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Ratio of Neck Length to Thyromental Distance as a Predictor of Difficult Airway: Prospective Observational Study

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Abstract

Background: It is very important to predict and manage difficult intubation because difficult or failed intubation is considered one of the major causes of morbidity and mortality in anaesthesia. Several preoperative airway assessment tests can be used for that purpose.

Aim of Study: This study aimed to assess the predictive accuracy of the ratio of Neck Length to Thyromental Distance (RNTMD) in identifying difficult laryngoscopy and intubation.

Patients and Methods: This observational study was done prospectively and involved adult patients undergoing elective operations under general anesthesia. The airway indices, namely the RNTMD, thyromental distance, modified Mallampati test, ratio of height to thyromental distance, and interincisor gap, were assessed preoperatively. Difficult laryngoscopy was considered when the Cromack-Lehane grade was >2, and difficult intubation was considered when the intubation difficulty scale was >5. Our primary outcome was the ability of RNTMD to predict difficult laryngoscopy using area under receiver operating characteristic curve (AUC) analysis. The ability of previously mentioned airway indices to expect difficult laryngoscopy and intubation were the secondary outcomes.

Results: We analyzed data from 129 patients, and the incidence of difficult laryngoscopy and intubation was 18/129 (14%) and 11/129 (9%), respectively. The RNTMD's AUC (95% confidence interval) for prediction of difficult laryngoscopy and intubation was 0.69 (0.60-0.76) and 0.69 (0.61-0.78). The ability of RNTMD to predict difficult laryngoscopy and intubation was not significantly different from that of other airway indices. At a cut-off value of 1.2, RNTMD a NPV of 94 and 97% for difficult laryngoscopy and intubation, respectively.

Conclusion: In adult patients, RNTMD can predict difficult airway with moderate accuracy. An RNTMD <1.2 can exclude difficult laryngoscopy and intubation with 94 and 97% accuracy.

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Key Words: *RNTMD – Difficult laryngoscopy – Difficult intubation – Airway tests.*

Introduction

PREDICTING and management of difficult intubation are very important skills to the practice of anaesthesiology. Difficult or failed intubation is considered one of the major causes of morbidity and mortality in anaesthesia **[1].**

There are several preoperative airway assessment tests including inter-incisor gap, mouth opening, Mallampati grading, and thyromental distance (TMD) used to predict difficult intubation with high specificity. Airway tests should act as a screening tests; therefore, it is important to have high sensitivity. However, these tests showed low sensitivity **[2]** and subsequently there would be many false negative cases, which is reflected in practice as unanticipated difficult airway. Therefore, there is still continuing search for the ideal airway test that would provide good accuracy with high sensitivity.

Some of airway tests involve external airway measurements such as thyromental distance (TMD). Recent data showed that indexing the TMD to patient's height (ratio of height to TMD: RHTMD) improved the accuracy of the original measurement **[3].**

Since short neck is a predictor of difficult airway **[4],** we hypothesized that using neck length instead of patient's height (ratio of neck length to TMD: RNTMD) would improve the test accuracy in predicting difficult airway.

In this study, our aim was to evaluate the accuracy of a new airway index, RNTMD, in predicting difficult airway and compare it to other commonly used tests.

Patients and Methods

This prospective observational study was performed at Cairo University Hospital operating theatres, from August 2023 to December 2023, after institutional ethics committee approval (MS-99-2023). Written informed consents were obtained from all patients before being included in the study.

Participants were adult (18-60 years) patients with American society of Anesthesiologists (ASA) physical status I-II who were scheduled for elective surgical operations under general anesthesia.

Exclusion criteria were history of difficult airway, apparent airway abnormalities, history cervical spine surgery or deformity, any airway management technique other than conventional laryngoscopy, and pregnancy.

Preoperatively, a trained anesthetist performed and recorded the results of the airway tests in addition to patient's demographic data (age, sex, weight, height, body mass index, and ASA physical status). The airway assessment included the modified

Mallampati test (MMT) **[5]**, inter-incisor gap **[6],** and thyromental distance (TMD) **[7]**.

