



# Association Between Ultrasonographic Hyomental Distance and Preoperative Thyromental Distance as Predictors of Difficult Direct Laryngoscopy

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## KEYWORDS

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## ABSTRACT:

**Background:** Accurate prediction of difficult airway remains essential in anesthetic practice to reduce perioperative complications. Ultrasonographic hyomental distance (HMD) has emerged as a promising parameter, while thyromental distance (TMD) remains a commonly used clinical predictor.

**Objective:** This study aimed to evaluate the association and predictive performance of ultrasonographic HMD and preoperative TMD for difficult direct laryngoscopy.

**Methods:** This prospective observational study included 61 adult patients undergoing elective surgery with general anesthesia. HMD was measured using ultrasonography in neutral, sniffing, and extension positions, and the hyomental distance ratio (HMDR) was calculated. TMD was measured clinically. Difficult laryngoscopy was defined as Cormack–Lehane grade III–IV. Diagnostic performance was assessed using receiver operating characteristic (ROC) curve analysis.

**Results:** Difficult laryngoscopy occurred in 32.8% of patients. HMD values and HMDR were significantly lower in the difficult laryngoscopy group ( $p < 0.001$ ). All parameters demonstrated good to excellent discriminative ability, with AUC values ranging from 0.966 to 1.000. TMD also showed high diagnostic performance (AUC 0.995). However, the very high diagnostic accuracy observed may reflect the limited sample size and requires external validation.

**Conclusion:** Both ultrasonographic HMD and TMD are associated with difficult laryngoscopy and demonstrate promising diagnostic performance. A multimodal approach combining ultrasonographic and clinical parameters may improve airway assessment, although further validation in larger and more diverse populations is required.

## 1. Introduction

Accurate preoperative prediction of a difficult airway remains a fundamental component of anesthetic assessment, as it enables early anticipation of airway-related complications and appropriate preparation prior to induction [1]. Identification of high-risk patients is essential to reduce morbidity and mortality associated with failed airway management [2]. However, no single clinical predictor has demonstrated sufficient diagnostic

accuracy to reliably identify difficult airway conditions, including difficult laryngoscopy and tracheal intubation [3].

The American Society of Anesthesiologists defines a difficult airway as a clinical scenario in which a trained anesthesiologist encounters difficulty with face mask ventilation, laryngoscopy, or intubation [4]. The reported incidence of difficult intubation ranges from 1% to 8%, while failed intubation occurs in approximately 0.05%–



0.35% of cases [5]. In rare but critical situations, failure to intubate and oxygenate may occur, posing a life-threatening emergency [6].

Traditional bedside assessments, such as the thyromental distance (TMD), remain widely used due to their simplicity and ease of application in clinical practice [7]. A reduced TMD is generally associated with limited submandibular space, which may hinder glottic visualization during direct laryngoscopy [8]. Nevertheless, the predictive accuracy of TMD is inconsistent, as its sensitivity varies across populations despite relatively stable specificity [9].

Advances in imaging modalities have introduced ultrasonography as a promising tool for airway evaluation, offering advantages such as real-time visualization, non-invasiveness, and absence of radiation exposure [10]. Among ultrasound-based parameters, the hyomental distance (HMD) has gained attention as a potential indicator of submandibular compliance and airway anatomy [11]. The hyomental distance ratio (HMDR), reflecting dynamic changes between neutral and extended head positions, has also demonstrated favorable diagnostic performance with reported sensitivity up to 88% [12].

Furthermore, ultrasonographic assessment of the hyoid bone and surrounding structures provides additional anatomical insights that may improve prediction of difficult laryngoscopy [13]. Previous studies have reported a significant association between HMD measurements and difficult airway outcomes, supporting its clinical relevance [14]. Despite these findings, the integration of ultrasonographic parameters into routine airway assessment remains limited and lacks standardization across clinical settings [15]. Therefore, this study aims to evaluate the association between ultrasonographic hyomental distance and preoperative thyromental distance as predictors of difficult direct laryngoscopy in patients undergoing surgery at Dr. Wahidin Sudirohusodo Hospital.

