Appendix 1 – The searches

How should we screen patients who need to be evaluated preoperatively by the anaesthesiologist?

At what time should the patient be seen preoperatively

Who should examine the patient?

Search Strategy:

----

1   pre?operative.mp.

2   screen.m_titl.

3   screening.m_titl.

4   questionnaire.m_titl.

5   timing.m_titl.

6   nurse.m_titl.

7   staff.m_titl.

8   staffing.m_titl.

9   2 or 3 or 4 or 5 or 6 or 7 or 8

10   1 and 9

11   limit 10 to yr="2000 -Current"

Search conducted 23.05.2010

Medline – 584

Embase – 523

How should the airway be evaluated?

Search Strategy:

----

1   "predict*".m_titl.

2   evaluation.m_titl.

3   ventilation.m_titl.

4   airway.m_titl.

5   mallampati.m_titl.

6   laryngoscopy.m_titl.

7   3 or 4 or 5 or 6

8   1 or 2

9   7 and 8

10   limit 9 to yr="2000 -Current"

Search conducted 1.05.2010

Medline – 586

Embase – 594

Specific clinical conditions where the patient should be evaluated more thoroughly

Cardiovascular disease

Search limited to beta-blockade, since 2008.

Search Strategy:

----

1   an?esth*.mp.

2   surgery.mp.

3   pre?operative.mp.

4   peri?operative.mp.

5   1 or 2 or 3 or 4 (1521445)

6   beta blocker.mp.

7   beta blockade.mp.

8   metoprolol.mp.

9   atenolol.mp.

10   labetalol.mp.

11   bisoprolol.mp.

12   6 or 7 or 8 or 9 or 10 or 11

13   5 and 12

14   limit 13 to yr="2008 -Current"

Search conducted 12.04.2010

Embase – 765

Medline – 200

Respiratory disease, smoking, obstructive sleep apnoea syndrome

Search Strategy:

----

1   pre?operative.mp.

2   respiratory.m_titl.

3   smoking.m_titl.

4   Predicted FEV1.mp.

5   Predicted DLCO.mp.

6   VO2 max.mp.

7   PEFR.mp.

8   asthma.m_titl.

9   bronchitis.m_titl.

10   OSA.m_titl.

11   sleep apnoea.m_titl.

12   COAD.m_titl.

13   COPD.m_titl.

14   Chronic obstructive.m_titl.

15   2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14

16   1 and 15

17   limit 16 to yr="2000 -Current"

Search conducted 29.04.2010

Medline – 390

Embase – 490

Renal disease

Search Strategy:

----

1   pre?operative.mp.

2   renal.m_titl.

3   creatinine.m_titl.

4   "kidney*".m_titl.

5   2 or 3 or 4

6   1 and 5

7   assessment.mp.

8   evaluation.mp.

9   predict*.mp.

10   7 or 8 or 9

11   surgery.mp.

12   6 and 10 and 11

13   limit 12 to yr="2000 -Current"

Search conducted 01.06.2010

Medline – 286

Embase – 781

Diabetes

Search Strategy:

----

1   pre-operative.mp.

2   preoperative.mp.

3   1 or 2

4   pre-admission.mp.

5   preadmission.mp.

6   3 or 4 or 5

7   diabetes.m_titl.

8   insulin.m_titl.

9   carbohydrate.m_titl.

10   7 or 9

11   6 and 10

12   limit 11 to yr="2000 -Current"

Search conducted 04.02.2010

Medline – 192

Embase – 250

Obesity

Search Strategy:

----

1   pre?operative.mp.

2   obesity.m_titl.

3   weight.m_titl.

4   bariatric.m_titl.

5   2 or 3 or 4

6   1 and 5

7   limit 6 to yr="2000 -Current"

Search conducted 05.06.2010

Medline – 704

Embase – 873

Allergy

Search Strategy:

----

1   pre-operative.mp.

2   preoperative.mp.

3   1 or 2

4   allergy.m_titl.

5   anaphylaxis.m_titl.

6   hypersensitivity.m_titl.

7   4 or 5 or 6

8   3 and 7

9   limit 8 to yr="2000 -Current"

Search conducted 14.01.2010

Medline – 37

Embase – 53

Drug and alcohol addiction

Search Strategy:

----

1   pre?operative.mp.

2   alcohol.m_titl.

3   cocaine.m_titl.

