Difficult intubation in ENT and maxillofacial surgical patients: a prospective survey.
P Wong, S Parrington

Citation

Abstract
The incidence of and predictors of difficult intubation in 644 adult patients presenting for elective ‘head and neck’ and ‘emergency’ ENT/maxillofacial surgery were recorded over a 12 month period. Predictors of difficulty included bedside tests of the airway, a history of previous surgery or radiotherapy and the presence of airway symptoms. Difficult intubation was defined as a Cormack and Lehane grade 3 or 4 at direct laryngoscopy. There were 565 patients with a recorded intubation grade, 15.4% (n=87) were documented as a difficult intubation. Subgroup analysis revealed difficult intubation occurring in 2.1% (n=2) of patients with a fractured mandible; 30.8% (n=12) of patients with oro-facial abscess; 33.3% (n=6) following previous major head and neck surgery; 42.5% (n=17) following head and neck radiotherapy; and, 31.6% (n=24) of patients presenting with symptoms of upper airway obstruction. Predictors of difficult intubation were then identified using unifactorial and multifactorial analysis. Single bedside tests that predict difficult intubation had low to moderate sensitivity and specificity. In patients with a fractured mandible, bedside tests frequently predicted difficult intubation, but the majority were an easy intubation (97.9%, 95% CI 0.3-7.5%). After excluding data for patients with fractured mandibles, logistic regression identified four independent predictors of difficulty in this group of patients: a history of previous head and neck radiotherapy, a reduced inter-dental distance, a reduced mandibular luxation and the presence of airway symptoms.

INTRODUCTION
Data regarding airway assessment and prediction of difficult intubation for general and obstetric populations are well documented [1]. This is in contrast with data for patients admitted for elective and ‘emergency’ ENT/maxillofacial surgery [2]. These patients may present with underlying pathology that can cause difficulty in airway management e.g. oro-facial infection, trauma, tumours, and a history of previous surgery or radiotherapy to the head and neck. The incidence of difficult intubation has been shown to be higher in ENT cancer patients than general surgery patients (12.3% vs 2.0%).[3]. Difficult intubation may lead to increased morbidity and higher rates of unplanned ICU admissions [4]. Prediction of difficult intubation using multifactorial models has been described but previous radiotherapy and the presence of airway symptoms as predictive variables have not been incorporated [5,6,7]. A subsidiary aim was to identify risk factors for difficult intubation in these patients. Patients were categorised into three subgroups:

1. Patients with anaesthetic bedside tests that predicted difficult intubation.
2. Patients with airway symptoms.
3. Diagnostic subgroups according to disease presentation or previous treatment e.g. fractured mandible (FM), orofacial abscess (OFA), previous radiotherapy to the head and neck (DXT), upper airway obstruction (UAO), previous major head and neck surgery (PS) or both previous head and neck major surgery and radiotherapy (PS+DXT).

METHOD
Ethics approval was sought and the local Research Ethics Committee advised that as the project was a prospective survey formal approval was not required. A prospective survey on consecutive adult patients scheduled for elective and emergency head and neck surgery requiring general
anaesthesia was performed. Data were collected over a
12-month period from April 2007 at a large London teaching
hospital. Elective patients were those on the operating lists
of six surgeons specialising in ENT and maxillofacial
oncology surgery. All adult patients were included whether
the surgery was for benign or malignant disease.
‘Emergency’ patients were those who presented with FM,
OFA or UAO. All cases were managed by an anaesthetic
consultant or specialist registrars with at least four years
anaesthetic experience.

