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GACETA MÉDICA DE MÉXICO **ORIGINAL ARTICLE**

Diagnostic utility of the hyomental distance ratio as predictor of difficult intubation at UMAE 25

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Abstract

Background: *The hyomental distance ratio is defined as the ratio of the hyomental distances in neutral position and at head extension. The aim of the study was to establish the diagnostic utility as predictor of difficult intubation.* **Methods:** *In a cross-sectional study, the assessment of the airway was performed in 70 patients (35 male and 35 female, 15-75 years old) undergoing general anesthesia with endotracheal intubation for elective surgery. We assessed Mallampati, Patil Aldreti, interincisive distance, Bellhouse Dore scales and hyomental distance ratio. Subsequently, laryngoscopy was performed and the view graded with Cormack scale. We define "difficult intubation" as Cormack III and IV. We determined the diagnostic utility of the scales and the hyomental distance ratio.* **Results:** *For hyomental distance ratio of ≤ 1.2 we calculated sensitivity, 60%; specificity, 20%; positive predictive value, 5%; negative predictive value, 86%; positive likelihood ratio of 0.75 and negative likelihood ratio of 2.* **Conclusions:** *The hyomental distance ratio, as predictor of difficult intubation, has little utility.* (Gac Med Mex. 2015;151:559-66)

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KEY WORDS: *Hyomental distance ratio. Difficult intubation. Airway.*

Introduction

Anesthesiology is a medical specialty mainly oriented to the management of the patient undergoing a surgical procedure. For this purpose it uses different techniques and procedures, with airway management standing out.

The first reported intubation in a human being corresponds to Avicenna in the year 1000 and the first airway instrumentation similar to current technique corresponds to William MacEwen in 1800[1]. Inadequate approach to the airway exposes the patient to injury and increases the risk for death. Therefore, its adequate assessment is important.

By definition, the airway is a conduit through which the air passes[2]; or it is the route by which the air travels from the nose or mouth to the lungs[3]. Hence, difficult airway can be defined as complexity to access the conduit through which the air passes from the nose or mouth to the lungs[1].

The American Society of Anesthesiologists defines the difficult airway as the clinical situation in which a conventionally trained anesthesiologist experiments difficulty with facemask ventilation of the upper airway, difficulty with tracheal intubation, or both[4,5]. Difficulty with intubation occurs when more than three intubation attempts have been made using conventional laryngoscopy in optimal conditions and by experieced personnel[6]. Facemask inadequate ventilation occurs when

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oxygen saturation (SpO2) fails to be maintained above 90% with oxygen administered at 100%, under positive pressure[6].

Additionally, difficult intubation is defined as inadequate visualization of the glottis when direct laryngoscopy is performed. Endotracheal intubation failure is defined as incapacity to insert the tube across the oropharynx and towards the trachea[7,8].

Physical examination of the airway does not require special equipment and it does not take more than a minute; first, it focuses on the teeth, then on examination of the mouth's interior, it follows with the mandibular space and finally with the neck[9].

In the interincisor distance scale, the patient is explored with the mouth wide open; it assesses the distance beween upper and lower incisors; if the patient has anodontia, the distance between upper and lower gums will be measured at the level of the midline[10-13]. Mouth opening under 3 cm is a predictor of difficult intubation[14]. There are 4 classes:

- Class I: more than 3 cm.
- Class II: from 2.6 to 3 cm.
- Class III: from 2 to 2.5 cm.
- Class IV: less than 2 cm.

In 1985, Mallampati proposed a simple test that is widely used and that was modified by Samsoon and Young in 1987[15,16]. It consists in a simple clinical assessment system where the size of the tongue is observed in relation to the oropharynx[6]. It is performed with the patient sitting up straight, the head in neutral position; then, the examiner asks the patient to open the mouth as widely as possible and to stick out the tongue without speaking or articulating[16]. There are 4 classes:

- Class I: visibility of soft palate, uvula and tonsillar pillars.
- Class II: visibility of soft palate and uvula.
- Visibility of soft palate and base of uvula.
- Class IV: impossibility to visualize soft palate.

