ORIGINAL ARTICLE

Influence of pharyngolaryngeal anomalies diagnosed through indirect laryngoscopy in the prediction of difficult intubation


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KEYWORDS
Airway management/methods; Laryngoscopy—methods; Laryngoscopes; Intratracheal intubation; Epiglottis—pathology; Logistic models

Abstract
Objective: To determine the pharyngolaryngeal anomalies not usually included in the evaluation of difficult airway, in order to investigate the influence of these anomalies in the prediction of difficult intubation. To do this, indirect laryngoscopy with a 70° rigid laryngoscope was performed on all patients during the preoperative period.

Methods: This is an observational, prospective study on 300 consecutive patients who were scheduled for endotracheal intubation under general anesthesia. In addition to assessing the airway in the preoperative period by demographic and clinical predictors of difficult airway, rigid indirect laryngoscopy was performed to diagnose pharyngolaryngeal anomalies. Later, under general anesthesia and direct laryngoscopy it was checked to see if there was difficulty in intubating the larynx, and its association with all previous variables was investigated. A logistic regression model for prediction purposes was developed, and its power of discrimination was achieved by assessing the area under the curve.

Results: During the examination by indirect laryngoscopy 46 anomalies were found, which were as follows: 31 abnormalities of the epiglottis (22 omega epiglottis, nine flaccid or hypertrophic epiglottis); six findings of hypertrophic lingual tonsils, three cases of upper airway tumors, and six patients with tongue disorders. Intubation difficulty was found in 14 cases (4.66%). The regression model found and its coefficients to develop it were: \( f(x) = 1.322 + (2.173 \text{ thyromental distance} - 6.5 \text{ cm}) + (1.813 \text{ omega epiglottis}) - (1.310 \text{ cm opening mouth}) \). Global power of discrimination was 0.83, with a 95% confidence interval from 0.709 to 0.952.

Conclusion: Indirect laryngoscopy allowed pharyngolaryngeal anomalies to be diagnosed, including omega epiglottis, which was one of the variables included in the logistic regression model.

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Introduction

The Mallampati scale, dental anomalies, macroglossia and tonsillar hypertrophy are the most common predictors of difficult airway (DA). Nevertheless, indexes such as that developed by Arne\textsuperscript{1} have low sensitivity and specificity for predicting DA in ENT surgery patients. For this reason, preoperative upper airway (UA) examination of ENT surgery patients by means of indirect laryngoscopy (IL) using a nasal fibroscope or rigid laryngoscope will show any pathological abnormalities present, predict DA, and allow surgeons to choose the best intubation method.\textsuperscript{2-4}

Pharyngolaryngeal anomalies such as those involving the epiglottis\textsuperscript{5,5-7} and tonsillar hypertrophy (TH)\textsuperscript{8-9} can be found at any time in patients undergoing general anesthesia (GA), and can also contribute to DA. Epiglottic anomalies\textsuperscript{10} can be divided into: curved, floppy and hypertrophic (or leaf shaped). These anomalies are only detected if patients undergo preoperative IL examination of the UA.\textsuperscript{3,6,9} A recent study\textsuperscript{11} reported using a laryngeal mirror to predict difficult intubation (DI) in obese patients. The mirror technique was compared with the results of other tests, finding that it was more discriminatory, although no mention was made of anomalies that could contribute to DI prediction. The rigid laryngoscope has only recently been introduced in ENT departments for UA examination. In addition to other advantages over the conventional laryngeal mirror (greater patient comfort, short learning curve), it allows clinicians to record the examination. The recording can then be viewed to determine the presence of anomalies.\textsuperscript{3,4}

The main aims of this study were to diagnose patients with pharyngolaryngeal anomalies only visible on preoperative rigid indirect laryngoscopy, and to study the importance of these anomalies as DI predictors in relation to other demographic and clinical predictors. The secondary aims were to determine whether our intubation protocol would be altered on the basis of the IL examination, and whether diagnosis of the anomalies found on IL differed between anesthesiologists and otolaryngologists.

Materials and methods

This prospective observational study was approved by our hospital’s ethics committee and carried out between September 2009 and November 2010 in 300 patients scheduled for surgery under GA with tracheal intubation. All prospective patients signed an informed consent form prior to inclusion in the study. Exclusion criteria were: aged under 18 years, unable to sit upright, ankylosing spondylitis, nasogastric tube in place, heart disease or infections such as hepatitis, HIV or TB, emergency or obstetric surgery, or recent neck surgery.

