Original research article

Hyomental distance ratio as the diagnostic predictor of difficulty in laryngoscopy

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Abstract

The Hyomental Distance (HMD) has been used to estimate the mandibular space. This study has been undertaken with a purpose to evaluate the usefulness of the Hyomental Distance Ration (HMDR) for accurately predicting difficulty in visualisation of larynx in apparently normal patients. This prospective, single blinded, unicentric evaluation of airway screening tests for difficult laryngoscopy was conducted on 300 subjects, over the period of 24 months, with the approval of the Ethics committee, and written informed consent of the subjects. The sensitivity of HMDR with cut off value of 1.2 is 93.3%, specificity 81.7%, PPV 56%, NPV 98%. It showed a positive co-relation with Cormack-Lehane grading ($p<0.05$). It has overall Accuracy of 84%. The AUC is 0.88. When Modified Mallampati test & HMDR of cut-off value 1.17 are used in combination, 231(94%) cases of easy visualization of larynx and 46(84%) cases of difficulty in visualization of larynx were predicted correctly.

Keywords: Hyomental distance ratio, diagnostic predictor, difficulty in laryngoscopy

Introduction

General anaesthesia is associated with various effects on the respiratory system, including the loss of airway patency, loss of protective airway reflexes, and hypoventilation or apnea. Therefore one of the fundamental responsibilities of the anaesthesiologist is to maintain airway patency and to ensure adequate ventilation and oxygenation. The term *airway management* refers to the practice of establishing and securing a patent airway and is a cornerstone of anaesthetic practice. Traditionally, ventilation via a mask and endotracheal intubation has been the foundation of airway management; in the past 25 years. However, the laryngeal mask airway (LMA) has emerged as one of the most important developments in airway devices. Because failure to secure a patent airway can result in hypoxic brain injury or death in only a few minutes, difficulty with airway management has potentially grave complications [1].

Airway management is safest when potential problems are identified before surgery, enabling the adoption of a strategy, a series of plans, aimed at reducing the risk of complications [2]. Preoperative airway assessment should be performed routinely in order to identify factors that might lead to difficulty with face-mask ventilation, tracheal intubation ,supraglottic airway device insertion, , or front-of-neck access [3].

Successful airway management requires a range of knowledge and skill sets-specifically, the ability to predict difficulty with airway management, to formulate an airway management plan, and to have the skills necessary to execute that plan using the wide array of available airway devices [4].

A difficult airway is defined as the clinical situation in which a conventionally trained anaesthesiologist experiences difficulty with face mask ventilation of the upper airway, difficulty with tracheal intubation, or both [5]. Difficult laryngoscopy is described as not being able to visualize any portion of the vocal cords after multiple attempts at conventional laryngoscopy, and many investigators include grades III and IV or grade IV alone, according to the Cormack-Lehane grading of the rigid laryngoscopic view [6]. Difficult laryngoscopy (a grade III or IV view) is synonymous with difficult intubation in the majority of patients [7].

The incidence of difficult intubation and laryngoscopy in the general population is reported to be between 1 to 18% [8, 9]. S. Das *et al.* (2011) and Shiga *et al.* (2005) reported the incidence of difficult intubation in the general population to be 5.8% [10, 11].

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Difficult intubation may occur not only in patients with apparent pathologies in the oro-facial region but also, unexpectedly, in those without abnormalities.

The first step in airway management is the identification of a difficult airway, followed by formulation of contingency plans for its management and finally having the required skills and devices to execute those plans effectively. The identification of a difficult airway starts with a detailed patient history, including that of a previous difficult intubation, obstructive sleep apnoea, snoring and relevant congenital or acquired disease states followed by general, physical and regional examination including but not limited to mouth opening, oro-pharyngeal anatomy, dentition, temporo-mandibular joint movement and measurement of submental space [12].

There are several studies comparing different airway parameters with varying results. There is no single airway assessment test which can alone predict difficulty in laryngoscopy or intubation [13, 14].

The Hyomental Distance (HMD) has been used to estimate the mandibular space. This study has been undertaken with a purpose to evaluate the usefulness of the Hyomental Distance Ration (HMDR) for accurately predicting difficulty in visualisation of larynx in apparently normal patients. The preoperative airway predictors, alone and in combination like HMD in the neutral position, HMD at the extreme of head extension, HMDR and the modified Mallampati test (most commonly used test by anaesthesiologists), were examined.

The principal adverse outcomes associated with the difficult airway include (but are not limited to) death, cardiopulmonary arrest, brain injury, unnecessary surgical airway, airway trauma, and damage to the teeth [2]. The first step to prevent this is the identification of a potential difficult airway. This once again justifies the need and importance of studies such as this for safer anaesthetic practice.