Preoperatively, data were collected on patient’s physical
characteristics, grade of anaesthetist, and an airway
assessment was performed. Predictive risk factors for
difficult intubation were recorded under the following
headings 1) airway symptoms – hoarse voice, stridor,
dyspnoea or postural symptoms, 2) anatomical airway
bedside tests (see Appendix A) – modified Mallampati score
(MP) \[1\], inter-dental distance (IDD), thyromental distance
(TMD) and mandibular luxation score (ML) \[2\], and 3)
patient’s disease or previous treatment – FM, OFA, DXT,
PS or PS+DXT or UAO. Trismus was defined as IDD≤2.5
cm. Laryngoscopic view was graded according to the
modified Cormack-Lehane (CL) scoring system (see
Appendix A) \[3\]. The best view obtained at direct
laryngoscopy was recorded whether using standard or long
Macintosh laryngoscope, or whether cricoid pressure or
external laryngeal manipulation was applied. If direct
laryngoscopy was performed after tracheal intubation e.g.
after awake fibreoptic intubation (FOI) or blind nasal
intubation, then the best estimate of CL grade was recorded.

Induction and airway techniques, and any complications
during airway management, were recorded. Conduct of
anaesthesia was operator specific. There were no restrictions
or impositions placed on intubating position, method of
anaesthetic induction or muscle relaxants used, type of
airway devices or adjuncts used.

STATISTICAL ANALYSIS
Statistical analyses were carried out using SAS (version 9).
The association between difficult intubation and bedside
tests, presenting disease or previous treatments, and presence
of airway symptoms was determined using uni-factorial
logistic regression. Stepwise logistic regression analysis was
used to identify multi-factorial independent predictors of
difficult intubation.

RESULTS
There were a total of 706 operations on 644 patients, 49
patients returned for an additional 62 operations. Their
characteristics are shown in Table 1. Only data from the first
admission (644 operations) were included in the statistical
analysis, but subsequent admissions were included for
descriptive analysis. Details of operative procedures are
shown in Table 2.

Figure 1
Table 1: Patient’s characteristics (n=644)

<table>
<thead>
<tr>
<th></th>
<th>Total population</th>
<th>Elective head and neck surgery (maxillofacial and ENT surgery)</th>
<th>“Emergency” maxillofacial surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of pt</td>
<td>644</td>
<td>304</td>
<td>100</td>
</tr>
<tr>
<td>Mean age (SD yrs)</td>
<td>52.48 ±11.4</td>
<td>57.9 ±11.7</td>
<td>54.8 ±11.2</td>
</tr>
<tr>
<td>MF</td>
<td>49/21</td>
<td>200/175</td>
<td>91/19</td>
</tr>
<tr>
<td>Mean weight (SD kg)</td>
<td>74 (11.7)</td>
<td>74 (11.7)</td>
<td>72 (11.9)</td>
</tr>
</tbody>
</table>

FM = fractured mandible, OFA = oro-facial abscess, DXT = previous head and neck radiotherapy only, PS = previous major head and neck surgery only, and PS+DXT = both previous head and neck major surgery and radiotherapy.
Out of 706 operations, 565 had a CL score recorded. The incidence of difficult intubation was 15.4\% (n=87). The number of patients with ‘positive’ bedside tests and difficult intubation for each of the subgroups are shown in Table 3.

MP = Mallampati score, TMD = thyromental distance, ML = mandibular luxation score, CL = Cormack-Lehane laryngoscopic view, DXT = previous head and neck radiotherapy only, PS = previous major head and neck surgery only, and PS+DXT = both previous head and neck major surgery and radiotherapy, FM = fractured mandible, OFA = oro-facial abscess.

The sensitivity, specificity and positive predictive value (PPV) of each bedside test are shown in Table 4.
Difficult intubation in ENT and maxillofacial surgical patients: a prospective survey.

Sens = sensitivity, Spec = specificity, PPV = positive predictive value,
DXT = previous head and neck radiotherapy only,
PS = previous major head and neck surgery only
PS+DXT = both previous head and neck major surgery and radiotherapy,
FM = Fractured mandible,
OFA = Oro-facial abscess.

AIRWAY MANAGEMENT AND COMPLICATIONS

There were five recorded cases of failed intubation in 706 operations, three of whom had previous DXT. One case resulted in a “can’t intubate, can’t ventilate” situation (0.1%). 327 cases (out of 706 i.e. 46.3%) used alternative methods of securing the airway other than tracheal intubation with conventional direct laryngoscopy or simple insertion of J tubes in pre-existing tracheal stomas. They included awake tracheotomy, use of the flexible or rigid fibrescope, Airtraq, Glidescope, LMA, intubating LMA (ILMA), blind nasal intubation and jet ventilation.