The same protocol was followed in all patients; on entering the surgery unit on the day of the intervention, the anesthesiologist reviewed the preoperative examination...
Table 1  Bivariate analysis of demographic variables, predictive variables and anomalies in DI.

<table>
<thead>
<tr>
<th></th>
<th>DI (n = 14)</th>
<th>NDI (n = 286)</th>
<th>p, χ²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex M/F</td>
<td>5/9</td>
<td>130/156</td>
<td>NS</td>
</tr>
<tr>
<td>Age (years)</td>
<td>55.50 (16.09)</td>
<td>56.25 (18.134)</td>
<td>NS</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>28.62 (5.37)</td>
<td>28.06 (5.34)</td>
<td>NS</td>
</tr>
<tr>
<td>BMI &gt; 30 kg/m²/BMI &lt; 30 kg/m²</td>
<td>6/8</td>
<td>85/201</td>
<td>NS</td>
</tr>
<tr>
<td>Neck circumference (cm)</td>
<td>39.36(4.25)</td>
<td>38.96 (4.26)</td>
<td>NS</td>
</tr>
<tr>
<td>Neck circumference &gt;43/neck circumference &lt;43</td>
<td>2/12</td>
<td>44/242</td>
<td>NS</td>
</tr>
<tr>
<td>TMD (cm)</td>
<td>6.5 (1.33)</td>
<td>7.62 (1.15)</td>
<td>0.001*</td>
</tr>
<tr>
<td>TMD &lt; 6.5 cm/TMD &gt; 6.5 cm</td>
<td>8/6</td>
<td>28/258</td>
<td>0.000*</td>
</tr>
<tr>
<td>Gape (cm)</td>
<td>3.70 (0.43)</td>
<td>4.26 (0.63)</td>
<td>0.001*</td>
</tr>
<tr>
<td>Gape &lt; 3.5 cm/gape &gt; 3.5 cm</td>
<td>3/11</td>
<td>13/273</td>
<td>0.006*</td>
</tr>
<tr>
<td>Mallampati score 3-4/Mallampati score 1-2</td>
<td>9/5</td>
<td>87/199</td>
<td>0.008*</td>
</tr>
<tr>
<td>Normal/impaired neck movement</td>
<td>9/5</td>
<td>240/46</td>
<td>0.056-NS</td>
</tr>
<tr>
<td>Snoring yes/no</td>
<td>8/6</td>
<td>131/154</td>
<td>NS</td>
</tr>
<tr>
<td>Retrognathism yes/no</td>
<td>3/11</td>
<td>7/279</td>
<td>0.000*</td>
</tr>
<tr>
<td>Curved epiglottis yes/no</td>
<td>3/11</td>
<td>19/267</td>
<td>0.038*</td>
</tr>
<tr>
<td>TH yes/no</td>
<td>1/13</td>
<td>5/281</td>
<td>NS</td>
</tr>
<tr>
<td>Other epiglottic anomalies yes/no</td>
<td>1/13</td>
<td>8/278</td>
<td>NS</td>
</tr>
<tr>
<td>Tongue anomalies yes/no</td>
<td>1/13</td>
<td>5/281</td>
<td>NS</td>
</tr>
<tr>
<td>UA tumors yes/no</td>
<td>0/14</td>
<td>3/283</td>
<td>NS</td>
</tr>
<tr>
<td>Dental anomalies yes/no</td>
<td>1/13</td>
<td>17/269</td>
<td>NS</td>
</tr>
</tbody>
</table>

TH, tonsillar hypertrophy; TMD, thyromental distance; UA, upper airways. Data expressed as mean and standard deviation in brackets, or frequency.
* p < 0.05.

The DL cart was present in the operating room, together with a fibroscope ready for use. All the patients were premedicated with fentanyl (50 µg), and then the patient was pre-oxygenated with FiO₂ 1 under spontaneous ventilation for 3 min. Following this, a different anesthesiologist from the one performing the IL, and therefore blind to the findings of the examination, delivered ventilation via the face mask following administration of propofol (2 mg kg⁻¹); the patient was then given succinylcholine 1 mg kg⁻¹, ventilation permitting (using this muscle relaxant in all patients allowed us to shorten the period of apnea in those with anomalies and possible DI), and intubation was achieved using a Macintosh blade. Cricoid pressure was used in patients with a Cormack-Lehane score of III and IV. If this enabled visualization of the glottis opening, the surgeon proceeded with intubation. If visualization was poor, and more than three attempts with the Macintosh blade were needed, the patient was considered to be a DI case, the appropriate measures were taken (endotracheal stylet, Eschman introducer, or others), as needed, and the incident was noted. In patients with anomalies, the number of times these were correctly identified by the anesthesiologist was noted.