Modified Mallampati has become an oropharyngeal assessment standard method, although as only test is thought to be of limited diagnostic value. In addition, there may be inter-observer variations if phonation is associated or if the patient curves outwards or depresses the tongue[17].

In spite of its deficiencies, this test remains an important element of the patient's assessment prior to intubation, since Mallampati classes I and II are associated with low rates of failure during intubation, whereas difficult intubation is more likely with Mallampati classes III and IV[18,19].

The Patil-Aldreti scale measures the distance between the thyroid cartilage (superior notch) and the lower edge of the chin[21,22]. It includes 3 classes:

- Class I: more than 6.5 cm (laryngoscopy and endotracheal intubation without difficulty).
- Class II: from 6 to 6.5 cm (laryngoscopy and intubation with certain degree of difficulty).
- Class III: less than 6 cm (laryngoscopy and intubation very difficult).

In the Bellhouse Doré scale, the patient is explored in the sitting position with the head fully extended, it assesses the extension of the atlanto-occipital articulation with regard to the 35º of normality[23,24]. There are 4 grades:

- Grade I: no limitation.
- Grade II: 1/3 limitation.
- Grade III: 2/3 limitation.
- Grade IV: complete limitation.

An extension of less than 30º may difficult the "sniffing" position for intubation, and limit laryngoscopic vision as well; when extension of the head above the spine is absent or reduced by two thirds, intubation difficulties can be anticipated[25].

The scale proposed by Cormack and Lehane in 1984 describes four grades of glottic exposure during direct laryngoscopy; final score is obtained when direct visualization is made during the laryngoscopic procedure[26].

- Grade I: glottic opening is entirely visible (intubation very easy).
- Grade II: only the commissure or upper half of the glottic opening is visible (difficult)
- Grade III: only the epiglottis is visible with no visualization of the glottic opening (very difficult).
- Grade IV: impossibility to visualize even the epiglottis (intubation only possible with special techniques).

Consequently, it is accepted that difficulty for intubation can be suspected and even confirmed when Grade III or IV of this classification is scored with laryngoscopy[26].

Currently, available tests for difficult intubation detection have only poor to moderate discriminating power when used alone. The combination of tests increases the diagnostic value for difficult intubation[25].

In 2006, Takenaka et al., in their publication "Preoperative Evaluation of Extension Capacity of the Occipitoatlantoaxial Complex in Patients with Rheumatoid Arthritis, Comparison between the Bellhouse Test and a New Method, Hyomental Distance Ratio", introduced a new tool to assess the airway. They defined

the hyomental distance ratio as the ratio of the hyomental distances in neutral position and in head extension position[27]. Subsequently, in "Diagnostic Predictor of Difficult Laryngoscopy: The Hyomental Distance Ratio", published by Duk-Kyung Kim et al., the authors established that the 1.2 ratio has the highest diagnostic accuracy to predict difficult visualization of the larynx[28].

"Predictive Value of Difficult Airway Assessments"[29] by Ríos García and "Difficult airway prediction by means of airway assessment scales"[20] by Orozco Díaz reviewed the usefulness of difficult airway predictor assessments in Mexican cohorts. The same was done by Vasudevan with an Indian cohort in his study "Predictors of difficult intubation – a simple approach"[30]. None of the above mentioned studies includes the hyomental distance ratio.

The airway and its managements is one of the cornerstones of antesthetic treatment. Particularly, the difficult airway represents a considerable challenge and sometimes it constitutes an emergency situation. Difficulty in intubation is usually associated with difficulty to expose the glottis by direct laryngoscopy[30].

Although difficult airway is classically associated with the surgical act, it can occur in any area of the hospital, since this must be identified and diagnosed in every patient susceptible to be managed with mechanical ventilation[29].

