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PREDICTION OF THE DIFFICULT LARYNGOSCOPY WITH ULTRASOUND MEASUREMENTS OF HYOMENTAL DISTANCE

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Ultrasound measurement of hyomental distance is promising as a predictor for difficult laryngoscopy in cases of difficult airway management. The aim of the study was to evaluate the prognostic value of ultrasound measurement of hyomental distance (HMD) for prediction of difficult laryngoscopy. Hyomental distance was sonographically measured in neutral (HMDn) and extreme head extension (HMDe) positions for fifty-six patients scheduled for elective surgery requiring tracheal intubation. Then the hyomental distance ratio (HMDR) was calculated. According to presence of difficult laryngoscopy assessed by the Cormack–Lehane (CL) score, patients were divided into a difficult laryngoscopy group (DL, n = 15) and easy laryngoscopy group (EL, n = 41). We calculated the sensitivity and specificity of HMDn, HMDe, and HMDR for difficult laryngoscopy. DL was present in 15 (27%) patients. We found a significant intergroup difference in HMDR between the DL and EL groups (1.12 ± 0.04 vs. 1.24 ± 0.06, respectively; $p < 0.001$*). In contrast, we were not able to find a significant difference for HMDn and HMDr. HMDR had the highest sensitivity 86.7% and specificity 85.4% (*$p < 0.01$*) to predict difficult laryngoscopy, where the area under the curve was 0.939;* $p < 0.01$ *for HDMR < 1.2 cm. Moreover, we found that difficult laryngoscopy was associated with higher body mass index (BMI), with higher values in the DL group compared to EL patients (34.3 ± 9.1 vs. 28.5 ± 5.7 kg/m*^{2}*, respectively;* $p = 0.035$*). HMDR < 1.2 cm measured by ultrasound might have a good predictive value for prediction of difficult laryngoscopy.*

Keywords: *airway ultrasound measurements, direct laryngoscopy, difficult intubation.*

INTRODUCTION

There exists no single precise definition of a difficult airway. It is accepted that a difficult airway can be defined as a clinical situation in which a conventionally trained anaesthesiologist has trouble with facemask ventilation of the upper airway, difficulty with tracheal intubation, or both (Jeffrey *et al*., 2013). The incidence of difficult intubation is 5.8%–9%, and failed intubation occurs in 0.005%–0.45% of cases (Workeneh *et al*., 2017; Schnittker *et al*., 2020). The rates are very variable, because there are different methods of detecting difficult intubation, and usually difficult intubation is a self-reported complication.

Difficult/failed intubation is associated with many factors like the patient's characteristics (age, weight, comorbidities), type of operation (common in neurosurgical or goiter operations), emergency surgery and skills of the operator as well. Consequently, there are many assessment methods used for evaluation of the airways. The most commonly used are Mallampati classification, thyromental distance, head and neck movement, body mass index (BMI), buck teeth, inter-incisor gap, upper lip bite test, presence of beard, and obvious external signs of head and neck (Seo *et al*., 2012; Crawley *et al*., 2015). Any of these signs have some value in prediction of the difficult intubation, but the precision of these single tests is poor. The predictive value increases by using combinations of these tests. Several multivariate scoring systems have been produced, including the Wilson Score, MTAC, and the Simplified Airway Risk Index (SARI) and Cormack Lehane (CL) score (Cattano *et al*., 2013; Nørskov *et al*., 2016; Vidhya *et al*., 2020). The evaluation of the combination of many clinical signs is time consuming and there is large interpersonal variability. Moreover, the airway assessment scores have not gained popularity as the benefits do not outweigh the invested time (Nørskov *et al*., 2016).

Ultrasound in recent years has been gaining popularity in anaesthesiology. Point-of-care ultrasound can be used for assessment of the airway and prediction of difficult intubation, and it is one of fields where there is still place for new research (Li *et al*., 2020; Bloom and Gibbons, 2022). The hyomental distance (HMD) is the distance between the hyoid bone and the tip of the chin. When the occipito-atlanto-axial complex is involved in the movement of the head, the chin bone moves away from the hyoid bone. In contrast, if head extension is performed only by sub axial joints, the lower jaw does not change its position with respect to the hyoid bone (Nichol *et al.,* 1983; Refshauge *et al.,* 1994; Sawin *et al.,* 1996). These movements of the chin bone from hyoid bone can be observed with ultrasound, with calculation of the hyomental distance ratio (HMDR). Furthermore, HMDR is correlated well with the radiologic occipito-atlanto-axial extension angle (Takenaka *et al.,* 2006).