4   amphetamines.m_titl.

5   cannabis.m_titl.

6   ectasy.m_titl.

7   speed.m_titl.

8   heroin.m_titl.

9   illicit.m_titl.

10   illegal.m_titl.

11   ketamine.m_titl.

12   drugs.m_titl.

13   2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12

14   1 and 13

15   limit 14 to yr="2000 -Current"

Search conducted 19.06.2010

Medline – 164

Embase – 219

Coagulation disorders

Search Strategy:

----

1   (preoperative or pre-operative).mp.

2   (haemostasis or hemostasis).m_titl.

3   bleeding.m_titl.

4   (haemophilia or hemophilia).m_titl.

5   (thrombocytopenia or thrombocytopaenia).m_titl.

6   platelets.m_titl.

7   Factor V.m_titl.

8   Factor II.m_titl.

9   Factor VII.m_titl.

10   Factor X.m_titl.

11   Factor XII.m_titl.

12   VonWillebrand.m_titl.

13   2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12

14   1 and 13

15   an?esth*.af.

16   14 and 15

17   limit 16 to yr="2000 -Current"

Search conducted 25.01.2010

Medline – 85

Embase – 145

<u>Anaemia</u>

Search Strategy:

----

1   pre?operative.mp.

2   an?emia.m_titl.

3   h?emaglobin.m_titl.

4   transfusion.m_titl.

5   iron.m_titl.

6   macrocytic.m_titl.

7   microcytic.m_titl.

8   thalassaemia.m_titl.

9   megaloblastic.m_titl.

10   haemolytic.m_titl.

11   erythropoeitin.m_titl.

12   2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11

13   1 and 12

14   limit 13 to yr="2000 -Current"

Search conducted 27.06.2010

Medline –479

Embase – 555

<u>The elderly/Cognitive Disorders</u>

Search Strategy:

----

1   dementia.m_titl.

2   elderly.m_titl.

3   delirium.m_titl.

4   cognitive.m_titl.

5   pre?operative.mp.

6   1 or 2 or 3 or 4

7   5 and 6

8   limit 7 to yr="2000 -Current"

Search conducted 06.06.2010

Medline – 589

Embase – 873

Obstetrics

Search Strategy:

----

1   pre?operative.mp.

2   "obstetric*".m_titl.

3   caesarean section.m_titl.

4   section.m_titl.

5   twins.mp.

6   labour.m_titl.

7   obstetric epidural analgesia.m_titl.

8   2 or 3 or 4 or 5 or 6 or 7

9   1 and 8

10   limit 9 to yr="2000 -Current"

Search conducted 20.02.2010

Medline – 257

Embase – 377

Psychiatric Disorders

Search Strategy:

----

1   pre-operative.mp.

2   preoperative.mp.

3   1 or 2

4   psychiatric.m_titl.

5   psychosis.m_titl.

6   depression.m_titl.

7   bipolar.m_titl.

8   manic.m_titl.

9   mania.m_titl.

10   schizophrenia.m_titl.

11   obsessive.m_titl.

12   compulsive.m_titl.

13   delusional.m_titl.

14   suicidal.m_titl.

15   anorexia.m_titl.

16   4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15

17   3 and 16

18   limit 17 to yr="2000 -Current"

Search conducted 04.03.2010

Medline – 165

Embase – 232

How should we deal with concurrent medication that might interfere with anesthesia?

"Over the counter" medication

Search Strategy:

----

1   pre?operative.mp.

2   over the counter.m_titl.

3   alternative medicine.m_titl.

4   herbal.m_titl.

5   homeopathy.m_titl.

6   echinacea.m_titl.

7   ginseng.m_titl.

8   gingko.m_titl.

9   "St. John's wart".m_titl.

10   valerian.m_titl.

11   garlic.m_titl.

12   passiflora.m_titl.

13   senna.m_titl.

14   ephedra.m_titl.

15   kava.m_titl.

16   peri?operative.mp.

17   1 or 16

18   2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15

19   17 and 18

20   limit 19 to yr="2000 -Current"

Search conducted 24.04.2010

Medline – 76

Embase – 72

Psychotropic drugs

Search Strategy:

----

1   pre?operative.mp.

2   peri?operative.mp.

3   psychotropic.mp.

4   anti-depressant.mp.

5   stimulant.mp.

6   antipsychotic.mp.

7   mood stabilizer.mp.