Table 5

<table>
<thead>
<tr>
<th>Advanced airway techniques</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOI</td>
<td>21.5%</td>
</tr>
<tr>
<td>Retrograde FOI</td>
<td>10.2%</td>
</tr>
<tr>
<td>Flexible FOI</td>
<td>20.2%</td>
</tr>
<tr>
<td>LMA</td>
<td>1.3%</td>
</tr>
<tr>
<td>ILMA</td>
<td>0.9%</td>
</tr>
<tr>
<td>Blind nasal</td>
<td>0.8%</td>
</tr>
<tr>
<td>Awake tracheotomy</td>
<td>0.8%</td>
</tr>
<tr>
<td>Awake oral induction</td>
<td>0.8%</td>
</tr>
<tr>
<td>Awake nasal induction</td>
<td>0.8%</td>
</tr>
</tbody>
</table>

Percentage figures are derived from the total of 706 anaesthetics.

FIBREOPTIC AIRWAY MANAGEMENT

Flexible FOI was used on 152 recorded occasions (out of the 706 operations i.e. 21.5%). There were 43 cases of difficult intubations (33.3%). FOI (awake or asleep) was used to aid tracheal intubation in FM, OFA and DXT groups in 32%, 58% and 26% of cases, respectively. 41 cases (28.1%) experienced one or more complications during the FOI. These were: fogging (n=5), red or white out (n=5), secretions (n=9), blood (n=1), coughing (n=12), difficulty in railroading the tracheal tube over the fibrescope (n=9) and one case of regurgitation.

There were also six failed FOI (3.9%), and were due to: secretions (two cases); failure to railroad the tracheal tube over the fibrescope (one awake and one asleep FOI); loss of airway (resulting in CICV, described above); and, one unrecorded cause.

The Bonfils fibrescope was used in 72 cases (10.2%). 31 of these cases were difficult intubation (43.1%) – eight cases CL IV and 23 CL III. There were four failures to intubate using the Bonfils. Three patients had CL III; two had laryngeal tumours that were grossly oedematous or friable, and one had a tongue base tumour. The airway was secured with the rigid bronchoscope in two of these patients, and with bougie-assisted tracheal intubation in the third. The remaining patient had a CL grade I and failure was due to the presence of secretions.

After exclusion of data for patients with FM, in whom bedside predictors showed poor sensitivity and specificity, unifactorial analysis demonstrated difficult intubation was more common in certain diagnostic groups and when airway symptoms were present (Table 6).

Table 6

<table>
<thead>
<tr>
<th>Diagnostic sub groups</th>
<th>Incidence of difficult intubation</th>
<th>Odds ratio per unit</th>
<th>95% Wald confidence limits</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sx (or 0 or 1)</td>
<td>80 = 12.4%</td>
<td>2.861</td>
<td>1.618, 5.059</td>
<td>&lt;0.0003</td>
</tr>
<tr>
<td>OFA (or 0 or 1)</td>
<td>12 = 70.8%</td>
<td>2.186</td>
<td>1.059, 4.513</td>
<td>0.0345</td>
</tr>
<tr>
<td>DXT (or 0 or 1)</td>
<td>17 = 42.5%</td>
<td>3.947</td>
<td>2.003, 7.777</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>PS (or 0 or 1)</td>
<td>6 = 33.3%</td>
<td>2.367</td>
<td>0.86, 6.496</td>
<td>0.09</td>
</tr>
<tr>
<td>PS+DXT (or 0 or 1)</td>
<td>17 = 51.5%</td>
<td>5.781</td>
<td>2.786, 11.997</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>OF (or 0 or 1)</td>
<td>33 = 9.7%</td>
<td>0.161</td>
<td>0.097, 0.266</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

MP = Mallampati score, TMD = thyromental distance, ML = mandibular luxation score, Sx = presence of airway symptoms.
OFA = oro-facial abscess,
DXT = previous head and neck radiotherapy only,
PS = previous major head and neck surgery only,
PS+DXT = both previous head and neck major surgery and radiotherapy,
OS ‘other surgery’ group = 0 = absence, 1 = presence of a variable.

