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Airway assessment factors as a predictive marker of difficult direct laryngoscopy: A prospective study

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Abstract
Background and objectives: Preoperative evaluation of anatomical landmarks help identify potentially difficult laryngoscopies; however, predictive reliability is unclear. Thus, this study was undertaken to identify and compare the most reliable variables, in prediction of difficult direct laryngoscopy.
Methodology: Pre-operative assessment of ten parameters using clinical and goniometric measurement were taken and consecutively predictors of difficult intubation were identified. On the day of surgery, after premedication and induction, laryngoscopy was performed. The glottic views were graded according to the Cormack and Lehane classification. Patients of Cormack Lehane class II B and above were considered as difficult to intubate**.**
Results: 15.4% of the cases were identified as difficult intubation. Cormack and Lehane classification had the highest diagnostic accuracy followed by Thyromental distance, sternomental distance and Modified Mallampati classification in that order. Mandibular-hyoid distance had highest sensitivity. when all ten parameters were taken into consideration, 95.7% of cases were classified correctly. Also, it classified correctly 97.7% of easy and 84.2% difficult intubation.
Conclusion: Apart from Cormack-Lehane grading, upon comparison of all the parameters, a combination of Thyromental distance, Atlanto-occipital joint extension and Modified Mallampati classification were able to correctly classify 95.3% of difficult intubation.

Keywords: difficult laryngoscopy, predictive airway assessment, endotracheal intubation

1. Introduction
Airway management occupies pivotal importance to an anaesthesiologist. For securing the airway, the gold standard is tracheal intubation through direct laryngoscopy. To ensure a safe anaesthetic technique, diligent efforts and absolute precision is required to secure and maintain a patent airway. The prime concern for the anaesthesiologist and the foremost task is the unanticipated difficult laryngoscopy and endotracheal intubation. Difficult tracheal intubation accounts for 17% of the respiratory related injuries and results in significant morbidity and mortality. In fact, up to 28% of all anaesthesia related deaths are secondary to the inability to mask ventilate or intubate [1]. To aid the Anaesthesiologist in identifying these patients, several preoperative airway assessment tests have been proposed [2-6]. It was conceptualised that the visualization of larynx during intubation is not affected by one but a plethora of factors, the concept of multivariate factors came into existence[7]. Despite large scale evaluations and efforts, predicting a difficult intubation employing a myriad of measurements and observations has not proven itself to be practicable or even reliable. Thus, the search for a predictive test which can provide an anaesthesiologist with ease of applicability, reliability and precision of prediction (discriminating power) continues. Thus, we proposed a prospective model to study the usefulness of ten different airway assessment predictors before surgery. They are: Modified Mallampati classification (MMC), Atlanto-occipital joint extension, Thyromental distance (TMD), Steno-mental distance (SMD), Mandibular hyoid distance (MHD), Ratio of height to thyromental distance (RHTMD), Inter-incisor distance (IID), Upper lip bite test (ULBT) or Mandibular protrusion test (MPT) & Cormack-Lehane grading (CLG).

2. Materials and Methods
This study was conducted at Meenakshi Medical College, Hospital & Research institute between January to September 2019 on two hundred and fifty-three adult patients aged between

18-65 years, assessed under ASA I- Ⅲ, requiring surgery under GA with endotracheal intubation. Institutional ethical committee clearance and written informed consent from the patients were obtained prior to the proposed surgery. Patients with following were excluded from the study; Obvious airway malformations, need for rapid sequence intubation, Pregnancy and lactating mothers, Edentulous patients, cervical spine pathology requiring specific manipulation, Patients not willing to participate in the study and patients with BMI> more than 35kg/m [2].

2.1. Course of Action
All patients underwent a preanesthetic assessment prior to the surgery. A routine general physical examination was done on all patients along with routine laboratory investigations, ECG and chest X-ray.

