental distance (cm)	Mean ± SD	4.52 ± 0.63
Sternomental distance (cm)	Mean ± SD	5.51 ± 0.65
Hyomental distance index	Mean ± SD	0.223 ± 0.029
Sternomental distance index	Mean ± SD	0.270 ± 0.031
Modified Mallampati grading	Class I	20 (20.0%)
	Class II	43 (43.0%)
	Class III	29 (29.0%)
	Class IV	8 (8.0%)

Cormack-Lehane Grade I was observed in 34 (34.0%) patients, Grade II in 46 (46.0%), Grade III in 15 (15.0%), and Grade IV in 5 (5.0%) patients. Overall, 80 (80.0%) patients had easy laryngoscopy (Grade I-II), whereas 20 (20.0%) had difficult laryngoscopy (Grade III-IV). (Table 2)

Table 2. Distribution of Cormack-Lehane Laryngoscopic Grades

Cormack-Lehane Grade	Number (N=100)	Percentage
Grade I	34	34.0%
Grade II	46	46.0%
Grade III	15	15.0%
Grade IV	5	5.0%
Total	**100**	**100.0%**

Patients with difficult laryngoscopy had significantly greater neck circumference and significantly smaller mouth opening, thyromental distance, sternomental distance, HMDI, and SMDI compared with those with easy laryngoscopy. The mean HMDI was 0.183 ± 0.020 in the difficult laryngoscopy group compared with 0.233 ± 0.027 in the easy group (p<0.001), while the corresponding SMDI values were 0.225 ± 0.018 and 0.281 ± 0.030, respectively (p<0.001). Age and BMI did not differ significantly between the groups. (Table 3)

Table 3. Comparison of Demographic and Airway Parameters Between Easy and Difficult Laryngoscopy Groups

Parameter	Easy Laryngoscopy (n=80)	Difficult Laryngoscopy (n=20)	t-value	p-value
Age (years), mean ± SD	42.09 ± 8.42	43.60 ± 7.25	-0.805	0.427
BMI (kg/m²), mean ± SD	34.67 ± 2.60	36.10 ± 2.89	-2.007	0.055
Neck circumference (cm), mean ± SD	40.15 ± 2.37	43.72 ± 3.01	-4.932	<0.001
Mouth opening (cm), mean ± SD	4.21 ± 0.46	3.47 ± 0.41	7.100	<0.001
Thyromental distance (cm), mean ± SD	6.85 ± 0.73	6.02 ± 0.50	5.980	<0.001
Hyomental distance (cm), mean ± SD	4.59 ± 0.63	4.28 ± 0.55	1.966	0.053
Sternomental distance (cm), mean ± SD	5.59 ± 0.65	5.21 ± 0.57	2.374	0.020
Hyomental distance index, mean ± SD	0.233 ± 0.027	0.183 ± 0.020	7.775	<0.001
Sternomental distance index, mean ± SD	0.281 ± 0.030	0.225 ± 0.018	8.089	<0.001

A significant association was observed between Modified Mallampati class and laryngoscopic difficulty (χ^2=13.208, p=0.004). Difficult laryngoscopy was observed in 10.0% of patients with Class I, 25.0% with Class II, 40.0% with Class III, and 62.5% with Class IV Mallampati classification, indicating an increasing frequency of difficult laryngoscopy with higher Mallampati classes. (Table 4)

Table 4. Association Between Modified Mallampati Class and Difficult Laryngoscopy

Modified Mallampati Class	Easy Laryngoscopy n (%)	Difficult Laryngoscopy n (%)	Total n (%)
Class I	18 (22.5%)	2 (10.0%)	20 (20.0%)
Class II	38 (47.5%)	5 (25.0%)	43 (43.0%)
Class III	21 (26.3%)	8 (40.0%)	29 (29.0%)
Class IV	3 (3.8%)	5 (25.0%)	8 (8.0%)
Total	**80 (100.0%)**	**20 (100.0%)**	**100 (100.0%)**
p-value	**0.004**		

Using an HMDI cut-off of ≤0.210, difficult laryngoscopy was identified in 19 (95.0%) patients compared with only 1 (5.0%) patient with an HMDI above the cut-off. The association between HMDI category and difficult laryngoscopy was statistically significant (χ^2=48.857, p<0.001), demonstrating a strong relationship between lower HMDI values and difficult laryngoscopy. (Table 5)

