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Preoperative assessment for difficult intubation in general and ENT surgery: predictive value of a clinical multivariate risk index†

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Summary

Several clinical multifactorial indexes have been described for predicting difficult laryngoscopy or intubation, or both, mostly in general surgery, and less frequently in ENT surgery. The objective of this study was to develop and validate a single clinical index for prediction of difficulty in tracheal intubation in both ENT and general surgery. We studied a population of 1200 consecutive ENT and general surgical patients. Clinical criteria were tested using univariate and multivariate analysis. Difficult intubation was defined as requiring unusual techniques. Logistic regression identified seven criteria as independent predictors of difficult tracheal intubation: previous history of difficult intubation; pathologies associated with difficult intubation; clinical symptoms of pathological airway; inter-incisor gap and mandible luxation; thyromental distance; head and neck movement; and Mallampati's modified test. Point values were assigned to each of these factors in proportion to regression coefficients representing the relative weight of each predictive intubation difficulty factor, the sum comprising the score. The best predictive threshold was chosen using a receiver operating characteristic curve. We then prospectively studied and validated the score in a population of 1090 consecutive ENT and general surgery patients. The sensitivity and specificity of the predictions were 94% and 96% in general surgery, 90% and 93% in non-cancer ENT surgery, and 92% and 66% in ENT cancer surgery, respectively. (*Br. J. Anaesth*. 1998; **80**: 140–146)

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Difficult tracheal intubation may increase anaesthetic morbidity and mortality, especially during obstetric[1 2] and others types of anaesthesia.[3 4] Several prospective studies have identified various individual clinical symptoms possessing a significant association with laryngoscopy or intubation difficulties.[5–13] Sensitivity and positive predictive values of these individual signs are low, ranging from 33% to 71% for sensitivity. Thus six studies have challenged multifactorial prediction indexes of difficult tracheal intubation or difficult view of the glottis, or both; five found a decrease in falsely predicted laryngoscopy or intubation difficulty,[14–18] whereas no improvement in sensitivity was found by Tse, Rimm and Hussain.[19] Another study[20] calculated the probability of difficult laryngoscopy using different combinations of predictive signs and a multivariate analysis; however, the optimal predicting level of these associations was not determined. Finally, comparison of these studies led to the conclusion that a multifactorial clinical index generally improves the prediction of difficult laryngoscopy or tracheal intubation.

Studies of multifactorial clinical index assessed predictions of difficult laryngoscopy in ENT and oral,[14] general[15 17–19] and gynaecological and obstetric populations.[16 20] To date, no single multifactorial index can be applied to the various surgical populations. Moreover, most, with the exception of Wilson's index, have not been validated prospectively.[17 21] However, Wilson's index is validated only for prediction of difficult laryngoscopy, as defined by Cormack and Lehane,[22] as inability to see the glottis in the standard intubation position. Finally, no index, including Wilson's, has been validated prospectively for detection of difficult tracheal intubation per se.

For these reasons, we undertook the development and validation of a predictive clinical multifactorial risk index, based on a multivariate analysis, aimed at predicting difficult tracheal intubation, both in general and ENT surgery.

Patients and methods

This prospective study was conducted in two steps. First, 12 different criteria, selected because of previously demonstrated statistical associations with difficult laryngoscopy or tracheal intubation, were recorded in a consecutive series of patients. Using a multivariate analysis, we then established a multifactorial clinical index to predict difficult tracheal intubation. In a second prospective step, this index was tested, and its performances evaluated in another series of patients.

INITIAL STUDY

During an 18-month period, any patient older than 15 yr of age undergoing ENT or general surgery

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with tracheal intubation was considered as potentially eligible for this prospective study. Five senior anaesthetists served as investigators and 1200 consecutive patients were included during this period based on the following factors recorded during preoperative consultation.

(1) Weight, height and age.

(2) Knowledge by the patient of previous difficulty with laryngoscopy or intubation, that is had the patient been informed previously of a difficulty during a previous operation in another medical centre.

