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Assessment, prediction and occurrence of difficult intubation

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Abbreviations:
Mallampati (Ma)
Patil-Aldreti (PA)
Bell House-Doré (BHD)
Interincisive distance (ID)
Cormack -Lehane (Co-L)
Back up right position (BURP)

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SUMMARY

Generally, when evaluating upper tract in patients who were given general anesthesia, we expect that these tests present a high sensitiveness, allowing the tracheal instrumentation be performed with the fewest number of attempts and approaches. The predictive criteria of difficult intubation are classified by the scales of Mallampati II-IV, Bell House Doré II-III, Patil Aldreti II-III and interincisive distance; with a variation in both sensitiveness and specificity, according to the author of the research. This comparative study was carried out on 124 patients, both male and female, ranging from 18 to 60 years old, divided into two groups, I without predictive criteria, and II with predictive criteria. The data correlation by the laryngoscopy revealed: r = 0.80 by Mallampati. El Bell House Doré showed a sensitiveness of 0.76 and a specificity of 0.90; while the positive predictive value for interincisive distance was of 1, and the negative predictive value by Bell House Doré and Patil Aldreti was of 0.71. These values differ according to the evaluated anatomic structure; therefore, the prediction of a difficult intubation, as well as its presence, will depend on the used scale.

Key words: Difficult intubation, Mallampati, Patil Aldreti, Bell House Doré, interincisive distance, Cormack Lehane.

RESUMEN

Generalmente, al evaluar la vía aérea de pacientes, a quienes se administra anestesia general, esperamos que estas pruebas tengan una sensibilidad alta, permitiendo que la instrumentación de la tráquea se logre con el menor número de intentos y maniobras. Los criterios predictivos de intubación difícil, se clasifican según las escalas de Mallampati II-IV, Bell House Doré II-III, Patil Aldreti II-III y distancia interincisivos; variando tanto la sensibilidad como la especificidad, de acuerdo al autor de la investigación. Se realizó este estudio comparativo, en 124 pacientes, femeninos y masculinos, de 18 a 60 años, divididos en dos grupos, I sin y II con criterios predictivos. La correlación de los datos con la laringoscopía, reveló: r = 0.80 para el Mallampati. El Bell House Doré mostró sensibilidad de 0.76 y especificidad de 0.90; mientras que el valor predictivo positivo de la distancia interincisivos fue de 1, y el valor predictivo negativo para el Bell House Doré y Patil Aldreti de 0.71. Estos valores varían de acuerdo a la estructura anatómica evaluada, por lo que predecir una intubación difícil y que ésta se presente dependerá de la escala utilizada.

Palabras clave: *Intubación difícil, Mallampati, Patil Aldreti, Bell House Doré, distancia interincisivos, Cormack Lehane.*

BACKGROUND

The ability to secure the airway in a wide variety of patients and different clinical circumstances is a mandatory skill for healthcare providers. As difficult intubation is one of the most frequent causes of anesthesia-related morbidity and mortality, the evaluation of its risk in every surgical patient is essential for anesthesiologists. In a review of 1,541 cases, the American Society of Anesthesiologists (ASA) reported the existence of three injury mechanisms that resulted from three respiratory adverse effects, namely: inadequate ventilation, undetected esophageal intubation and unexpected difficult tracheal intubation. It is estimated that 30% of anesthesia-related deaths are caused by the inability to secure the airway. The ASA defines a *difficult airway* as the presence of clinical factors that complicate both the ventilation through a face mask and the intubation performed by an experienced individual under these clinical conditions. The *difficult ventilation* is defined as the inability of a trained anesthesiologist to maintain the oxygen saturation above 90% by means of a face mask, with a fraction of inspired oxygen of 100%; its occurrence is 0.05% to 0.1%. *Difficult intubation* is defined as the need for more than three attempts for intubation or more than 10 minutes to get it; it represents 1.2 to 3.8% of cases. It should be noted that the more difficult the intubation, the higher the incidence and severity of complications[1-5].