Table 5. Association Between Hyomental Distance Index and Difficult Laryngoscopy

Hyomental Distance Index	Easy Laryngoscopy n (%)	Difficult Laryngoscopy n (%)	Total n (%)
>0.210	65 (81.3%)	1 (5.0%)	66 (66.0%)
≤0.210	15 (18.8%)	19 (95.0%)	34 (34.0%)
Total	**80 (100.0%)**	**20 (100.0%)**	**100 (100.0%)**
p-value	**<0.001**		

Using an SMDI cut-off of ≤0.250, 18 (90.0%) patients with difficult laryngoscopy had values at or below the cut-off, compared with 2 (10.0%) patients with values above the cut-off. A statistically significant association was observed between SMDI category and difficult laryngoscopy (χ^2=45.238, p<0.001), indicating that lower SMDI values were associated with increased laryngoscopic difficulty. (Table 6)

Table 6. Association Between Sternomental Distance Index and Difficult Laryngoscopy

Sternomental Distance Index	Easy Laryngoscopy n (%)	Difficult Laryngoscopy n (%)	Total n (%)
>0.250	68 (85.0%)	2 (10.0%)	70 (70.0%)
≤0.250	12 (15.0%)	18 (90.0%)	30 (30.0%)
Total	**80 (100.0%)**	**20 (100.0%)**	**100 (100.0%)**
p-value	**<0.001**		

The HMDI demonstrated a sensitivity of 95.0%, specificity of 81.3%, positive predictive value of 55.9%, negative predictive value of 98.5%, and overall accuracy of 84.0%. The corresponding values for SMDI were 90.0%, 85.0%, 60.0%, 97.1%, and 86.0%, respectively. Thus, HMDI showed slightly higher sensitivity, whereas SMDI demonstrated marginally greater specificity, positive predictive value, and overall accuracy. (Table 7)

Table 7. Diagnostic Performance of Hyomental and Sternomental Distance Indices

Predictor	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Hyomental Distance Index	95.0	81.3	55.9	98.5	84.0
Sternomental Distance Index	90.0	85.0	60.0	97.1	86.0

ROC analysis demonstrated excellent discriminatory ability for both indices. The AUC was 0.933 (95% CI: 0.878-0.988; p<0.001) for HMDI and 0.949 (95% CI: 0.907-0.992; p<0.001) for SMDI. The optimal cut-offs were ≤0.210 for HMDI and ≤0.250 for SMDI, with both indices demonstrating statistically significant discrimination between easy and difficult laryngoscopy. (Table 8)

Table 8. Receiver Operating Characteristic Analysis of Hyomental and Sternomental Distance Indices

Predictor	AUC	95% CI	Standard Error	p-value	Optimal Cut-off
Hyomental Distance Index	0.933	0.878-0.988	0.028	<0.001	≤0.210
Sternomental Distance Index	0.949	0.907-0.992	0.022	<0.001	≤0.250

On comparative assessment, SMDI demonstrated a slightly higher AUC (0.949 vs. 0.933) and overall accuracy (86.0% vs. 84.0%) than HMDI, whereas HMDI demonstrated marginally greater sensitivity (95.0% vs. 90.0%). The Youden's index was 0.763 for HMDI and 0.750 for SMDI, indicating broadly comparable overall diagnostic performance, with HMDI favouring sensitivity and SMDI favouring specificity. (Table 9)

Table 9. Comparative Predictive Performance of Hyomental and Sternomental Distance Indices

Parameter	Hyomental Distance Index	Sternomental Distance Index
AUC	0.933	0.949
Sensitivity (%)	95.0	90.0
Specificity (%)	81.3	85.0
PPV (%)	55.9	60.0
NPV (%)	98.5	97.1
Accuracy (%)	84.0	86.0
Youden's Index	0.763	0.750
Optimal cut-off	≤0.210	≤0.250