(3) Pathologies associated with difficulties in laryngoscopy or intubation, such as malformation of the face,[23] acromegaly,[24] cervical spondylosis with limitation of neck movements,[6] occipito–atlanto–axial disease,[7] tumours of the airway and long-term diabetes mellitus with "stiff joint syndrome".[25–27]

(3) Clinical symptoms of airway pathology, such as dyspnoea related to compression of the airway, dysphonia, dysphagia and sleep apnoea syndrome[28 29] (this syndrome was considered either in the case of a previously fully documented illness or in the case of snoring associated with two other major symptoms among sudden arousal with choking, excessive day time sleepiness or unrefreshing sleep).

(4) Inter-incisor gap (IG) and mandible luxation (ML) evaluated using three levels: (i) IG <3.5 cm and negative ML; (ii) IG 3.5–5 cm and no ML; (iii) IG >5 cm or positive ML.

(5) Tooth morphology: buck teeth or normal teeth.

(6) Cervical morphology: short thick neck or normal neck.

(7) Thyromental distance measured with the head fully extended: $<$ or >6.5 cm.

(8) Maximum range of the head and neck movement, measured as described by Wilson and colleagues[17]: the patient was asked to fully extend the head and neck while a pencil was placed vertically on the forehead. The orientation of the pencil was adjusted so that it was parallel to a distant window frame. Then, while the pencil was held firmly in position, the head and neck were fully flexed and the pencil was sighted against the horizontal of the window frame to judge if it had moved through 90°. This criterion was graded into three levels: $<80°$; near 90° ($90° \pm 10°$); $>100°$.

(9) Mallampati's modified test[11] divided into four classes: class I = soft palate, fauces, uvula and pillars seen; class II = soft palate, fauces and uvula seen; class III = soft palate and base of uvula seen; and class IV = soft palate not visible.

The results of these factors were noted.

In the operating room, each patient was placed on the table with the head and neck in the optimal intubating position (sniffing position). The anaesthetist chose an anaesthetic induction technique according to the preoperative assessment, his own beliefs and any concomitant medical problems. General anaesthesia with neuromuscular block (vecuronium 0.1 mg kg^{-1}) was chosen by anaesthetists when they thought that intubation would be easy or when this mode of induction was thought to be the most appropriate for any other specific medical problem. When any difficulties were anticipated, a topical anaesthetic was used with gradual application of 5% lidocaine 120 mg from the lips to the glottis with 1% lidocaine 30 mg on the trachea using a spray (Abbott Laboratories, North Chicago IL, USA), accompanied by slight anaesthesia (midazolam 1 mg, fentanyl 50 μg and propofol 1 mg kg^{-1}) maintaining spontaneous breathing. Then, laryngoscopy was performed using a Macintosh blade and the glottic view was noted using Cormack and Lehane's classification[22]; intubation was then attempted. Adjuvant manoeuvres, such as external cricoid pressure or upward pressure on the epiglottis with the tip of the blade, or both, were also used. When the first attempt failed, a second was made using the large Miller blade and other manoeuvres. In case of failure, a second senior anaesthetist was required for further attempts using the same techniques and deepening anaesthesia if warranted. In case of failure by the second anaesthetist, intubation was said to be difficult and other special devices, not available routinely in every operation room, were considered. Thus intubation was defined as difficult when special techniques were required, as assessed by two senior anaesthetists. If their evaluation differed, intubation was not considered as difficult. The special techniques used in our department are: gum elastic bougies, fibreoptic intubation, the Piquet–Crinquette–Vilette's laryngoscope,[30] which is used mainly in France for ENT patients, and the Bullard laryngoscope.[31–33] Several other laryngoscopes are also available but were not used.