2.1.1 Assessment criteria with Abbreviations
The enrolled patients were subjected to the following assessments preoperatively: Modified Mallampati classification (MMC), Atlanto-occipital joint extension (using goniometer), Thyromental distance (TMD), Steno-mental distance (SMD), Mandibular hyoid distance (MHD), Ratio of height to thyromental distance (RHTMD), Inter-incisor distance (IID), Upper lip bite test (ULBT) and or Mandibular protrusion test (MPT)

2.1.2 Predictors of Difficult Intubation
Predictors of Difficult Intubation were identified as MMC grade Ⅲ, Ⅳ [8]; IID < 3.5cms, TMD < 6.5cms [9], SMD < 12.5 [10], MHD [13] < 4cms, RHTMD < 23.5 [14], ULBT class 3 [15], MPT grade B & C; Atlanto-occipital joint extension grade Ⅲ, Ⅳ (12-21° & <12° respectively; Normal >35°) [11, 12]. On the day of surgery, after premedication and induction, the patients' head and neck were kept in optimal intubating position with a pillow under the occiput during intubation (sniffing position), laryngoscopy was done using appropriate sized Macintosh blade and the glottic views were graded according to a modified classification scheme with five different grades based on the Cormack-Lehane scoring system described by Yentis [16], who proposed that grade II be differentiated into IIA (partial view of the glottis) and IIB (arytenoids or posterior vocal cords only are visible). Intubation is rarely difficult when a grade I or IIA view is achieved; grades IIB and III are associated with a significantly higher incidence of failed intubation. A Grade IV laryngoscopic view requires an alternate method of intubation.

2.2 Methods used for Analysis
The preoperative airway assessment data and the findings during intubation were used to determine the sensitivity, specificity, positive and negative predictive values for each test. Fisher exact test, Chi square test, Independent sample T-Test and McNemar's test were used to calculate statistically significant difference in sensitivity and specificity between these tests respectively.

3. Results
Of the total, 39(15.4%) had difficult intubation at laryngoscopy grade Ⅱ B, III and IV. The overall prediction for difficult intubation considering all ten parameters has sensitivity 82.1%; specificity 97.2%; and diagnostic accuracy of 94.9%. A combination of all other factors except CLG, were able to correctly classify 95.3% of difficult intubation. Amongst this CLG, TMD & MMC, when grouped together, 95.3% of cases were correctly identified.

3.1 Most significant parameters
Three most significant factors apart from CLG were TMD, MMC and Atlanto-occipital joint extension; 92.9% of original grouped cases correctly classified when these three parameters were considered. While when all ten parameters were taken into consideration, the correct classification of difficult intubation was 95.7%, which implies that there is a marginal improvement in correctly identifying difficult intubation upon addition of rest seven parameters. The difficult cases were intubated with aid of either of the following: OELM (Optimal External Laryngeal Manipulation), bougie, stylet, video-laryngoscopy or fibreoptic bronchoscopy (FOB).