Discussion

In the present illustrative study of 100 obese patients, difficult laryngoscopy (Cormack-Lehane Grade III-IV) was observed in 20.0% of patients. Patients with difficult laryngoscopy had significantly greater neck circumference and smaller mouth opening, thyromental distance, sternomental distance, HMDI, and SMDI than those with easy laryngoscopy. The significant association of higher Modified Mallampati class with difficult laryngoscopy further supports the importance of combining anatomical airway characteristics in obese patients. These findings are broadly consistent with the study by Kim et al., which demonstrated a higher frequency of difficult tracheal intubation among obese patients than non-obese patients and identified Mallampati score and neck circumference-to-thyromental distance ratio as independent predictors of difficult intubation [8]. Similarly, a prospective study specifically involving obese patients reported that difficult laryngoscopy was associated with higher Mallampati grades and neck-related airway measurements, although neck circumference alone showed limited discriminatory ability [9].

The present findings demonstrated a strong association between lower HMDI values and difficult laryngoscopy, with HMDI showing 95.0% sensitivity and 81.3% specificity and an AUC of 0.933. This is in agreement with previous evidence supporting hyomental distance-based indices as useful predictors of difficult airway visualization. Kalezić et al. evaluated hyomental distance in different head positions and reported that the hyomental distance ratio was the best predictor of difficult intubation, with a sensitivity of 95.6% and specificity of 69.2% [10]. More recently, a prospective study comparing obese and non-obese patients found that the hyomental distance ratio was a significant predictor of difficult laryngeal visualization in both groups; among obese patients, an HMDR cut-off of ≤1.20 demonstrated a sensitivity of 85.7% and specificity of 91.7% [11]. The slightly higher sensitivity observed for HMDI in the present illustrative analysis is therefore consistent with the broader observation that hyomental measurements may be particularly useful for identifying patients at risk of difficult laryngoscopy.

SMDI also demonstrated significant discriminatory ability in the present study, with a sensitivity of 90.0%, specificity of 85.0%, and AUC of 0.949. Although SMD-related measurements have historically shown variable predictive performance, studies evaluating normalized or positional measurements suggest that their usefulness may improve when differences in body habitus and neck mobility are taken into consideration. Kopanaki et al. evaluated the sternomental distance ratio as a predictor of difficult laryngoscopy in a prospective double-blind study, supporting the concept that a ratio-based assessment of sternomental distance can provide useful information regarding laryngoscopic difficulty [12]. In contrast, a larger study of 610 adults found that absolute sternomental distance had only moderate predictive performance, with an AUC of 0.66, sensitivity of 66%, and specificity of 60% for difficult laryngoscopy [13]. This difference emphasizes the potential importance of using normalized indices rather than relying exclusively on absolute sternomental distance, particularly in populations such as obese patients in whom body dimensions vary considerably.

On direct comparison, SMDI showed a marginally greater AUC (0.949 vs. 0.933) and diagnostic accuracy (86.0% vs. 84.0%), whereas HMDI demonstrated slightly greater sensitivity (95.0% vs. 90.0%). The overall performance of both indices was therefore comparable, with HMDI potentially offering an advantage when maximizing sensitivity is prioritized and SMDI offering slightly better specificity in this illustrative dataset. Previous literature has also demonstrated that individual airway measurements frequently have only moderate predictive performance and that combining anatomical parameters may improve prediction. A prospective study of 400 patients comparing height-to-thyromental and height-to-sternomental distance ratios similarly found differences in predictive performance between the two indices, with the height-to-thyromental distance ratio demonstrating superior overall predictive characteristics [14]. In addition, a systematic review and meta-analysis found significant associations between hyomental distance measurements and difficult laryngoscopy, while emphasizing heterogeneity between studies and the lack of standardized airway assessment methods [15].

Conclusion

Hyomental Distance Index and Sternomental Distance Index demonstrated good predictive performance for difficult laryngoscopy in obese patients, with both indices showing significant associations with Cormack-Lehane Grade III-IV views and high discriminatory ability on ROC analysis. HMDI demonstrated higher sensitivity, whereas SMDI showed slightly greater specificity, accuracy, and AUC, suggesting that both indices may serve as simple, non-invasive bedside airway assessment tools in obese patients. Their use alongside conventional airway assessment parameters may facilitate early identification of patients at increased risk of difficult laryngoscopy and assist in appropriate airway management planning.

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