8   anxiolytic.mp.

9   sedative.mp.

10   hypnotic.mp.

11   3 or 4 or 5 or 6 or 7 or 8 or 9 or 10

12   1 or 2

13   11 and 12

14   limit 13 to yr="2000 -Current"

Search conducted 02.05.2010

Medline – 198

Embase – 584

Preoperative bridging of anticoagulation therapy

Search Strategy:

----

1   pre?operative.mp.

2   peri?operative.mp.

3   1 or 2

4   anti-coagulant.m_titl.

5   warfarin.m_titl.

6   heparin.m_titl.

7   clexane.m_titl.

8   deep vein thrombosis.m_titl.

9   DVT.m_titl.

10   pulmonary embolus.m_titl.

11   PE.m_titl.

12   prosthetic valve.m_titl.

13   4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12

14   3 and 13

15   limit 14 to yr="2000 -Current"

Search conducted 24.04.2010

Medline – 348

Embase – 401

Anti-hypertensives

Search Strategy:

----

1   pre?operative.mp.

2   "anti-hypertensive*".m_titl.

3   blood pressure.m_titl.

4   ACEi.m_titl.

5   "Ace inhibitor*".m_titl.

6   angiotensin.m_titl.

7   calcium.m_titl.

8   thiazide.m_titl.

9   "beta block*".m_titl.

10   2 or 3 or 4 or 5 or 6 or 7 or 8 or 9

11   1 and 10

12   limit 11 to yr="2000 -Current"

Search conducted 12.03.2010

Medline – 213

Embase – 277

How should the patient be informed about the preoperative risks?

Search Strategy:

----

1   pre?operative.mp.

2   pre?admission.mp.

3   communication.m_titl.

4   information.m_titl.

5   oral.m_titl.

6   written.m_titl.

7   multi-media.m_titl.

8   consent.m_titl.

9   education.m_titl.

10   3 or 4 or 5 or 6 or 7 or 8 or 9

11   1 or 2

12   10 and 11

13   limit 12 to yr="2000 -Current"

Search conducted 11.07.2010

Medline 2000-present – 841

Embase 2000-present – 967

Appendix 2 – Evaluation of the Airway: a review

Pierre Diemunsch

Introduction

The search for predictive signs for difficult airway management is an essential part of the pre-anaesthesia evaluation. The aim of this part of the patient's assessment is to avoid the occurrence of an unexpected difficulty in airway control, and eventually the death of a patient impossible to intubate and impossible to ventilate. On a global scale, difficult or impossible intubation/ventilation has been reported to kill up to an estimated 600 people a year. [1] During the period 1999-2005, failed or difficult intubation caused 2.3% i.e. 50 of the 2211 anaesthesia related death in the USA. [2]

The entire scope of this subject including the definition of what is a difficult intubation (DI), underwent profound modifications since the general introduction and acceptance of the supraglottic airway devices and again since the introduction and widespread of the videolaryngoscopes, both innovations having been recognized as life saving devices in many difficult cases. Particularly the laryngeal masks and the intubation laryngeal mask do belong to most of the algorithms for difficult airway management.

Therefore the usual predictive signs for DI may look old fashioned. Moreover, these well accepted clinical predictors are almost all predictors for difficult laryngoscopy and not for difficult intubation. Nevertheless, they remain of major importance in the usual clinical setting since

1. the direct laryngoscopy is still the worldwide gold standard for intubation and

2. difficult laryngoscopy (DL) is an acceptable surrogate for DI were no subglottic obstacle is present. On the other hand, validated predictive signs, specific for difficult videolaryngoscopy and difficult laryngeal mask placement, are lacking so far.

Prediction of difficult face mask ventilation (DMV) was unduly disregarded until the actual century but is of major importance since face mask ventilation represents the ultimate non invasive step to maintain proper oxygenation of the anaesthetized patient when attempts to instrumental airway control failed.

Finally, in the context of the recent major technical improvements in airway management and of the acceptance of the multimodal approach of their combination [3], the predictive signs for DL and DMV, rather than descriptive tools for the risk associated with airway control, represent the cornerstones for a logical implementation of these advances in the clinical practice of anaesthesia. Screening for high-risk situations using simple clinical signs, albeit not sufficient on its own, is crucial in order to take preventive measures and to be prepared to apply first-line treatment, which will be optimized by avoiding the stress of a surprise situation. In this sense, when properly evaluated and taken in account the predictive signs for difficult airway management aim at the risk reduction and at the improvement of the outcome for the patient requiring anaesthesia.

