Original Article

Ethnicity and upper airway measurements: A study in South Indian population

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ABSTRACT

Background and Aims: Most studies on upper airway are conducted based on airway measurements in the western population. We set out to find the normal values of upper airway measurements in South Indian population. The aim of this study was to perform various upper airway examinations and to set standards for normal measurements in the South Indian population as well as to analyse the data for predictors of difficult intubation. **Methods:** This prospective observational study was conducted in a tertiary cancer hospital in Southern India. Airway assessment parameters, including modified Mallampati classification (MPC), upper lip bite test (ULBT), sternomental distance, thyromental distance (TMD), and the inter-incisor distance were documented for 2004 patients meeting the inclusion criteria. Laryngoscopic view after induction was graded as per Cormack and Lehane's (CL) classification. Any CL ≥3 was considered to be difficult laryngoscopy. The collected data (2004 cases) was analyed with SPSS software version 17. Receiver operating characteristics (ROC) curve was used to determine cut-offs in the population. Sensitivity, specificity, positive and negative predictive value were computed. **Results:** MPC, ULBT, and ratio of height to TMD (RHTMD) predicted difficult intubation with sensitivity of 40.86%, 45.53% and 64.60%, respectively and these were statistically significant with $P < 0.001$. Using the area under the curve of the ROC curve and discrimination analysis normal RHTMD in our population had a cut off value of 17.1. **Conclusion:** The cut off value for RHTMD to predict difficult laryngoscopy in the South Indian population is 17.1.

Key words: Airway measurements, difficult laryngoscopy, endotracheal intubation, ratio of height to thyromental distance, thyromental distance

INTRODUCTION

Endotracheal intubation with direct laryngoscopy continues to be the gold standard both in emergency and elective airway management. Despite the advances in airway management a recent prospective study on complications of airway management in routine anaesthesia emphasises that even death can occur as a complication.[1] All India Difficult Airway Association (AIDDA) guidelines[2] recommend routine preoperative airway assessment to prevent complications but also state that none of the available tests are completely reliable, and thus one should be prepared for a difficult airway at all times. The Difficult Airway Society 2015 guidelines emphasise the importance of the first attempt at laryngoscopy with the aim of plan A being to "maximise the likelihood of successful intubation at the first attempt." To follow these guidelines, we should be able to predict difficult intubation. However, the diagnostic value of upper airway examinations to predict diffcult laryngoscopy is limited due to low sensitivity and low positive predictive values (PPV).[3,4]

Most studies for prediction of difficult airway have been done in Caucasians, and the cut off set by them cannot be extrapolated to the Indian population.[5] According to anthropometric studies, there are racial

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differences in body habitus and craniofacial features.[6] Sleep studies have shown that different craniofacial characteristics predict upper airway collapsibility in different ethnic groups.[7] The anthropological literature emphasises that there is ethnic variation in morphology and morphometry of mandible and maxillary bones.[8,9] Schmitt[10] has set a cut off of >25 for the ratio of height to thyromental distance (RHTMD) to predict difficult intubation but has stated that this may be specific to different ethnic groups. We hypothesised that airway measurements in the Indian population will be different from the Caucasians and decided to do the various upper airway examinations such as TMD, sternomental distance (SMD) and interincisor distance (IID) with the aim of setting standards of normal values in the Indian population. We also wanted to see the sensitivity and specificity of these measurements and determine cut-offs for our patients.

METHODS

Hospital scientific advisory committee approval and the ethical committee approval were obtained. We registered the study with Clinical Trials Registry of India with the registration number of CTRI/2017/06/008820. Assuming an incidence of difficult laryngoscopy of 9%, and a relative error of 20%, power of 80% and 5% level of significance the sample size required was 1981; hence we decided to sample 2000 patients. This prospective observational study was conducted in a tertiary referral cancer hospital in Southern India between January 2015 and June 2016. All patients scheduled for elective surgery under general anaesthesia with tracheal intubation who were over 18 years of age and were the American Society of Anesthesiologists physical status1 or 2 were included. Patients with airway anomalies and head and neck pathologies in the form of prior surgery, trauma or radiation were excluded. Verbal informed consent was taken from all patients recruited as per our ethics committee advice.