Neck length was measured from the tip of the Mastoid process, as it is at the same level of the first cervical vertebrae (Atlas) to the meeting point between the neck and the shoulder (inflection point). Neck length was done using ruler while the head in the neutral position **[4]**.

We calculated the RNTMD as follow: Neck length in cm divided by TMD in cm, and RHTMD as follow: Height in cm divided by TMD in cm **[3]**.

After three min of preoxygenation, induction of anesthesia was performed by 2mg/kg propofol and 1mcg/kg fentanyl. After loss of consciousness, Laryngoscopy and intubation was facilitated by 0.5mg/kg atracurium. Appropriately sized Mcintosh blade was used for laryngoscopy. Correct position of endotracheal tube was confirmed by presence of appropriate capnographic wave.

Grading the laryngoscopic view was done using the Cormack Lehane (C-L) classification; Grade 1—able to visualize the entire laryngeal aperture, grade 2—able to visualize parts of the laryngeal aperture or the arytenoids, grade 3—able to visualize only the epiglottis, and grade 4— able to visualize only the soft palate]. CL grade >2 was considered difficult laryngoscopy **[8]**.

An experienced anesthetist who was responsible for tracheal intubation and grading the laryngoscopic view was blinded to the aim of the study.

The intubation difficulty scale (IDS) was used to assess difficult intubation. The scale includes seven variables, the number of additional intubation trials required, number of additional operators needed, number of alternative intubation assistant techniques used, CL classification, increased lifting effort applied during laryngoscopy, use of external laryngeal pressure, and the position of the vocal cords during intubation.

Difficult intubation was considered when the IDS score >5 **[9]**.

The primary outcome was the ability of RNTMD to predict difficult laryngoscopy.

Secondary outcomes included the ability of RNTMD to expect difficult intubation, the ability of other airway test to predict difficult laryngoscopy and intubation, and comparing the accuracy of airway test to expect difficult laryngoscopy and intubation.

Sample size:

Sample size was calculated using MedCalc Software version 14 (MedCalc Software bvba, Ostend, Belgium) to detect area under receiver operating characteristic curve (AUC) of 0.75 with null hypothesis AUC of 0.5. We took in consideration that the rate of difficult laryngoscopy is 10% **[2]**; therefore, we calculated a minimum number of 120 patients (with at least 12 difficult laryngoscopy cases) to have a study power of 80% and alpha error of 0.05.

Statistical analysis:

Statistical package for social science (SPSS) software, version 21 for Microsoft Windows (IBM Corp., NY, USA) were used for data analysis. Categorical data are presented as frequency (%). Distribution of continuous data was checked for normality using the Shapiro-Wilks test. Normally distributed data are presented as means (standard deviations), and skewed data are presented as medians (quartiles).

Data analysis included comparison of patients with difficult laryngoscopy and patients with easy laryngoscopy, and comparison of patients with difficult intubation and patients with easy intubation. The Chi-squared test was used to compare frequencies between the study groups. Unpaired *t*-test and Mann-Whitney test were used to compare continuous data as appropriate. The AUC was calculated for different airway tests for predicting difficult laryngoscopy and difficult intubation. Positive predictive value (PPV), negative predictive value (NPV), and best cut-off values for all parameters were also calculated. The AUC curves were compared using a Hanley-McNeil test. Multivariate analysis was done including age, sex, ASA classification, MMT, interincisor gap, and RNTMD was done, and odds ratio (95% confidence interval [CI]) was reported. A p-value <0.05 was considered statistically significant.

Results

In this study, 140 patients were screened for eligibility, 11 patients were excluded, and 129 patients were included and were analyzed. (Fig. 1).