Existing evidence

<u>*criteria for DMV and impossible MV*</u>

The first prospective study specifically devoted to the prediction of DMW was published 2000. [4] DMV was found in 75 patients over 1502 (5%). This incidence was 0.08% in a previous series. [5] (see below). A multivariate analysis showed 5 criteria to be

independent factors for a DMV in this population of adults undergoing scheduled general surgery: 1. age older than 55 years, 2. body mass index > 26 kg/m^2, 3. presence of a beard, 4. lack of teeth, and 5. history of snoring. The presence of 2 of these factors predicts DMV with a sensitivity of 72% and a specificity of 73%. In the absence of these factors, the patient is very likely to be easy to ventilate (negative predictive value: 98%). The risk for DI is 4 times higher in the presence of risk for DMV.

In 2006, Kheterpal addressed the question of the DMV in a series of 22 660 patients. [6] He described 4 grades of difficulty and their respective incidences in the setting of a general anaesthesia with or without muscle relaxant. (Table 1)

The incidence of grade 3 or 4 associated with DI was 0.37%. Multivariate regression analysis identified the independent predictors that are listed in Table 2. Patients with 2 and 3 points in the predictor scale had a grade 3 MV incidence of respectively nearly 10 and 20 times the baseline incidence of 0.26% for patients with zero risk factors.

The importance of the mandibular protrusion test in predicting DMV and DMV combined with DI is stressed. A beard is the only easily modifiable risk factor for DMV (grade 3 MV). Patients should be informed of this risk especially when other risk factors for DMV are present and shaving may be recommended before the procedure.

Upon the observation of a large hypopharyngeal tongue in patients with difficult mask ventilation, difficult intubation and obstructive sleep apnea, Chou proposed the distance between the hyoid bone and the mandible as a predictive criterion for DMV. This radiologic measurement is neither validated nor possible on a routine basis. [7]

On the same anatomical basis, Takenaka proposed the **mandibular mobility** as a predictor for DMV. [8] Interestingly, the mandibular protrusion test belongs to the items

found as independent predictors in the Katherpal series and the **upper lip bite test** has been shown to be of interest in the prediction of DI [9], even more when combined with history of snoring and high neck circumference.

Conditions as the presence of a pharyngostome, or orbital exenteration with a communication between the orbit and the rhino pharynx represent exceptional causes of DMV. [10] They are generally obvious at the patient's examination.

In a study devoted to **impossible MV**, Kheterpal confirmed the incidence of grade 4 MV to be 0.15 % in a series of 53,041 patients. [6] The 5 independent predictors of impossible MV were: 1. neck radiation changes, 2. male sex, 3. sleep apnea, 4. Mallampati class III or IV, and 5. presence of a beard; the relative weights of these predictors being respectively of 6, 4, 3, 2, and 2. Patients with 3 or 4 risk factors demonstrated odds ratio of 8.9 and 25.9 respectively for impossible MV when compared with patients with no risk factors. One patient on 4 having an impossible MV had also a DI. [6]

criteria for DI

We lack predictive criteria for DI that are simple, rapid, affordable, reliable, 100% sensitive and specific, and that have good positive and negative predictive values. Most proposed assessments include common points or variable approaches of the same criteria (neck extension and sternomental distance, for example).

Mallampati classification

The Mallampati classification [11] (Table 3) is established when the patient is awake, either sitting, or standing, and has been validated in the supine position. [12] The patient is asked to open the mouth as wide as possible, and to stick out the tongue as far as possible,

without phonation. The classification was initially limited to the first 3 classes, and was completed by the addition of class IV represented by a limited view of the hard palate. Ezri has suggested adding a class 0 to the 4 others. Class 0 is defined as the visualization of the epiglottis with an open mouth and protruding tongue. [13] The incidence of class 0 is 1.18% in the author's study. It is consistently associated with a Cormack and Lehane grade I laryngoscopic view.

The correlation with the Cormack and Lehane grades is not very reliable for Mallampati classes II and III, because patients with these intermediary airway classifications have a relatively uniform distribution of the 4 grades of laryngoscopic view. However, there is a good correlation between the observance of a class I and a grade I laryngoscopy. Likewise, a class IV is generally associated with a grade III or IV.