STATISTICAL ANALYSIS

The association between different variables and difficulty in intubation was evaluated using the chi-square test for qualitative data and the Student's *t* test for quantitative data. $P < 0.05$ was regarded as significant. Sensitivity, specificity, positive and negative predictive values were calculated according to standard formulae. Stepwise logistic regression analysis, using the SAS program, was performed with data from 1200 patients to identify multivariate independent predictors of difficult intubation. Variables in the predictor sets were found by a forward selection process such that introduction of additional variables was permitted only if P remained less than 0.05. Regression coefficients of each predicting factor in the final regression analysis were then used as "points", their sum giving "the exact score". These coefficients represent the relative weight of each predictive factor assessing difficult intubation. The discriminant function coefficient assigned to each statistically significant factor was then multiplied by a fixed value and rounded to the nearest whole number to derive a "point" value suitable for clinical purposes. Addition of these "point" values led to a simplified score.

SCORE VALIDATION STUDY

The effectiveness of this simplified score was tested subsequently by 17 senior anaesthetists in 1090 consecutive patients. The aim of this second series was to validate prospectively the simplified index and its optimal predictive level when used by several investigators. In this study, we calculated index performance in the prediction of difficult tracheal intubation. The same design was used as in previous studies.

Table 1 Number of patients undergoing different surgical procedures in the two studies (initial and validation studies)

Surgical population	Initial study (*n*)	Validation study (*n*)
ENT surgery		
Cancer	187	83
Non-cancer	425	290
General surgery		
Oral	312	421
Neurosurgery	102	
Abdominal	92	53
Gynaecology	29	53
Orthopaedic	28	32
Urology	25	88
Cardiac		70
Total	1200	1090

Results

INITIAL STUDY

As shown in table 1, among the 1200 patients included, 588 were undergoing general surgery; neurosurgical procedures were mainly lumbar slipped disc or intracranial lesions; orthopaedic operations were mainly joint prosthesis, without any atlanto–axoido–occipital joint surgery. A total of 425 patients were undergoing non-cancer ENT surgery, including 12 (2.8%) patients for sleep apnoea syndrome; 187 patients were undergoing ENT cancer surgery, including laryngectomy, pharyngectomy, glossectomy and endoscopy for diagnosis. For the whole population, in 50 patients (4.2%) the trachea was difficult to intubate: 12 (2.0%) undergoing general surgery, 15 (3.5%) ENT non-cancer surgery and 23 (12.3%) ENT cancer surgery. No intubation failed completely.

In tables 2 and 3, the number of difficult tracheal intubations is given according to Cormack and Lehane grades and mode of induction selected, respectively. There were no significant differences in weight or height between patients without difficult intubation (mean 67 (SD 13) kg and 168 (9) cm) and patients with difficult intubation (67 (12) kg and 169 (7) cm). Patients with a trachea difficult to intubate were older (50 (17–78) yr) than those with easier ones (43 (15–92) yr) ($P = 0.006$). Each of our qualitative criteria (airway pathology, clinical symptoms, etc.) showed a significant association with difficult intubation, after univariate analysis, except for tooth morphology. Univariate analysis identified nine factors, including age, with a significant association with difficult intubation (table 4).

Stepwise logistic regression analysis identified seven factors as independent predictors of difficult

Table 2 Characteristics of patients and difficult intubations according to glottic view (Cormack and Lehane grades) in the initial study

	Global population		General surgery		ENT non-cancer surgery		ENT cancer surgery	
	Intubation easy	Intubation difficult	Intubation easy	Intubation difficult	Intubation easy	Intubation difficult	Intubation easy	Intubation difficult
Cormack grade 1	899	0	482	0	324	0	93	0
Cormack grade 2	190	2	80	0	67	1	43	1
Cormack grade 3	52	10	13	4	17	2	22	4
Cormack grade 4	9	38	1	8	2	12	6	18

Table 3 Choice of anaesthetic induction mode and difficulty of intubation in the initial study