3.1.1 Results of various parameters
3.1.2 Diagnostic accuracy of various parameters

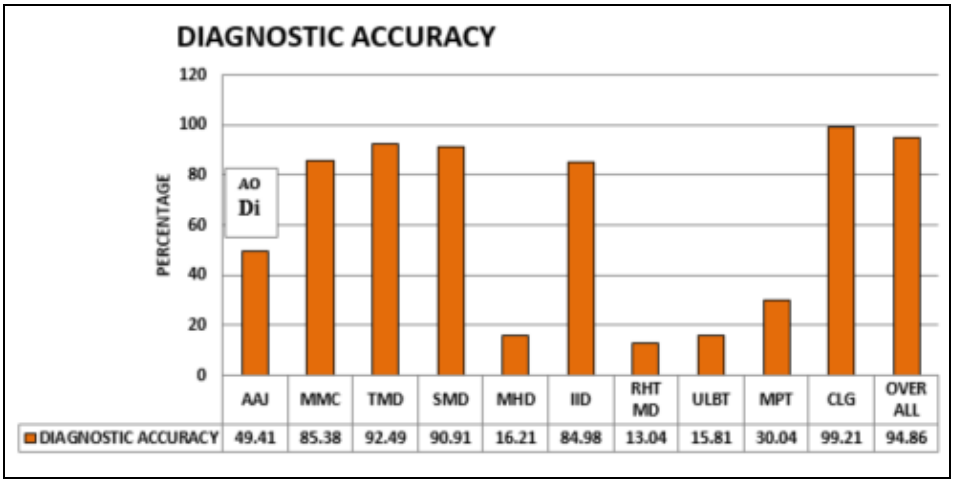

Fig 1: Cormack-Lehane Grading had highest diagnostic accuracy followed by Thyro-mental distance, Sternomental distance & Modified Mallampati classification

3.1.3 Sensitivity of various parameters

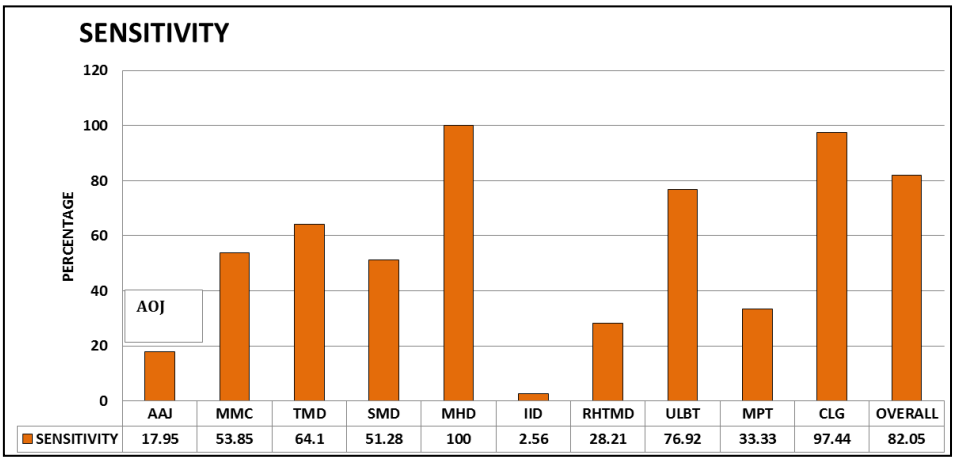

Fig 2: According to the study, Mandibular-hyoid (MHD) distance had highest sensitivity; inter-incisor distance (IID) was least sensitive

3.1.4 Specificity of various parameters

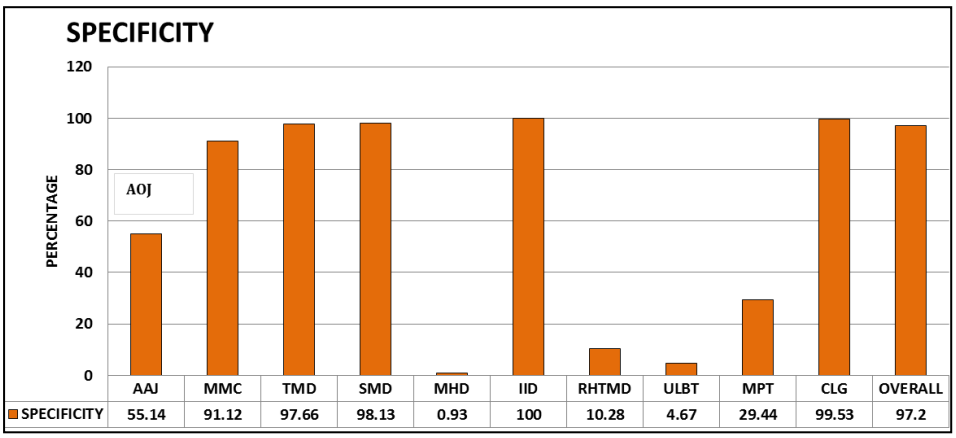

Fig 3: According to the study, Inter-incisor distance (IID) had highest specificity; Mandibular-hyoid (MHD) distance had least specificity