There are no statistical data in current literature on difficult airway incidence in the operating room[1]. Benumof et al. estimate that nearly 30% of anesthesia-associated deaths are due to failure to adequately manage the airway[9]. Numerous multi-center studies conducted in the USA at emergency departments show an intubation success rate higher than 98%, with a failed intubation frequency of 1 in 500[6].

Domino et al. published and analysis on the incidence of airway injuries during general anesthesia, where they found the larynx to be the most common site of injury (33%), followed by the pharynx (19%) and the esophagus (18%)[1]. Tracheal and esophageal lesions are correlated with difficult intubation[1]. Therefore, it is highly important for the patient's safety to identify a difficult airway beforehand in order to establish an appropriate approach plan.

For the diagnosis of difficult airway it is necessary to obtain a complete history and to perform a thorough physical examination that includes the difficult airway predictive classifications. However, neither of the assessments predicts difficult intubation with absolute sensitivity and predictive value, since endotracheal intubation depends on different anatomical factors[31-33]. Ríos and Reyes recommend the concurrent use of at least 3 of these assessments[29].

The hyomental distance ratio is an assessment that has been little studied world-wide and its application in Mexican population has not yet been described. Potentially, it represents yet another tool in the assessment of the difficult airway that would facilitate the work for the anesthesiologist and for every physician who routinely performs endotracheal intubation in our institution, as well as in other healthcare centers. Early detection of the patient with difficult airway allows for an anesthetic management adequate plan to be established, which increases the safety of the anesthetic procedure.

Our purpose is to establish the diagnostic usefulness of the hyomental distance ratio in a patient sample of the UMAE 25, as well as to determine its sensitivity and specificity.

Material and methods

Cross-sectional, analytic, observational study, approved by the Local Committee of Research and Ethics for Research on Health of the UMAE 25. The study did not represent any additional risk to the patient, since regardless of inclusion or not in the study, the patient was to undergo an anesthetic-surgical procedure, which had already been previously programmed by physicians foreign to the study. Refusal to participate in the study was in no moment reason for deferral of the anesthetic or surgical procedure and neither had an impact on medical treatment. All patients signed an informed consent letter and, in the case of minors, their legal guardians authorized their participation.

A non-probabilistic sample was performed by selecting consecutive cases over the month of January 2014 in the surgical area of the UMAE 25.

Inclusion criteria were the following:

- Male and female patients of 15 to 75 years of age.
- Elective surgical procedure.
- General anesthesia requiring orotracheal intubation.

Exclusion criteria were:

- Patients who refused to participate in the study. In the case of minors, patients whose legal guardians refused their participation in the study.
- Patients who, due to their clinical status, were unable to cooperate with airway assessment (low Glasgow comma scale score, mental retardation, dementia, etc.).