	Global population		General surgery		ENT non-cancer surgery		ENT cancer surgery	
	Intubation easy	Intubation difficult	Intubation easy	Intubation difficult	Intubation easy	Intubation difficult	Intubation easy	Intubation difficult
Topical airway anaesthesia with sedation	290	42	107	9	71	10	112	23
General anaesthesia with neuromuscular block	860	8	469	3	339	5	52	0

Table 4 Accuracy of risk factors in predicting difficult tracheal intubation (univariate analysis in 1200 patients in the initial study). DI = difficult tracheal intubation

Risk factors	True positives	True negatives	False positives	False negatives	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Association with DI (P)
Previous knowledge of DI	7	1148	2	43	14	99	78	96	< 0.00001
Pathologies associated with DI	35	1002	148	15	70	87	19	99	< 0.00001
Clinical symptoms of airway pathology	33	976	174	17	66	85	16	98	< 0.00001
Inter-incisor gap < 5 cm and mandible luxation < 0	21	1114	36	29	42	97	37	97	< 0.00001
Short thick neck	11	1065	85	39	22	93	11	96	0.001
Thyromental distance < 6.5 cm	8	1090	60	42	16	95	12	96	< 0.01
Head and neck movement < 90°	27	982	168	23	54	85	14	98	< 0.00001
Mallampati class III or IV	39	982	168	11	78	85	19	99	< 0.00001
Tooth morphology									ns

Table 5 Multivariate analysis: preoperative factors related to the occurrence of difficult intubation. DI = difficult intubation; IG = inter-incisor gap; ML = mandible luxation

Factors (in order of decreasing significance)	Stepwise significance level when added to previous factors in column	Multivariate discriminant function coefficient
Pathologies associated with DI	< 0.0001	1.63
Mallampati class 3	< 0.0001	1.93
Mallampati class 4	< 0.0001	2.52
Thyromental distance < 6.5 cm	< 0.0001	1.36
IG < 3.5 cm and ML < 0	< 0.0001	4.12
Clinical symptoms of airway pathology	< 0.0001	0.98
IG 3.5–5 cm and ML = 0	0.0009	1.09
Previous knowledge of DI	0.0084	3.28
Head and neck movement about 90°	0.0087	0.65
Head and neck movement < 90°	0.0149	1.46
Mallampati class 2	0.0255	0.66

tracheal intubation among the 12 factors studied (table 5). The multivariate discriminant function coefficient of these factors, which represents the relative predictive value of each variable, was used as "points", their sum giving the exact score. For clinical purposes, we simplified this score by arbitrarily multiplying each of the points by 3.15 and then rounding to the nearest whole number to derive a simplified point value for the factor and a simplified score. The risk factors and corresponding "points" of these two scores are presented in table 6. The optimal predictive level of the scores were determined using receiver operating characteristic curve (ROC) analysis (fig. 1). This method consists of constructing a graphic representation of each possible score level where the Y coordinates are the sensitivities and the X coordinates are the false positive percentages (= 1 − specificity). The optimal predictive level is that which is nearest to the ideal point (sensitivity = 100%, false positive = 0%). Our ideal point was 3.55 for the exact score and 11 for the simplified score (fig. 1). ROC analysis of the two scores provided a high and comparable discriminant power for predicting difficult tracheal intubation as the area under the curve was 0.958 for the exact score and 0.956 for the simplified score. Therefore, simplification of the exact score into the simplified score did not significantly decrease performance. Statistical performances of the simplified score for predicting difficult tracheal intubation in the different surgical groups, with the optimal level of 11, are presented in table 7.

SIMPLIFIED SCORE VALIDATION STUDY

Among the 1090 patients included in the validation study, 717 were undergoing general surgery, 290 for non-cancer ENT surgery and 83 for ENT cancer surgery (table 1). In the overall population, 41 patients (3.8%) had a trachea which was difficult to intubate: 18 (2.5%) undergoing general surgery, 10 (3.4%) ENT non-cancer surgery and 13 (15.7%) ENT cancer surgery. No intubation failed. Statistical performances of the score for predicting difficult tracheal intubation in the different surgical groups are presented on table 7.