During pre-anaesthetic evaluation age, sex, height, weight and modified Mallampati classification (MPC) were recorded. Upper lip bite test (ULBT), where the patient was asked to bite the upper lip with lower incisors was graded as class I: lower incisors can bite the upper lip above the vermilion line, class II: lower incisors can bite the upper lip below the vermilion line, class III: lower incisors cannot bite the upper lip. We used a graduated metal scale to measure the (IID - the distance between the upper and lower incisors with mouth maximally open). SMD was the distance from the suprasternal notch to the mentum with head maximally extended with mouth closed) and TMD was the distance between thyroid notch and mentum with head maximally extended with mouth closed. RHTMD was computed. All measurements were done by the same group of four anaesthesiologists.

Before induction of anaesthesia, MPC was done in the supine posture with the observer facing the patient. In the operating theatre, the patients were positioned with a pillow of 10 cms thickness under the head to achieve the sniffing position. Each patient was monitored with an electrocardiogram, pulse oximeter and non-invasive arterial pressure. Patients inhaled 100% oxygen through a facemask for 3 min. Anaesthesia was induced with intravenous (IV) Fentanyl 2 μg/kg, followed by propofol 2 mg/kg IV. Vecuronium 0.1 mg/kg IV was used to facilitate muscle relaxation. Laryngoscopy was done after 3 min by an anaesthesiologist with more than 2 years of experience after post graduation, with an appropriately sized Macintosh laryngoscope and the view graded as per Cormack and Lehane (CL) grading system[11] The CL grading was also done after external laryngeal manoeuvre with backwards/upwards/rightward pressure (BURP). Any CL of 3 or more was considered difficult laryngoscopy and therefore potentially difficult intubation. The anaesthetist intubating the patient's trachea was blinded to the airway examination data.

The collected data (2004 cases) were analysed with SPSS software version ['SPSS statistics for Windows. Version 17.0 Release 17.0 (SPSS inc., Chicago, Ill., USA)'] Descriptive statistics was done using appropriate measures of central tendency. Logistic regression was employed to elicit the odds ratio for difficult intubation. The factors were analysed separately and in combination and were also adjusted for age. To determine the discriminative power of each test and to get cut offs of each parameter for our population we did receiver operating characteristic (ROC) analysis and the area under the curve (AUC) with 95% confidence interval was computed. To test the predictive power of each parameter for identifying difficult laryngoscopy, sensitivity (Se), specificity (Sp), PPV and negative predictive value (NPV) were calculated using cross tabulation.

RESULTS

3041 patients were recruited, and data were complete in 1927 patients. In 77 other patients, all data were

available except for that on ULBT. We had 78.6% (1575) females and 21.4% (429) males of age range 50.21 ± 12.04 years. Any CL of ≥3 was considered a potentially difficult intubation. With this criterion, we had 12.8% incidence of difficult laryngoscopy (257 out of 2004 patients). The demographics details and of easy (CL 1 and 2) and difficult laryngoscopy (CL 3 and 4) are in Table 1. We could intubate all our patients either with external laryngeal manoeuvre or guided by a bougie. Our incidence of difficult laryngoscopy with BURP was only 1.09%. Out of 481 patients with MPC ≥3, 105 (40.9%) had CL of ≥3 which was significant with $P < 0.0001$. MPC supine was higher than MPC by one grade in almost all patients but did not significantly contribute to the prediction. MPC, ULBT and RHTMD predicted difficult intubation with sensitivity of 40.8%, 45.5% and 64.6% [Table 2]. Table 3 has the data for logistic regression of the parameters separately (univariate) and adjusted for age (multifactorial) and these were statistically significant with $P < 0.001$. To find the interplay between parameters and to narrow down the risk set for difficult laryngoscopy, every possible combination of parameters was analysed in univariate setting [Table 4].