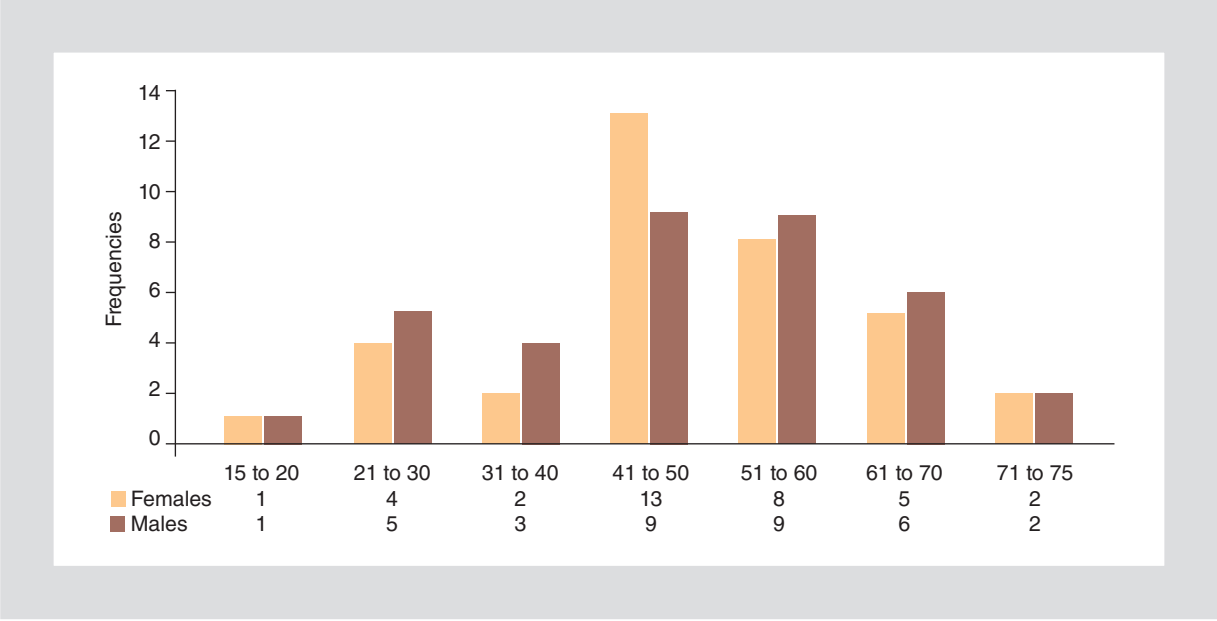

Figure 1. *Distribution of frequencies in females and males, according to age range in years.*

- Anatomical abnormalities altering the airway (deformity, tumors, etc.) and that precluded airway exploration regardless of the diagnosis the surgical procedure was to be performed for.
- Patients already intubated.

One of the responsible physicians of the study selected the patients and assessed the airway in those who decided to participate. The Samsoon and Young-modified Mallampaty classification, the Patil Aldreti scale, the interincisor distance and the Bellhouse Doré classification were assessed, the hyomental distance was measured with the head in neutral position and head in maximal extension position and the hyomental distance ratio was calculated. Name, sex, presurgical diagnosis and planned surgery were also recorded.

Patients with probable difficult airway were identified. We defined "probable difficult airway" as the presence of the following 4 characteristics:

- Class III or IV Samsoon and Young-modified Mallampaty.
- Class III Patil Aldreti.
- Class II, III or IV interincisor distance.
- Grade III or IV Bellhouse Doré.

The information was collected in case report forms specially designed for this study.

The patient remained in charge of the treating anesthesiologist from his/her admission to the operating room to his/her discharge. In the operating room, standard monitoring and anesthetic induction were carried out. Direct laryngoscopy was performed using a #3 Macintosh blade, and the patient's Cormack Lehane was recorded in the report form. We defined "difficulty at intubation" as Cormack Lehane grades III and IV. After intubation, the patient's participation in the study was considered terminated.

For the data analysis, Student's t and chi-square statistical techniques were used. The selected value of significance was $p < 0.05$. Specificity, sensitivity, likelihood ratios and predictive values were obtained.

Results

In the present cross-sectional-type investigation, which was carried out with the purpose of determining the hyomental distance ratio in patients attending the UMAE 25, where 70 patients aged from 15 to 75 years who met the inclusion criteria participated, the following values were identified with regard to the arithmetic mean and the standard deviation.

The arithmetic mean value with regard to the age variable was 48.228, and the value of the standard deviation was 14.609 (Fig. 1). Frequency distribution of participants with regard to gender was as follows: 35 participants (50%) were females, with a number of 35 (50%) corresponding to males.

