Original Article

Identification of Ideal Preoperative Predictors for Difficult Intubation

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Abstract

Background: Unexpected difficult intubation is probably the result of inadequate preoperative examination of airway and a lack of accurate predictive tests for difficult intubation. Preoperative evaluation forms basis to suspect and be prepared for a difficult airway situation. **Aim:** The aim of our study was to identify the ideal preoperative predictors of difficult intubation. **Materials and Methods:** It was a Prospective Observational study done on 350 patients in a community-based hospital. Preoperative airway assessment included: Mallampati Class (MC), Mouth opening (MO), Thyromental distance (TMD), Ability to prognath (AP) and Neck mobility and size (NM). Monitors were attached, anesthesia induced and laryngoscopy performed. Intubation Difficulty Scale (IDS) score was used to grade difficulty in intubation. **Results:** The overall incidence of Difficult Intubation was 24.6 %. A slight difficulty in 24% (IDS = 1-5) and moderate to major difficulty (IDS >5) in 0.6% cases was noted. Intubation was possible in all the patients. Mallampati class III & Mouth opening was less than 4 cm in about 6% cases and Thyromental distance less than 6 cm in 5.4%. 12.5% were unable to prognath and Neck mobility was restricted in 4.6% patients. Sensitivity and specificity of MC- 16.3 % and 97%, MO- 16.3% and 96.6%, TMD - 12.8% and 97%, AP - 33.3% and 93.9% , NM - 10.5% and 97.3%. Positive and Negative Predictive Values for MC, MO, TMD, AP and NM were 63.6% and 78%, 60.9% and 78%, 57.9 and 77.3 %, 62.8% and 81.9%, 56.3% and 76.9% respectively. **Conclusion:** We concluded that Mallampati grading and ability to prognath are the most important of the variables studied.

Key words: Airway predictors, difficult intubation, intubation difficulty scale

Introduction

"To be forewarned is to be forearmed." Unexpected difficult intubation is probably the result of inadequate preoperative examination of the airway and a lack of accurate predictive tests for difficult intubation. Preoperative evaluation forms the basis to suspect and prepare for a difficult airway situation. However, the best anatomical indicators and clinical predictors are still debated.[1-6]

Although several studies have tried to predict the occurrence of a difficult airway with the use of a single risk factor[7,8] or risk factors used in combination,[9,10] the ideal indicator or set of indicators remains elusive.

Objectives

- To identify the ideal preoperative predictors of difficult intubation
- To find out the sensitivity and specificity of the following variables: (a) Mallampati score (b) Mouth opening (c) Thyromental distance (d) Ability to prognath (e) Neck mobility and size in predicting difficult intubation
- To identify the best predictors among the preoperative airway indices included in the study.

Materials and Methods

Ours was a prospective observational study conducted on 350 patients over a period of 3 months (September to November 2014). The study was conducted at a tertiary care community-based hospital. The protocol was approved by the Institutional Review Board, and informed consent was taken from all the patients.

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Access this article online

Quick Response Code:

Website: www.karnatakaanaesthj.org

DOI: 10.4103/2394-6954.180649

How to cite this article: Garg R, Dua CK. Identification of ideal preoperative predictors for difficult intubation. Karnataka Anaesth J 2015;1:174-80.

The inclusion criteria were:

All adult patients were scheduled for elective surgery under general anesthesia.

The exclusion criteria were:

- Patients with facial abnormalities, both congenital and traumatic
- Patients in whom airway assessment was not possible, such as comatose patients or patients requiring cervical spine immobility
- Patients unable to understand the request for airway assessment.

The preoperative airway assessment included five variables: (a) Mallampati score (b) Mouth opening (c) Thyromental distance (d) Ability to prognath (e) Neck mobility and size, These were recorded in Proforma 1. This set of variables was taken from the Anesthesiology Clinics of North America, March 1998.[11]

All the patients were preoperatively assessed by a single observer and laryngoscopy was performed intraoperatively by an experienced anesthesiologist who was blinded to the observations made by the observer in Proforma 1.