Table 1: Demographics of easy and difficult intubation groups with patient characteristics

Patient detail	Values mean±SD or *n* (%) *n*=2004	CL 1-2	CL 3-4
Sex F/M	1575/429	1416/331	159/98
Age (years)	50.22±12.04	49.49±12.09	55.04±10.49
Height (cm)	154.96±8.42	157.61±8.2	154.36±9.46
Weight (kg)	60.14±12.44	59.64±12.22	63.53±13.45
BMI (kg/m^2)	25.13±5.26	25.04±5.20	25.79±5.64
MP 3 and 4	481	376	105
MP supine 3 and 4	939	741	198
IID (cm) ≤3.5	43	5±0.74	4.83±0.69
TMD (cm)	9.03±1.25	9.06±1.26	8.79±1.2
SMD (cm)	16.59±1.86	16.63±1.86	16.27±1.80
RHTMD	17.46±2,43	17.36±2.44	18.16±2.25

IID – Inter incisor distance; SMD – Sternomental distance; TMD – Thyromental distance; RHTMD – Ratio of height to thyromental distance; BMI – Body mass index; MP- Mallampati

Compared to the sensitivity of MPC (40.8%) or ULBT (45.5%) alone a combination of MPC and ULBT yielded a better sensitivity of 69.2%. While RHTMD had a good sensitivity of 64.6% combination of this with ULBT (30.4%) or MPC (28.7%) led to a decreased sensitivity. Combining all three parameters of MPC, ULBT and RHTMD gave a better sensitivity of 58.7% with an odds ratio of 6.081. All the combinations were statistically significant for prediction of difficult laryngoscopy with $P < 0.0001$. The NPV was high around 90% for all airway exams and their combinations. The ROC curve [Figure 1] for the various airway data showed that only RHTMD had an AUC >0.5. The AUC for RHTMD was 0.641 and the corresponding cut off value for RHTMD was fixed at 16.4. All other data such as SMD, TMD and IID had AUC value <0.5 on the ROC and so we could not set any cut off value for these measurements. The upper cut off for RHTMD in our study was fixed at 17.13 (16.49 + 0.64 [95% confidence interval]).

DISCUSSION

Advances in various airway rescue devices have decreased the incidence of major airway complications, but recent reports have indicated that life-threatening airway complications still occur in patients undergoing anaesthesia.[12] To decrease the airway related complications prediction of possible difficult intubation becomes essential.

The incidence of difficult intubation in the Indian population can be as high as 30%.[13] Our incidence was similar to other studies in Indian population.[14,15] Looking at our demographic data we had more females. This could be since our hospital receives more female patients compared to the males in a ratio of 3:2 and

Table 2: Predictive values for mallampatti classification, upper lip bite test, and ratio of height to thyromental distance and their combinations to predict the occurrence of a Grade 3 or 4 laryngoscopy according to the modified Cormack-Lehane classification

ME	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	OR	95% CI
MPC	40.86	78.47	21.83	90.02	2.519	1.916-3.312
UL	45.53	66.61	17.26	89.59	2.649	1.175-5.971
RHT	64.6	53	16.8	91.1	2.057	1.567-2.702
MPC + UL	69.23	52.74	17.72	92.10	4.477	2.980-6.725
MPC + UL + RHT	58.7	21.37	21.2	93.2	6.081	3.567-10.36
UL + RHT	30.4	35.8	21.2	95.7	3.672	2.465-5.469
MPC + RHT	28.7	42.3	27.6	92.8	4.935	3.350-7.269

ME – Measures; MPC – Mallampati classification; UL – Upper lip bite test; RHT – Ratio of height to thyromental distance; OR – Odds ratio; PPV – Positive predictive value; NPV – Negative predictive value; CI – Confidence interval

Table 3: Univariate and multifactorial analysis of difficult intubation parameters by logistic regression