Discussion

Ideally, any preoperative assessment of difficult tracheal intubation should have high sensitivity and specificity and result in minimal false positive and false negative values. The advantage of our clinical multivariate risk index is the association of high specificity with improved sensitivity in comparison with previous multivariate studies. False negative prediction is therefore minimized. In addition, the same risk index can be used for both general and ENT surgical populations.

The consequences of a false negative result may be deleterious and even life-threatening. Our predictive risk index results in minimal detection failure of difficult tracheal intubation whatever the studied population. We believe this is our most important finding. Our results are comparable with those described previously by El-Ganzouri and colleagues[18] regarding preoperative assessment of the difficult airway. Indeed, multivariable composite risk index performs better than single independent criteria. Previous work based on multivariate analyses, mainly emphasized the reduction in false positive prediction compared with a single criterion.[14–18] Although this may result in less time expended or in fewer unnecessary manoeuvres, our belief is that decreasing false negative prediction is the main goal of any prediction.

Comparing predictive values obtained from different studies based on multivariate analyses requires a brief review of the limitations of predictive risk indices and diagnostic tests. This point has been summarized previously by Dupuis, Nathan and Wynands[34]

Table 6 Risk factors retained by the multivariate analysis for predicting difficult tracheal intubation, and the corresponding points of the exact and simplified score. "Points" of the exact score are given by the values of multivariate discriminant function coefficient of every factor. The "points" of the simplified score were obtained by multiplying the "points" of the exact score by 3.15 and then rounding the results to the nearest whole number

Risk factors	"Points" of the exact score	"Points" of the simplified score
Previous knowledge of difficult intubation		
No	0	0
Yes	3.28	10
Pathologies associated with difficult intubation		
No	0	0
Yes	1.63	5
Clinical symptoms of airway pathology		
No	0	0
Yes	0.98	3
Inter-incisor gap (IG) and mandible luxation (ML)		
IG ⩾ 5 cm or ML > 0	0	0
3.5 < IG < 5 and ML = 0	1.09	3
IG < 3.5 cm and ML < 0	4.12	13
Thyromental distance		
⩾ 6.5 cm	0	0
< 6.5 cm	1.36	4
Maximum range of head and neck movement		
Above 100°	0	0
About 90° (90° ± 10°)	0.65	2
Below 80°	1.46	5
Mallampati's modified test		
Class 1	0	0
Class 2	0.66	2
Class 3	1.93	6
Class 4	2.52	8
Total possible	15.35	48

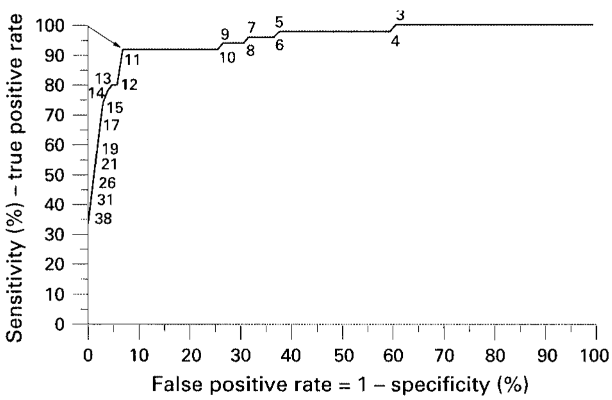

Figure 1 Receiver operating characteristic curve for the simplified score to predict difficult tracheal intubation in the global population. The numbers on the curve represent the different levels of the risk index. The sensitivity of the risk index is highest at low score values, whereas specificity is low. Highest score values give very good specificity at the expense of a reduced sensitivity. The cut-off value of 11 gives the best compromise between sensitivity and specificity.