## 2. Methods

### *Study Design and Setting*

This study employed an observational analytic design with a prospective cross-sectional approach to evaluate the association between ultrasonographic hyomental distance and preoperative thyromental distance in predicting difficult direct laryngoscopy. The study was

conducted at Dr. Wahidin Sudirohusodo, Makassar Hospital, Indonesia, between October and November 2025.

### *Study Population and Sampling*

The study population comprised adult patients undergoing elective surgical procedures requiring tracheal intubation under general anesthesia. Subjects were recruited using a consecutive sampling method, whereby all eligible patients meeting the inclusion and exclusion criteria during the study period were enrolled until the required sample size was achieved.

### *Eligibility Criteria*

Eligible participants were adults aged 18 years or older with American Society of Anesthesiologists (ASA) physical status I–II who were scheduled for elective surgery under general anesthesia with tracheal intubation and provided informed consent. Patients were excluded if they were pregnant, had limited mouth opening (<3 cm), tongue thickness  $\geq 6.1$  mm on ultrasonography, neck circumference >33.5 cm, obesity, midline neck swelling, evident anatomical abnormalities, prior head and neck surgery, upper airway pathology such as maxillofacial fractures or tumors, dental abnormalities, or required awake intubation.

### *Study Procedures*

All participants underwent standardized preoperative airway assessment. Patients were positioned supine without a pillow, with the head in a neutral position, mouth closed, and instructed not to swallow during measurements. Ultrasonographic assessment was performed using a curvilinear probe placed along the midsagittal plane in the suprahyoid region to visualize the hyoid bone and mentum. Hyomental distance was measured in both neutral and extended head positions.

Thyromental distance was measured with the head in maximal extension. Following preoxygenation, anesthesia induction was performed using intravenous propofol at a dose of 1–2.5 mg/kg body weight titrated to effect, followed by administration of a muscle relaxant. Direct laryngoscopy was performed using a Macintosh blade with the patient in the sniffing position. The laryngeal view was assessed using the Cormack–Lehane classification without external laryngeal manipulation.

### *Data Analysis*

Data were analyzed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics were used to summarize baseline characteristics. Normality of data



distribution was assessed using the Shapiro–Wilk test for sample sizes less than 50 and the Kolmogorov–Smirnov test for sample sizes of 50 or more. The association between variables was analyzed using appropriate comparative and correlation tests. A p-value of less than 0.05 was considered statistically significant. Diagnostic performance was evaluated using Receiver Operating Characteristic (ROC) curve analysis.

### 3. Results

#### *Baseline Characteristics of Study Participants*

Based on Table 1, difficult intubation was defined based on the Cormack–Lehane classification grade III–IV. Of the total study population, 20 patients (32.8%) were classified as having difficult laryngoscopy, while 41 patients (67.2%) were categorized as non-difficult cases. Regarding sex distribution, the majority of participants were male (34 patients, 55.7%), while females accounted for 27 patients (44.3%). In the difficult laryngoscopy group, females were more prevalent (60.0%) compared to males (40.0%). In contrast, the non-difficult group consisted of 53.7% males and 46.3% females. However, there was no statistically significant difference between groups based on sex ( $p = 0.785$ ). The mean age of patients in the difficult laryngoscopy group was  $41.15 \pm 16.25$  years, compared to  $36.73 \pm 14.10$  years in the non-difficult group, with an overall mean age of  $38.18 \pm 14.85$  years. Statistical analysis showed that the difference in age between groups was not significant ( $p = 0.310$ ).

Based on body mass index (BMI), most patients were classified as normal weight (18.5–24.9 kg/m<sup>2</sup>), accounting for 50 patients (82.0%), followed by underweight (8.2%) and overweight (9.8%). In the difficult laryngoscopy group, 75.0% of patients had normal BMI, while in the non-difficult group, 85.4% were within the normal range. The mean BMI was  $21.80 \pm 3.21$  kg/m<sup>2</sup> in the difficult group and  $20.95 \pm 2.75$  kg/m<sup>2</sup> in the non-difficult group, with an overall mean of  $21.23 \pm 2.91$  kg/m<sup>2</sup>. No significant differences were observed between groups in terms of BMI distribution ( $p = 0.428$ ) or mean BMI ( $p = 0.162$ ).