The mediocre performance of the Mallampati classification has been attributed to errors in methodology, such as having the patient say "ah" (phonation that falsely improves the view), or allowing the patient to arch his or her tongue (falsely obscuring the view). Variations between observers are an additional source of false positives and false negatives for the Mallampati classification, which is not sufficient on its own to predict DL nor, *a fortiori*, DI. The insufficiency of the Mallampati classification has been specifically shown for obese patients. [14] It remains useful in this population (BMI $\geq$ 40) only when performed with the patient's craniocervical junction extended rather than neutral and if the patient is diabetic. [15] These data indicate that this classification should no longer be considered individually capable of predicting, with precision, what the laryngoscopic view will be. [16]

Combining the assessment of the mouth opening improves the specificity without altering the sensitivity of the Mallampati classification as a predictor of DI. [17] Another

recent study showed the Mallampati class other than one and the Mallampati class equals to 4 were 2 of the 5 easily evaluable bedside criteria from a simplified risk score for difficult airway (the 3 other items being a mouth opening less than 4 cm, an history of a DI and the presence of upper front teeth). [18]

Wilson score (Tables 4 and 5)

Wilson's study [19] was an important development in the attempt to deductively identify patients for whom intubation will be difficult. It should be emphasized that this study tests the predictability of DL and not DI. When a threshold value of 2 (Wilson score) is chosen to predict a DL, 75% of difficult cases were correctly detected (true positives) and 12.1% of easy cases were incorrectly detected as being difficult (false positives). These data illustrate the relatively weak power of the tests and the absolute need to train all anaesthesiologists in DI techniques.

El-Ganzouri score [5] (Table 6)

Established according to the same principle as the Wilson score, it includes similar criteria, in addition to the thyromental distance, Mallampati classification and history of DI. A value of 4 or more has a better predictive value than the Mallampati classification. It is a predictive score for DL, established from a study of 10,507 patients of whom 5.1% are grade III and 1% are grade IV according to Cormack and Lehane.

More recently, the El-Ganzouri score has been shown to be of particular interest when the laryngoscopy is performed with the GlideScope **videolaryngoscope** rather than with a conventional direct Macintosh laryngoscope and in this setting, the score was considered as a decisional tool by the authors. [20]

Sternomental distance

The comparison of 4 predictive tests on the same population (n=350) confirms that a Mallampati classification >II is not reliable on its own. [21] (Table 7) Measurement of sternomental distance proved to be more sensitive and more specific, with a threshold value of 12.5 (head fully extended on the neck and the mouth closed). The thyromental distance (less or equal to 6.5 cm) was less useful, as was the inability to bring the mandibular teeth anterior to the maxillary teeth (subluxation), refuting the results reported by Wilson.

In 2003, Khan [22] described the **upper lip bite test** (ULBT) with its 3 classes: Class I; the lower incisors can bite the upper lip, making the mucosa of the upper lip totally invisible, Class II; the same biting maneuver reveals a partially visible upper lip mucosa, Class III; the lower incisors fail to bite the upper lip. In the initial series, the ULBT Class III was a better predictor for DI than a Mallampati class $\geq$ 2. Its value has been disputed [23] and a prospective evaluation in 6.882 consecutive patients showed the ULBT to be a poor predictor of difficult laryngoscopy when used as the single bedside screening test in a North American patient population. [24] As the Mallampati classification, it has to be used as a part of a multimodal evaluation for DI. The combination with the thyromental distance (6.5 cm), and inter incisor distance (i.e. mouth opening; 4.5 cm) is easy to perform and more reliable as a predictor for DI. [25]

Of particular interest, the ULB, along with difficult direct laryngoscopy, is a validated predictor for difficult Glide Scope videolaryngoscopy. [26]

Trials for a synthesis

Benumof [27] grouped together 11 main elements of a physical examination and the criteria that must be met in order to indicate that intubation will not be difficult (Table 8). This evaluation uses the most relevant elements of the main tests or scores proposed. It is carried out easily and quickly, and requires no specific equipment.