An unexpected difficult intubation can be very challenging and worsens the patient's outcome, if not managed properly. This implies that the situation of difficult airway must be predicted, and airway assessment is a fundamental skill for the anaesthesiologist. We hypothesised that HMD measurements performed with ultrasound might have a good prognostic value for difficult laryngoscopy and could be a helpful tool to improve prediction of a difficult airway. Therefore, our aim was to assess the prognostic value of ultrasound measurement of hyomental distance (HMD) to predict difficult laryngoscopy, with a primary object to determine the sensitivity and specificity of HMD measurements for difficult laryngoscopy.

MATERIALS AND METHODS

The study protocol and the informed consent form were approved by the Ethics Committee of Rīga East Clinical University Hospital (Approval Number ZD/08-06/01-19/232).

Between 1 October and 31 December 2020, 56 consecutive adult patients were included in this prospective cohort study. The patients were scheduled for elective surgery under general anaesthesia and tracheal intubation in the Rīga East Clinical Hospital Gaiļezers, Rīga, Latvia. The inclusion criteria were: 18 years of age or older and ASA score of I-III. Exclusion criteria were planned fiberoptic intubation, patients with head and neck deformities, patients after head and neck operations, urgent patients with suspected full stomach and ASA score IV.

For further analysis patients were allocated into two groups according to presence of difficult laryngoscopy assessed by the Cormack–Lehane [CL] score: difficult laryngoscopy group (DL, n = 15) and easy laryngoscopy group (EL, n = 41).

Before the operation, HMD in neutral (HMDn) and extreme head extension (HMDe) positions was sonographically measured. Ultrasound scanning of the submandibular region was performed with a curvilinear transducer in sitting position. The ultrasound machine (Fujifilm, Sonosite Edge II, Bothell, USA) was used to perform measurements. In the suprahyoid region, a midsagittal longitudinal scan reveals the hypoechoic muscles forming the floor of the mouth between two hyperechoic bony structures that have a posterior acoustic shadowing: the hyoid bone and the posterior aspect of the *symphysis menti*, as seen in Figure 1 (Nørskov *et al.,* 2016).

The HMDR was calculated by dividing HMDe in extreme head extension by HMDn in neutral head position. The cut-off points for the DL predictors were HMDe < 5.3 cm, HMDn ≤ 5.5 cm, and HMDR ≤ 1.2. These measurements were made as described previous studies (Kalezić *et al.,* 2016). Also, the Cormack Lehane (CL) score (Table 1) was

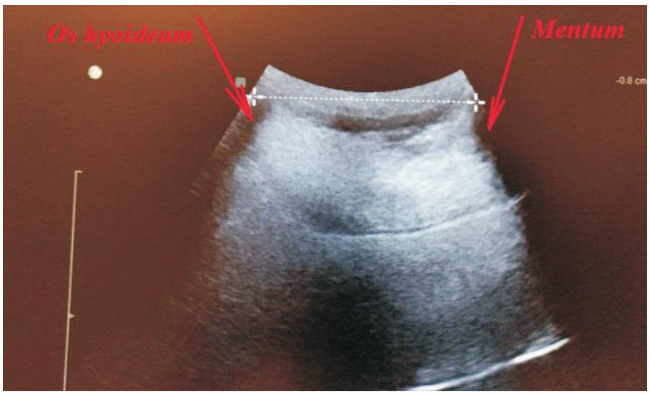

Fig. 1. Ultrasound picture of hyomental distance (HMD).

Table 1. Cormack–Lehane (CL) grade score system (Yentis *et al.,* 1998)

Grade	Description	Approximate frequency	Likely to have difficult intubation
1	Full view of glottis	68–74%	1%
2a	Partial view of glottis	21–24%	4.3–13.4%
2b	Only posterior extremity of glottis seen or only arytenoid cartilages	3.3–6.5%	65–67.4%
3	Only epiglottis seen, none of glottis seen	1.2–1.6%	80–87.5%
4	Neither glottis nor epiglottis seen	very rare	very likely

used to assess grade of difficult laryngoscopy (Cormack and Lehane, 1984; Koh *et al.,* 2002).

