Hyomental distance in the different head positions and hyomental distance ratio in predicting difficult intubation

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ABSTRACT

The hyomental distance ratio (HMDR) is the ratio between the hyomental distance (HMD) (the distance between the hyoid bone and the tip of the chin) at the extreme of head extension (HMDe) and the one in the neutral position (HMDn). The objective of the study was to examine the predictive value, sensitivity, and specificity of HMDe, HMDn, and HMDR in predicting difficult endotracheal intubation (DI). A prospective study included 262 patients that underwent elective surgical operations. The following parameters were observed as possible predictors of DI: HMDR, HMDe, HMDn, Mallampati score, and body mass index (BMI). The cut-off points for the DI predictors were HMDe <5.3 cm, HMDn ≤5.5 cm, and HMDR ≤1.2. The assessment that DI existed was made by the anesthesiologist while performing laryngoscopy by applying the Cormack-Lehane classification. DI was present in 13 patients (5%). No significant difference was observed in the frequency of DI with regard to the sex, age, and BMI of the patients. Our research indicated HMDR as the best predictor of DI with a sensitivity of 95.6% and specificity of 69.2%. HMDR can be used in the everyday work of anesthesiologists because HMDR values ≤1.2 may reliably predict DI.

KEY WORDS: Laryngoscopy; airway; difficult intubation; hyoid bone; chin; the hyomental distance ratio
DOI: http://dx.doi.org/10.17305/bjbms.2016.1217 *Bosn J Basic Med Sci. 2016;16(3):232-236. © 2016 ABMSFBIH*

INTRODUCTION

Provision and maintenance of the airway are one of the basic postulates in the work of anesthesiologists and an integral part of the everyday work in operating rooms and intensive care units. The frequency of difficult intubation (DI) varies and in high-risk patients it is up to 20% [1-4]. In obese patients, the frequency is up to 15% [5], in thyroid surgery it is between 5.5 and 17% [2], while in patients with Morbus Bechterew it is up to 20% [5].

Today, there is no general agreement on the application of a single diagnostic predictor of DI. The latest studies are attempting to verify the specificity and sensitivity of the existing predictors. They are also applying different combinations and scoring systems attempting to introduce new predictors in the everyday practice.

The hyomental distance ratio (HMDR) is the ratio between the hyomental distance (HMD) (the distance between the hyoid bone and the tip of the chin) at the extreme of head extension (HMDe) and the one in the neutral position (HMDn). Takenaka et al. first introduced HMDR as the predictor of a reduced occipitoatlantoaxial extension capacity [6]. Huh et al. applied HMRD as the predictor of difficult visualization of the larynx. In the study by Huh, the values of HMDR of 1.2 or less point to difficult visualization of the larynx [7].

In 2012, Wojtczak noted that there was a statistically significant difference in the values of HMRD between a group of patients with DI anda group with no DI, which was measured using ultrasound [8].

The aim of this study is to examine the predictive value, sensitivity, and specificity of HMDe, HMDn, and HMDR in predicting DI.

MATERIALS AND METHODS

Patients

A prospective cohort study included 262 patients that underwent elective surgical operations at the Clinical Centre of Serbia in the period from April 2011 to April 2012. The ethical approval for this study was received from the School of Medicine, University of Belgrade Ethics Committee (reference number 29/XI-12).

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Submitted: 20 March 2016/Accepted: 02 May 2016

The research included adult patients (over the age of 18) who underwent elective surgical operations under general endotracheal anesthesia, American Society of Anesthesiologists physical status 1-3. The exclusion criteria for participating in the study were as follows: The presence of big anatomical deformities, earlier surgical operations of the head and neck, diseases of the upper respiratory tract (e.g., fracture or tumours of the maxillofacial region), loose teeth, surgical operations requiring the application of urgent endotracheal intubation or awake intubation.

All patients were premedicated intramuscular with midazolam (0.08 mg/kg). After being anesthetized with propofol (1.5-2 mg/kg), fentanyl (1.5 μg/kg), or with alfentanil (15 μg/kg) they were ventilated with 100% oxygen. The patients underwent surgical operations at the urology clinic, abdominal surgery clinic, gynaecology clinic, endocrine surgery clinic, and otorhinolaryngology clinic.

Parameters of DI

The following parameters were observed as possible predictors of DI:

1. Patient's sex, age, Body mass index (BMI) (the values of BMI >25 (pre-obese and obese groups) were investigated as an indicator of DI).
2. Mallampati score (visibility of the soft palate, uvula, and faucial pillars when the patient is asked to open his mouth and protrude his tongue as much as possible).The following four grades were noted:
   Grade 1: Faucial pillars, uvula, soft, and hard palate visible
   Grade 2: Uvula, soft, and hard palate visible
   Grade 3: Base of uvula or none, soft, and hard palate visible
   Grade 4: Only hard palate visible
   Grades 1 and 2 were predicted as easy laryngoscopy and Grades 3 and 4 were taken as difficult viewing of glottis [9].
3. HMDe. The values of HMDe <5.3 cm were investigated as an indicator of DI
4. HMDn. The values of HMDn that were 5.5 cm and less were investigated as an indicator of DI
5. HMDR. The values of HMDR that were 1.2 or less were investigated as an indicator of DI.