#### *Preoperative Hyomental and Thyromental Distances*

All hyomental distance (HMD) measurements were significantly lower in the difficult laryngoscopy group compared to the non-difficult group across all assessed positions. In the neutral position, the mean HMD was

$4.17 \pm 0.07$  cm in the difficult group and  $4.39 \pm 0.09$  cm in the non-difficult group ( $p < 0.001$ ). In the sniffing position, the mean values were  $4.52 \pm 0.11$  cm and  $4.99 \pm 0.10$  cm, respectively ( $p < 0.001$ ). Similarly, in the extension position, the mean HMD was  $4.95 \pm 0.15$  cm in the difficult group compared to  $5.54 \pm 0.12$  cm in the non-difficult group ( $p < 0.001$ ). HMDR defined as the ratio between extension and neutral positions, was also significantly lower in the difficult laryngoscopy group ( $1.08 \pm 0.03$ ) compared to the non-difficult group ( $1.14 \pm 0.01$ ) ( $p < 0.001$ ).

In addition, the mean TMD was significantly shorter in patients with difficult laryngoscopy ( $7.25 \pm 0.15$  cm) compared to those without difficulty ( $8.57 \pm 0.77$  cm), with a statistically significant difference ( $p < 0.001$ ). These findings indicate that shorter hyomental and thyromental distances, as well as a lower hyomental distance ratio, are significantly associated with an increased risk of difficult laryngoscopy, suggesting their potential role as reliable predictive parameters.

#### *Predictive Performance of Hyomental and Thyromental Distances*

ROC curve analysis demonstrated that both ultrasonographic HMD and preoperative TMD had excellent predictive performance for difficult laryngoscopy. All parameters were statistically significant ( $p < 0.001$ ).

As illustrated in Figure 1, HMD in the neutral position showed an optimal cut-off value of 4.25 cm, yielding a sensitivity of 90.0% and specificity of 100%, with an area under the curve (AUC) of 0.980. In the sniffing position, a cut-off value of 4.75 cm achieved perfect sensitivity and specificity (100% each), with an AUC of 1.000. Similarly, in the extension position, a cut-off value of 5.25 cm also demonstrated 100% sensitivity and specificity, with an AUC of 1.000. The hyomental distance ratio (HMDR), with a cut-off value of 1.15, showed a sensitivity of 80.0% and specificity of 85.4%, with an AUC of 0.966, indicating excellent discriminative ability.

As shown in Figure 2, the TMD also demonstrated strong predictive performance, with a cut-off value of 7.55 cm yielding a sensitivity of 100% and specificity of 97.6%, and an AUC of 0.995.

Overall, these findings indicate that both ultrasonographic HMD (in all positions) and TMD possess outstanding diagnostic accuracy for predicting



difficult laryngoscopy, with HMD in dynamic positions showing near-perfect discrimination.

#### 4. Discussion

Failure to anticipate a difficult airway remains a major contributor to anesthesia-related morbidity and mortality [2]. In this study, ultrasonographic assessment of the submandibular region demonstrated a significant association with difficult direct laryngoscopy, supporting the expanding role of point-of-care ultrasound in airway evaluation [10]. These findings are consistent with prior systematic reviews showing that ultrasound-based airway parameters improve preoperative risk stratification [11,13].

The present findings confirm that reduced hyomental distance reflects limited submandibular space and restricted anterior displacement of the tongue during laryngoscopy. This aligns with previous studies demonstrating that HMD is closely associated with airway difficulty due to impaired anatomical alignment of the oral, pharyngeal, and laryngeal axes [14,16]. Similar findings were reported by Wu and Wang (2022), who observed high sensitivity of HMD in predicting difficult intubation, although with variable specificity [17]. However, other studies such as Kalezić et al. (2016) reported lower sensitivity, indicating that diagnostic performance may vary depending on patient population and measurement technique [18].

Importantly, our study extends existing evidence by demonstrating that HMD measured in dynamic positions, particularly sniffing and extension, provides superior discriminative ability compared to static measurements. This observation is in agreement with Wang et al. (2022), who reported improved diagnostic accuracy of HMD in the sniffing position, and with Petrișor et al. (2020), who emphasized that measurements obtained during head extension better reflect functional airway mechanics [3,19]. These findings suggest that functional assessment of airway mobility may better represent real-world laryngoscopic conditions.