Parameters	*n*	Univariate analysis		Multifactorial/ adjusted for age	
		OR	95% CI	OR	95% CI
Age (years)		*P*<0.001		-	
≤30	120	1.000	-		
31-50	897	5.94	1.44-24.46		
≥51	987	12.539	3.07-51.22		
MPC		*P*<0.00		*P*<0.001	
I and II	1467	1.000	-	1.00	-
III and IV	460	2.519	1.91-3.31	2.148	1.62-2.84*
ULBT		*P*<0.00		*P*<0.008	
1	1249	1.000	-	1.00	-
2 and 3	678	2.649	1.17-5.97	1.615	1.21-2.14*
RHTMD		*P*<0.00		*P*<0.001	
Easy	1017	1.000		1.00	-
Difficult	987	2.057	1.567-2.702	1.89	1.43-2.50*

*Every parameter adjusted for each other and the age. MPC – Mallampati classification; ULBT – Upper lip bite test; RHTMD – Ratio of height to thyromental distance; OR – Odds ratio; CI – Confidence interval

Table 4: Combined analysis of parameters by logistic regression

Combined parameters	*n*	OR	95% CI
MPC + ULBT		*P*<0.00	
Both easy	962	1.000	-
Anyone difficult	792	2.143	1.58-2.90
Both difficult	173	4.477	2.98-6.72
MPC + RHTMD		*P*<0.00	
Both easy	843	1.000	-
Anyone difficult	904	1.998	1.43-2.79
Both difficult	257	4.935	3.35-7.27
ULBT + RHTMD		*P*<0.00	
Both easy	645	1.000	-
Anyone difficult	928	2.185	1.52-3.13
Both difficult	354	3.672	2.46-5.47
MPC + ULBT + RHTMD		*P*<0.00	
Both easy	375	1.000	-
Anyone/two difficult	872	2.455	1.41-4.25
Both difficult	680	6.081	3.56-10.37

MPC – Mallampati classification; ULBT – Upper lip bite test; RHTMD – Ratio of height to thyromental distance; OR – Odds ratio; CI – Confidence interval

all head and neck cancers which are more common in males fell in the exclusion criteria. There are multiple studies stating male gender as a predictor of difficult intubation.[16] Our study too had more males with difficult laryngoscopy. We had a total of 429 males with 22.8% (98) having difficult laryngoscopy compared to 1575 females with 10.09% (159) difficulty. We hypothesise that our difficult laryngoscopy incidence may have been higher if there were more males in the study population.

The demographics of difficult and easy intubation show that variables such as IID, body mass index (BMI) and age were significant contributors for difficult

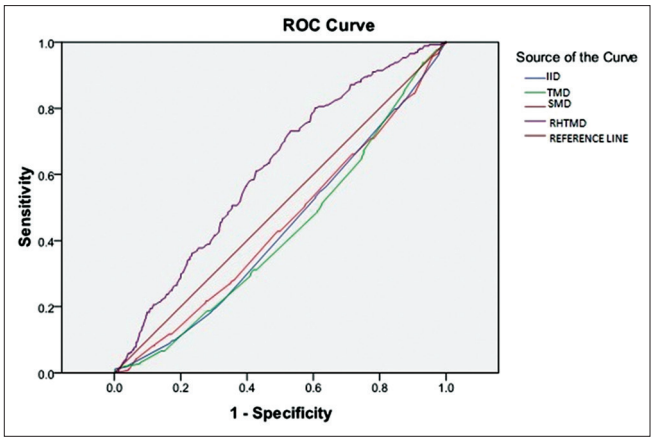

Figure 1: Receiver operating characteristics curve

Area under the ROC curve

Test result variable (s)	Area	SE[a]	Asymptotic significant[b]	Asymptotic 95% CI	
				Lower bound	Upper bound
IID	0.432	0.018	0.000	0.396	0.468
TMD	0.422	0.018	0.000	0.387	0.458
SMD	0.445	0.019	0.004	0.408	0.482
RHTMD	0.641	0.018	0.000	0.580	0.649

[a]Under the non parametric assumption. [b]Null hypothesis; True area is = 0.5. CI – Confidence interval; SE – Standard error; ROC – Receiver operating characteristics; IID – Inter incisor distance; SMD – Sternomental distance; TMD – Thyromental distance

laryngoscopy. Age is an independent variable that can have effects on ease of laryngoscopy.[17] We found that as the age advanced to more than 50 years, the odds ratio increased to 12.5 meaning that there is a 12 fold increased odds of difficult laryngoscopy in this group. All the parameters (MPC, ULBT and RHTMD) were significant predictors of difficult laryngoscopy even after adjusting for age.