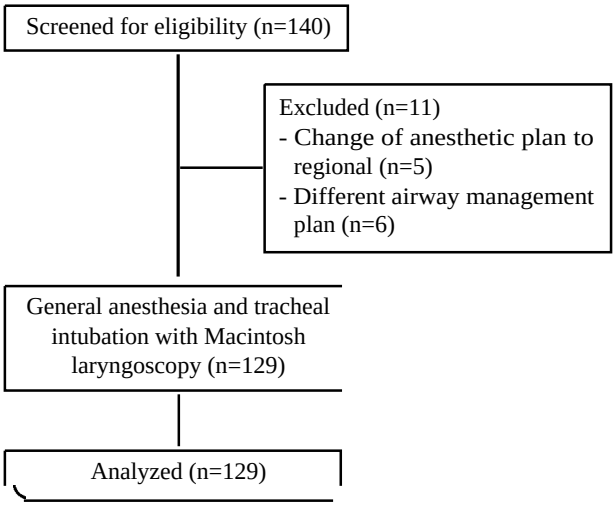

Fig. (1): Patient's enrollment flowchart.

Difficult laryngoscopy was encountered in 18 (14%) patients, and difficult intubation was encountered in 11 (9%) patients. Patients' demographic and airway measurements are detailed in Table (1).

The AUC (95% CI) was 0.69 (0.60-0.76) and 0.69 (0.61-0.78) for the ability RNTMD to predict difficult laryngoscopy and intubation, respectively. (Table 2). The AUCs for the ability to predict difficult laryngoscopy and intubation were comparable among the evaluated airway tests (*p*-value >0.05).

Univariate analysis revealed that predictors for difficult laryngoscopy were age, male sex, interincisor gap, TMD, MMT grade, RNTMD, and RHTMD. While predictors for difficult intubation were interincisor gap, TMD, MMT and RHTMD. (Table 3).

Multivariate analysis (including age, male sex, ASA-PS, MMT, Interincisor gap, and RNTMD) showed that male sex and interincisor gap are independent risk factors for difficult laryngoscopy and intubation. (Table 4).

Table (1): Demographic and airway measurements data. Data presented as median (quartiles) and frequency (%).

	n=129
Age (years)	38 (27, 47)
Male sex	54 (42%)
Weight (kg)	75 (65, 91)
Height (cm)	163 (157, 174)
Body mass index ($kg.m^{-2}$)	28 (25, 33)
ASA-PS:	
I	106 (82%)
II	23 (18%)
MMT:	
1	45 (35%)
2	29 (23%)
3	43 (33%)
4	12 (9%)
Interincisor gap (cm)	4.5 (4.0, 5.0)
Neck length (cm)	9.5 (8.5, 10.5)
TMD (cm)	8.0 (7.0, 9.0)
RNTMD	1.2 (1.1, 1.4)
RHTMD	21.0 (18.5, 23.7)
Cormack-Lenhance grade:	
1	70 (54%)
2	41 (32%)
3	16 (12%)
4	2 (2%)
Difficult laryngoscopy	18 (14%)
Difficult intubation	11 (9%)

ASA-PS : American Society of Anesthesiologist-Physical Status.
MMT : Modified Mallampati test.
RHTMD: Ratio of height to thyromental distance.
RNTMD: Ratio of neck length to thyromental distance.
TMD : Thyromental distance.

Table (2): Accuracy of airway tests in predicting difficult airway.

	AUC (95% CI)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Cut-off value
			Difficult laryngoscopy (n=18/129)			
RNTMD	0.69 (0.60-0.76)	78	56	22	94	>1.2
RHTMD	0.78 (0.70-0.85)	83	62	26	96	>21.5
TMD	0.76 (0.68-0.83)	100	41	21	100	≤8 cm
MMT	0.75 (0.66-0.82)	83	64	27	96	>2
Interincisor gap	0.76 (0.68-0.83)	83	70	31	96	≤4 cm
			Difficult intubation (n=11/129)			
RNTMD	0.69 (0.61-0.78)	82	54	14	97	>1.2
RHTMD	0.77 (0.69-0.84)	91	60	18	99	>21.5
TMD	0.76 (0.68-0.83)	82	59	16	97	≤7.5 cm
MMT	0.77 (0.69-0.84)	82	61	16	97	>2
Interincisor gap	0.82 (0.74-0.88)	91	68	21	99	≤4 cm