HMDR, as a dynamic parameter, further supports the importance of cervical mobility and submandibular compliance. Lower HMDR values observed in the difficult airway group indicate reduced adaptability of airway structures during head extension. These results are consistent with Andruszkiewicz et al. (2016) and Petrișor et al. (2018), who demonstrated that HMDR is a

reliable predictor with favorable sensitivity and specificity [3,14]. More recent studies, such as Sood et al. (2025) and Giordano et al. (2023), also highlight the value of dynamic ultrasonographic parameters in capturing airway functional reserve [20,21].

Thyromental distance, although widely used, has shown variable predictive performance in previous studies. In the present study, TMD demonstrated high diagnostic accuracy and remained significantly associated with difficult laryngoscopy. This is consistent with findings by Tantri et al. (2016) and Artawan et al. (2024), which support its clinical utility [22,23]. However, other studies such as Namratha et al. (2025) suggest that difficult intubation may still occur in patients with normal or longer TMD, highlighting its limitation as a standalone predictor that does not account for soft tissue compliance or dynamic airway changes [7].

A notable finding in this study is the very high diagnostic performance of several parameters, with some AUC values approaching 1.0. While this suggests strong discriminative ability, such results should be interpreted cautiously. The relatively small sample size and single-center design may lead to overestimation of diagnostic accuracy, particularly in ROC analysis. Similar concerns have been raised in previous airway prediction studies, where excellent performance in small cohorts was not consistently replicated in larger populations [11,15]. Therefore, these findings require validation in larger, multicenter populations before clinical generalization.

Taken together, these results support a multimodal approach to airway assessment that integrates ultrasonographic parameters with traditional clinical measurements. This approach is in line with current recommendations emphasizing combined predictive models to enhance diagnostic accuracy and improve patient safety [2,15]. By incorporating both anatomical and functional assessments, clinicians may achieve more reliable identification of high-risk patients and better preparation for airway management.

#### 5. Limitations

Despite its strengths, this study has several limitations. The relatively small sample size, particularly in the difficult laryngoscopy group, may limit statistical power and affect the stability of diagnostic estimates. Additionally, the single-center design may reduce the generalizability of the findings to broader populations



with different demographic and anthropometric characteristics. Therefore, future multicenter studies with larger sample sizes are warranted to validate these findings and establish standardized cut-off values for clinical implementation.

## 6. Conclusions

The incidence of difficult direct laryngoscopy in this study was relatively high, affecting nearly one-third of patients. Both ultrasonographic and clinical parameters demonstrated strong predictive value, with significantly shorter HMD and TMD observed in patients with difficult laryngoscopy. Among these, HMD measured in neutral, sniffing, and extension positions, as well as the HMDR, showed excellent diagnostic performance, with several cut-off values achieving near-perfect sensitivity and specificity. Similarly, TMD also demonstrated high predictive accuracy, although its role remains complementary rather than definitive. These findings highlight that reduced submandibular space and limited cervical extension are key anatomical contributors to difficult laryngoscopy. Importantly, the integration of ultrasonographic parameters, particularly HMD and HMDR, with conventional bedside assessment such as TMD provides a more robust and reliable approach for preoperative airway evaluation. Therefore, a multimodal assessment strategy combining ultrasound and clinical measurements is recommended to improve early identification of difficult airway and enhance patient safety in anesthetic practice.

## 7. Declarations

### *Ethics Approval and Consent to Participate*

This study was approved by the Biomedical Research Ethics Committee of the Faculty of Medicine, Universitas Hasanuddin, Makassar (Approval No. 254/UN4.6.4.5.31/PP36/2026; Protocol No. UH26010176). Ethical approval was granted on February 18, 2026, with validity until February 18, 2027. The study was conducted at Dr. Wahidin Sudirohusodo Hospital, Makassar. Written informed consent was obtained from all participants prior to enrollment in the study.

### *Consent for Publication*

Not applicable.

### *Availability of Data and Materials*

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

### *Competing Interests*

The authors declare that they have no competing interests.

### *Funding*

This research received no external funding.