Complementary elements are obtained by questioning the patient and studying previous anaesthesia reports, keeping in mind that intubation difficulty can vary in the same patient from one procedure to another, and even only a few hours apart. [28]

A criteria that is pathologic to the point of establishing the diagnosis of an impossible intubation on its own is exceptionally rare. Usually, the probability of a DI is backed up by several, converging elements. The reliability of the assessment increases with the number of criteria that are considered. Wong confirmed this conclusion in his series of 411 women. The study indicates that **pregnancy** does not increase the risk of DI (prevalence of 1.99% versus 1.55% for non-pregnant women). [29]

For Karkouti [30], the ideal combination includes 3 airway tests: mouth opening, chin protrusion and atlantooccipital extension. This preference is based on a multivariable analysis of predictive criteria, in an observational study of 461 patients of whom 38 had a DI. The conclusions reached by Benumof [27] are based on common sense and on the author's expertise.

In a prospective evaluation of 212 intubations, Iohom [31] found that combining the Mallampati Class III or IV with either a thyromental distance <6.5 cm or a sternomental distance <12.5 cm increased the specificity and positive predictive values of the screening to 100% with a negative predictive value maintained at 93%. These results were confirmed in a

meta analysis of 35 studies on screening tests, where Shiga [32] found the most useful bedside test for prediction of DI to be the combination of the Mallampati classification with thyromental distance (ROC AUC of 0.84).

Paraclinical examinations for systematic detection of DI

Among the paraclinical evaluations, **indirect laryngoscopy** seems to be the easiest to perform (sitting position, tongue held out by operator, angled mirror) and the easiest to interpret. A view that is equivalent to Cormack and Lehane grades III and IV is predictive of a direct laryngoscopy revealing the same grades and of DI. The positive predictive value, sensitivity and specificity of this test are better than those of the Mallampati classification and of the Wilson score. [33] (Table 9) This examination may not be possible to perform in certain patients, including 15% who have a strong gag reflex, and others who cannot sit up or who refuse it. It seems unrealistic to propose this evaluation to every patient. The combination of clinical and radiological criteria proposed by Naguib is interesting from a retrospective point of view, but cannot be systematically applied as a detection tool. [34]

High-risk groups

Intubation is generally considered more difficult in pregnant women and in otolaryngology (ENT) [35] and traumatology patients. Contradictory data have been reported, however, notably in obstetrics. [29]

Certain pathologies are particularly predisposing. Among the most common of these is **diabetes.** The positive "prayer sign" is patients' inability to press their palms together completely without a gap remaining between opposed palms and fingers and is a marker for probable ligament rigidity of the finger joints as in the TMJ and the cervical spine (stiff joint

or stiff man syndrome). When present, DI should be anticipated. Another test that has been proposed is a palm print study of the patient's dominant hand. A grade above 0 is considered a more sensitive predictor of DL than the Mallampati classification, the thyromental distance and the degree of neck extension [36]; (in this study, the prayer test was not compared to the palm print test). (Table 10)

Acromegaly is also considered a risk factor. DI occurs in about 10% of patients with this disease. [37]

Obesity by itself, including morbid obesity (BMI >35 kg/m^2) was not always considered a factor in DL. [38] The combination of obesity and lack of teeth, however, is strongly predisposing. A more recent series conversely suggested that DI is more common in obese than in lean patients, with a DI rate of 15.5% in obese patients (BMI > 35 kg/m^2) compared to 2.2% in lean patients (BMI < 30 kg/m^2) respectively. Desaturation is common and fast occurring with DI in obese patients. [39]

In general, problems linked to **congenital disease, rheumatic conditions, local pathologies and previous history of trauma** are easily identified during the **physical exam** or by **questioning** the patient. In otolaryngology, surgeons who are prepared to perform a direct tracheal approach in case of impossible intubation are immediately available to assist the anaesthesiologist.

Cowden syndrome, lingual papillomatosis and **angioedemas** can also be formidable pitfalls. [40]

Examples of obvious or less obvious situations that predispose to DI :

- congenital facial and upper airway deformities;

- maxillofacial and airway trauma (current or previous);

- airway tumors and abscesses

- immobile cervical spine

- fibrosis of the face and neck from burns or radiation exposure

- obstructive sleep apnea syndrome [41]

- history of neurosurgical procedures, with or without division of the temporal muscle, that can lead to pseudoankylosis of the mandible [42]

- tongue piercing [43]

Weighted approach of the predictive factors : towards a quantitative clinical index for DI

Clinical multifactorial indexes have been described to predict DI. Defining DI as the failed attempt of 2 anaesthesiologists to use basic direct laryngoscopy, Arné [44] has developed a clinical index that obtains predictive scores with a sensitivity and specificity of 94% and 96% in general surgery, 90% and 93% in ENT non-cancer surgery, and 92% and 66% in ENT cancer surgery. The defined index was validated in a prospective study (n=1090) after being established in an initial study (n = 1200). The overall incidence of DI for all patients is 4.2%. No impossible intubation was reported.