The CL grade was evaluated by experienced anaesthesiologist during direct laryngoscopy before the intubation, defining difficult laryngoscopy as CL grade 3 and 4, and easy laryngoscopy – CL grade 1 and 2.

All patients were premedicated with peroral 7.5 mg Midazolam (Dormicum®, F. Hoffman-La Roche AG, Switzerland) or 3 mg Bromazepam (Bromazepam Lannacher, GL Farma, Belgium). All patients underwent standard general anaesthesia including endotracheal intubation. We induced anaesthesia by injection of 1.5 μg/kg fentanyl (Fentanyl-Kalceks® 0.05 mg/ml, A/S Kalceks, Latvia), 1.5–2 mg/kg propofol (Propofol-Lipuro® 10 mg/ml, B. Braun Melsungen AG, Germany) and 0.5 mg/kg atracurium (Tracrium® 2mg/ml, GlaxoSmithKline Manufacturing,S.Polo, Torrile PR, Italy) intravenously and the intubation with direct laryngoscopy was performed after three minutes. Anaesthesia was maintained with inhalation of sevoflurane (Sevoflurane®, Piramal, Healthcare Ltd, United Kingdom) at 0.8–1.2 MAC, combined with fentanyl. Muscle relaxation was obtained with atracurium applied at 0.25 mg/kg per hour.

Statistical analysis was performed using SPSS 23.0 (Statistical Package for Social Sciences). We compared DL and EL patients. We used descriptive statistics for analysis of baseline demographics and clinical data, and chi-square analysis for comparison between groups, and within groups using independent samples test. Continuous variables were presented as mean ± standard deviation (SD) and categorical variables as percentages (%). ROC (Receiver Operator Characteristic) curve analysis was used to determine prognostic efficiency, and to estimate sensitivity and specificity using HMDR of 1.2 cm and for the Mallampati score between DL and EL groups. Results were expressed as area under the curve in the receiver-operator curve graph. Statistical significance was defined as $p < 0.05$.

RESULTS

In total, 56 consecutive patients, 28 (50%) males, and 28 (50%) females, 53 ± 13 years (mean ± SD) of age, scheduled for elective surgery under general anaesthesia with direct laryngoscopy and intubation, were considered for inclusion.

Difficult laryngoscopy with CL grade 3 and 4 occurred in 15 (27%) patients, who were included in the DL group. Comparison of demographic characteristics and airway measurements between the two groups is presented in Table 2. In the DL group, mean age was 51.3 ± 11.3, and in the EL group — 53.9 ± 14.5; $p = 0.526$. We found that BMI was significantly higher ($p = 0.035$) in the DL group than in the EL group. There was no significant intergroup difference in mean HMDn ($p = 0.164$) nor in the mean HMDe ($p = 0.054$) measurements. In contrast, HMDR significantly differed between both groups, with lower HMDR in the DL group: 1.12 ± 0.04 vs. EL group 1.24 ± 0.06; $p < 0.001$.

Table 2. Demographic characteristics and hyomental distance measurements of patients divided into two groups by CL grade

n = 56	EL group, n (%)	DL group, n (%)	*p* value
Age, years (mean ± SD)	53.9 ± 14.5	51.3 ± 11.3	0.526
Sex, male/female (n, %)	19/22 (46.3/53.7)	9/6 (60/40)	0.000
Body Mass Index (mean ± SD)	28.5 ± 5.7	34.3 ± 9.1	0.035
HMDn, cm	5.04 ± 0.5	5.28 ± 0.57	0.164
HMDe, cm	6.26 ± 0.59	5.9 ± 0.56	0.054
HMDR	1.24 ± 0.06	1.12 ± 0.04	< 0.001

Data are presented as mean ± SD or number (n) and percentage (%).

EL, easy larygoscopy; DL, difficult laryngoscopy; HMDR, hyomental distance ratio; HMDn, hyomental distance in neutral head position; HMDn, hyomental distance in extreme head extension position.

Within the DL group, six (40%) patients required one intubation attempt, six (40%) required two attempts, and three (20%) needed three attempts for successful intubation. Within the DL group with CL grades were 3 and 4, we observed low sensitivity 66.7% and specificity 53.7% ($p > 0.05$) for the modified Mallampati score in predicting difficult laryngoscopy.