### *Authors' Contributions*

K contributed to study conception, data collection, analysis, and manuscript drafting. NSW contributed to study design, supervision, and critical revision of the manuscript. AMTB contributed to methodological oversight and manuscript review. All authors read and approved the final manuscript.

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## References

1. Detsky ME, Jivraj N, Adhikari NK, et al. Will This Patient Be Difficult to Intubate?: The Rational Clinical Examination Systematic Review. *JAMA*. 2019;321(5):493-503. doi:10.1001/JAMA.2018.21413
2. Carsetti A, Sorbello M, Adrario E, Donati A, Falcetta S. Airway Ultrasound as Predictor of Difficult Direct Laryngoscopy: A Systematic Review and Meta-analysis. *Anesth Analg*. 2022;134(4):740-750. doi:10.1213/ANE.0000000000005839
3. Petrișor C, Trancă S, Szabo R, Simon R, Prie A, Bodolea C. Clinical versus Ultrasound Measurements of Hyomental Distance Ratio for the Prediction of Difficult Airway in Patients with and without Morbid Obesity. *Diagnostics (Basel)*. 2020;10(3). doi:10.3390/DIAGNOSTICS10030140
4. Apfelbaum JL, Hagberg CA, Connis RT, et al. 2022 American Society of Anesthesiologists Practice Guidelines for Management of the Difficult Airway. *Anesthesiology*. 2022;136(1):31-81. doi:10.1097/ALN.0000000000004002
5. Galway U, Wang M, Deeby M, Zura A, Riter Q, Abdelmalak B. Recognition and management of



- the difficult airway—a narrative review and update on the latest guidelines. *Journal of Oral and Maxillofacial Anesthesia*. 2023;2(0). doi:10.21037/JOMA-23-3/COIF
6. Ahmad I, El-Boghdadly K, Bhagrath R, et al. Difficult Airway Society guidelines for awake tracheal intubation (ATI) in adults. *Anaesthesia*. 2020;75(4):509-528. doi:10.1111/ANAE.14904
  7. Namratha B, Gupta A, Devi SP, Vasudev V, Gupta R. Thyromental distance is a good difficult airway indicator: Truth or a misconception- A prospective observational study. *Indian Journal of Clinical Anaesthesia*. 2025;10(2):175-181. doi:10.18231/J.IJCA.2023.034
  8. Pantaleo G CA. Difficult Intubation in Patient with Short Thyromental Distance: Usefulness of Tongue Traction Maneuver. *J Anesth Clin Res*. 2014;05(12). doi:10.4172/2155-6148.1000491
  9. Kishor Badhe V, Govind Deogaonkar S, Vilasrao Tambe M, Singla A, Vinayak Shidhaye R, Professor A. Clinical comparison of five different predictor tests for difficult intubation. *Anaesthesia, Pain & Intensive Care*. 2019;18(1):31-37. doi:10.35975/APIC.V0I0.549
  10. Sorbello M, Falcetta S. Time to include ultrasounds in pre-procedural airway evaluation? *Trends in Anaesthesia and Critical Care*. 2021;38:1-3. doi:10.1016/J.TACC.2021.02.006
  11. Gomes SH, Simões AM, Nunes AM, et al. Useful Ultrasonographic Parameters to Predict Difficult Laryngoscopy and Difficult Tracheal Intubation-A Systematic Review and Meta-Analysis. *Front Med (Lausanne)*. 2021;8. doi:10.3389/FMED.2021.671658
  12. Rao ST, Gowda V, Reddy R. Hyomental Distance Ratio as a Diagnostic Predictor of Difficult Laryngoscopy. *Indian J Appl Res*. 2013;3(8):511-513.
  13. Dabo-Trubelja A. Point-of-Care Ultrasound: A Review of Ultrasound Parameters for Predicting Difficult Airways. *Journal of Visualized Experiments*. 2023;2023(194). doi:10.3791/64648
  14. Andruszkiewicz P, Wojtczak J, Sobczyk D, Stach O, Kowalik I. Effectiveness and Validity of Sonographic Upper Airway Evaluation to Predict Difficult Laryngoscopy. *J Ultrasound Med*. 2016;35(10):2243-2252. doi:10.7863/ULTRA.15.11098
  15. Pandit JJ, Heidegger T. Putting the “point” back into the ritual: a binary approach to difficult airway prediction. *Anaesthesia*. 2017;72(3):283-288. doi:10.1111/ANAE.13720
  16. Sotoodehnia M, Rafiemanesh H, Mirfazaelian H, Safaie A, Baratloo A. Ultrasonography indicators for predicting difficult intubation: a systematic review and meta-analysis. *BMC Emerg Med*. 2021;21(1). doi:10.1186/S12873-021-00472-W
  17. Wu H, Wang H. Diagnostic Efficacy and Clinical Value of Ultrasonography in Difficult Airway Assessment: Based on a Prospective Cohort Study. *Contrast Media Mol Imaging*. 2022;2022. doi:10.1155/2022/4706438
  18. Kalezić N, Lakićević M, Miličić B, Stojanović M, Sabljak V, Marković D. Hyomental distance in the different head positions and hyomental distance ratio in predicting difficult intubation. *Bosn J Basic Med Sci*. 2016;16(3):232. doi:10.17305/BJBMS.2016.1217
  19. Wang B, Wang M, Yang F, et al. Predicting difficult intubation: the hyomental distance ultrasound evaluation is superior to the thyromental distance. *Anaesth Crit Care Pain Med*. 2022;41(6). doi:10.1016/j.accpm.2022.101144
  20. Sood P, Saroa R, Palta S, Saxena P, Gill RK. Comparison of sonographic hyomental distance ratio and thyromental height as predictors of difficult intubation. *Trends in Anaesthesia and Critical Care*. 2025;60:101520. doi:10.1016/J.TACC.2025.101520
  21. Giordano G, Alessandri F, Zulian A, Bilotta F, Pugliese F. Pre-operative ultrasound prediction of difficult airway management in adult patients: A systematic review of clinical evidence. *Eur J Anaesthesiol*. 2023;40(5):313-325. doi:10.1097/EJA.0000000000001805
  22. Tantri AR, Firdaus R, Salomo ST. Predictors of Difficult Intubation Among Malay Patients in Indonesia. *Anesth Pain Med*. 2016;6(2). doi:10.5812/AAPM.34848
  23. Artawan IM, Rante SDT, Sagita S. Comparison of the Thyromental Distance, Thyrohyoid Distance, and Mallampati Scores in Prediction of Difficult Intubation in Patients Undergoing General Anaesthesia: An Observational Study. *Bali Journal of Anesthesiology*. 2024;8(3):154-157. doi:10.4103/BJOA.BJOA\_116\_24