MPC supine considered to be better predictor of difficult intubation[18] did not improve the prediction in our set of patients.

The airway parameters studied like MPC, ULBT, and RHTMD may be useful as predictors of difficult laryngoscopy both individually and in combination. The combination of tests provided better prediction than single tests as has been documented earlier. RHTMD when combined with MPC and ULBT led to decreased sensitivity than RHTMD alone. This was due to our grouping preference, wherein we clustered as difficult laryngoscopy only if it was predicted by each of ULBT, MPC and RHTMD and we excluded cases when only two of the parameters predicted difficult intubation. Among the parameters studied we found MPC + ULBT

had the highest sensitivity at 69.2% followed by RHTMD at 64.6%. This means that with a combination of MPC and ULBT can predict difficult laryngoscopy in 69% of patients with difficult laryngoscopy and RHTMD in 64%. Our specificity was highest for MPC at 78.4%, followed by ULBT meaning if MPC or ULBT are of lower grade it predicts an easy laryngoscopy. The NPV was more than 90% for all variables except ULBT showing the probability that if patients test negative, they will not have difficult laryngoscopy, meaning we can predict that they will have an easy laryngoscopy. The low individual sensitivities also meant the possibility of missing a difficult laryngoscopy unless a combination of tests is done.

We used ROC curve to set our cut offs. We took the value with highest TPR and FPR on the graph as our cut off [Figure 1]. Our upper limit for RHTMD was 17.13 and was lower than in other Indian studies[13,14,16] but was similar to that reported by Liaskou *et al*.[19] Schmitt proposed an RHTMD of 25 or more for prediction of difficult laryngoscopy in Caucasians. Krobbuaban *et al*.[20] had a cut off of 23.5 in Thai patients. Honarmand *et al*.[21] had a cut off of 22.7 in Iranian population, and Liaskou *et al*. had 18.4 cut off in Greek patients. There have been multiple publications from Isfahan, Iran with different values of cut off for RHTMD in the Iranian population, varying from 29.3.[22] 28.8,[23] to 21.06.[24] It is not clear if all the data were procured from the same ethnic group. In our study, the AUC for RHTMD was 0.641. The false positive value was 47% (1-Sp on ROC) denoting that if RHTMD >17.1 then the false positivity can be 47% - meaning laryngoscopy can be easy in these patients. In the Indian population, there were studies that used 25 as cut off[25] and others that used 23.5.[14] All these studies did not have large numbers, one had recruited 200 cases and the other 250, however, they had good sensitivity and specificity for RHTMD. Another study[17] with 330 patients had a value of 24.9 ± 4 for RHTMD. The mean height in their study (159.4 ± 11.5) was higher than in our study (157.36 ± 9.46) and the TMD (6.5 ± 0.9) was much less than our patient population (9.03 ± 1.2). A recent systematic review[26] has quoted normal TMD of 6–7.2 but mean TMD in our population was much higher than in the study by Schmitt *et al*.[9] (7.9 ± 1. 2). Other studies with high TMD were Baker *et al*.[27] with 6–8 cm and a study in Turkish population[28] quoting a cut off TMD of 8.2 cm. We hypothesised that in South Indian population the TMD is longer compared to height. RHTMD is considered a robust test as it allows for individual body proportions and is a reproducible test as all that is needed is a metal graduated scale, as compared to MPC.[29] However RHTMD in our population was much lower than in other Indian studies.[13,14,17,25]