On the day of surgery, patients were monitored with standard monitoring as per American Society of Anesthesiologists (ASA) guidelines. All patients were premedicated with intravenous glycopyrrolate (0.2 mg) and midazolam (2 mg). After preoxygenation with 100% oxygen for 3 min, anesthesia was induced using fentanyl (1.5 μg/kg) and propofol (1.5 mg/kg). The patient's head was positioned on a 10-cm pillow, with the head extended on flexed neck. Endotracheal intubation was done after adequate muscle relaxation was achieved, which was monitored using a neuromuscular monitor. Laryngoscopy was performed by an experienced anesthesiologist using Macintosh blade. Although the laryngoscopist was blinded to the observations made preoperatively (Proforma 1), they made their own assessment of the airway before intubation.

Glottic visualization was assessed using modified Cormack–Lehane[12] classification. Apart from Cormack–Lehane grading, the number of attempts taken to intubate, the number of operators, the number of alternative techniques used, lifting force and external laryngeal pressure if required, and vocal cord mobility on visualization were also recorded.

The Intubation Difficulty Scale (IDS)[13] score, a function of seven parameters, resulting in a progressive, quantitative determination of intubation complexity, was used. This score was calculated by the operator immediately after intubation.

Intubation difficulty is defined as a measure of the degree of divergence from a predefined "ideal" intubation, that is, one performed without effort, on the first attempt, practiced by one operator, using one technique, with full visualization of the laryngeal aperture and vocal cords abducted. Such an intubation is accorded an IDS value of 0. Each variation from this defined "ideal" intubation increases the degree of difficulty, the overall score being the sum of all variations from this definition. Impossible intubation is defined by infinity (IDS = ∞). The seven variables are as shown in Proforma 2.

The preoperative assessment data and the IDS scores were used to evaluate the predictive value of each test for difficult laryngoscopy. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of each test were calculated. The data was entered in EPI 6 software and analyzed using SPSS 10 (Statistical Package for Social Sciences) for Windows software.

Statistical methods used

- The Chi-square test
- Sensitivity, specificity, PPV, and NPV
- Odds ratios
- Multiple logistic regression.

Results

The total number recruited for the study was 350 patients, out of which 342 patients were included in the final analysis (8 patients were excluded as they were unable to understand the request for airway assessment).

Incidence of Difficult Intubation: A moderate to major difficulty (IDS > 5) in intubation was observed in 0.6% ($N = 2$) of the study subjects [Figure 1].

Predictive factors

I. Univariate analysis

1. Mallampati Classification: Nearly 6% patients ($N = 22$) were found to be in Mallampati class III, on preoperative airway assessment [Figure 2].

2. Mouth Opening: The distribution of patients according to their ability to open the mouth wide is given below in Figure 3.

3. Thyromental distance: On assessment of the thyromental distance, 19 patients measured 4–6 cm [Figure 4].

4. Ability to prognath: Of the 350 patients studied, 8 could not

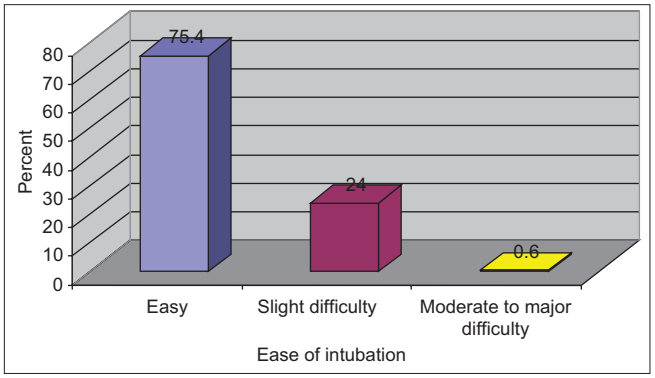

Figure 1: Incidence of difficult intubation

understand the request to prognath, so they were excluded from the analysis in the later sections [Figure 5].

5. Neck mobility and size: Approximately 4.6% ($N = 16$) of the study patients had restricted neck mobility [Figure 6].

II. Bivariate Analysis

In bivariate analysis, variables included were tested for association, primarily using the Chi-square test and then measured for association using odds ratio analysis.

1. Testing for association: The results of the Chi-square test are given below in Table 1.

In our study, all the variables had a $P < 0.01$.

