Predictive variables for difficult intubations in oral and maxillofacial surgery

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Abstract

Summary Many factors affect the difficulty of endotracheal intubation some of which are related to the condition of the patients. A few assessment tools have been developed to predict intubation difficulty but none is all inclusive thereby being inadequate for comprehensive and accurate evaluation. We assessed the usefulness of four categories of predictive variables namely; the LEMON score, Demographic indices, Tumour site and Intraoral Position of tumour (IOP), in predicting intubation difficulty among a group of patients with orofacial tumours. By statistical analysis, a significant correlation between predictions by LEMON score and actual intubation difficulty was observed while neck mobility ($P=0.28$) and Mallampati scores ($P=0.49$) were the most important criteria in the scoring system. Significant association was also observed with demographic indices and difficulty whereby the Optimal Interincisal Distance (OID) had the greatest impact ($P=0.048$). There was no difference in the difficulty posed by the different sites and intraoral positions of tumours in this study. We therefore suggest the adoption of the LEMON score and consideration of the demographic indices when assessing patients with orofacial tumours for intubation difficulty. Three important variables should be given greater value, these are, neck mobility, Mallampatti score and optimal interincisal distance.

Keywords Intubation · Lemon score · Endotracheal intubation

Introduction

The American Society of Anaesthesiology (ASA) considers a ‘difficult airway’ to include cases where a conventionally trained anaesthesiologist requires three or more laryngoscopies or more than 10 minutes to accomplish successful endotracheal intubation [1]. In the literature, some factors have been associated with difficult intubation, these include increasing number of attempts, introduction of a second operator; usually a more experienced personnel, and abandoning one technique of intubation for another [2]. Many clinicians believe that experience and proficiency affect the ease of performing endotracheal intubation [3].

The incidence of difficult intubation (DI) reported in the world literature ranges between 1.2% and 3.8% [4–7]. It is reportedly

higher in life-saving emergency situations as in pre-hospital rescues and emergency room, compared to elective procedures in the operating room [8]. This can be due to the fact that the planned procedure is advantaged by adequate preoperative evaluation and the greater likelihood of it being undertaken by trained anesthetists under a more organized condition. However, patients undergoing elective oral and maxillofacial surgical procedures under general anesthesia present peculiar challenges for endotracheal intubation. Unlike abdominal, urologic, orthopedic or vascular surgery, patients requiring oncologic and trauma maxillofacial surgery present additional complexity in that the orofacial and sometimes pharyngeal anatomy is almost always invariably distorted, making mask ventilation, laryngoscopy and intubation more difficult.

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Generally, preoperative evaluation is important in the detection of patient at risk for difficult airway management. Essential and relevant history as well as anatomical and clinical risk factors are usually noted; but the question of whether or not true prediction is possible lingers [9]. Although many interesting criteria for assessing intubation difficulty have been developed, only few have achieved significant predictive ability in any study [10,11]. Some of them are fraught with obvious limitations: the Mallampatti score and the Cormack-Lehane score of the laryngeal inlet are single-factor predictors, they have been found to be inaccurate [10,12,13]. They do not put into cognizance some other important variables that affect difficulty. Similarly, the Intubation Difficulty Scale (IDS) of Adnet et al. [2] is an intra-procedural

evaluation technique and possesses no value for predictive purpose.

It has been noted that the patients' illness affect the difficulty of intubation [6,8]. Sometimes among oral and maxillofacial surgical patients, the real intra-operative experience betrays preoperative judgment. A fractured mid-face may move posteriorly during face-mask ventilation causing obstruction to laryngoscopy and significant hemorrhage may occlude laryngeal view in patients with hemorrhagic intraoral tumours, especially if tinkered during intubation.

Recognizing the potential for a difficult airway before anaesthesia allows time for optimal preparation, proper selection of equipment and technique and participation of personnel experienced in difficult airway management. This study was therefore embarked upon to determine the variables capable of enhancing preoperative prediction of endotracheal intubation difficulty among patients with orofacial tumours requiring elective surgery.

Methods

The primary outcome measured is the actual difficulty of endotracheal intubation among patients undergoing elective oral and maxillofacial tumour surgery, hence, operations for faciomaxillary trauma, TMJ problems and other maxillofacial conditions were excluded. The subjects include all consecutive patients with orofacial tumours who gave informed consent for the assessment prior to intubation and were treated in our hospital over a one year period spanning from December 1, 2006 to November 30, 2007.