Methodology

This prospective, single blinded, unicentric evaluation of airway screening tests for difficult laryngoscopy was conducted on 300 subjects, over the period of 24 months, with the approval of the Ethics committee and written informed consent of the subjects.

Inclusion Criteria

1. Patients between 18yrs to 60yrs of age.
2. Patients undergoing general anesthesia with endotracheal intubation.

Exclusion Criteria

1. Gross anatomical abnormalities.
2. Recent surgery of head & neck.
3. Midline neck swellings.
4. Maxillo-facial fracture or tumor.
5. Loose teeth.
6. Obese patients with a BMI >30 kg/m^2.
7. Those requiring rapid sequence or awake intubation.
8. Pregnancy.

Pre-Operative Assessment

Following routine pre-anaesthetic check-up, written informed consent was obtained from the patient. The airway assessment and demographic variables were measured and recorded by the principal investigator for all patients entering the study.

The Mallampati-Samsoon Classification System or Modified Mallampati Test (MMT): The patient was seated in a neutral position and asked to open the mouth as wide as possible and protrude the tongue as far as possible and phonation was not allowed. The oro-pharyngeal structures were viewed and graded as follows:

Grade I: Soft palate, uvula, fauces, and pillars, (till the bases) are seen.
Grade II: Soft palate, part of uvula and fauces seen.
Grade III: Soft palate and base of uvula seen.
Grade IV: Soft palate not visible, only hard palate visible.

The Hyo-Mental Distance(HMD) was assessed by keeping patients in the supine position, with the head on a firm table. The patients were instructed to look straight ahead, keep the head in the neutral position, close the mouth and not swallow. A hard-plastic bond ruler was pressed on the skin surface just above the hyoid bone, and the distance from the tip to the anterior-most part of the mentum was measured and defined as the HMD in the neutral position. The patients were then instructed to extend the head maximally, without lifting the shoulders. The HMD was measured again in this position, and this variable was defined as the HMD at the extreme of head extension and the HMD ratio was calculated.

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Results

Table 1: Modified Mallampati Grade

Mallampati	Cormack-Lehane		Total
	Grade-I & II	Grade-III & IV	
1&2	219	30	249
	87.9%	12.1%	100%
3&4	21	30	51
	41.2%	58.8%	100%
Total	240	60	300
	80%	20%	100.0%

The modified Mallampati test predicted 30 difficult laryngoscopies out of 60 difficult laryngoscopies and 30 which were predicted to be easy were difficult.
Many cases of difficult laryngoscopies were missed by the test. 12.1 % of predicted easy laryngoscopies were actually difficult. This makes MMT less reliable when used alone.

Table 2: Validity of Modified Mallampati test

Sensitivity	Specificity	PPV	NPV	Accuracy	AUC	p value
50.0%	91.3%	58.8%	87.9%	83%	0.71	0.006

The sensitivity of Modified Mallampati test is 50%, specificity 91.3%, PPV 58.8%, NPV 87.9%. It showed a positive co-relation with Cormack-Lehane grading (P<0.05). It has a PPV of 58.8%, NPV of 87.9% and overall accuracy of 83%. The AUC is 0.71.

Table 2: Hyomental Distance in Neutral Position (HMDn)

Variable	CL	N	Min	Max	Mean	SD	p-value
HMDn	Grade 1 & 2	240	2.0	8.0	5.21	0.75	0.002
	Grade 3 & 4	60	3.0	7.0	5.52	0.84	

HMDn of 5.52±0.84cm shows a statistical significance with p value of <0.05 in predicting difficulty in visualization of larynx.

Table 3: Hyomental Distance in Extension (HMDe)

Variable	CL	N	Min	Max	Mean	SD	p-value
HMDe	Grade-1&2	240	4.5	11.0	6.65	0.77	0.045
	Grade-3&4	60	4.5	8.0	6.34	0.91	

The mean HMDe in predicting difficulty in laryngoscopy was 6.34±0.91cm which has a statistical significance of 0.045.

Table 4: Hyomental Distance Ratio 1.2 (HMDR)

HMDR	Cormack Lehane		Total
	Grade-1&2	Grade-3&4	
>1.2	196	4	200
	98%	2%	100%
≤1.2	44	56	100
	44%	56%	100%
Total	240	60	300
	80%	20%	100.0%

HMDR of ≤1.2 predicted that 100 pt would have difficulty in visualization of larynx and HMDR of >1.2 predicted that 200 of them would be easy out of a total of 300 cases.
However, only 56(56%) out of the predicted 100 cases had difficulty in visualization of larynx and 196(98%) of the 200 easy in visualization of larynx were easy.