3.1.5 Positive predictive value of various parameters

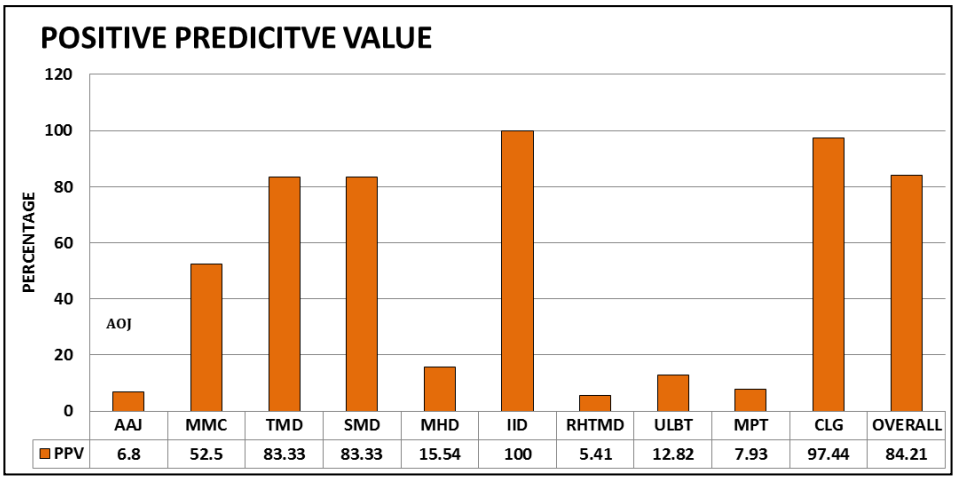

Fig 4: According to the study, Inter-incisor distance (IID) had highest positive predictive value; Ratio of height to thyromental (RHTMD) distance had least positive predictive value.

3.1.6 Sample T-Test to compare mean values between Easy and Difficult laryngoscopy (Table 1)

1. The mean TMD in easy intubation is 7.74 ± 0.77 and in difficult intubation is 6.38 ± 0.91. These two mean values are statistically highly significant ($p < 0.001$).
2. The mean SMD in easy intubation is 14.657 ± 1.2910 and in difficult intubation is 12.769 ± 1.5124. These two mean values are statistically highly significant ($p < 0.001$).
3. The mean MHD in easy intubation is 5.362 ±.9399 and in difficult intubation is 4.513 ±.5559. These two mean values are statistically highly significant ($p < 0.001$).

4. The mean IID in easy intubation is 5.48 ±.537 and in difficult intubation is 4.90 ±.641. These two mean values are statistically highly significant ($p < 0.001$).
5. The mean RHTMD in easy intubation is 20.69 ± 1.98 and in difficult intubation is 25.11 ± 4.47. These two mean values are statistically highly significant ($p < 0.001$).

Table 1: Independent sample T-Test to compare mean values between Easy and Difficult laryngoscopy

Predictor	Reality	N	Mean	Std. Dev	p-value*
3. TMD	Easy	214	7.74	.772	<0.001
	Difficult	39	6.38	.907	
4. SMD	Easy	214	14.657	1.2910	<0.001
	Difficult	39	12.769	1.5124	
5. MHD	Easy	214	5.362	.9399	<0.001
	Difficult	39	4.513	.5559	
6. IID	Easy	214	5.48	.537	<0.001
	Difficult	39	4.90	.641	
7. RHTMD	Easy	214	20.69	1.98	<0.001
	Difficult	39	25.11	4.47	