Factors contributing to a difficult intubation reported in literature are: obesity, limited neck mobility or mouth opening, inexperienced laryngoscopist, inadequate assistance, erroneous drug administration, dysfunctional or protuberant teeth, failure of the equipment, laryngeal or neck tumors, beard, masseter muscles spasm and recent traumatic intubation, among others. The most frequent complications associated to a difficult intubation are: arterial oxygen desaturation < 90%, esophageal intubation, cyanosis, regurgitation, bronchospasm, laryngospasm, dental injury, arrhythmia, endobronchial intubation, epistaxis, pharyngeal trauma and masseter muscles spasm[6].

There are multiple methods to identify patients at risk for a difficult intubation. The Mallampati (Ma) classification system, modified by Samsoon and Young, is widely used in the preoperative evaluation of patients. This system predicts the grade of difficulty for laryngoscopy based upon the visualization of the posterior pharyngeal structures. Assessment by the Ma score is conducted with the patient in sitting position by requesting mouth opening and maximum protrusion of the tongue. The physician observes the pharyngeal structures without the aid of a tongue depressor and class is diagnosed according to the visible structures (Class I: uvula, palatoglossal arch and soft palate; Class II: palatoglossal arch and soft palate; Class III: only soft palate; Class IV: only hard palate). Classes I or II predict a relatively easy intubation, whereas Classes III and IV indicate an increased probability for a difficult intubation and the need for special maneuvers or materials in the procedure.[7].

Other predictive factors for difficult intubation are: mouth opening less than 3 cm, interincisor distance (ID); Bell Hosuse-Doré (BHD) score; cervical motion less than 35° at the atlantooccipital joint; thyromental distance less than 7 cm as described on the Patil-Aldrete (PA) score (this measurement is considered an indicator of the mandibular space, which predicts the difficulty of displacement during laryngoscopy); protuberant incisors, short neck, narrow palate, and poor mandibular protrusion[8].

In 1984, Cormack and Lehane (Co-L) described a classification on the basis of the observed structures under direct laryngoscopy. This classification consists of four grades: Grade I: the larynx in its entirety; Grade II: only the posterior portion of the laryngeal opening; Grade III: epiglottis only; Grade IV: soft palate only. They conclude that Grades 3 and 4 foresee a difficult intubation. In order to use this score, the laryngoscopy must be performed with the patient in maximal "sniffing" position, under complete muscular relaxation, with firm traction, and firm external laryngeal manipulation[4,9].

Diverse correlations of multiple predictive criteria for difficult intubation have been conducted. Unfortunately most of the developed indexes for preoperative evaluation, when compared to the laryngoscopy and tracheal intubation, fail to identify difficulty showing low sensitivity or yielding false negative results, i.e., low specificity. However, Ma classification has been correlated with the Co-L score in several studies, among which Mallampati's (1985) study is remarkable. He concludes that the airway classes III and IV correspond with Co-L classes III and IV[2,4].

Several algorithms have been developed to simplify the difficult airway management and to reduce the incidence of its adverse events. They stress the value of an appropriate preoperative evaluation focusing on the search of difficult airway. The prediction is based on factors associated with a difficult intubation such as mouth opening, score obtained by Ma score, assessment of mobility of atlantooccipital and mandibular joints, thyromental and sternomental distances, degree of obesity, and history of difficult intubation [10-12].

Recognition of predictors using the appropriate material and the algorithms of the difficult airway contributes significantly in reducing morbidity and mortality associated with anesthetic induction. There are other factors that may complicate the access to the airway which are not considered in the previously mentioned classifications, such as: macroglossia, protruding incisors, beard, mustache and adontia, which can altogether be classified as *confounding* variables. However, criteria vary among studies and according to the type of population they address; most of them have been conducted on European and Northamerican population, with few reports in Latin America[13-18].