Multifactorial analysis was then performed, which identified four independent risk factors for difficult intubation i.e. DXT, IDD, ML and presence of airway symptoms (Table 6).

**Figure 7**

Table 7: Multiple logistic regression with forward variable selection showing variables that are independently predictive of difficult intubation. This was performed after exclusion of FM patients.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds ratio</th>
<th>95% Wald confidence limits</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DXT (0 or 1)</td>
<td>3.7</td>
<td>1.4 9.7</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>IDD (per cm)</td>
<td>0.38</td>
<td>0.28 0.51</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>ML (1, 2, 3)</td>
<td>1.9</td>
<td>1.1 3.2</td>
<td>0.0147</td>
</tr>
<tr>
<td>Sx (0 or 1)</td>
<td>6.8</td>
<td>3.1 15.2</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

DXT=previous head and neck radiotherapy, IDD=inter-dental distance, ML=mandibular luxation score and Sx=presence of airway symptoms

**DISCUSSION**

The definition of difficult intubation remains controversial and its reported incidence ranges from 1.5-20.2%, with an overall incidence of 5.8% [1]. We used the most commonly applied definition i.e. a CL 3 or 4 on direct laryngoscopy. A higher incidence of difficult intubation in ENT/maxillofacial patients has been reported previously [2-3] and our study of elective and emergency ENT and maxillofacial surgical patients found similar results. The range in our study was from 2.1% in patients with FM to 51.5% in patients with PS+DXT. In a previous study of ENT patients, the incidence of difficult intubation was 3.4-3.5% and 12.3-15.7% in non-cancer and cancer surgery patients, respectively [2].

Multifactorial models have been used to derive composite airway risk index scores or mathematical equations based on logistic regression analysis to predict difficult intubation [2-3,6,8,9,10] although two studies failed to demonstrate an increase in predictive power [11]. The sensitivities, specificity and PPV in these studies ranged from 5-93%, 76-99% and 9-38%, respectively. The models used also differ considerably in the predictive variables that are incorporated. In our survey of patients who would be expected to be a difficult intubation, new predictors were identified that included DXT, IDD, ML and the presence of airway symptoms. In combination they may be used to predict a difficult airway more reliably than individual variables in our patient population.

MP and TMD were not found to be independent variables despite them being incorporated in the risk index scoring or equations of El-Ganzouri, Arne, Ayuso and Naguib [2,3,8,10]. The absence of OFA, PS and PS+DXT as independent predictors, despite high incidences of difficult intubation in these groups, may be due to the fact that a reduced IDD, which is frequently present in these pathologies, is itself an independent predictor and may account for difficult intubation.

There are many limitations in the use bedside tests to predict difficult intubation. These include differences in study populations, the exact definition of tests, cut-off points used to predict difficult intubation, the definition of difficult intubation, inter-observer variability and the effects of different induction techniques. Many studies have used different patient populations that range from normal, obese, diabetic, obstetric, gynaecological to ENT and their conclusions may not be applicable to other groups [1]. The precise definition of individual bedside tests also varies between studies e.g. MP grade is based on the visibility of the “soft palate, uvula, fauces and tonsillar pillars”, but the exact definition and differences between these components is not clear [12,14]. With MP and TMD, there is little consistency in the literature in describing body, head, tongue and neck positions, or the use of phonation during measurement [15]. The method of measuring anatomical reference points also varies. For example, with TMD, should the measurement be from the thyroid notch to inside, in line with, or outside the mentum [15]? Inter-observer variability occurs, especially with the use of MP but less so with IDD and ML [16]. Bias also occurs if the same person performs both bedside tests and CL grade. This may explain the 93% PPV value for a MP 3 grade to predict difficult intubation by Mallampati et al. [14].