2. Odds ratio analysis: Odds ratios for the variables included in the study are above 4 [Table 2].

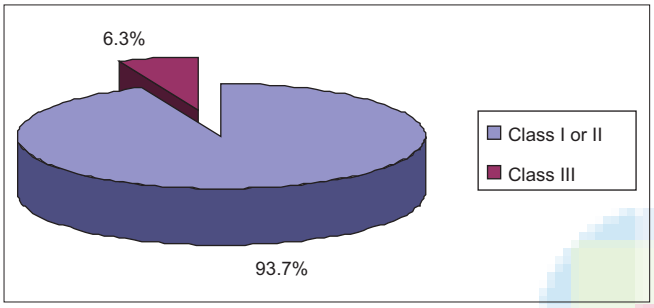

Figure 2: Mallampati classification

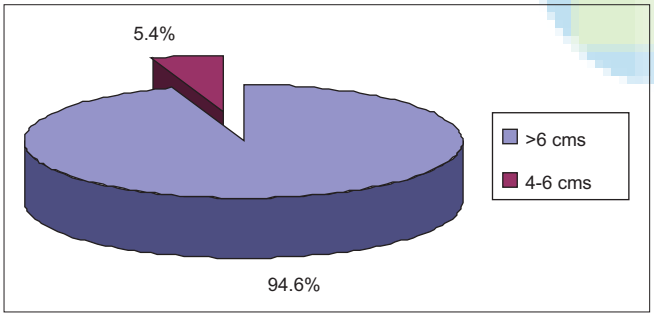

Figure 4: Thyromental distance

III. Multivariate analysis

Multivariate logistic regression analysis shows the adjusted odds ratio for the Mallampati classification as 3.68 ($P = 0.025$) and for the ability to prognath as 5.35 ($P < 0.001$). $R^2 = 0.134$ [Table 3].

IV. Sensitivity and specificity analysis

The sensitivity, specificity, PPV, and NPV of the airway predictors studied are given below in Table 4.

Discussion

This was a prospective, observational study conducted with 350 patients over a period of 3 months (September to November 2013).

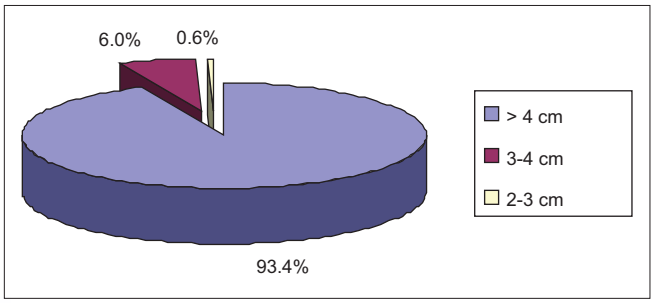

Figure 3: Mouth opening

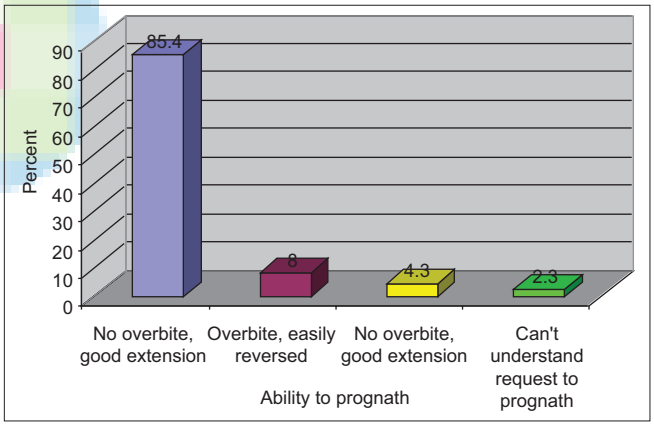

Figure 5: Ability to prognath

Table 1: Association of preoperative assessment and difficult intubation

Preop. assessment		On laryngoscopy*		Chi-square (*P* value)
Variables	**Class/grade**	**Difficulty in intubation**	**No difficulty**	
Mallampati class	Class III	14 (63.6)	8 (36.4)	19.33 (<0.001)
	Class I or II	72 (22.0)	256 (78.0)	
Mouth opening	≤4 cm	14 (60.9)	9 (39.1)	17.50 (<0.001)
	>4 cm	72 (22.0)	255 (78.0)	
Thyromental distance	≤6 cm	11 (57.9)	8 (42.1)	12.03 (0.001)
	>6 cm	75 (22.7)	256 (77.3)	
Ability to prognath	Either overbite/not, or unable/easy to reverse or poor extension	27 (62.8)	16 (37.2)	41.62 (<0.001)
	No overbite, good extension	54 (18.1)	245 (81.9)	
Neck mobility and size	<30°, normal/short neck	9 (56.3)	7 (43.8)	9.08 (0.003)
	≥30°, normal neck	77 (23.1)	257 (76.9)	