The score by Adnet *et al.* classifies the difficulty for intubation based upon seven parameters: N_1 = number of attempts for intubation; N_2 = number of additional operators; N_3 = number of alternative techniques used for intubation; N_4 = glottic exposure according to Co-L score, Grade 4 minus 1 Grade (Co-L grade 1 = N_4 of 0; 2 = N_4 of 1.3 = N_4 of 2 and 4 = N_4 of 3); N_5 = strength applied on the laryngoscopy ($N_5 = 0$ if it was not considerable, and $N_5 = 1$ if it was considerable); N_6 = external laryngeal pressure used to observe the larynx ($N_6 = 0$ if it was not needed or Sellick maneuver was enough, $N_6 = 1$ if laryngeal pressure was needed), and N_7 evaluates the position of the vocal cords at the moment of intubation ($N_7 = 0$, abducted or not visible and $N_7 = 1$ adducted). One point is to be added for each additional attempt, additional operator or alternative technique. The first attempt of intubation is the one that is classified as the glottic exposure. The sum of these parameters indicates the actual classification of the performed intubation (Table 1). The patients with predictive criteria for difficult intubation do not always display this condition; however, this condition is observed in some patients without these criteria, which points out the need to establish a correlation between both cases[19,20].

OBJECTIVES

Establish if the preoperative evaluation of the airway with predictive scores is correlated with the Co-L score when preformed by the same individual, as well as to determine if this evaluation decreases the occurrence of unexpected difficult intubation along with its secondary morbidity and mortality. Establish if criteria not included in these classifications affect the occurrence of unexpected difficult airway.

Table I. Scale of difficult intubation.*

Level of difficulty of intubation	Points
Easy	0
Light	$0 \leq 5$
Moderate to high	> 5
Impossible	∞

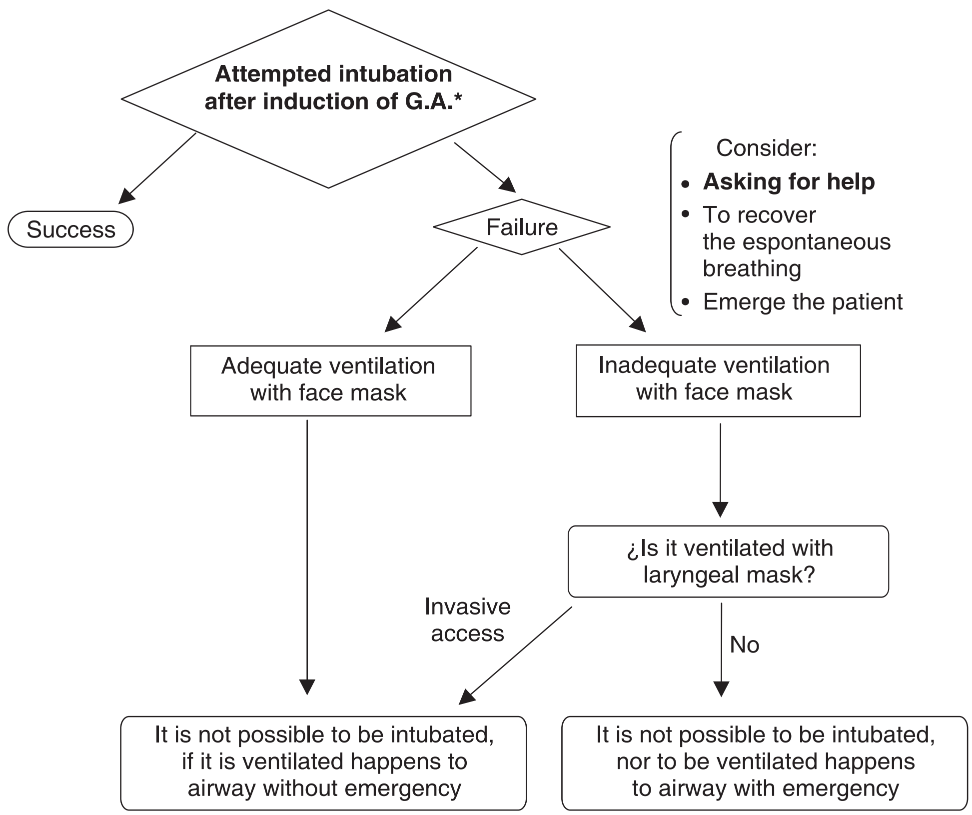
*The sum of points obtained during laryngoscopy, locates the degree of difficulty of intubation.