Procedures

The basic criteria that were observed were the frequency of difficult visualization of the larynx and DI. Six experienced anesthesiologists performed the preoperative airway assessment using standardized guidelines. The standard Macintosh metal reusable blades were used, sizes 3 or 4. The assessment that difficult visualization of the larynx and DI existed was made by the anesthesiologist while doing laryngoscopy by applying the Cormack-Lehane classification [10]. The classification includes four grades (Grade I - Full view of glottis, Grade II - Supraglottisis not seen, Grade III - Epiglottis is visible while glottis is not visible, and Grade IV - Neither glottis nor epiglottis are seen). Good visualization of the larynx includes Grade I and II of the classification while Grades III and IV imply the impossibility to visualize the glottis, thus being predictors of DI. Based on the classification, the patients were divided into a group with DI and a group with no DI (easy intubation group).

Laryngoscopy and intubation were performed after the use of muscular relaxants that were chosen by the anesthesiologist. Opioid bolus doses were added in accordance with the clinical requirements, while inhalational anesthetic sevoflurane was used for the maintenance of anesthesia. Normocapnic mechanical ventilation was performed with the gas mixture composed of nitrous oxide and oxygen.

Statistical methods

All numerical features of observation were described using central tendency measures (average and median values) and variability measures (standard deviation, minimum, and maximum). Attributive features of observation were described using absolute and relative numbers. Normality of distribution was investigated by applying the Kolmogorov-Smirnov test. However, for comparing the differences between the patients with and without DI the Mann-Whitney U test was applied. Concerning DI the Chi-square test was used to compare the observed data with the data expected to obtain. For determining the predictor of differences between the patients with and without DI logistic regression analysis was used.

By determining the sensitivity and specificity of the observed scoring systems in predicting DI, the adequacy of their application was assessed. SPSS 22.0 (IBM, Armonk, NY, United States of America) was used for the statistical data processing.

RESULTS

The research included 262 patients of which 114 (43.5%) were males, and 148 (56.5%) were females. DI was present in 13 patients (5% of the total number of patients). In this group of 13 cases with DI, five were females (38.5%) and eight were males (61.5%). Two (15.4%) had a BMI <25 kg/m^2 (underweight and normal weight groups) and 11 (84.6%) patients had a BMI ≥25 kg/m^2 (pre-obese and obese groups). In the easy intubation group, 143 (57.4%) were females and 106 (42.6%) were males, 97 (39.0%) had a BMI <25 kg/m^2 and 152 (61.0%) had a BMI ≥25 kg/m^2. The average age of the patients was higher among the DI group (60.62 ± 6.68 years) when compared with the easy intubation group (52.52 ± 15.37 years). No significant

TABLE 1. General characteristics of the patients from our cohort

Observed factors		DI		*p*-value
		No	Yes	
Number of patients (n)		249	13	
Age (X±SD (Med, min-max))		52.52±15.37 (56; 19-82)	60.62±6.68 (60; 53-73)	[c]*p*=0.111
Sex n	Men (%)	106 (42.6)	8 (61.5)	[b]*p*=0.179
	Women (%)	143 (57.4)	5 (38.5)	
BMI n	<25 (%)	97 (39.0)	2 (15.4)	[b]*p*=0.087
	>25 (%)	152 (61.0)	11 (84.6)	

[b]χ^2-test, [c]Mann Whitney U test, DI: Difficult intubation, SD: Standard deviation, BMI: Body mass index

statistical difference was observed in the frequency of DI in relation to the sex, age, and BMI of the patients (Table 1).

Furthermore, no significant statistical difference was observed in the HMDn between the groups with and without DI, while for the Mallampati score, the HMDe and HMDR were significantly different between the two groups (Table 2). Out of the 249 patients without DI, 207 (83.1%) had HMDn ≤5.5 cm and 42 (16.9%) had HMDn >5.5 cm. In this group of patients, 60 (24.1%) had HMDe <5.3 cm and 189 (75.9%) had HMDe 5.3 cm and more. Furthermore, 11 (4.4%) patients had HMDR 1.2 and less and 238 (95.6%) had HMDR more than 1.2. According to the Mallampati test, 86 (34.5%), 147 (59.0%), and 16 (6.4%) patients in this group had Grade 1, 2, and 3, respectively. Out of the 13 patients with DI, 9 (69.2%) had HMDn ≤5.5 cm, 8 (61.5%) had HMDe <5.3 cm, and 9 (69.2%) had HMDR 1.2 and less. According to the Mallampati test, 5 (38.5%), 3 (23%), and 5 (38.5%) patients in this group had Grade 1, 2, and 3, respectively. There was no Mallampati 4 in this study.