In some patients with anomalies detected during direct laryngoscopy (DL), we attempted to record images of the anomaly (without giving further medication: propofol or...
succinylcholine) once it had been identified and evaluated. The images were recorded with the help of a second anesthesiologist, who inserted through the patient’s mouth the prepared fibroscope kept on hand in case of a DA. This instrument was connected to a video recording system.

Once the patient was stable, their medical records were checked if surgery had been scheduled by the ENT department. If a prior rigid indirect laryngoscopy or nasofibroscopy had been performed, the results were noted and compared to those reported by the anesthesiologist to detect any differences. If anomalies such as TH had been noted in the pre-assessment request form given to the anesthesiologist, this was also recorded.

Once all the data had been gathered, we performed a bivariate descriptive analysis to detect the existence of a statistically significant relationship between demographic and clinical predictors and the presence of DI anomalies confirmed by DL. Following this, we performed a logistic regression analysis to estimate the DI-predictive strength of the anomalies, and to determine which explanatory or independent variables (demographic, clinical and anomaly-based predictors) correlated with the DI response or dependent variable. Based on the ratios obtained, we created an $f(x)$ formula to identify the theoretical probability $(y)$ of finding a DI in each case.

$$y = \frac{e^{f(x)}}{1 + e^{f(x)}}.$$

We then constructed a receiver operating characteristic (ROC) curve based on the prognostic probability values of finding a DI for each patient. Each of the foregoing values represents a sensitivity/1-specificity pair. The area under the curve gives the overall discriminatory power of the equation. The ROC curve can also identify the prognostic probability threshold value at which a DI will be found. To do this, we chose as the cut off point the (prognostic probability) value with the greatest sensitivity and lowest number of false positives (1-specificity). The ideal prognostic probability is found in the upper left hand corner of the curve, where all DI patients are detected and no non-DI results are false positives.

Finally, we constructed a box plot to check for differences in prognostic probability values between DI and non-DI patient groups.

The data were analyzed using SPSS 15® for Microsoft Windows®. The results are expressed as mean, median (range) and frequency. The Kolmogorov-Smirnov test was used to test the goodness of fit for continuous variables. The Student’s $t$ test was used to find the bivariate difference of means of the groups in the case of continuous variables, while the $\chi^2$ or Fisher’s test was used for categorical variables. Statistical significance values were set at $p < 0.05$.

**Results**

Initially, 324 patients were included in the study. However, in 23 (7%) of these IL was unsuccessful due to nausea or coughing; another patient had an epiglottic tumor that obscured the UA on IL and awake intubation by means of a nasal fibroscope was indicated; this patient was also excluded.

A total of 46 anomalies were found during rigid IL examination of the UA: 31 epiglottic anomalies (22 cases of curved epiglottis and nine of floppy or leaf-shaped epiglottis; Fig. 1A)

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**Figure 1** (A) Curved epiglottis. (B) Leaf-shaped epiglottis; (C) TA: all the foregoing images were obtained with rigid IL during preoperative examinations. (D) TA, obtained with DL, with the fibroscope inserted into the mouth. The 2 images of TA show lobules invading the lateral edge of the epiglottis. In all images, a, posterior arytenoid; b, base of the tongue; e, epiglottis. In the TH images, c, lobules; g, glottis; i, isthmus separating lobules; p, Macintosh laryngoscope blade situated a few millimeters behind the vallecula to facilitate visualization of the TH lobules.
and B); six findings of tonsillar hypertrophy (which usually present as two masses separated by an isthmus; Fig. 1C); three cases of UA tumor; six patients with abnormalities of the tongue (four cases of hypertrophy of the base of the tongue, one case of hemiglossectomy with follow-up radiotherapy, and one case of a cyst at the base of the tongue).

In three patients with anomalies (all from the ENT department) the original awake intubation with nasal fibroscope indication was changed to tracheal intubation under GA. Two of these patients had UA tumors (the first of these is shown in Fig. 2A and B), and the third had undergone hemiglossectomy (shown in Fig. 2C and D). In all three anomalies, the opening of the glottis was visible during IL examination. Later, under GA and DL, all 3 were classified as Cormack-Lehane I-II.

In Fig. 1D, obtained while introducing the DL, the mass of the TH can be seen invading the epiglottis (after depressing the vallecula slightly with the blade of the laryngoscope). Fig. 2A and B, the first obtained with rigid IL and the second with DL via a nasal fibroscope, shows how the images captured by both instruments are reversed.