Regarding HMD measurements estimated by ultrasound, we were not able to find significant difference in predicting difficult laryngoscopy for HMDn ≤ 5.5 cm (sensitivity only 40% and specificity 78%). In contrast HMDe ≤ 5.3 cm had sensitivity 33.3% and specificity 95.1%; $p < 0.05$. The calculated HMDR showed highest sensitivity and specificity — 86.7% and 85.4%, respectively, with strong statistical significance $p < 0.05$. HDMR < 1.2 cm gave an area under the curve of 0.939 ($p < 0.01$), shown in Figure 2. In contrast, for the Mallampati score, the area under the curve was low — only 0.647, without significant difference.

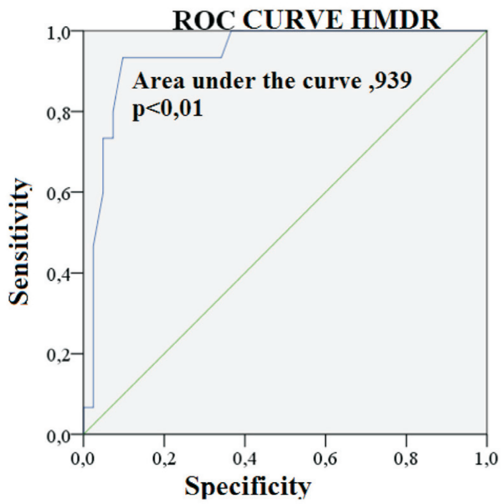

Fig. 2. HMDR specificity 86.7% and sensitivity 85.4% to predict difficult laryngoscopy ($p < 0.05$). For HDMR cut off value 1.2 cm area under the curve 0.939 ($p < 0.01$).

DISCUSSION

It is still a concern to avoid unanticipated difficult intubation, and it is likely the most important cause of major anaesthesia-related morbidity (Combes *et al.,* 2004). Up to now, mouth opening and the Mallampati score are the most often used tools in preoperative evaluation to anticipate a difficult airway. However, not all patients with a difficult airway have obvious specific signs. Ultrasound measured HMD might be a new tool for more precise prediction of difficult laryngoscopy, and awake fiberoptic intubation could be a gold standard for difficult airway management (Juels, 2018).

In the present study, difficult direct laryngoscopy was observed in 27% (15 patients). These patients also had a significantly lower HDMR compared to those who had easy laryngoscopy. To assess difficult laryngoscopy, we used the Cormack Lehane (CL) score grade 3 and 4. Other studies have shown that the incidence of difficult laryngoscopy is very variable, ranging from 9.5–16.7% (Dargin *et al.,* 2013; Prakash *et al.*, 2013; De Jong *et al.,* 2015; Wang *et al.,* 2018). This noticeable difference can be explained by patient selection bias. Therefore, the incidence of a difficult airway in the general population was not the aim of our study. We tested whether HMD measurement by ultrasound and calculated HMDR might be helpful and a more precise tool in prediction of a difficult laryngoscopy. Our most compelling finding was that HMDR showed the highest sensitivity and specificity in prediction of a difficult laryngoscopy and consequently more often difficult intubation. We admit that the studied patients in both groups were overweight with mean BMI 28.5 kg/m^2 in the EL group and 34.3 kg/m^2 in the DL group, which might have contributed to a higher incidence of difficult laryngoscopy incidence. Therefore, it is still uncertain to conclude that HMDR is correlated with difficult laryngoscopy in the general population.

In the present study, we also found that patients with greater BMI had difficult laryngoscopy more often than patients with smaller BMI. In contrast, patient body weight alone was not a specific factor for a difficult laryngoscopy.

We also found that the Mallampati score had relatively low sensitivity and specificity (66.7% and 53.7%, respectively) to predict a difficult laryngoscopy. This was also reported in several other studies (Adamus *et al.,* 2010; Lundstrøm *et al.,* 2011), which concluded that the Mallampati score is inadequate as a stand-alone test of a difficult laryngoscopy or tracheal intubation, but it may well be a part of a multivariate model for the prediction of a difficult tracheal intubation.