The impact of all the observed factors on DI was investigated by applying the univariate logistic regression analysis. The Mallampati score (I+II vs. III+IV) (p = 0.000), HMDe (p = 0.006), and HMDR (p = 0.000) stood out as statistically significant factors in the univariate logistic regression and were included in the logistic regression model confirming the predictive value of these parameters regarding DI. This relationship was not observed for the HMDn (p = 0.209) (Table 3).

The validity of the distinguished predictors of DI was assessed by determining the sensitivity and specificity of each parameter separately (Table 4). The HMDR manifested the best diagnostic performance in assessing DI. The HMDR had a sensitivity of 95.6% and specificity of 69.2%. The HMDe demonstrated a lower sensitivity (75.9%) (The possibility to mark the patients with DI) than the previously mentioned parameter, however, it showed a similar specificity (61.5%) (The possibility to mark the patients without DI). The Mallampati score (I+II vs. III+IV) demonstrated a considerably lower sensitivity (6.4%) than the two previously mentioned parameters, however, the specificity was similar (61.5%). The sensitivity of the HMDn for predicting DI was 30.8% and specificity was 83.1% (Figure 1).

TABLE 2. Parameters of DI

Observed factors	DI		*p*-value
	No (%)	Yes (%)	
Mallampati n (%)			
I	86 (34.5)	5 (38.5)	[a]*p*=0.000*
II	147 (59.0)	3 (23.1)	
III	16 (6.4)	5 (38.5)	
HMDe n (%)			
<5.3 cm	60 (24.1)	8 (61.5)	[a]*p*=0.003*
5.3 cm and more	189 (75.9)	5 (38.5)	
HMDn n (%)			
5.5 cm and less	207 (83.1)	9 (69.2)	[a]*p*=0.199
>5.5 cm	42 (16.9)	4 (30.8)	
HMDR			
1.2 and less	11 (4.4)	9 (69.2)	[a]*p*=0.000*
>1.2	238 (95.6)	4 (30.8)	

*Statistically significant difference; [a]χ^2-test, DI: Difficult intubation, HMDe: Hyomental distance at the extreme of head extension, HMDn: Hyomental distance in the neutral position, HMDR: Hyomental distance ratio

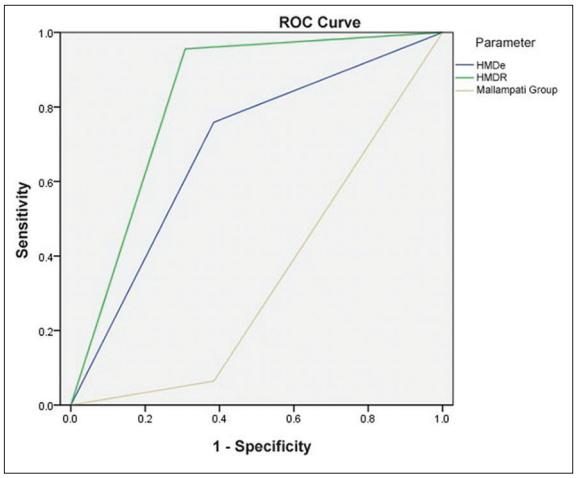

FIGURE 1. Receiver-operating-characteristic (ROC) curve of the sensitivity and specificity of hyomental distance at the extreme of head extension (HMDe), hyomental distance ratio (HMDR), and the Mallampati group in predicting difficult intubation.

DISCUSSION

Difficult visualization of the larynx is the most common cause of DI in a large number of patients. The frequency of DI varies depending on the characteristics of the subpopulation (with or without anatomical anomalies), the experience of the anesthesiologist, equipment, and other factors [1-3]. In our study, the frequency of DI was 5% and HMDR stood out as the most significant predicting factor.

Although our study showed that DI was much more present in men than in women (7% vs. 3.4%), this proved not to be statistically relevant. Other studies showed similar results, including the study by Rose and Cohen which investigated 18,500 patients and established that DI was often present in men [11]. Furthermore, the study by Kalezić et al. [2] noted that the frequency of DI was more present in men. This fact was established by investigating 2,000 patients that underwent thyroid operations.