*Figures in parentheses are percentages

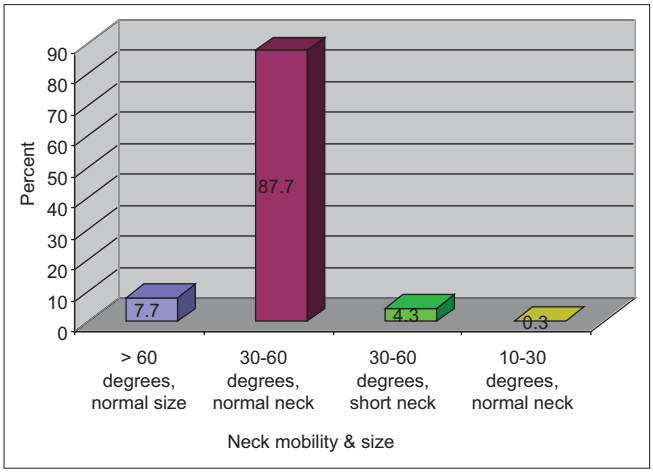

Figure 6: Neck mobility and size

The overall incidence of difficult intubation (IDS >0) was observed to be 24.6%. This includes the incidence of 24% for slight difficulty (IDS = 1-5) and of 0.6% for moderate to major difficulty (IDS >5). However, there was no case where intubation was impossible.

The study results published by Crosby *et al*.[14] showed the incidence of difficult intubation as 1.5–8.5%. Shiga[15] in his study found that the overall incidence of difficult intubation was 5.8%. Neither of the studies provides any information regarding the degree of difficulty in intubation. Our high value of difficult intubation can be attributed to the inclusion of slight difficulty, in addition to moderate to major difficulty in intubation.

Adnet *et al*.[13] in his study observed that the IDS was 0 in 53% cases and >5 in 6.3% cases. They concluded that there was an incidence of 40.6% for slight difficulties (IDS = 1–5). Our proportions of incidence of difficulty in intubation, IDS 1–5 in 24% and >5 in 0.6%, are much less than those reported by Adnet *et al*. In our study, an experienced anesthesiologist intubated all the cases; in their study, some of the intubations were done by trainees under the supervision of an experienced anesthesiologist.

The airway predictors used in this study were the Mallampati classification, mouth opening, thyromental distance, ability to prognath, and neck movement and size. We measured the association of these variables with the outcome and also compared the sensitivity and specificity of these variables with those reported in other studies. The Chi-square test showed all the five included variables to be significantly associated with the outcome ($P < 0.01$).

We measured the association of these variables that yielded unadjusted odds ratios, varying 4–8. A multivariate logistic regression identified Mallampati classification and ability to prognath as independent predictors of difficult airway [Table 3]. From the multivariate logistic regression analysis, we observed the proportion of variability as explained by these variables to be only 13%.

The validity of any screening tool is assessed by its sensitivity and specificity.

Table 2: Unadjusted odds ratios

Predictive factor	Odds ratio	95% C.I. odds ratio
Mallampati classification	6.2	2.5-15.4
Mouth opening	5.51	2.3-13.2
Thyromental distance	4.69	1.8-12.1
Ability to prognath	7.66	3.9-15.2
Neck mobility and size	4.29	1.6-11.9

C.I.: Confidence interval

Table 3: Adjusted odds ratio

Predictive factor	Odds ratio	95% C.I. odds ratio	*P*
Mallampati classification	3.68	1.18-11.48	0.025
Mouth opening	1.7	0.53-5.49	0.375
Thyromental distance	2.07	0.62-6.94	0.237
Ability to prognath	5.35	2.57-11.14	0.000
Neck mobility and size	2.28	0.68-7.64	0.181

C.I.: Confidence interval

Table 4: Sensitivity, specificity, positive predictive values and negative predictive values

Predictive factor	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)
Mallampati classification	16.3	97	63.6	78
Mouth opening	16.3	96.6	60.9	78
Thyromental distance	12.8	97	57.9	77.3
Ability to prognath	33.3	93.9	62.8	81.9
Neck mobility and size	10.5	97.3	56.3	76.9

Mallampati classification: The sensitivity in our study (16.3%) was lower compared to the studies by Tse *et al*.[4] (66%), Merah *et al*.[16] (61.5%), and El-Ganzouri *et al*.[17] (44.7%). However, the specificity (97%) was comparable in our study to that in Tse *et al*.,[4] Merah *et al*.,[16] and El-Ganzouri *et al*.[17] (65%, 98.4%, and 89% respectively). Crosby *et al*.[14] reported the sensitivity to vary between 44.7% and 67.9% and the specificity between 52.5% and 89%.