METHODS

In order to obtain the sample size of the population, it was established a difference of 0.25 from reviewed studies, a power of 0.9 and α 0.10, resulting in 62 patients per group. Under approval of the local Committee of Ethics and Research and with written informed consent obtained from patients, male and female patients aged 18 to 60 years, scheduled to undergo balanced general anesthesia, were recruited at the Anesthesiology Department of our Institution.. Pregnant women and patients suffering from diabetes, rheumatoid arthritis and collagen diseases were excluded. Patients without predictive criteria for difficult intubation were allocated to Group I or Control. Patients with one or more predictive criteria for difficult intubation (Ma III-IV, PA III, BHD II-III, ID less than 3 cm, history of difficult intubation, macroglossia, protruding incisors, short neck, obesity, presence of mustache and/or beard and snoring) were allocated to Group II. Airway evaluation of the patients who agreed to participate in the study was performed and a classification was established on the basis of the criteria for difficult intubation. Subsequently, direct laryngoscopy was performed during the anesthetic induction by establishing Co-L grade. Material used on the procedure, additional maneuvers, number of attempts and confounding variables were registered in record sheets. Monitoring of patients included continuous DII electrocardiogram, non-invasive blood pressure measurement, pulse oximetry and capnography. In both groups, anesthetic induction was obtained using 3 μg/kg fentanyl, 5 mg/kg thiopental sodium, and 80-100 μg/kg pancuronium or vecuronium. In the cases of difficult intubation, the ASA algorithm for the difficult airway management was followed. Data was analyzed to determine the cases to be classified as difficult intubation (Figures 1, 2, and 3).

RESULTS

Female gender was predominant in both groups, with 80 and 44 male patients, respectively. Group I was formed by 63% women and 37% men. Group II was formed by 66% women and 34% men. Age range was comparable among both groups (18 to 60 years old). Weight ranged between 30 and 95 kg in Group I and 40 and 108 in Group II; height ranged 1.44 to 1.81 m in Group I, and 1.44 to 1.94 m in Group II, which yielded a body mass index of 12.5 to 37.77 for Group I and 17 to 44.4 for Group II. Mean age, weight and height were superior in Group II. Moreover, 7 women with obesity were included in Group I; and 23 women and 4 men with obesity were included in Group II. The most frequent physical state according to ASA was Grade II in both groups. (Table II).



* G.A: General Anesthesia

Figure 1. Difficult airway algorithm, modified from Difficult Airway Society.