We found that HMDR demonstrated the highest prediction rate for difficult laryngoscopy, with sensitivity of 86.7% and specificity of 85.4% ($p < 0.01$), but difficult laryngoscopy was not always associated with difficult intubation. In our study, for six (40%) patients in the DL group one intubation attempt was sufficient to successfully secure the airways. One intubation attempt suggests that intubation was easy even if the CL grade was 3 and 4. These findings are consistent with those of other studies (Huh *et al.,* 2009; Prakash *et al.* 2013; Kalezić *et al*., 2016; Sotoodehnia *et al.,* 2021), which reported that there were no patients with failed intubation. When the first attempt was unsuccessful, the intubation was performed by videolarygoscopy. It was not necessary to apply fiberoptic intubation. As convincingly observed by other authors, videolarygoscopy can significantly improve the success rate in a difficult airway (Stroumpoulis *et al.,* 2009; Lewis *et al.,* 2016).

LIMITATIONS

Our study was conducted in a single centre, which resulted in a patient selection bias. Also, the overall sample size was only 56 and in the DL group there were only 16 patients. Nevertheless, our results represent a good pilot study for further investigation on point-of-care ultrasound use to predict difficult airways. Moreover, our results cannot be addressed to the overall population, as the studied cohort had a high proportion of overweight patients, causing a bias in difficult laryngoscopy incidence. Last but not the least, it is likely that an experienced airway operator potentially would be more successful than an unexperienced one, and in this study all of the direct laryngoscopy attempts were performed by one experienced anaesthesiologist.

CONCLUSION

HMDR < 1.2 cm measured by ultrasound might have a good predictive value for prediction of a difficult laryngoscopy affecting difficult airway management strategy. It is still difficult to conclude that a difficult laryngoscopy is always associated with difficult intubation. Therefore, further studies are needed.

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GRŪTAS LARINGOSKOPIJAS PROGNOZĒŠANA AR HIOMENTĀLĀ ATTĀLUMA IZMĒRA ULTRASKAŅAS MĒRĪJUMIEM

Veiksmīgai intubācijas norisei vissvarīgākais ir laicīgi paredzēt grūtu intubāciju un tai sagatavoties. Pētījuma mērķis bija novērtēt ultrasonogrāfiski izmērīto hiomentālo attālumu (HMA) un tā prognostisko lomu grūtas laringoskopijas prognozēšanā. Pētījumā iekļāva 56 pacientus, kuriem veica plānveida operāciju ar trahejas intubāciju. Pirms operācijas ultrasonogrāfiski tika izmērīts hiomentālais attālums neitrālā (HMAn) un maksimāli atliektā galvas pozīcijā (HMAma). Tad tika izrēķināta hiomentālo attālumu attiecība (HMAA). Pacienti tika iedalīti grūtas laringoskopijas (GL, n = 15) un vieglas laringoskopijas (VL, n = 41) grupā atkarībā no Kormaka–Lehana (*Cormack-Lehane*) skalas novērtējuma tiešās laringoskopijas laikā. Tika noteikts jutīgums un specifiskums HMAn, HMAma, HMAA. Statistiskā ticamība $p < 0{,}05$. No 56 pacientiem GL bija 15 (27%) pacientiem. Mēs atradām, ka HMAA mērījumi GL grupā bija statistiski mazāki nekā VL grupā, attiecīgi 1,12 ± 0,04 vs. 1,24 ± 0,06; $p < 0{,}001$. Savukārt, HMAn un HMAma mērījumos nebija statistiski ticamu atšķirību starp grupām. Mēs konstatējām, ka grūta laringoskopija bija saistīta ar palielinātu ķermeņa masas indeksu (ĶMI), kas GL grupā bija 34,3 ± 9,1 kg/m^2, savukārt VL grupā — 28,5 ± 5,7 kg/m^2, $p = 0{,}035$. HMAA uzrādīja visaugstāko jutīgumu 86,7% un specifiskumu 85,4%, lai prognozētu grūtu laringoskopiju; $p < 0{,}01$. HMAA < 1,2 uzrādīja AUC (*Area under curve*) 0,939; $p < 0{,}01$. Ultrasonogrāfiski izmērītai HMAA < 1,2 cm ir augsta prognostiskā vērtība grūtas laringoskopijas paredzēšanā.