Before surgery, each patient received a clinical physical evaluation with an emphasis on the anatomical features of the head and neck that are known to affect endotracheal intubation. Demographic indices of the patients such as sex, age, Body Weight (BW), Body Mass Index (BMI), Body Surface Area (BSA) and Optimal Interincisal Distance (OID) were recorded. The OID is the mouth opening measured (in this case, with a vernier caliper) when the mouth is opened without straining the jaw muscles. Other variables recorded were the site of tumour, and the intraoral anatomical extent of the tumour (to be described as Intraoral Position (IOP) henceforth). The site was described as maxillary region, mandibular region or tongue/floor of the mouth while the IOP was described as anterior (if the canine

Table 1 Prediction of intubation difficulty based on LEMON score

Score	Grade of difficulty
1–3	Easy
4–5	Moderately difficult
6–7	Definitely difficult
8–9	Very difficult
10	Extremely difficult

Table 2 Algorithm for actual difficulty of intubation

Criterion	Grade of difficulty
Intubation performed by a junior resident in ≤ 2 attempts	Easy
Intubation performed by a senior resident in ≤ 2 attempts	Moderately difficult
Intubation performed by a senior resident in >2 attempts or a specialist anaesthesiologist in ≤ 2 attempts	Definitely difficult
Intubation performed by a specialist anaesthesiologist in > 2 attempts	Very difficult
If direct nasotracheal/ orotracheal intubation is abandoned for fiberoptic intubation or tracheostomy	Extremely difficult

Table 3 Types of orofacial tumours and site distribution

Type of tumour	Maxilla	Site mandible	Tongue/Floor
Odontogenic tumours	1	10	-
Benign non-odontogenic tumour	-	2	-
Fibro-osseous lesions	3	3	-
Osteosarcoma	-	1	-
Squamous cell carcinoma	1	2	-
Pleomorphic adenoma of palate	2	-	-
Soft tissue sarcoma	-	-	2
Benign tongue tumour	-	-	1

Table 4 Regression table for LEMON Criteria

Model	Unstandardized co-efficient B	Std. Error	Standardized co-efficient Beta	t	Sig.
(Constant)	1.212	.625	-	1.941	.065
L	-.224	.404	-.095	-.553	.586
E	-.189	.376	-.109	-.501	.621
M	.381	.207	.327	1.840	.049
O	-2.55E-03	.343	-.001	-.007	.994
N	1.587	.676	.508	2.347	.028

R (Regression co-efficient) = 0.62, Sig - Significance

region formed the posterior limit of the tumour), middle (if the first molar formed the posterior limit of the tumour), and posterior (if the tumour is further posterior than the first molar). A preoperative prediction of intubation difficulty was

undertaken based on the LEMON score [14] by a trained evaluator. The score, with a maximum of 10 points, was calculated by assigning 1 point for each of the following LEMON criteria: 'L' (looking externally to observe any extraoral features

that may cause difficulty during intubation, 1 point is assigned if any is found); 'E' (Evaluate the 3–3–2 rule, 1 point each is assigned for: (interincisor distance <3 fingerbreadths, hyoid/mental distance <3 fingerbreadths, thyroid-to-mouth distance <2 fingerbreadths); M (the Mallampatti score is assigned (i.e 1–4 points range), O (obvious obstruction in the oropharyngeal airway), N (limited neck mobility). Each item is assigned 1 point if finding was unfavourable or zero if the finding favours easy intubation. The total LEMON score was used to predict the difficulty of intubation (Table 1). In defining the actual difficulty of intubation, an algorithm (Table 2) was developed based on the number of attempts, the introduction of a more experienced operator and the abandonment of the direct endotracheal intubation technique for other alternatives. The recording was done by an independent observer and throughout the study; the operators were blind to the recording being done and the criteria being used.

Statistics

Four categories of predictor variables were defined namely; the LEMON criteria, the demographic indices, the site of tumour and the IOP. The correlation between the predictions made by LEMON score and the actual difficulty of intubation was tested, and the significance of each item in the LEMON criteria in determining difficulty was assessed by a multivariate regression. Multivariate regression of the demographic indices was performed to determine the contribution to actual intubation difficulty and to identify the significant variables in the group. The influence of differences in tumour site and IOP on intubation difficulty was assessed by chi-square and Fischer Exact tests. The analysis was accomplished using SPSS version 11.0 and a P value <0.05 was statistically significant.