for cardiac risk indices. A low prevalence of the "disease" (herein difficult intubation) in the test population causes the positive predictive value to decrease and the negative predictive value to increase. In our series, the overall incidence of difficult intubation was increased (3.8%) compared with previous studies[16–18] (see table 8). It might thus have favoured low negative predictive value and high positive predictive value. Nevertheless, our risk index allows the highest negative predictive value, as shown in table 8. This indicates that the risk index adequately eliminates patients without difficulties in tracheal intubation at a score level of 11, and suggests that it may be applicable to other institutions, even with a high incidence of difficult intubation. However, our risk index performs poorly for positive predictive values (30–52%). This implies that difficult intubation is falsely predicted in approximately two of three patients, or one of two patients. This is a common limitation of any risk index, as values of 9–21% have been described previously.[16–18] In our studies, as in others (table 8), the incidence of difficult intubation seems to be a major determinant of positive prediction. Nevertheless, we believe that decreasing false negative prediction is far more important than diagnosing difficult intubation in unaffected patients.

Another characteristic of the ideal predictive method is both high sensitivity and specificity. A general problem encountered with predictive risk indexes is the fact that high derived index values result in high positive predictive values, obtained with reduced sensitivity and an increased incidence of false negative predictions when considering minimal index score values. In contrast, low index score values are associated with high sensitivity and reduced false negatives, but specificity is low and false positives are increased.[34] This relationship between sensitivity and specificity is demonstrated by the ROC representation. When considering our simplified risk index at the level of 11, both sensitivity (90–94% in the various surgical populations) and specificity (66–96%) are high, especially in general surgery and ENT non-cancer surgery (see table 7). These results show improvement compared with previous studies. Sensitivity and specificity were 75%

Table 7 Predictive values of the simplified score when it is equal to or higher than 11 (best predicting cut-off) in the different surgical groups: initial and validation study (95% confidence intervals in parentheses). DI = difficult tracheal intubation

	Global population				General surgery		ENT non-cancer surgery		ENT cancer surgery	
	Initial study		Validation study		Initial study	Validation study	Initial study	Validation study	Initial study	Validation study
Incidence of DI (%)	4.2		3.8		2.0	2.5	3.5	3.4	12.3	15.7
Sensitivity (%)	92	(80.8–97.8)	93	(80.1–98.5)	92	94	87	90	96	92
Specificity (%)	93	(91.7–94.6)	93	(91.4–94.5)	98	96	95	93	71	66
Positive predictive value (%)	37	(28.4–45.3)	34	(25.2–42.7)	52	37	38	30	31	33
Negative predictive value (%)	99	(99.0–99.9)	99	(99.1–99.9)	99	99	99	99	99	98
Misclassification rate (%)	7		7		2	4	5	8	26	30

Table 8 Assessment of difficult intubation in predictive clinical multivariate studies. *Only 10% of the population had a pregnancy of more than 6 months. The different predictive values and incidences of false negatives were estimated after calculations based on the data given by the different studies

Score	Definition of difficult intubation	Population studied	*n*	Incidence (%)	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	False negative	Misclassification rate (%)
Wilson and colleagues[17]	Cormack 3 and 4	General surgery?	778	1.5	75	88	9	99	0.4%	12
Pottecher and colleagues[16]	Cormack 3 and 4	Gynaecological and obstetric*	663	5.8	70	84	21	98	1.8%	17
El-Ganzouri and colleagues[18]	Cormack class 4	General surgery?	10507	1	65	94	10	99	0.3%	7
Our simplified score	Unusual techniques	General surgery	717	2.5	94	96	37	99	0.2%	4
Our simplified score	Unusual techniques	Global population	1090	3.8	93	93	34	99	0.3%	7

and 88% for Wilson and colleagues,[17] 70% and 84% for Pottecher and colleagues[16] and 65% and 94% for El-Ganzouri and colleagues.[18] In addition, with the exception of El-Ganzouri and colleagues, these studies did not take into account the inverse relationship between sensitivity and specificity. Conversely, in the first part of our study we found that the value of 11 produced the best compromise between sensitivity and specificity, that is this is the point where the test assigned the fewest patients to the wrong category. The second part of the study confirmed the cut-off value of 11 and the misclassification rate of 7%, regardless of the number of investigators. This indicates that the reliability of the simplified risk index is investigator-independent. Finally, the main advantage of the risk index is a high sensitivity without a reduction in specificity when applied to a general surgical population. When applied to cancer ENT surgery, both sensitivity and specificity are comparable with values obtained in previous studies. The risk index can therefore be used for prediction in both general and ENT surgery.