The factors taken into consideration are:

1. Weight, age and height
2. History of DI (if patient was informed)

3. Predisposing pathologies such as facial deformities, acromegaly, rheumatic conditions of the neck, ENT tumors, diabetes

4. Symptoms of respiratory tract diseases such as dyspnea, dysphonia, dysphagia and OSAS in particular

5. Mandibular mobility as in the Wilson score, but with a 3.5 cm mouth opening

6. Mobility of the head and the neck as in the Wilson score

7. Prominence of the upper incisors as in the Wilson score

8. Aspect of the neck: short and thick or not

9. Thyromental distance, > or <6.5 cm

10. Mallampati classification

The statistical analysis based on 1200 observations was used to assign point values to each of these factors in proportion to regression coefficients representing the relative weight of each predictive intubation difficulty factor, which was validated in the second prospective study of 1090 patients. (Table 11)

More recently, Naguib [45] validated an equation to predict DI. The prediction (l) was determined by the following formula :

l = 0.2262 – 0.4621 x thyromental distance + 2.5516 x Mallampati score – 1.1461 x inter incisor distance + 0.0433 x height

in which the thyromental distance, inter incisor gap, and height were measured in centimeters and Mallampati score was 0 or 1. Using this equation for predicting difficult intubation, the laryngoscopy and intubation would be easy if the numerical value (l) in the equation is less than zero (i.e., negative) but difficult if the numerical value (l) is more than zero (i.e., positive).

Opinions concerning the usefulness of this type of index are sometimes very negative. [46] Nevertheless, they introduce a relative weight for the different criteria and may play a justifiable role in the evaluation of situations that are neither obviously easy nor obviously difficult.

It seems therefore that although predictive tests of DI are numerous, noneis perfect. The reproducibility of the tests from one observer to another is inconsistent as it is across age, sex [47] and ethnic groups. A certain amount of false negatives will persist, no matter what method of detection is used. Prevention is the best cure. However, foreseeing, when possible, does not guarantee prevention [48] There is a perceptible association in the literature between foreseeing difficulty and preventing death due to impossible intubation. Since our final goal is the latter, we should direct our efforts towards the management of DI as much as towards detecting it. [49,50]

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Table 1: grades of difficult mask ventilation (MV)

Grade 1 MV: 77.4% Ventilated by mask

Grade 2 MV: 21.1% Ventilated by mask with oral airway/adjuvant

Grade 3 MV: 1.4% Difficult ventilation i.e. inadequate,unstable, or requiring two providers

Grade 4 MV: 0.16% Unable to mask ventilate

Table 2:   The independent predictors of difficult intubation

Predictors for grade 3 mask ventilation

1. Body mass index $\geq$ 30 kg/m^2

2. Jaw protrusion severely limited

3. Snoring

4. Beard

5. Mallampati III or IV

6. Age $\geq$ 57 yr

Predictors for grade 4 mask ventilation

1. Snoring

2. Thyromental distance < 6 cm

Predictors for grade 3 or 4 mask ventilation combined with difficult intubation

1. Body mass index $\geq$ 30 kg/m2

2. Jaw protrusion limited or severely limited

3. Snoring

4. Thick/obese neck anatomy

5. Sleep apnea

Table 3: The Mallampati classification modified by Samsoon and Young (addition of class IV) and outcome of test.

Class	Visible structures (patient upright, maximal opening of mouth and protrusion of tongue)
I	*Uvula, fauces, soft palate, hard palate*
II	Fauces, soft palate, hard palate
III	Soft palate, hard palate
IV	Hard palate alone

Mallampati class predictive of a DI	True positives (%)	False positives (%)
>II	55	5

Table 4:   The Wilson score

Criterion	Points		
	0	**1**	**2**
Weight (kg)	<90	90-110	>110
Head and neck mobility (degrees)	>90	90	<90
Mandibular mobility	MO* >5 cm or subluxation[†] >0	MO* <5 cm and subluxation[†] =0	MO* <5 cm and subluxation[†] <0
Retrognathism	None	Moderate	Severe
Prominence of upper incisors	None	Moderate	Severe

*MO: mouth opening; [†]subluxation: possibility of advancing the mandibular incisors in front of the maxillary incisors (>0); or just to their level (=0); or impossibility of advancing the mandible in relation to the maxilla (<0). A score of 2 or more is predictive of a DL.