## TABLES AND FIGURES

Table 1. Baseline Characteristics of Study Participants

Characteristics	Group		Total	p-value
	Difficult Intubation (n = 20)	Non-difficult Intubation (n = 41)		
<b>Sex (n, %)</b>				
Male	12 (40.0%)	22 (53.7%)	34 (55.7%)	0.785 <sup>a</sup>
Female	8 (60.0%)	19 (46.3%)	27 (44.3%)	
<b>Age (years)</b>				
mean ± SD	41.15 ± 16.25	36.73 ± 14.10	38.18 ± 14.85	0.310 <sup>b</sup>
<b>Body Mass Index (kg/m<sup>2</sup>)</b>				
Underweight (< 18.5)	2 (10.0)	3 (7.5%)	5 (8.2%)	0.428 <sup>a</sup>
Normoweight (18.5-24.9)	15 (75.0%)	35 (85.4%)	50 (82.0%)	
Overweight (25.0-29.9)	3 (15.0%)	3 (7.3%)	6 (9.8%)	
mean ± SD	21.80 ± 3.21	20.95 ± 2.75	21.23 ± 2.91	0.162 <sup>b</sup>

<sup>a</sup>Chi-square test/Fisher's exact test; <sup>b</sup>Mann-Whitney U test

Table 2. Preoperative Hyomental and Thyromental Distances

Variabel	Group		p-value
	Difficult Intubation (n = 20)	Non-difficult Intubation (n = 41)	
<b>Hyomental Distance (HMD) (cm)</b>			
Neutral	4.17 ± 0.07	4.39 ± 0.09	<0.001*
Sniffing	4.52 ± 0.11	4.99 ± 0.10	<0.001*
Extension	4.95 ± 0.15	5.54 ± 0.12	<0.001*
Ratio (extension/neutral)	1.08 ± 0.03	1.14 ± 0.01	<0.001*
<b>Thyromental Distance (cm)</b>	7.25 ± 0.15	8.57 ± 0.77	<0.001*