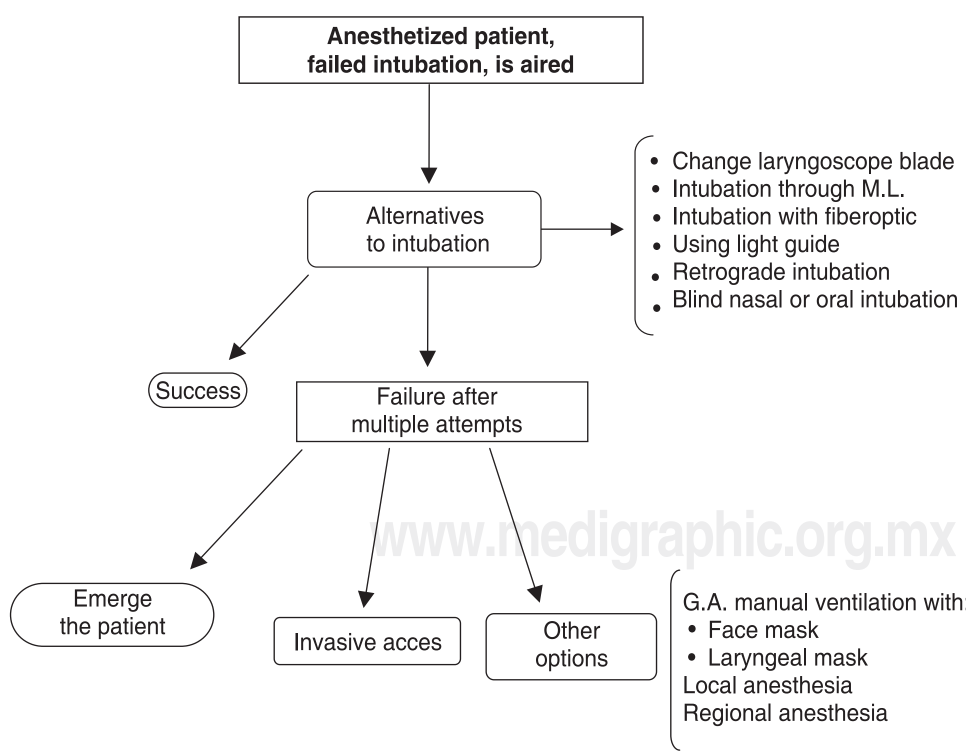


Figure 2. Difficult airway algorithm, without emergency, modified from Difficult Airway Society.

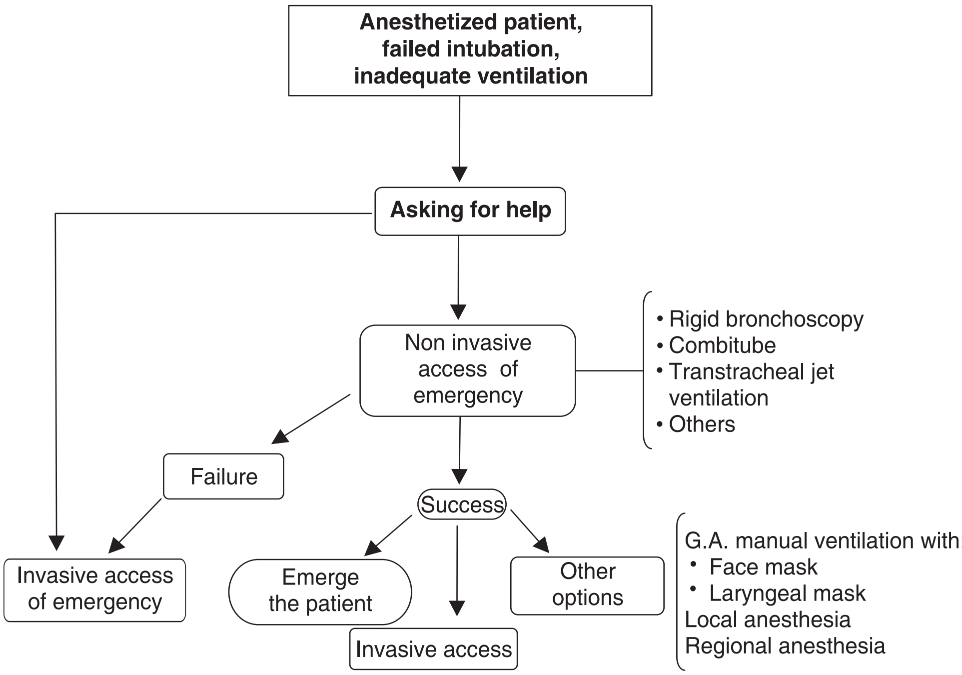


Figure 3. Difficult airway algorithm, with emergency, modified from Difficult Airway Society.

Abdominal surgeries were the most frequent among both study groups, including oncological, transplant and general surgery. Head surgery, corneal transplantation and rhinoseptoplasty were the next most frequent.

The predictive criteria for intubation (Ma, PA, BHD, and ID less than 3 cm) of Group I yielded inferior classes compared to those obtained in Group II. Co-L was also classified and Group I was distributed as follows: Grade I: 54.8%; Grade II: 30.6%; Grade III: 14.51%, whereas Group II showed the following distribution: Grade I: 9.67%; Grade II: 40.32%, Grade III: 41.93%, Grade IV: 8.06%. Distribution of frequencies is displayed in Table III.