Table 5: Performances of the Wilson score depending on the chosen threshold

Choice of threshold value of Wilson score	True positives (%)	False positives (%)
≥ 4	42	0.8
≥ 3	50	4.6
≥ 2	75	12.1
≥ 1	92	26.6

Table 6: The El-Ganzouri score

Criterion	Points		
	0	**1**	**2**
Weight (kg)	< 90	90 - 110	>110
Head and neck mobility (degrees)	< 90	90 ±10	<80
Mouth opening	≥ 4 cm	< 4 cm	
Subluxation >0	possible	not possible	
Thyromental distance	> 6.5 cm	6-6.5 cm	< 6 cm
Mallampati class	I	II	III
History of DI	no	possible	established

Table 7: Comparison of 4 predictive tests on the same population (n=350)

Test compared in 350 subjects	Sensitivity	Specificity	Positive predictive value
Mallampati >II	64.7 %	66.1 %	8.9 %
Thyromental distance <=6.5 cm	64.7 %	81.4 %	15.1 %
Sternomental distance <=12.5 cm	82.4 %	88.6 %	26.9 %
Subluxation 0 or <0	29.4 %	85.0 %	9.1 %

Table 8: Main elements of the examination to detect DI. The 11 items are presented in logical order, superiorly to inferiorly (teeth followed by mouth and then neck); no element is sufficient on its own. (TMJ: temporomandibular joint).

11 elements of the examination	Criteria in favor of an easy intubation
Length of the upper incisors	Short incisors – qualitative evaluation
Involuntary anterior overriding of the maxillary teeth on the mandibular teeth (retrognathism)	No overriding of the maxillary teeth on the mandibular teeth.
Voluntary protrusion of the mandibular teeth anterior to the maxillary teeth	Anterior protrusion of the mandibular teeth relative to the maxillary teeth (subluxation of the TMJ)
Inter-incisor distance (mouth opening)	Over 3 cm
Mallampati classification (sitting position)	I or II
Configuration of the palate	Should not appear very narrow or highly arched
Thyromental distance (mandibular space)	5 cm or 3 fingerbreadths
Mandibular space compliance	Qualitative palpation of normal resilience/softness
Length of neck	Not a short neck – qualitative evaluation

Thickness of neck	Not a thick neck – qualitative evaluation
Range of motion of head and neck	Neck flexed 35° on chest, and head extended 80° on the neck (ie sniffing position)

Table 9: Sensitivity, specificity and positive predictive value of different tests to predict difficult intubation (DI)

Test (n=6148, DI: 1.3%) [268]	Sensitivity (%)	Specificity (%)	Positive predictive value (%)
Wilson score >2	55.4	86.1	5.9
Mallampati classification >2	67.9	52.5	2.2
Indirect laryngoscopy; grade >II	69.2	98.4	31.0

Table 10: The Palm print test

Palm print
Grade 0 – *View of all phalangeal surfaces.*
Grade 1 – *Phalangeal surfaces of fourth or fifth fingers missing from print.*
Grade 2 – *Phalangeal surfaces of the second to fifth fingers missing from print.*
Grade 3 – *Print of fingertips only.*

Table 11: Points for the different variables that predict difficult intubation

Criteria	Simplified value	With 11 as the threshold value for this index, the test gave the following results:
Past history of DI	10	
Predisposing pathologies	5	
Respiratory symptoms (as snoring...)	3	sensitivity: 93%
MO >5 cm or subluxation >0	0	specificity: 93%
3.5 cm<MO<5 cm and subluxation =0	3	PPV: 34%
MO <3.5 cm and subluxation <0	13	NPV: 99%
Thyromental distance < 6.5 cm	4	General population
Mobility of head and neck >100°	0	Validation study: n=1090
Mobility of head and neck 80-100°	2	Difficult intubation: 3.8%
Mobility of head and neck <80°	5	
Mallampati classification 1	0	
Mallampati classification 2	2	
Mallampati classification 3	6	
Mallampati classification 4	8	

Maximum total	**48**	