Mann-Whitney U test; \*p < 0.05

Table 3. Predictive Performance of Preoperative Hyomental and Thyromental Distances

Variable	Cut-off	Sensitivity	Specificity	AUC	p-value
<b>Hyomental Distance</b>					
Neutral	4.25 cm	90.0%	100%	0.980	<0.001
Sniffing	4.75 cm	100%	100%	1.000	<0.001
Extension	5.25 cm	100%	100%	1.000	<0.001
Ratio (extension/neutral)	1.15	80.0%	85.4%	0.966	<0.001
<b>Thyromental Distance</b>	7.55 cm	100%	97.6%	0.995	<0.001

\*p < 0.05

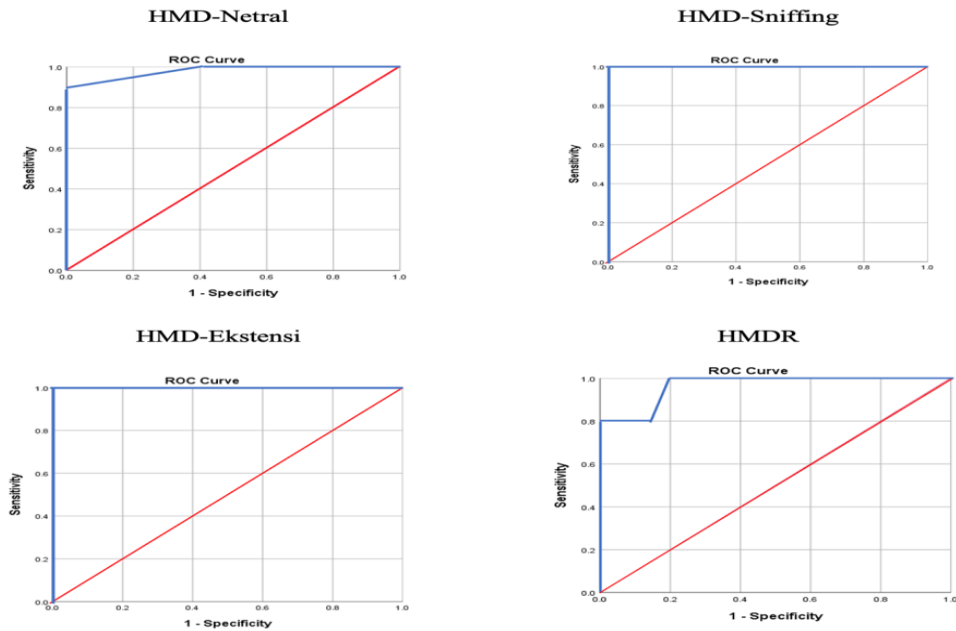


Figure 1. ROC Curve of Preoperative Hyomental Distance for Predicting the Incidence of Difficult Intubation

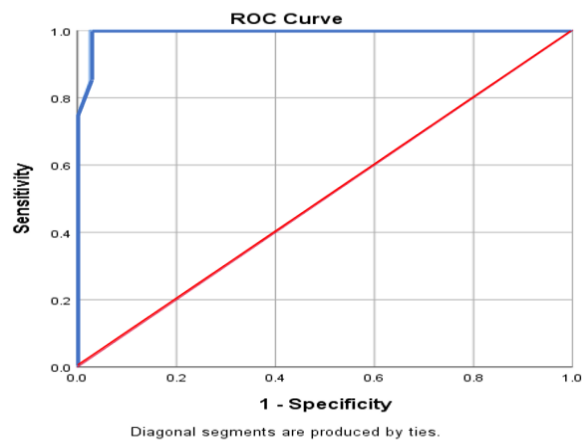


Figure 2. ROC Curve of Preoperative Thyromental Distance for Predicting the Incidence of Difficult Intubation