The use of Cormack-Lehane grading also presents several problems. Bedside tests are done before the induction of anaesthesia, whereas direct laryngoscopy and CL scoring are performed after induction. Elimination of the effects of pain and muscle spasm following the induction of anaesthesia and the use of muscle relaxants e.g. in patients with FM and OFA, changes beside tests such as IDD dramatically. In
addition, the CL scoring system applies to conventional direct laryngoscopy when there is an attempt to align the oral, pharyngeal and laryngeal axes. Indirect laryngoscopy does not rely on this manoeuvre and so beside tests and CL grading are less relevant. Finally, most CL 3 can be intubated with the use of a bougie and so only 10% of such grades are “truly difficult” intubations [4].

FRACTURED MANDIBLE
In our FM group, ‘positive’ predictive tests for MP, TMD, IDD and ML grade occurred in 75.0%, 28.6%, 64.90% and 70.2% of cases, respectively. However, only two cases (2.1%) were difficult intubations and this resulted in high false positive rates and low PPV (2.9-3.8%). Since both cases fell within the large pool of ‘positive’ test patients, all four bedside tests achieved 100% sensitivity. The poor performance of these tests can be explained by the fact that alleviation of trismus after induction of anaesthesia results in improved test scores, and subsequently tracheal intubation is often easy.

Patients with a FM are commonly managed using awake FOI techniques. In our study, only 2% of FM were “difficult intubation” according to CL grade but awake FOI was used in 16 cases. The inability of anaesthetic bedside tests to predict difficult intubation in this group of patients makes it difficult to justify performing an awake FOI, a potentially unpleasant procedure with the potential for complications (including failure). However, awake FOI may be indicated in specific cases of fractured mandible where mouth opening may be difficult or impossible, such as: condylar dislocation ahead of the articular tubercle (subsequently held there by the masseter muscles) or into the middle cranial fossa; and, zygomatic fracture with impingement of the coronoid process, preventing translatory movement of the condyle [18,19].

MAXILLO-FACIAL AND ENT PATIENTS
Abscesses involving the floor of the mouth are associated with less improvement of trismus after induction of anaesthesia and with a higher likelihood of difficult intubation [1]. Out of 50 patients presenting with OFA, 63.3% had trismus, with a mean IDD (SD) of 2.3 (1.3) cm, and 30.8% were difficult intubations. Unlike FM, these patients with trismus, where the infective process affects the muscles of mastication, a stronger argument for the use of an awake FOI technique can be made.

The presence of peri-glottic tumours doubles the incidence of difficult intubation [3]. In our study, there were 19 cases of upper airway obstruction, due to peri-laryngeal tumours. Not surprisingly, a large proportion (37%) required a tracheotomy to secure their airway.

RADIOTherAPY
DXT to the head and neck is frequently associated with a difficult airway. The reason for this is multifactorial It causes increased vascularity, thrombi of vessels, blocked vascular and lymphatic outflow, increased vascular permeability, and oedema which usually resolves after 1-2 months but may persist. [30]. Longer term changes include: altered soft tissue structure (fibrosis, contractures and loss of elastic recoil), decreased neck movement and increased forward head posture, limited mouth opening oedema of the upper airway and salivary gland hypofunction [31,32,33,34]. Furthermore, increased risk of bleeding leads to a reluctance to perform awake tracheotomy in these patients.

The incidence of trismus reportedly varies from 5-38% in head and neck patients who have had previous radiotherapy [35,36]. These results are similar to the results in our study. In our DXT and PS+DXT patients, trismus occurred in 24.4% and 47.4%, respectively. These patients also had a higher incidence of difficult intubation (42.5% and 51.5%, respectively) than the OFA group (30.8%). which can not be solely explained by a reduced IDD since the mean (SD) IDD for the DXT was greater than the OFA groups (3.8 (1.3) cm and 2.3 (1.3) cm, respectively).