Mouth opening: In our study, sensitivity was 16.3%, which is lower than that in the studies by Merah *et al*.[16] (30.8%), El-Ganzouri *et al*.[17] (26.3%), and Crosby *et al*.[14] (26.3%). However, specificity (96.6%) was comparable to those in other studies.[14,16,17]

Thyromental distance: The sensitivity and specificity in our study (12.8% and 97%) were comparable to the study by Merah *et al*.[16] (15.4% and 98.1%), and El-Ganzouri *et al*.[17] (7% and 99.2%).

Ability to prognath: In our study, the sensitivity (33.3%) was found to be higher and the specificity (93.9%) comparable to those found by El-Ganzouri *et al*.[17] (16.5% and 95.8%).

Neck mobility and size: The sensitivity and specificity (10.5% and 97.3%) in our study was found to concur with Tse *et al*.,[4]

El-Ganzouri *et al*.[17] and Crosby *et al*.[14] (10% and 93%, 10.4% and 98.4%, 10% and 93–98% respectively).

The sensitivity of Mallampati classification in our study is lower as compared to other studies. The wide range of results in other studies has been attributed to interobserver variability. There is no single observer making preoperative assessments in other studies, as compared to our study where there was a single observer doing all the airway assessments preoperatively. In addition, prevention of phonation was shown to be a critical factor in achieving a reliable score, as suggested by Tham *et al*.[18].

The other probable reasons would include inability to standardize the laryngoscopist performing laryngoscopy (although laryngoscopy was performed in our study, by an experienced anesthesiologist according to ASA guidelines). As it is not practical for a single person to perform all laryngoscopies in our setup, there is a possibility of interobserver variability.

The PPV was higher for all the variables in comparison to that reported in meta-analysis study,[14] as the incidence in our study includes slight difficulty in intubation. As the individual sensitivities were low and the specificities high, we classified the patients as those who may probably have difficulty in intubation and those who may not have, based on the presence or absence of any of the five predictors [Figure 7].

When the criterion of presence of at least one predictor was considered, it was observed that 21.3% of patients fall into the risk category for difficult intubation. For this risk category, the sensitivity is 46.9%, with a specificity of 86.6%. We also tried to find the best possible combination in order to increase the sensitivity without much altering the specificity. The results are shown in Table 5.

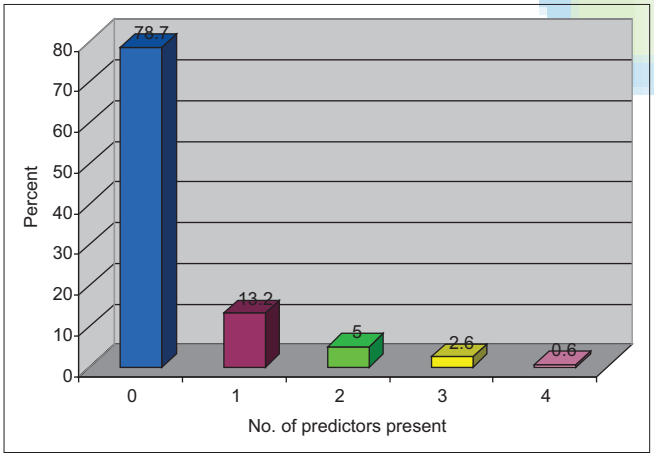

Figure 7: Distribution of patients according to no. of predictors present

Table 5: The sensitivity and specificity of included variables in different combinations

Variable	Sensitivity (%)	Specificity (%)
MC	16.3	97
AP	16.3	96.6
MC+AP	39.5	91.6
MC+AP+MO	42	89.7
MC+AP+MO+TMD+NM	46.9	86.6

MC: Mallampati classification, AP: Ability to prognath, MO: Mouth opening, TMD: Thyromental distance, NM: Neck mobility and size

We found that Mallampati classification and ability to prognath had a good specificity but low sensitivity. These were the two variables that were independent predictors in multiple logistic regression analysis. When these two were studied together as a combination (i.e., both the predictors present), the sensitivity improved to 39.5%. However, there was no significant improvement in sensitivity and specificity when other variables were included in different combinations. But when all the five variables were included, the sensitivity slightly increased from 39.5% to 46.6%, with a decrease in specificity from 91.6% to 86.6%.