From the airway assessment, we obtained 12 patients (17.1%) with class I modified Mallampati, 17 class II patients (24.3%), 13 class III patients (18.6%) and 28 class IV patients (40%) (Fig. 2). In the

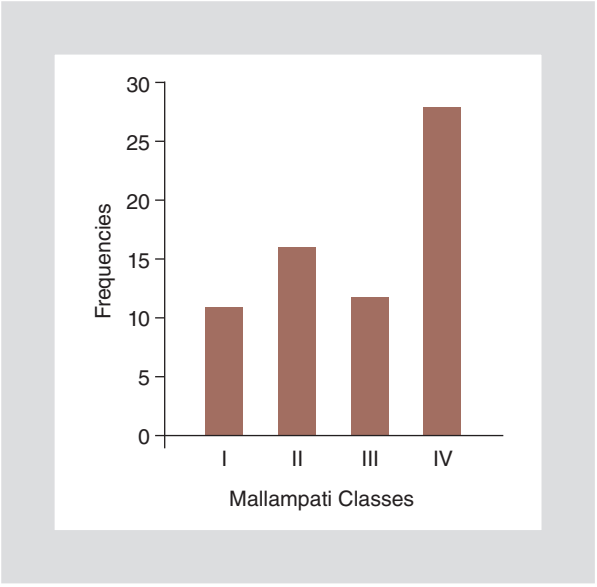

Figure 2. *Distribution of Samsoon and Young-modified Mallampati scale frequencies.*

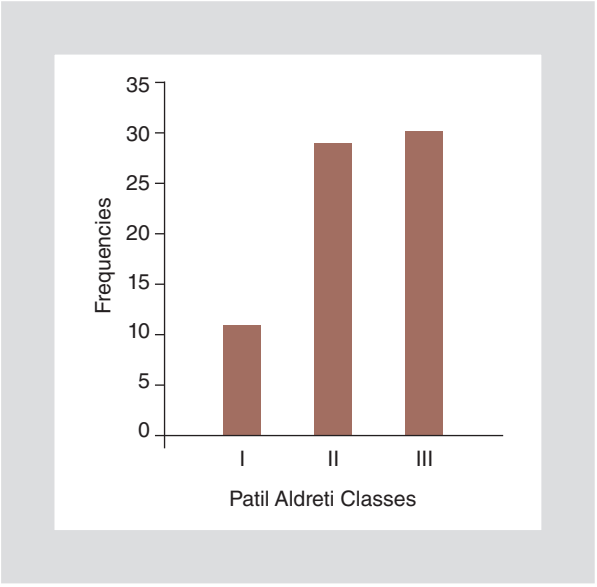

Figure 3. *Distribution of Patil Aldreti scale frequencies.*

Patil Aldreti scale: 12 class I patients (17.1%), 28 class II patients (40%) and 30 class III patients (42.9%) (Fig. 3). As for interincisor distance, 61 patients (87.1%) were classified in class I, 5 patients (7.1%) in class II, 4 patients (5.7%) in class III and none in class IV (Fig. 4). In the Bellhouse Doré scale, 33 patients (47.1%) were found to be in grade I, 32 (45.7%) in grade II, 5 (7.1%) in grade III, and no patients were in grade IV (Fig. 5).

Of the 70 patients, none met the characteristics for "probable difficult airway" according to our definition.

When direct laryngoscopy was performed, of the entire sample of patients, 46 (65.7%) were observed to correspond to grade I Cormack Lehane, 19 (27.1%) to grade II, 4 (5.7%) to grade III and only 1 (1.4%) to grade IV (Fig. 6). According to our definition of "difficulty at intubation" 5 patientes (7.1%) meet the criteria.

The shortest hyomental distance with the head in neutral position was 2 cm and the longest was 4.5 cm. The most frequent distance was 3.5 cm (27 patients, 38.6%) and the lowest frequency corresponds to the 3.3 and 4.3 cm distances (1 patient each, 1.4% each).