We also considered CL grading as a predictor of difficult intubation, without any external laryngeal pressure. With BURP the occurrence of difficult laryngoscopy was reduced to 22 out of 2004 patients (1.09%) which is similar to the Danish[30] cohort study. This was a very low prevalence of difficult intubation in the population studied and so the PPV was also low. Yentis[31] in an editorial has questioned the usefulness of predictive tests. In any predictive examination accuracy is better if the results are binary and clear cut, like an easy or difficult intubation, but in the clinical scenario, there is a lot of overlap; an intubation deemed difficult by CL view becomes easy with BURP or by the use of a bougie. To replicate the clinical scenario, it has been proposed that a grey zone exists and the actual values are on either side of the binary division.[32] While many airway examinations are statistically significant by ROC analysis, using the grey zone approach shows large inconclusive zones that possibly explain the inconsistent results in predicting diffcult laryngoscopy.[33]

The limitations of our study were that it was skewed towards females. AUC for RHTMD was 0.641, any AUC of <0.7 is considered poor and this was a major limitation. We did not evaluate other predictors such as IID, BMI and comorbidities. We found that many patients could not understand ULBT and there were limitations in collecting data from edentulous patients.

We consider the prospective nature and number of cases recruited as major strengths of the study. We feel that the very low prevalence of difficult laryngoscopy in our study (CL ≥3 with BURP - 1.09%) and possible areas of grey zones that are not quantified led to poor outcomes of predictive values and state that 17.1 is the cut off value for RHTMD in the population studied. We found that MPC, ULBT, and RHTMD predicted difficult intubation even after adjustments for age.

CONCLUSION

Our upper limit for normal RHTMD in the South Indian population is 17.1. More studies in South Indian population are needed to confirm our finding and set standards for all airway measurements.

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Conflicts of interest

There are no conflicts of interest.

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Announcement

CALENDAR OF EVENTS OF ISA 2017

The cut off dates to receive applications / nominations for various Awards / competitions 2017 is as below. Hard copy with all supportive documents to be sent by Regd. Post with soft copy (Masking names etc.) of the same by E Mail to secretaryisanhq@gmail.com. The masked soft copy will be circulated among judges. Only ISA members are eligible to apply for any Awards / competitions. The details of Awards can be had from Hon. Secretary & also posted in www.isaweb.in

Cut Off Date	Name of Award / Competition	Application to be sent to
30 June 2017	Bhopal Award for Academic Excellence	Hon. Secretary, ISA
30 June 2017	Late Prof. Dr. A .P. Singhal Life Time Achievement Award	Hon. Secretary, ISA
30 June 2017	Rukmini Pandit Award	Hon. Secretary, ISA
30 June 2017	Dr. Y. G. Bhoj Raj Award Award	Hon. Secretary, ISA
30 Sept. 2017	Kop's Award	Chairperson, Scientific Committee ISACON 2017 copy to Hon. Secretary, ISA
30 Sept. 2017	ISACON Jaipur Award	Chairperson, Scientific Committee ISACON 2017 copy to Hon. Secretary, ISA
30 Sept. 2017	Prof. Dr. Venkata Rao Oration 2017	Hon. Secretary, ISA
30 Sept. 2017	Ish Narani Best poster Award	Chairperson, Scientific Committee ISACON 2017
30 Sept. 2017	ISA Goldcon Quiz	Chairperson, Scientific Committee ISACON 2017
10 Nov. 2017	Late Dr. T. N. Jha Memorial Award & Dr. K. P. Chansoriya Travel Grant	Hon. Secretary, ISA, copy to Chairperson Scientific Committee of ISACON 2017
20 Oct. 2017	Awards (01 Oct 2016 to 30 Sept 2017)	Hon. Secretary, ISA

(Report your monthly activity online every month after logging in using Secretary's log in ID)

1. Best City Branch
2. Best Metro Branch
3. Best State Chapter
4. Public Awareness – Individual
5. Public Awareness – City / Metro
6. Public Awareness - State
7. Ether Day (WAD) 2017 City & State
8. Membership drive
9. Proficiency Awards

Send hard copy (where ever applicable) to
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