TABLE 3. Uni- and multivariate logistic regression analysis of the impact of observed risk factors for DI

Observed risk factors	Univariate		Multivariate	
	#expB (95%CI)	*p*-value	expB (95%CI)	*p*-value
Sex	0.463 (0.147-1.456)	*p*=0.188	-	-
Age	1.042 (0.997-1.088)	*p*=0.067	-	-
BMI	3.510 (0.762-16.177)	*p*=0.107	-	-
Cormack Lehane	0.001 (0.000-0.002)	*p*=0.989	-	-
Mallampati score	9.102 (2.669-31.039)	*p*=0.000*	7.369 (1.266-42.911)	*p*=0.026*
HMDe	0.198 (0.063-0.629)	*p*=0.006*	0.056 (0.006-0.499)	*p*=0.010*
HMDn	2.190 (0.644-7.446)	*p*=0.209	-	-
HMDR	0.021 (0.005-0.077)	*p*=0.000*	0.007 (0.001-0.061)	*p*=0.000*

*Statistically significant; #Relative risk, DI: Difficult intubation, BMI: Body mass index, CI: Confidence interval, HMDe: Hyomental distance at the extreme of head extension, HMDn: Hyomental distance in the neutral position, HMDR: Hyomental distance ratio

TABLE 4. Validity of distinguished predictors of DI (diagnostic performances of distinguished risk factors for DI)

Predictors of difficult intubation	Sensitivity	Specificity	AUC of ROC curve (95% CI)
Mallampati score	0.064	0.615	0.340 (0.162-0.518)
HMDR	0.956	0.692	0.824 (0.672-0.976)
HMDe	0.759	0.615	0.687 (0.529-0.845)
HMDn	0.308	0.831	0.570 (0.399-0.740)

DI: Difficult intubation , AUC: Area under the curve, ROC: Receiver operating characteristic, CI: Confidence interval, HMDR: Hyomental distance ratio, HMDe: Hyomental distance at the extreme of head extension, HMDn: Hyomental distance in the neutral position

The term HMDR was the first introduced by Takenaka et al. [6]. The authors measured the values of HMDR of 40 patients with rheumatoid arthritis. They were in a sitting position, which was a predictor of a reduced occipitoatlanto-axial extension capacity.

In their study, Huh et al. used HMDR as a predictor of difficult visualization of the larynx. By investigating 213 adult patients who underwent elective surgical operations under general endotracheal anesthesia Huh et al. measured HMDR of the patients who were in a lying position comparing it with the values of the existing predictors (the Mallampati score, the thyromental distance, HMDe, and HMDn). In their view, the values of HMDR which were 1.2 or less indicated that difficult visualization of the larynx was present. Furthermore, it indicated greater sensitivity of this parameter than the other parameters, despite its somewhat lower specificity [7]. Rao and Gowda [12] investigated HMDR, HMDe, and HMDn in 198 patients, and this was also performed by Honarmand et al.[13] who compared HMDR with several other parameters including the modified Mallampati test (MMT). These studies showed that HMDR was a significant predictor of DI.

Our research also indicated HMDR as the best predictor of DI. 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. Therefore, it stood out as an autonomous, i.e., the most powerful predictor of DI.

In our study, the Mallampati score proved to be a significant predictor of DI. Similar results were obtained by other studies. The values of the Mallampati score in predicting DI were analyzed in a meta-analysis, which investigated 34,513 patients from 42 studies [14]. For predicting DI, the modified Mallampati test was accurate (area under the sROC curve = 0.83 +/- 0.03) whereas the original Mallampati test demonstrated poor performance (area under the sROC curve = 0.58 +/- 0.12). Another meta-analysis, which included 50,760 patients from 35 studies, measured the values of several predictors of DI and pointed to the significance of the Mallampati score [15]. By investigating 1,674 patients,Yildiz et al. showed the MMT sensitivity of 35% in predicting DI [16]. Investigating 53,041 patients Kheterpal et al. [17] confirmed that Mallampati III or IV was an independent predictor of DI (p = 0,014). Similar results showing the significance of the Mallampati score were confirmed by several other studies[18-21]

However, some studies showed that the Mallampati score is not a reliable predictor of DI. For example, in the meta-analysis by Lundstrøm et al. [22], which included 177,088 patients from 55 studies, the prognostic value of the MMT was investigated in predicting DI. The results showed that the MMT was a less reliable predictor of DI than some previous meta-analyses had shown.

The results of our investigation showed the reliability of the Mallampati score in predicting DI, and HMDR and HMDe stood out as significant predictors of DI. Other predictors proved to be statistically insignificant.

CONCLUSION

HMDR can be used in the everyday work of anesthesiologists with HMDR values ≤1.2 as a reliable predictor of DI.

DECLARATION OF INTERESTS

The authors declare no conflict of interests.

ACKNOWLEDGMENTS

This work was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Grants No. 175 042: "Epidemiological investigations of risk factors for selected health disorders").

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