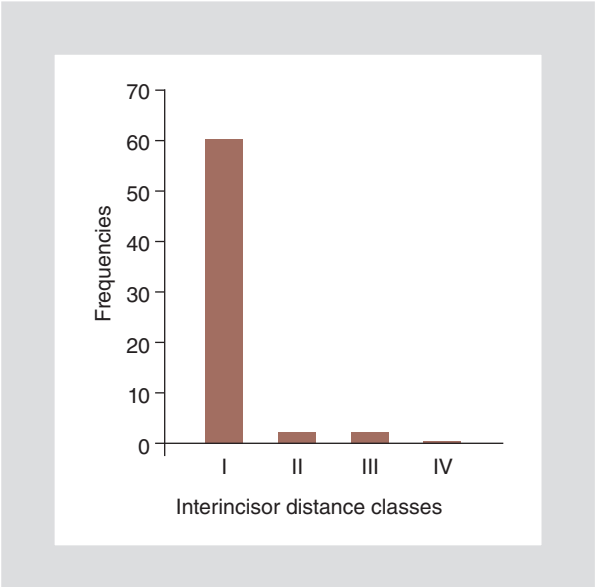

Figure 4. *Distribution of interincissor distance scale frequencies.*

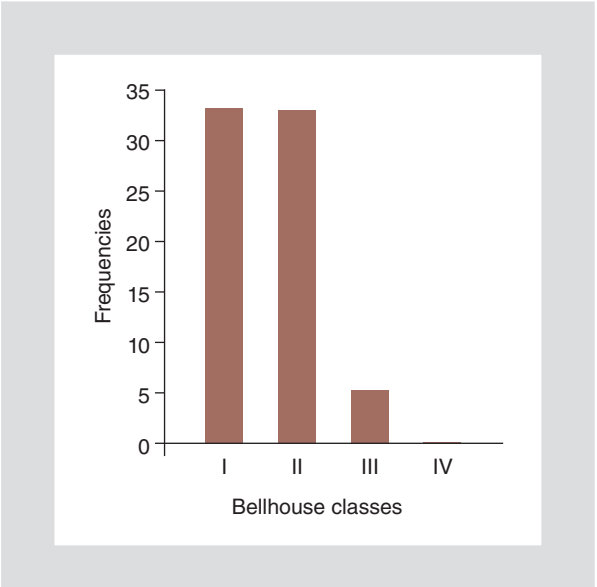

Figure 5. *Distribution of Bellhouse Doré scale classes frequencies.*

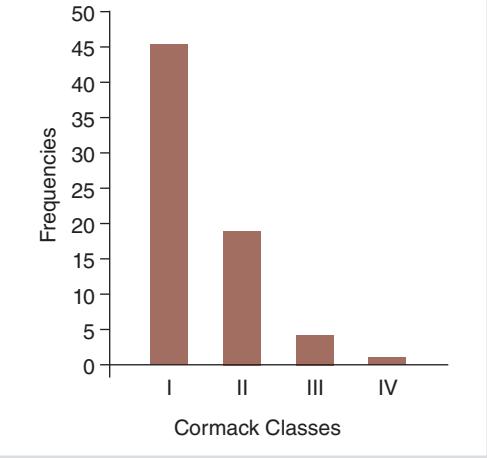

Figure 6. *Distribution of Cormack and Lehane scale classes frequencies.*

The longest and shortest measures were 2.5 and 5.5 cm, respectively, for the hyomental distance with maximum head extension. The most common distance was 4 cm (29 patients, 41.4%). The 3.8 and 4.7 cm distances were the least frequent (1 patient each, 1.4% each).

As for the hyomental distance ratio, the lowest value was 1.04, and the highest, 1.5. The ratio with the highest incidence was 1.14 (24 patients, 34.3%). Four ratios had the lowest incidence with a single patient each (1.4%): 1.06, 1.11, 1.26 and 1.37 (Fig. 7). A total of 55 patients (78.6%) have a ratio of 1.2 or lower.

Discussion

We consider that the assessed patients constitute a very heterogeneous group, since they comprise a broad age range with multiple diagnoses and surgical procedures.