A total of 14 (4.66%) cases of DI were identified. The instruments used to facilitate tracheal intubation were the Eschman introducer, in nine cases, and a metallic stylet in five.

The diagnosis of the anesthesiologist performing the DL coincided with the IL diagnosis in 12 cases of curved epiglottis, five of floppy or leaf-shaped epiglottis, two of TH and two patients with UA tumors. No cases of hypertrophy of the base of the tongue were diagnosed using DL.

Of the total study cohort, 67 came from the ENT department. Of these, 35 had undergone an IL (25 using rigid laryngoscopy and 10 nasal fibrosopy). Thirteen of this group were among the 46 patients with pharyngolaryngeal anomalies: two cases of TH (neither of which were notified to our department, and the finding was not noted in the preoperative examination report prepared by the anesthesiologist), three UA tumors, two patients with tongue anomalies, and six cases of curved epiglottis. Both groups of specialists (ENT and anesthesiology) concurred in their diagnosis of the first seven of these patients. However, the ENT specialists did not describe any of the six cases of curved epiglottis during their examination. Of these 13 patients, two presented DI: one with TH and another with hypertrophy of the base of the tongue.

Table 1 shows the results of the bivariate analysis of the demographic variables, the DA predictors, and the different anomalies observed using IL with DI. Among the 14 cases of DI, six had anomalies that were only visible on IL: three curved epiglottis, one hypertrophied rigid epiglottis, one TH, and one hypertrophy of the tongue.

Table 2 shows the independent predictors of DI found by logistic regression analysis. The following formula was constructed using the coefficients obtained:

\[
\log \frac{p}{1-p} = 1322 + (2173 \text{ triomentoniana distance } < 6.5 \text{ cm}) \\
+ (1813 \text{ curled epiglottis}) \\
- (1310 \text{ cm mouth opening})
\]

This gives a correct result in 95.3% of cases.
Table 2  Independent predictors of difficult tracheal intubation.

<table>
<thead>
<tr>
<th>B</th>
<th>Sig</th>
<th>Exp (B)</th>
<th>Cl 95% for Exp (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gape (cm)</td>
<td>-1.310</td>
<td>0.029</td>
<td>0.270</td>
</tr>
<tr>
<td>TMD &lt; 6.5</td>
<td>2.173</td>
<td>0.001</td>
<td>8.780</td>
</tr>
<tr>
<td>Curved epiglottis</td>
<td>1.813</td>
<td>0.033</td>
<td>6.126</td>
</tr>
<tr>
<td>Constant</td>
<td>1.322</td>
<td>0.578</td>
<td>3.753</td>
</tr>
</tbody>
</table>

* B, coefficient of the variable; CI, confidence interval; Exp (B), odds ratio (risk of a patient presenting DI if this event occurs when compared with another patient in which it does not occur); TMD, thyromental distance; Sig, statistical significance.

Fig. 3 shows the ROC curve. The discriminatory power of the formula (area under the curve) is 83% (CI 95%; 0.70–0.95). The best cut off point is a prognostic probability of 0.0958363, corresponding to a sensitivity of 90% and a 28% rate of false positives.

The median prognostic probability (y) of the 286 non-DI patients was 0.019489. The median prognostic probability (y) of the 14 DI patients was 0.20005.

The prognostic probability (y) of each of the three patients in whom the intubation protocol was changed was: 0.0053 in the first case (left vocal cord tumor), with a sensitivity of 5.9% and a false positive rate of 0%; 0.01949 in the second case (parapharyngeal tumor), with a sensitivity of 43% and a false positive rate of 7%; and 0.03686 in the third case (hemiglossectomy) with a sensitivity of 68% and a false positive rate of 28%. It is interesting to note that the prognostic probability (y) of all three fell below the median prognostic probability of DI patients.

Fig. 4 shows the box chart representing the distribution of predicted probabilities in DI and non-DI patients with different median levels (horizontal line in each box) and the 17 outliers in the first box.

![Figure 3](http://www.example.com/figure3.png)

**Figure 3**  ROC prognostic probability curve for DI. Sensitivity or the fraction of true positives lies on the Y axis, and the fraction of false positives or 1-specificity lies on the X axis. The curve shows the optimal cut off point.

![Figure 4](http://www.example.com/figure4.png)

**Figure 4**  Note the different level of both medians. Note also that 7 non-DI patients have a prognostic probability (y) above the median of DI patients (outlying values).

Discussion

Table 1 shows that only patients with curved epiglottis show a significant association with DI; however, this is not true of TH, an entity traditionally associated with DA.\(^1\)\(^2\)\(^3\) It can be seen from Table 1 that of the six patients in whom TH was seen on IL, only one presented DI.