AUC : Area under receiver operating characteristic curve.
CI : Confidence interval.
MMT: Modified Mallampati test.
NPV : Negative predictive value.
RHTMD: Ratio of height to thyromental distance.
RNTMD: Ratio of neck length to thyromental distance.
TMD : Thyromental distance.

Table (3): Univariate analysis for predictors of difficult laryngoscopy and difficult intubation.

	Difficult laryngoscopy (n=18/129)		Difficult intubation (n=11/129)	
	Odd ratio (CI 95%)	*P*-value	Odd ratio (CI 95%)	*P*-value
Age (years)	1.07 (1.02-1.12)	0.007	1.05 (0.99-1.11)	0.087
Male sex	3.29 (1.15-9.41)	0.027	1.75 (0.51-6.06)	0.377
Weight (kg)	1.001 (0.99-1.03)	0.358	1.02 (0.99-1.04)	0.139
Height (cm)	1.03 (0.98-1.08)	0.309	1.01 (0.95-1.07)	0.720
Body mass index ($kg.m^{-2}$)	1.01 (0.96-1.07)	0.709	1.04 (0.98-1.10)	0.222
ASA-PS	2.77 (0.91-8.37)	0.072	2.95 (0.79-11.07)	0.109
MMT	2.63 (1.46-4.74)	0.001	3.06 (1.41-6.62)	0.005
Interincisor gap (cm)	0.2 (0.09-0.51)	0.001	0.13 (0.04-0.44)	0.001
Neck length (cm)	0.77 (0.54-1.10)	0.148	0.77 (0.49-1.20)	0.240
TMD (cm)	0.40 (0.24-0.67)	0.001	0.40 (0.21-0.76)	0.005
RNTMD	24.00 (1.79-326.93)	0.017	23.90 (0.99-576.18)	0.051
RHTMD	1.35 (1.16-1.58)	<0.001	1.32 (1.10-1.57)	0.002

ASA-PS: American Society of anesthesiologist-physical status.
CI : Confidence interval.
MMT : Modified Mallampati test.
RHTMD: Ratio of height to thyromental distance.
RNTMD: Ratio of neck length to thyromental distance.
TMD : Thyromental distance.

Table (4): Multivariate analysis for predictors of difficult laryngoscopy and difficult intubation.

	Difficult laryngoscopy (n=18/129)		Difficult intubation (n=11/129)	
	Odd ratio (CI 95%)	*P*-value	Odd ratio (CI 95%)	*P*-value
Age (years)	1.06 (1.00-1.13)	0.067	1.05 (0.97-1.13)	0.224
Male sex	13.34 (2.78-64.09)	0.001	5.96 (1.05-33.84)	0.044
ASA-PS	0.61 (0.13-2.92)	0.533	0.89 (0.16-5.07)	0.896
MMT	2.15 (0.97-4.80)	0.061	2.62 (0.84-8.21)	0.098
Interincisor gap (cm)	0.12 (0.04-0.40)	0.001	0.09 (0.02-0.41)	0.002
RNTMD	7.62 (0.23-249.37)	0.254	3.42 (0.05-229.72)	0.327

ASA-PS: American Society of anesthesiologist-physical status.
CI : Confidence interval.
MMT : Modified Mallampati test.
RHTMD: Ratio of height to thyromental distance.

Discussion

We reported that RNTMD had moderate accuracy to predict difficult airway, and it was comparable to the previously mentioned airway tests. An RNTMD >1.2 had a negative predictive value of 94 and 97% in expecting difficult laryngoscopy and intubation, respectively.