Pediatric patients (younger than 15 years) were not considered for this study due to the different anatomical variations they have in the airway, which precludes adequate application of commonly used scales for assessment.

The obtained results show that 41 patients (58.6%) are within Samsoon and Young-modified Mallampati classes III and IV, which are correlated with difficult intubation. Sensitivity was 80% and specificity 43% (Table 1). According to Rios, a sensitivity of 15.2% and specifity of 15.9% are established for the Mexican population[29]. Orozco reports a sensitivity of 39% and specificity of 84%[20].

For the Patil Aldreti scale, 30 patients (42.9%) correspond to very difficult laryngoscopy and intubation (class III). Sensitivity and specificity for this scale is 9 and 25.7%, respectively[29], whereas in other publication, 45% sensitivity and 46% spacificity are mentioned[20]. In our study, we obtained a sensitivity and specificity of 20 and 55% (Table 1).

Only 9 patients (12.8%) had an interincisor distance shorter than 3 cm (classes II, III and IV), which predicts difficult intubation. Sensitivity and specificity obtained were 0 and 86%, respectively (Table 1). For this scale, Ríos reports a sensitivity of 1.33% and specificity of

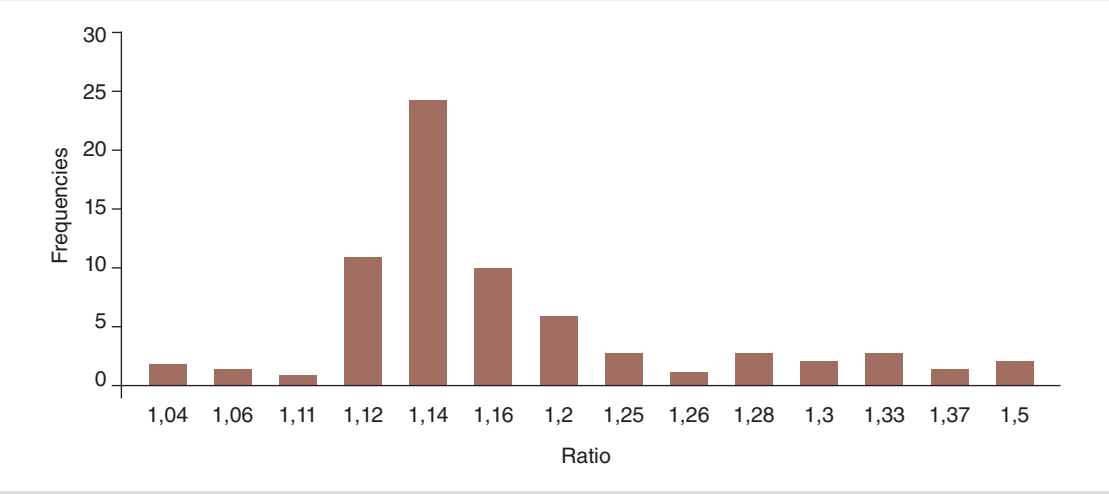

Figure 7. *Distribution of hyomental distance ratio frequencies.*

Table 1. Sensitivity and specifity of the different scales for airway assessment

Scale	Sensitivity	Specificity	PPV	NPV
Mallampati	80%	43%	9%	96%
Patil Aldreti	20%	55%	3%	90%
Interincisor distance	0%	86%	0%	91%
Bellhouse	0%	92%	0%	92%

PPV: positive predictive value; NPV: negative predictive value.

86.7%[29]. On the other hand, Orozco found sensitivity to be 10% and specificity, 98%[20].

Bellhouse Doré grades III and IV are considered to be difficult intubation. The scale has a sensitivity of 4.3% and specificity of 55%[29] in the study conducted by Ríos, and 13% sensitivity and 99% specificity in the study by Orozco[20]. We found 5 patients (7.1%) to be in these 2 grades; sensitivity was 0% and specificity 92% (Table 1).