In the operating room, after the anesthesia induction and during 100% oxygen ventilation through face mask (direct laryngoscopy) confounding variables that may complicate the ventilation or intubation were assessed. Among these are adontia which was observed in 5 and 11 patients in Groups I and II, respectively; protruding incisors which was observed in 3 and 2 patients; beard/mustache observed in in 9 and 6 patients; macroglossia observed only 3 patients in Group II. The total of patients with confounding variables was 14 in Group I and 25 in Group II.

If high probability of difficult intubation was suspected when assessing the predictive criteria, the ASA intubation algorithm was followed. Other resources were used, such as laryngoscopy with number 3 or 4 Maguill blade, the use of a stylet for the probe to be used, a pillow for cervical flexion, displacement of thyroid or cricoid cartilages in Back, Up, Right Position (BURP) conduction by two individuals, or tracheostomy. They were performed in both groups as shown in Table IV.

Table II. Demographic aspects.

Data	Group I $\overline{X}$ SD	Group II $\overline{X}$ SD
Age (years)	38.7 ± 13.54	41.97 ± 12.48
Weight (kg)	65.86 ± 11.81	70.02 ± 15.92
Height (m)	1.59 ± 0.09	1.59 ± 0.1
BMI	25.96 ± 4.48	27.7 ± 5.80
ASA I *(f)*	16	7
ASA II *(f)*	33	31
ASA III *(f)*	13	24

$\overline{X}$ = Mean; SD = ± 1 Standard deviation. BMI = Body mass index. Being similar to the height, but with greater weight in group II, BMI increases.

In Group II, 46 patients had anatomical characteristics that required the use of these maneuvers for the attainment of intubation and it was therefore classified as difficult. The number of maneuvers was quantified for each patient: four was the maximal number of them (stylet, pillow for neck flexion, "BURP" maneuvers, and intubation by two individuals) conducted in 3 patients; three was the maximal number in seven patients; two in 21 patients; one in 15 patients, and 16 patients did not need additional maneuvers. The most frequently used maneuver was "BURP" and the least used was intubation by two individuals. The

Table III. Frequency of predictive criteria of difficult intubation.

Scale	Group (*f*)	Degree I (*f*)	Degree II (*f*)	Degree III (*f*)	Degree IV (*f*)
Mallampati	I	31	31		
	II	1	15	38	8
Patil-Aldreti	I	48	14		
	II	16	30	16	
Bellhouse-Doré	I	54	8		
	II	17	41	4	
Interincisive distance	I	62			
	II	47	14	1	
Cormack Lehane	I	34	19	9	0
	II	6	25	26	5

f = Frequency. Frequency distribution by group of evaluated scales. When evaluating patients with Mallampati scale, of 46 likely to perform laryngoscopy, 31 were positive. Bell House Doré and Patil-Aldreti were similar. Interincisive distance, of 15, eight were positive.

Table IV. Frequency of realised maneuvers.

Maneuver		Group I (*f*)	Group II (*f*)
Attempts	1	58	49
	2	4	11
	3 or more	0	2
Number or sheet	3	59	53
Laryngoscope	4	3	9
Guide wire		8	40
Bulkhead		2	18
BURP		9	28
Two hands		0	4
Tracheostomy		0	0

f = Frequency. It shows the frequencies used, the maneuvers group totals, to achieve intubating the patient with difficult airway. The guidewire is used more often. The assistance of another person (two hands), less often.

additional maneuvers needed were also quantified in the Control Group : 52 patients did not require any, 2 patients required one, 7 patients needed two and one patient required 3 maneuvers. The most frequently used maneuver was "BURP" and the least needed was the use of a pillow for cervical flexion in the Group II. Data was analyzed using the difficult intubation score: in Group I, 33 intubations were classified as easy, 21 intubations were classified as mildly difficult, and 8 were classified as difficult. In Group II, 4 intubations were classified as easy, 32 were classified as mildly difficult, and 26 were classified as difficult. There were no cases of impossible intubation (Table V).