RNTMD is a novel predictor of difficult laryngoscopy and intubation as it involves measurement of neck length due to its important role in airway management. Short neck indicates the possibility of difficult airway **[4].** As the neck length decreases, the neck movement becomes more restricted, so vocal cords visualization becomes more difficult. TMD is a known predictor of difficult airway; however, it has high specificity but low sensitivity **[2]**. Therefore, in this study, we hypothesized that a new airway test that includes neck length and TMD would improve the ability to predict difficult airway. However, our study results suggest that the new test did not improve the ability of TMD to expect difficult airway.

We also evaluated the RHTMD and we report that its best cutoff value for prediction of difficult airway was 21.5. This cutoff-value was within the range of what previously reported (17.1-25) **[3,10].**

In this study, we reported that the interincisor gap was an independent predictor of difficult laryngoscopy and intubation. This is in line with previous data that showed that the interincisor gap is independent predictor of a difficult airway ***[11]***.

Predicting a difficult airway is imperative for patient safety and effective airway management. Potential complications because of inappropriate airway management include failed intubation or difficult ventilation, which can lead to life-threatening situations like hypoxia or cardiac arrest ***[12]***. Proper airway assessment allows healthcare providers to formulate a tailored airway management plan. This includes having specialized equipment, skilled personnel, and alternative techniques readily available ***[13]***.

Despite the presence of many predictors and clinical tests for airway assessment, no single test could accurately expect all cases of difficult laryngoscopy ***[13]***. It was found that only 50% of all the difficult airways, we encountered, could be predicted preoperatively ***[14]***. Therefore, there is still a continuous search for the ideal airway test. In this study we assessed a new airway test that includes two predictors of difficult airway, namely the neck length and TMD. The new test was able to predict difficult airway, but it did not improve the ability of TMD to expect difficult airway.

This study has some limitations. It was conducted in a single center. We included nonobese adult ASA I-II patients undergoing elective operations. Therefore, future studies are recommended to confirm our finding in other populations.

Conclusion:

In adult patients, RNTMD can predict difficult airway with moderate accuracy. An RNTMD <1.2 can exclude difficult laryngoscopy and intubation with 94 and 97% accuracy.

References

1- SHIGA T., WAJIMA Z., INOUE T. and SAKAMOTO A.: Predicting difficult intubation in apparently normal patients: A meta-analysis of bedside screening test performance. Vol. 103, Anesthesiology. American Society of Anesthesiologists, p. 429–37, 2005.

2- ROTH D., PACE N.L., LEE A., HOVHANNISYAN K., WARENITS A.M., ARRICH J. and HERKNER H.: Airway physical examination tests for detection of difficult airway management in apparently normal adult patients. Cochrane Database of Systematic Reviews, 2018 (5), 2018.

3- SCHMITT H.J., KIRMSE M. and RADESPIEL-TROGER M.: Ratio of Patient's Height to Thyromental Distance Improves Prediction of Difficult Laryngoscopy. Anaesth Intensive Care [Internet]. Dec. 1; 30 (6): 763–5, 2002. Available from: https://journals.sagepub.com/doi/10.1177/0310057X0203000607

4- FARAJ J.H., AHMED Y.E., RAVAL B., YOUSIF T.M., KUMAR N., KAMAT S., MAHDI S.K., ALIYAR A.L. and Mr TAHA A.: Short Neck, a New Criterion for Airway Assessment: A Pilot, Cross Sectional Single Blind Study. J. Anesth. Clin. Res., 11, 2020.

5- TIBERIU EZRI, R. DAVID WARTERS, PETER SZMUK, HUSAM SAAD-EDDIN, DANIEL GEVA, JEFFREY KATZ and CH.: The Incidence of Class "Zero" Airway and the Impact of Mallampati Score, Age, Sex, and Body Mass Ind. Anesth. Analg., 73 (4): 1073–5, 2001.