*$p<0.05$ was regarded as significant

3.1.7 Chi-Square test to compare proportions between Easy and Difficult laryngoscopy (Table 2)

1. Among ATLANTO-OCCIPITAL JOINT, in 12°-21°category 30.0% is easy intubation, 70.0% is difficult intubation; in 22°- 34° category 86.2% is easy intubation, 13.8% is difficult intubation; and in >35° category 93.2% is easy intubation, only 6.8% is difficult intubation. This indicates that smaller angle leads to difficult intubation and larger angle tends to easy intubation. These proportions are statistically highly significant ($p < 0.001$).
2. Among MMC, in grade 1- 94.3% is easy intubation, 5.7% is difficult intubation; in grade 2 – 87.9% is easy intubation, 12.1% is difficult intubation; in grade 3 – 50% is easy intubation, 50% is difficult intubation and in grade 4 – 33.3% is easy intubation, 66.7% is difficult intubation. This indicates that the greater grade leads to difficult intubation and lesser grade signifies easy intubation. These proportions are statistically highly significant ($p < 0.001$).
3. Among ULBT, able to perform, is 69.9% easy intubation and 31.1% difficult intubation and unable to perform is 91.8% easy intubation and 8.2% difficult intubation. This interprets that positive outcome is easy intubation and negative outcome is difficult intubation. These proportions are statistically highly significant ($p < 0.001$).
4. Among MPT, grade A – 92.1% is easy intubation, 7.9% is difficult intubation; grade B – 70.4% is easy intubation, 29.6% is difficult intubation and grade C – 75% is easy intubation, 25% is difficult intubation. Thus, grade A is easy intubation in comparison to grade B and C. These proportions are statistically highly significant ($p< 0.001$).
5. Among CLG, grade Ⅰ – 100% is easy intubation; grade 2A is 98.2% is easy intubation, 1.8% is difficult intubation; grade 2B is 4.3% is easy intubation, 95.7% is difficult intubation; grade 3A and 3B is 100% difficult intubation. This signifies that grade 1 and 2A are easy intubation and subsequently higher grades are predictors of difficult intubation. These proportions are statistically highly significant ($p < 0.001$).

Table 2: Chi-Square test to compare proportions between Easy and Difficult laryngoscopy

		Reality					p-value
		Easy		Difficult		Total	
		N	%	N	%	N	
1.Atlanto-Occipital Joint Extension	12° - 21°	6	30.0%	14	70.0%	20	<0.001*
	22° - 34°	112	86.2%	18	13.8%	130	
	> 35°	96	93.2%	7	6.8%	103	
	Total	214	84.6%	39	15.4%	253	
2.MMC	Grade 1	115	94.3%	7	5.7%	122	<0.001*
	Grade 2	80	87.9%	11	12.1%	91	
	Grade 3	17	50.0%	17	50.0%	34	
	Grade 4	2	33.3%	4	66.7%	6	
	Total	214	84.6%	39	15.4%	253	
8. ULBT	No	58	69.9%	25	30.1%	83	<0.001
	Yes	156	91.8%	14	8.2%	170	
	Total	214	84.6%	39	15.4%	253	
9. MPT	A	151	92.1%	13	7.9%	164	<0.001*
	B	57	70.4%	24	29.6%	81	
	C	6	75.0%	2	25.0%	8	
	Total	214	84.6%	39	15.4%	253	
10. CLG	Ⅰ	159	100.0%	0	0.0%	159	<0.001*
	2A	54	98.2%	1	1.8%	55	
	2B	1	4.3%	22	95.7%	23	
	3A	0	0.0%	15	100.0%	15	
	3B	0	0.0%	1	100.0%	1	
	Total	214	84.6%	39	15.4%	253	

*Fishers exact test.

4. Conclusion

Of all factors considered in the study, Cormack-Lehane grading is the ultimate parameter for correctly diagnosing difficult intubation, having both high sensitivity and specificity. Apart from Cormack-Lehane grading, upon comparison of all the parameters, a combination of Thyromental distance, Atlanto-occipital joint extension and Modified Mallampati classification were able to correctly classify 95.3% of difficult intubation. While when all ten parameters were taken into consideration, the correct classification of difficult intubation was 95.7%, which implies that there is a marginal improvement in correctly identifying difficult intubation upon addition of rest seven parameters. Hence, Thyromental distance, Modified Mallampati classification and Atlanto-occipital joint extension are the best parameters for predicting difficult intubation.

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