A correlation analysis between laryngoscopic grades and Ma, BHD, PA and ID scores in both groups was conducted. We calculated sensitivity and specificity, as well as positive (PPV) and negative (NPV) predictive values for each one of the evaluations of Group II. In Group I, 9 grade III laryngoscopies accordingly to Co-L score were detected, four of them were classified as Ma I and five as Ma II. The ID results had specificity and NPV of 1, along with low sensitivity. The BHD score proved superior in terms of sensitivity, specificity and PPV by detecting 90% of difficult intubations and 70% of normal cases, followed by Ma with 74%. PA score showed comparable values across measurements (Table VI).

DISCUSSION

Difficulty for intubation was detected by 74%. By performing the correlation between different scores and Co-L score; Ma proved to be superior. These findings differ from those obtained by El-Ganzouri *et al.* and Osornio, Palma *et al.*, who found a similar correlation using PA score. They propose this score as ideal for the evaluation of a difficult intubation. However, it is not advisable to use only a score to predict it, as has been demonstrated by several studies that conclude that the higher the number of predictive criteria are considered, the easier the identification of these cases. The second best correlation found in this study was PA score. BHD and ID scores showed a poor correlation[5,17].

Rose, in a study involving 18,500 patients, stated that the prediction of difficult intubation is more challenging in female obese patients aged 40 to 59. On the other hand, laryngoscopy was associated with a decreased mouth opening, decreased thyromental distance, limited range of motion of the neck and poor visibility of the hypopharynx. The difficulty was increased with the presence of more than one of these characteristics. The results of this study are consistent with those of Rose: difficult prediction proved more frequent for obese female patients over 40 years old[13].

Tse concludes in a study involving 471 patients that the use of a single score yields low sensitivity but it has also a high specificity. It is of notice that the evaluation and the laryngoscopy were performed by different individuals, whereas in our study, they were conducted by the same person[13].

"BURP" maneuver, described by Knill in 1993, is useful for the visualization of glottis during laryngoscopy in patients with Treacher Collins syndrome; it was validated by Takahata *et al.* in 1997. However, Snider *et al.* reported that the pressure over the cricoid cartilage along the use of BURP maneuver worsens the visibility of the larynx; in spite of, this maneuver was used in 45% of patients in the Group II, yielding an adequate visualization of larynx and allowing the orotracheal intubation. Therefore, it should be considered a valuable maneuver in laryngoscopy[20,21].

Table V. Intubation difficult scale.*

Parameters	Group I *(f)*	Group II *(f)*
N_1	4	13
N_2	0	4
N_3	9	36
$N_4$0	33	6
$N_4$1	19	26
$N_4$2	10	25
$N_4$3	0	5
$N_5$0	53	43
$N_5$1	9	19
$N_6$0	54	28
$N_6$1	8	34
$N_7$0	60	53
$N_7$1	2	9

* Measured parameters: N_1 = Additional attempts, N_2 = Additional operators, N_3 = Additional maneuvers, N_4 = Glottic exposure (degree of Co-L -1), N_5 = Force applied during laryngoscopy, N_6 = Applied external laryngeal pressure y N_7 = Vocal cords position. Frequency total is presented, in each group.

The literature reports an incidence of 0.3 to 4% of difficult intubation, therefore, assess the airway is intended to positively identify the difficult intubation in the patient, i.e., a high PPV. These values depend on the anatomic structure to be evaluated, as is shown by our results. The mobility of the atlantooccipital joint really difficult to align the anatomical axis to achieve intubation, and therefore it has very high sensitivity and specificity. Consequently, if the DI is assessed, the specificity is perfect, because if the patient opens mouth, obviously, intubation can be performed. Osornio Palma *et al.* found the highest PPV on PA and BHD scores and the highest NPV on ID. In this same study reported greatest sensitivity for the PA test and the highest specificity for BHD, as compared to Baeza, et al, they are similar in sensitivity and specificity of the tests, varying the obtained percentages only moderately.. However, the aforementioned studies were conducted by more than one researcher. In this study, both the assessment and the laryngoscopy were performed by a third-year resident physician in anesthesiology, therefore the results vary, they are higher than those reported by Baeza, Yamamoto, and Osornio[2,11,18].