We observe that independent predictors had very high specificity but a lower sensitivity, as compared to predictors when combined together.

In this study, we observed the following:

- Sensitivity = 46.6%, specificity = 86.6%, and PPV = 52.1%; criteria being any of the five predictors present
- Sensitivity = 39.5%, specificity = 91.6%, and PPV = 59.3%; criteria being the Mallampati classification (class III or IV) and inability to prognath.

In both the above situations, there was no significant difference in sensitivity and specificity. However, the higher PPV, when the presence of the Mallampati classification (class III or IV) and the inability to prognath is considered, inclines us to conclude that the Mallampati classification and ability to prognath are the most important among the five predictors included in the study. This is being supported by the multivariate logistic regression analysis, which suggests that the Mallampati classification and ability to prognath are the independent predictors of difficult intubation.

Conclusion

Though this study confirms the premise that there exists no ideal indicator for preoperative assessment of a difficult intubation, we found the following:

- Mallampati classification and ability to prognath are the most important of the five variables included in the study
- The best combination of predictors was found to be Mallampati classification and ability to prognath.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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Proforma 1

Name: Age/sex:

Hosp. no. S. no.

Airway assessment

Intubation predictors:

1: Mallampati class	
I or II	0
III	1
IV but improves with vocalizing	3
IV or no improvement with vocalizing	4

2: Mouth opening	
>4 cm	0
3-4 cm	1
2-3 cm	4
<2 cm	5

3: Thyromental distance	
>6 cm	0
4-6 cm	0.5
3-4 cm	1
2-3 cm	2
<2 cm	4

4: Ability to prognath	
No overbite, good extension	0
No overbite, poor extension	1
Overbite, easily reversed	0.5
Overbite, barely able to reverse	2
Overbite, unable to reverse	4
Can't understand request to prognath	0.5

5: Neck mobility (in degrees) and size	
>60°, normal size	0
>60°, short neck	0.5
30-60°, normal neck	0.5
30-60°, short neck	2
10-30°, normal neck	3
10-30°, short neck	4
<10° or immobilized	5

Total calculated score	
≤5	Easy airway
>5	Anticipated difficult airway

*Mouth opening: Additional points for moderate (0.5) or severe Temporo-mandibular joint (TMJ) (2)

*Neck mobility: Additional points for Down Syndrome (2), diabetes with lax joints (2), rheumatoid or comparable subluxation risk (2), moderate airway deviation or narrowing (2), obstruction or impending obstruction (5), radicular s/s on extension (5)

*Score modified by intubation history: Moderate difficulty (3), pronounced difficulty (4), impossible (5); if easy (*)

Proforma 2

Name: Age/sex:

Hosp. no.: S. no.

Intubation difficulty scale

Parameter	Score
No. of attempts >1	N1 =
No. of operators >1	N2 =
No. of alternative techniques	N3 =
Cormack grade I	N4 =
Lifting force required	N5 =
Laryngeal pressure	N6 =
Vocal cord mobility	N7 =
Total: IDS=Sum of scores	

Rules for calculating IDS score

NI - Every additional attempt adds 1 pt

N2 - Each additional operator adds 1 pt

N3 - Each alternative technique adds 1 pt; repositioning of the patient, change of materials (blade, Endotracheal tube, addition of a stylette), Change in approach (nasotracheal/orotracheal) or use of another technique (fibroscopy, intubation through a laryngeal mask)

N4 - Apply Cormack grade for 1st oral attempt

For successful blind nasal intubation N4 = 0

N5 - Normal = 0, Increased = 1

N6 - Not applied = 0, Applied = 1, Sellick's maneouvre adds no points

N7- Abduction = 0, adduction = 1

Impossible intubation: IDS takes the value attained before abandonment of intubation attempts

IDS score	Degree of difficulty
0	Easy
0< IDS ≤5	Slight difficulty
5< IDS	Moderate to major difficulty
IDS = ∞	Impossible intubation