6- WILSON M.E., SPIEGELHALTER D., ROBERTSON J.A. and LESSER P.: Predicting difficult intubation. Br. J. Anaesth [Internet]. Aug. 61 (2): 211–6, 1988. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0007091217493536.

7- MOHSIN M.U., ADNAN M., FAYYAZ M.A., RAZA H., HABIB M.Z. and KALEEM M.: Validation of Modified Mallampati Test with Addition of Thyromental Distance and Sternomental Distance to Predict Difficult Endotracheal Intubation in Adults Presenting in Surgical Emergency. Pakistan Journal of Medical and Health Sciences, 17 (1), 2023.

8- CORMACK R.S. and LEHANE J.: Difficult tracheal intubation in obstetrics. Anaesthesia, Nov. 39 (11): 1105–11, 1984.

9- ADNET F., BORRON S.W., RACINE S.X., CLEMESSY J.L., FOURNIER J.L., PLAISANCE P. and LAPANDRY C.: The Intubation Difficulty Scale (IDS). Anesthesiology, Dec. 1; 87 (6): 1290–7, 1997.

10- KROBBUABAN B., DIREGPOKE S., KUMKEAW S. and TANOMSAT M.: The predictive value of the height ratio and thyromental distance: Four predictive tests for difficult laryngoscopy. Anesth. Analg., 101 (5), 2005.

11- KARKOUTI K., ROSE D.K., WIGGLESWORTH D. and COHEN M.M.: Predicting difficult intubation: A multivariable analysis. Canadian Journal of Anesthesia, 47 (8), 2000.

12- COOK T.M., WOODALL N. and FRERK C.: Major complications of airway management in the UK: Results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult 1 Airway Society. Part 1: Anaesthesia. Br J Anaesth [Internet], 106 (5): 617–31, 2011. Available from: http://dx.doi.org/10.1093/bja/aer058

13- APFELBAUM J.L., HAGBERG C.A., CONNIS R.T., ABDELMALAK B.B., AGARKAR M., DUTTON R.P., FIADJOE J.E., GREIF R., KLOCK P.A., MERCIER D., MYATRA S.N., O'SULLIVAN E.P., ROSENBLATT W.H., SORBELLO M., TUNG A.: 2022 American Society of Anesthesiologists Practice Guidelines for Management of the Difficult Airway, Vol. 136, Anesthesiology, 31–81 p., 2022.

14- TEOH W.H. and KRISTENSEN M.S.: Prediction in airway management: What is worthwhile, what is a waste of time and what about the future? Vol. 117, British Journal of Anaesthesia, 2016.

نسبة طول العنق الى المسافة الدرقية الذقنية فى التنبؤ بصعوبة الممرات الهوائية : دراسة قائمه على الملاحظه

هذه الدراسة تهدف الي تقييم دقه توقع نسبة طول العنق الى المسافة الدرقية الذقنية فى التنبؤ بصعوبة الممرات الهوائية اثناء وضع الانبوبة الحنجرية باستخدام المنظار الحنجرى.

تم اجراء هذه الدراسة المسبقة واشتملت مرضى بالغين يقومون باجراء عمليات جراحية غير عاجلة باستخدام التخدير الكلى. تم عمل اختبارات لفحص الممرات الهوائية مثل نسبة طول العنق الى المسافة الدرقية الذقنية، والمسافة الدرقية الذقنية، ونسبة طول الانسان الى المسافة الدرقية الذقنية لتقييم قدره هذه الاختبارات فى التنبؤ بصعوبة الممرات الهوائية.

اشتملت هذه الدراسة على ١٢٩ مريض وقد واجهنا صعوبة فى إدخال الانبوبة الحنجرية فى بعض المرضى.

الخلاصة: نسبة طول العنق الى المسافة الدرقية الذقنية لها قدره متوسطة ١,٢ على التنبؤ بصعوبة الممرات الهوائية. فى حالة ان هذه النسبة اقل من فإن ذلك يستبعد صعوبة وضع المنظار الحنجرى وادخال الانبوبة الحنجرية.