Catano reports that the differences in finding a suitable positive and negative predictive value may be because measures used in different scales have been standardized, so that should be taken into account variations according to ethnicity, gender, weight, size, anatomical structures of the study population[21].

Table VI. Statistical results.

Scale	Mallampati	Patil-Aldreti	Bell Hose-Doré	Interincisive Distance
Group I	r = 0.87	r = 0.94	r = 0.90	r = 0.86
Group II	r = 0.80	r = 0.70	r = 0.42	r = -0.39
Sensibility	0.5	0.71	0.76	0.034
Specificity	0.5	0.71	0.9	1
PPV	0.74	0.71	0.90	1
NPV	0.26	0.71	0.71	0.54

r = Correlation coefficient between each valuation scale and the Cormack Lehane obtained during laryngoscopy. PPV = Positive predictive value, NPV = Negative predictive value. The sensitivity and specificity of the tests show us how many will be difficult or not to intubate. PPV of ID, express that 100% of patients with degree III, everyone will have difficult to be intubated, 90% with BHD, 74% of Ma and 71% of PA. NPV of PA, BHD with 71% of patients who can be intubated with a negative test, ID 54% and Ma 26%.

The use of the Ma score along with the PA score enhances the positive predictive value to identify a difficult airway. In a review meta-analysis of the evidence of Ma score to predict a difficult intubation, Lee found differences even within the definition and he emphasizes the fact that the consequences are primarily due to the impossibility to ventilate the patient rather than to the intubation *per se*. The modified Ma score has proven superior to predict a difficult intubation, but it is not reliable to predict difficult ventilation. In this study, factors able to complicate ventilation were classified along with other anatomical characteristics that may affect the laryngoscopy [22-25].

Identify the confounding variables which also hinder intubation (found in 39% of the total population) allows comprehensive assessments to reduce the presence of difficult airway (ventilation or intubation). Reports of previous studies consider a difficult intubation in the following cases; 1) When there is a degree IV of Co-L; 2) When 2 laryngoscopies are performed; or 3) When it is required more than 10 minutes to achieve the intubation. However, the number of additional maneuvers needed is not taken into consideration. An easily accessible airway allows a proper observation of the anatomical structures involved in intubation (Co-L I and II) without the need for additional maneuvers that modify anatomical axis, thus facilitating the intubation. By registering if additional maneuvers are performed to verify that indeed the intubation is difficult to access, it is possible to label the patient as difficult airway. Adnet score classifies the grade of difficulty for intubation only after it has been attempted. It measures some of the parameters here studied, but it does not assess the confounding variables. However, the grade of difficulty was classified using this score for both groups. Group II displayed a higher level of difficulty, from moderate to high. An ideal airway assessment test for predicting difficult intubation should have high sensitivity, thus identifying the majority of patients in which intubation will be really difficult, resulting in a high positive predictive value, so that when the patient is labeled as difficult to intubate, intubation is really difficult[12,17,19,26].

CONCLUSIONS

The airway of a patient must be evaluated by the physician conducting his/her intubation. This should decrease the number of unexpected difficult intubations and anticipate the instruments and possible help required to achieve intubation with the least number of attempts and in the shortest time possible before the anesthetic induction takes place and according to the algorithm of the institution where anesthesiological practice is carried out.

Assess the airway using the greatest number of predictive criteria of difficult intubation allows the person conducting the intubation to take the necessary steps to face difficulties in this technique, if it were so, as these anatomical structures involved in laryngoscopy are many and all have their importance for the laryngoscopy. Therefore, as has already been demonstrated by several studies, it is necessary to take the time and make careful assessments required to evaluate and predict the presence of a difficult airway.

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