It is more likely that trismus is more fixed in the DXT group, and is less likely to be relieved even after induction of anaesthesia compared with the OFA group. In head and neck patients, tumour or dose-dependent irradiation of the pterygoid muscles and TMJ reduces mouth opening by 18-32% [27,28]. Indirectly, limited neck movement secondary to DXT further decreases the degree of mouth opening. In patients with normal mouth and neck movements, IDD increases from 28 mm in slight flexion to 46 mm in full extension [30]. A history of DXT has also been reported to lead to difficult LMA insertion, and difficult or impossible ventilation [6]. In the latter situation, despite correct LMA placement, failure to ventilate may be due to laryngeal collapse caused by the LMA compressing a rigid airway. The authors recommend that ventilation may be improved in such cases by cuff deflation or the use of a smaller LMA. In an analysis of 1000 consecutive uses of the ProSeal LMA, there were six failures to achieve satisfactory placement, two of whom had received DXT to the neck [30]. In a study of the
use of the ILMA in patients with anticipated difficult airway, there were three failures out of 51 cases [13]. All three had a history of oropharyngeal cancer with previous cervical DXT. Finally, a study of FOI in 86 head and neck cancer patients following DXT, showed that difficult FOI occurred in 6% of cases and was associated with laryngeal oedema, or if the patient had a hoarse voice and stridor [13].

LIMITATIONS
This study was performed with the observer undertaking both bedside tests and CL grading, introducing the potential for observer bias. There was no standardisation of induction and intubating techniques, but this reflected the varied clinical practice amongst a group of experienced anaesthetists. In some cases, a tracheal tube was in place before CL was graded (e.g. FOI or blind nasal intubation). This often leads to a lower CL grade (easier intubation) since the epiglottis is lifted up by the tracheal tube and thus difficult intubation may be under-reported.

In conclusion, elective and emergency ENT and maxillofacial surgical patients commonly present with difficult airways which may require the use of advanced airway techniques. Traditional predictive bedside tests of the airway are difficult to apply consistently to different patient populations and hence their results are difficult to interpret with any degree of confidence. In our study, in patients presenting for elective and emergency ENT and maxillofacial surgery, in whom a difficult intubation may be more likely a history of previous DXT, the presence of airway symptoms, a reduced mouth opening and a reduced mandibular protrusion are independent predictors of a difficult intubation.

ACKNOWLEDGEMENTS
We would like to thank Professor George Hall, Dr Jean-Pierre van Besouw and Jan Poloniecki (Reader in Medical Statistics) for their contributions to the preparation of this manuscript.

APPENDIX A
The modified MP score was used: class 1 – soft palate, fauces, uvula and pillars seen; 2 – soft palate, fauces and uvula seen; 3 – soft palate and base of uvula seen; and, 4 – soft palate not visible [13]. The ML score consisted of: class A – lower incisors able to protrude anterior to upper incisors; B – lower incisors equal to upper incisors; and C – lower incisors posterior to upper incisors [13]. IDD was the distance between the incisors (or gingival borders in edentulous patients). TMD was the distance between the thyroid notch and the mentum. Laryngoscopic view was graded according to the modified Cormack-Lehane (CL) scoring system: grade 1 – full view of the glottis; 2 – partial view of the glottis or arytenoids; 3 – only epiglottis visible; and, 4 – neither glottis nor epiglottis visible [11].

ABBREVIATIONS
Sens = sensitivity, Spec = specificity, PPV = positive predictive value, FM = fractured mandible, OFA = oro-facial abscess, DXT = previous head and neck radiotherapy only, PS = previous major head and neck surgery only, PS+DXT = both previous head and neck major surgery and radiotherapy, and ‘other surgery’ group = patients of exclusion i.e. without FM, OFA, DXT or PS.

References
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Author Information

P. Wong, FRCA
Consultant Anaesthetist, St George’s Hospital, Anaesthetic Department

S. Parrington, FRCA
Specialist Registrar, St George’s Hospital, Anaesthetic Department