Table 5: Validity of HMDR

Sensitivity	Specificity	PPV	NPV	Accuracy	AUC	p value
93.3%	81.7%	56%	98%	84%	0.88	0.0001

The sensitivity of HMDR with cut off value of 1.2 is 93.3%, specificity 81.7%, PPV 56%, NPV 98%. It showed a positive co-relation with Cormack-Lehane grading (p<0.05). It has overall Accuracy of 84%.

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The AUC is 0.88.

Table 6: Hyomental Distance Ratio 1.17 (HMDR)

variable	CL	N	Min	Max	Mean	SD	P-value
HMDR	Grade I & II	240	1.07	2.25	1.29	0.10	<0.0001
	Grade III & IV	60	1.07	1.50	1.15	0.06	

The cut-off value for HMDR in predicting difficulty in visualization of larynx is 1.17.

Table 7: Cut-off value for HMDR

HMDR	Cormack-Lehane		Total
	Grade-I & II	Grade-III& IV	
>1.17	230	12	242
	95%	5%	100%
≤1.17	10	48	58
	17.2%	82.8%	100%
Total	240	60	300
	80%	20%	100%

HMDR of ≤1.17 predicted that 58 pt would have difficulty in visualization of larynx and HMDR 0f > 1.17 predicted that 242 of them would be easy out of a total of 300 cases.
However out of the predicted number of difficulty in visualization of larynx, only 48(82.8%) were difficult and out of 242 predicted easy laryngoscopies, only 230 (95%) were easy.
The sensitivity of HMDR with cut off value of 1.17 is 80%, specificity 95.8%, PPV 82.8%, NPV 95%. It showed a positive co-relation with Cormack-Lehane grading (P<0.05). It has overall Accuracy of 92.7%. The AUC is 0.88 with a very good sensitivity PPV and high specificity, HMDR is a very good predictor of difficulty in visualization of larynx. With AUC 0.88, it has a high degree of accuracy.
When Modified Mallampati test & HMDR of cut-off value 1.2 are used in combination, 236(89%) cases of easy visualization of larynx and 30(88%) cases of difficulty in visualization of larynx were predicted correctly.
The sensitivity & NPV of the combined test markedly decreased when compared with HMDR with cut off 1.2 alone and specificity& PPV increased. The accuracy & AUC also increased.
When Modified Mallampati test & HMDR of cut-off value 1.17 are used in combination, 231(94%) cases of easy visualization of larynx and 46(84%) cases of difficulty in visualization of larynx were predicted correctly.
The sensitivity & NPV of the combined test is decreased when compared with HMDR alone, but increased significantly when compared with Modified Mallampati test. The specificity and PPV of the combination of tests is higher than when the tests are used alone. It has a higher degree of accuracy with AUC 0.94.

Table 8: Comparision of Combination of MMT with HMDR with Cut off Values 1.17 & 1.2

Variable	AUC	LL	UL	P-value	Predicted
MMT+HMDR 1.17	0.94	0.9	0.98	<0.0001	92.3%
MMT+HMDR 1.2	0.91	0.87	0.96	<0.0001	88.7%

When modified Mallampati test in combination with HMDR with cut-off values of 1.17 & 1.2 are compared, MMT in combination with HMDR with cut-off value of 1.17 has more predicted probability and AUC making it a better predictor of difficulty in visualization of larynx.

Discussion

Modified Mallampati test is the most widely used test for pre-operative assessment of airway. The sensitivity of MMT in assessing difficult laryngoscopy in the present study is only 50% while it has a specificity of 91.3%. It has a PPV of 58.8% and NPV of 87.9% and accuracy of 83%. The high NPV indicates that it is more useful in ruling out a difficult intubation.
The values of the Mallampati score in predicting difficult intubation were analyzed in a meta-analysis by Lee A *et al*. [15] which investigated 34,513 patients from 42 studies. For predicting difficult intubation, the modified Mallampati test was accurate (area under the ROC curve = 0.83 +/- 0.03). Another meta-analysis, by Shiga *et al*. [11] which included 50,760 patients from 35 studies, measured the values of several predictors of difficult intubation and pointed to the significance of the Mallampati score (area under the ROCcurve-0.82). By investigating 1,674 patients, Yildiz *et al*. [16] showed the MMT sensitivity of 35% in predicting difficult intubation . Investigating 53,041 patients, Kheterpal *et al*. [17] confirmed that Mallampati III or IV was an independent predictor of difficult intubation.
However, some studies showed that the Mallampati score is not a reliable predictor of difficult

intubation. For example, in the meta-analysis by Lundstrøm *et al.* [18], which included 177,088 patients from 55 studies, the prognostic value of the MMT was investigated in predicting difficult intubation. The results showed that the MMT was a less reliable predictor of difficult intubation than some previous meta-analyses had shown.