We defined "probable difficult airway" as the presence of Samsoon and Young-modified Mallampati class III or IV, Patil Aldreti class III, interincisor distance class II, III or IV and Bellhouse Doré classification grade III or IV. We combined 4 tests in order to increase their diagnostic value. None of the participants in the present study met the criteria established for "probable difficult airway", which could mean that the use of these 4 tests in combination is not recommendable or that perhaps a larger number of tests is required to assess an individual.

We consider as "difficulty at intubation" those patients with Cormack and Lehane grades III and IV. We identified 5 patients (7.1%) in our study. Diffucult intubation incidence in Mexican populationis reported to be 15%[20,29]. In a study conducted in a population of India, an incidence of 8% was reported[30].

There are no publications on Mexican population assessing the hyomental distance or the hyomental distance ratio.

Vasudevan et al. evaluated the hyomental distance with the head completely extended and other scales. They found 385 patients (77.3%) with a measure of > 4 cm and 113 patients with a distance of ≤ 4 cm. They concuded that, in the following order, head extension restriction, decreased hyomental distance and a poor Mallampati class are significantly associated with difficult intubation. The odds ratio for patients with decreased hyomental distance (≤ 4 cm) was 3.4[30] and 0.6 in our study.

Wojtczak conducted a study where he used ultrasound to assess the airway in 12 obese patients (body mass index ≥ 30.1 kg/m^2). Among the variables he included the hyomental distances with neutral and maximum head extension and calculated the hyomental distance ratio. He concluded that ultrasound is particularly useful in obese patients because the hyoid bone is difficult to palpate on them. He divided them into 2 groups: easy intubation (Cormack Lehane I and II) and difficult intubation (Cormack Lehane III and IV). For the easy intubation group, the mean ratio was 1.02 ± 0.01[34]. In our study, mean hyomental distance ratio was 1.17 ± 0.08.

Takenaka et al. introduced the hyomental distance ratio in 2006 in a study where they compared it with the Bellhouse Doré test applied to patients with rheumatoid arthritis. They concluded that a ratio of 1.25 has a sensitivity of 90%, specificity of 84%, a positive likelihood ratio of 5.6 and a negative likelihood ratio of 0.12[57].

Duk-Kyung studied the usefulness of the hyomental distance ratio and other tests as predictors of difficult laryngoscopy. He obtained a sensitivity of 88%, specificity of 60%, a positive predictive value of 23% and negative predictive value of 97% for the ≤ 1.2 ratio [28].

The results obtained in our study, considering a ≤ 1.2 ratio, were 60% sensitivity, 20% specificity, 5% positive predictive value, 86% negative predictive value, a positive likelihood ratio of 0.75 and negative likelihood ratio of 2 (Table 2).

We managed to establish a sensitivity and specificity for the hyomental distance ratio applied to a Mexican cohort, especifically, in UMAE 25 patients. The present research enabled us to more clearly understand that the hyomental distance ratio, as a predictor of difficult intubation is of little use, although the desired statistical significance was not reached ($p < 0.05$), perhaps due to the size of the used sample.

The above allows us to mention that further medical studies are needed, assessing the hyomental distance

Table 2. Comparison of results for the hyomental distance ratio

Ratio	S	Sp	PPV	NPV	PLR	NLR
1.25*	90%	84%	–	–	5.6	0.12
≤ 1.2†	88%	60%	23%	97%	–	–
≤ 1.2‡	60%	20%	5%	86%	0.75	2

S: sensitivity, Sp: specificity; PPV: positive predictive value; NPV: negative predictive value; PLR: positive likelihood ratio; NLT: negative likelihood ratio.
*Takenaka et al.
†Duk-Kyung et al.
‡Obtained results.

ratio as difficult intubation predictor in different populations, different clinical situations and considering comorbidities that affect the airway.

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