We believe that the reason why epiglottic anomalies are more closely associated with DI is due to the valve action of this organ, which prevents foreign bodies from entering the respiratory system. This, however, can prevent visualization of the glottis and introduction of the tracheal tube. Tumor invasion of the epiglottis caused one patient to be excluded from the study; however, absence of the epiglottis following tumor excision\(^1\) could also cause DI. At times, an anomaly such as a curved epiglottis can be combined with other DA predictors in a single patient,\(^1\) a situation that strengthens the probability of DI. We also observed that nearly half of the anesthesiologists failed to diagnose curved epiglottis during DL, this is because this anomaly, together with others such as TH, is noticed more often when associated with UA visualization difficulties. If UA vision is unobstructed, the curved epiglottis anomaly usually goes unnoticed.

We also believe the ENT specialists did not describe curved epiglottis during IL examination of the six cases in
which this entity was detected by the anesthesiologists using
the same technique because epiglottic anomalies are usu-
ally only relevant for ENT specialists in the case of tumor
invasion or rhonchopathy surgery. This was confirmed
when we examined the records of the 35 patients undergo-
ing IL in the ENT department. It should also be noted that
ENT specialists usually describe TH during IL performed
during examination of patients with pharyngeal globe and pharyn-
golaryngeal reflux,16 or as a fortuitous finding. This is why
it is not usually notified to the anesthesia department
(there were two such cases in our study, one of which pre-
vented DI). Hypertrophy of the base of the tongue is usually
only seen during IL and not DL: one of our patients with
this anomaly, examined by the ENT department, presented
DI. This is why we recommend that the clinical records of
all patient scheduled for ENT surgery under GA, together
with the report of the IL examination performed in the
ENT department, should be checked during the preoper-
avive examination. This would prevent a TH15 or any other
anomaly described in these records from going unnoticed.

Table 2 shows that the factor with the highest predictive
power, according to our formula, is TMD <6.5 cm, with an
odds ratio of 8.78, while curved epiglottis has a predictive
power of 6.12. Both figures are obtained by raising the num-
ber to the power of the respective coefficient B. This,
however, only affects the positive predictive value (PPV)
of the test. Nearly all DI prediction models have low PPV
values17 owing to the low prevalence of the pathology.

Our model was found to be highly discriminatory (Fig. 3).
Nevertheless, Fig. 4 shows its shortcomings: the outlying
values in the first box correspond to false positives, i.e. patients
(each shown by a number) with high prognostic probability
values (y) suggesting a likelihood of DI that was later not
confirmed. This affects the positive predictive value (PPV)
of the test. Nearly all DI prediction models have low PPV
values owing to the low prevalence of the pathology.

Compared to DI prediction models in which laryngeal
mirror11 or similar instrument,18 was used, or that are based
on clinical DA predictors,19,20 our model has the advantage
of including UA anomalies as a potential DA predictor. These
UA anomalies include curved epiglottis, which is usually only
recognized as a cause of DI when performing DL. Never-
much, in practical terms, our model has some drawbacks,
such as nausea or coughing during IL (also reported in other
studies11,18), a factor that excluded 7% of our patients. Our
model, compared with other procedures21 using nasal fibro-
scope to determine the intubation approach, and with the
aforementioned methods,11,18-20 has a particular limitation:
the use of a 70° angle gave full or partial view of the glottis,1
even in patients with retrognathism or limited gape. Both
these variables are associated with DI, as can be seen in
Table 1. An earlier study9 used IL via a nasal fibroscope in
DI patients to determine the cause (TH), although this was
performed some time after surgery. In general, we can con-
clude that our model is limited by the need for a prior IL, and
we are aware that this technique is currently not available
in all anesthesiology departments.

This study lays the foundation for further research into
the use of rigid IL. Aside from obtaining images of the UA
prior to intubation as a means of graphically illustrating and
facilitating the planning of a particular procedure, rigid IL
can be used to study the influence of UA anomalies on face

mask ventilation and their involvement in rhonchopathy and
OSAS, both of which are associated with DA.

Conclusions

Rigid IL can diagnose pharyngolaryngeal anomalies that usu-
ally go unnoticed during preoperative examination, and that
can contribute to a DI. The findings of a rigid IL can prompt
clinicians to change their airway management plan before
GA induction.

Ethical standards

The authors declare that the procedures followed were in
accordance with prevailing ethical standards.

Conflict of interest

The authors declare they have no conflict of interest.

Acknowledgement

We thank the members of the ENT department of Hospital
Dr. Peset for their help in conducting this study.

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