Karkouti *et al.* [19] found that the MMT had had the worst inter observer reliability and mouth opening and chin protrusion tests have the best reliability. This may be the reason for the varied results in multiple studies regarding the predictive value of MMT.

The overall accuracy of MMT in predicting difficulty in visualisation of larynx in the present study is 83% which makes it a reliable indicator for predicting difficulty in visualisation of larynx.

Hyomental Distance in Neutral Position

The mean HMDn for predicting difficulty in visualisation of larynx is 5.52 ± 0.84 which is significant (p<0.005). This is more than the mean HMDn in the study conducted by Huh *et al.* [20] which was 4.7± 0.7 which was found not significant in their study. This difference in the mean HMDn may be attributed to differences in the ethnicities between the two study groups.

Hyomental Distance in Extension

The mean HMDe for predicting difficulty in visualisation of larynx in this study is 6.34± 0.91 which was not significant(P=0.015). This is more than the mean HMDe in the study conducted by Huh *et al.* [20] which was 5.5 ± 0.7 which was found significant in their study.

Hyomental Distance Ratio

With cut off point HMDR at 1.2, the sensitivity is 93.3% and specificity is 81.7%. However, the PPV is very less which is 56% and has highest NPV of 98%.

When the optimal cut off point for HMDR was calculated for the present study, it was found out to be 1.17. It is slightly less than the HMDR in the study done by Huh *et al.* [20] who used the optimal cut off point of 1.2. This might be due to the ethnic differences between the study population.

With cut-off point of 1.17 in the present study, the sensitivity is 80% and specificity is 95.8%, PPV is 82.8% and NPV is 95%. In their study, Huh *et al*. indicated greater sensitivity (88%) & NPV (97%) of this parameter than the other parameters, despite its somewhat lower specificity (60%) and PPV (23%).

In the study by Rao *et al*. sensitivity for HMDR is 27.3% which is very low compared with the present study and specificity is 98.8%, PPV is 71.43 and NPV is 93.1%.

In the study by Kalezic *et al.* [21], the sensitivity was 95.6% and specificity was 69.2%. HMDR covers the greatest area under the receiver operating characteristic curve of sensitivity and specificity.

These studies showed that HMDR was a significant predictor of difficult intubation.

The overall accuracy of HMDR is 92.7% and Area Under Curve is 0.88 which makes it a powerful predictor for difficulty in visualisation of larynx.

The HMDR was previously suggested as a new possible predictor of difficulty in visualisation of larynx and its utility is confirmed in the present study. Radiological studies revealed that the HMD increased during extension of the head at the occiput-atlanto-axial complex and remained so during extension of the head in the sub axial regions. This means that the hyoid bone moves parallel to the cervical spine during movement of the head and neck.

As a result, the HMDR alone was highly correlated with the Occiput-atlanto-axial complex extension capacity despite a concurrent degree of subaxial extension .In addition, the HMDR is easy and quick to perform at bedside without any special devices and was found to be more accurate than direct measurement of the Occiput-atlanto-axial complex extension angle using a goggles mounted goniometer [22].

The sensitivity, specificity, PPV, NPV of MMT combined with HMDR with cut off value 1.17 in the present study are 76.7%, 96.3%, 84%, 94% respectively and with cut-off point of 1.2 sensitivity, specificity, PPV, NPV are 50%, 98.3%, 88% & 89% respectively.

The combination of MMT with HMDR with cut-off value of 1.17 has more sensitivity, PPV, NPV and overall accuracy than MMT combined with HMDR with a cut-off value of 1.2 making MMT + HMDR 1.17 a more accurate predictor of difficulty in visualisation of larynx.

This is because the HMDR of 1.2 as a cut-off point for visualisation of difficulty in laryngoscopy was calculated in a different ethnic group than the population in which the present study was conducted [20].

In the study conducted by Huh *et al.* [20], the combination of HMDR + MMT resulted in increased specificity at the expense of decreased sensitivity when compared with HMDR alone.

Conclusion

1. The present study concluded that Hyomental Distance Ratio is superior to Modified Mallampati Test for pre-anesthetic evaluation of difficulty in visualization of larynx.
2. Modified Mallampati Test was found to be a good test for excluding a difficult airway rather than predicting it, due to its poor sensitivity.

3. The combination of Modified Mallampati Test with Hyomental Distance Ratio is more sensitive than Modified Mallampati test alone, hence the combination of the tests should be used.
4. The Accuracy of Hyomental Distance Ratio of 1.17 is greater than that of 1.2 in the present population.

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