The choice of anaesthetic technique (spontaneous or IPPV) was dependent on the anaesthetist and this may have introduced a potential bias into the study. In fact, the two modes may have potentially led to overestimation of the difficulties in tracheal intubation. During spontaneous ventilation, the patient may constrict airway muscles, reducing the laryngoscopic view, thus overestimating intubation difficulty. We tried to minimize this problem by using a meticulous and effective topical anaesthetic. In addition, when a second anaesthetist was called to intubate, he had the opportunity to deepen anaesthesia if warranted. In fact, it is not clear that the general anaesthesia mode allows a better glottic view, because with neuromuscular block the larynx is moved forwards and downwards,[35] decreasing the alignment between the pharyngeal and laryngeal axis, and thus the laryngoscopic view. In our first study, the mode of induction chosen seemed inappropriate in 298 patients (24.8%) (table 3). In 290 of 332 (87%) patients, the choice of sedation with topical anaesthesia was inappropriate, suggesting overestimation of difficult intubation. This shows that the choice of sedation and topical anaesthesia did not preclude misdiagnosis of difficult intubation in almost 87% of patients. Finally, we believe that in studying prediction of difficult intubation in different surgical populations, different modes of induction need to be included, even if a single standard method is ideal. Of previous studies, only that of Rocke and colleagues[20] used a single standard technique (thiopental followed by succinylcholine) when a difficult intubation was anticipated, as the population was limited to Caesarean section.

Another methodological question is still at issue: how to define a difficult intubation and why did we not use the Cormack and Lehane classification?[22] The reason was mainly because this classification relates only to the view gained at laryngoscopy. Despite grades 3 and 4 representing the most frequent difficulties in tracheal intubation, other causes may be involved, especially during cervical, thoracic or ENT surgery. In our first series, difficulty in glottic view was the main cause of difficulty in tracheal intubation (table 2). However, in two ENT patients, insertion of the tracheal tube was impeded by limited mouth opening, despite a good glottic view. We found the same problem in three other patients: one undergoing general surgery and two ENT surgery. In addition, numerous patients with Cormack and Lehane grade 3 and some grade 4 underwent successful intubation with usual blades and simple manoeuvres, such as external cricoid pressure or upward pressure on the epiglottis with the tip of the blade. These situations were not classified as difficult (table 2) according to our definition. With our definition for difficult intubation, our risk index aimed at predicting in which patients special laryngoscopes or techniques, not usually present in each operating room, may be required.

Our clinical predictive index has some limitations. We studied only a small number of patients with cervical spine pathology, and neither spondylosis or rheumatoid arthritis were included. Patients with occipito–atlanto–axial disease are also a high risk group,[7] not present in our studies. Thus it is possible that additional radiological evaluation may usefully complete the clinical prediction in this particular group. Another limitation is the item "previous knowledge of difficult intubation". To elucidate this during consultation is dependent on previous surgery, previous general anaesthesia with or without tracheal intubation and awareness of the patient about previously encountered difficult intubation. Omission of this information in the nine patients with this item in the initial series (table 4) would have failed to predict difficult intubation in two of seven patients with confirmed difficult intubation.

With these limitations in mind, the clinical predictive index can be applied to both general surgical and ENT populations with a general accuracy (misclassification rate 7% and errors in negative predictive value 1–2%). Its clinical use is easy, as one uses only seven risk factors and the "points" listed in table 6. Difficult intubation can be predicted if the score exceeds 11. When a score less than 11 is found, a difficult intubation can be excluded, with a risk of false prediction of 1–2%.

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