Results

There were 28 patients including 10 males and 18 females aged 7–66 years, mean = 33.4 + SD 14.8 years; weight 21–116 kg, mean = 58.4 + SD 18.8 kg. Their body mass index ranged between 9.5 kg m⁻² and 35.8 kg m⁻², mean = 21.1 + SD 6.6 kg m⁻²; while their body surface area was 0.8–2.4 m², mean = 1.62 + SD 0.3 m² and the OID ranged between 1.5–4.9 cm, mean 3.1 cm. The various types of tumours

Table 5 Regression of demographic indices

Model	Unstandardized co-efficient B	Std. Error	Standardized co-efficient Beta	t	Sig.
(Constant)	1.117	1.892	-	.590	.565
Gender	.848	.518	.423	1.639	.125
Age	2.100E-02	.016	.347	1.305	.215
BSA	.920	1.126	.292	.817	.428
BMI	-3.07E-02	.047	-.213	-.658	.522
OID	-.408	.186	.535	-2.188	.048

R (Regression Coefficient) = 0.69

Table 6 Crosstabulation of Tumour site and difficulty

Actual difficulty	Tumour site			Total
	Mandible	Maxilla	Tongue	
Easy	4(50%)	1(12.5%)	3(37.5%)	8(100%)
Moderate	8(72.7%)	3(27.3%)	-	11(100%)
Definite	4(57.1%)	3(42.7%)	-	7(100%)
Very	1(100%)	-	-	1(100%)
Extreme	1(100%)	-	-	1(100%)

Table 7 Actual difficulty versus IOP

Actual difficulty	Anterior	Middle	Posterior	Total
Easy	3	2	3	8
Moderate	2	3	6	11
Definite	2	1	4	7
Very	-	-	1	1
Extreme	1	-	-	1

Chi-square = .713, Fischer Exact test = .713

encountered and their site distribution are depicted on Table 3. Using the Pearson's test, the correlation between the predicted difficulty and the actual difficulty was significant ($r = 0.402$; $P = 0.034$). Having established this significant positive correlation, we performed a multiple regression dependent on the actual difficulty and with the five items of the LEMON criteria as the predictors. The regression co-efficient ($R = 0.62$) obtained was considerable, and of the five items, neck mobility (N) and Mallampatti (M) score appeared to have made the most significant contributions with P-values <0.05 (Table 4). A linear multivariate regression was also performed to determine the influence of demographic indices on actual difficulty, the regression coefficient ($R = 0.69$) was obtained and the OID tend to account most significantly ($P = 0.048$) for

the impact of this category of variables (Table 5). To investigate the impact of tumour site (Table 5) and the intraoral position of tumour (Table 6) on intubation difficulty, these two categories of variables were respectively crosstabulated with actual difficulty of intubation and assessed by Chi-square and Fischer Exact tests. There was no significant difference in the difficulty posed by the different tumour sites and intraoral positions of tumours.

Discussion

During surgery, maintaining a patent airway is essential for adequate oxygenation and ventilation and failure to do so, even for a brief period of time, can be life threatening [15] hence, the need for a proper endotracheal intubation. The ability to

perform endotracheal intubation can be affected by multiple factors involving the patient, the environment and the skill and experience of the operator. Sometimes it is difficult to quantify or control for the concurrent effect of these multiple factors. Thus we have only limited understanding of how these factors complicate airway management.

The problem associated with the environment depend largely on the settings and circumstances under which endotracheal intubation is required. Thus out-of-hospital and emergency room intubation have been associated with greater incidence of difficulty and failure. Under an elective condition, as in routine general anaesthesia for elective surgery, the effect of the environment should be largely minimized and optimal condition should be ensured before embarking on the exercise or better still, the patient is referred to another facility if a hospital is unable to provide the optimal environment required. Intubation difficulty or failure due to skill and experience of operator is expected to be minimal in a tertiary hospital setting where expertise of various levels should be available and an operator of greater experience can be called upon when difficulty is encountered. After eliminating the effect of the environment and operator, difficulty or failure of intubation is most often related to patient factors. Clinical and anatomical factors variations between patients account for the differences. Several studies have reported on these differences and postulated various methods by which difficulty can be predicted.

In the present study, we have looked at a unique group of patients; those undergoing elective surgery for orofacial tumours. We investigated the relevance of the LEMON score as a predictor of difficulty among these patients and the impact of some demographic patient factors. In addition to these usual factors known to affect intubation among patients undergoing elective general anaesthesia, this peculiar group of surgical patients often presents additional challenges to the anesthesiologists because of the tumour mass that often compromise their field of operation. The size and growth pattern of the tumour distort the anatomy of the face, mouth and sometimes the airway making mask ventilation, laryngoscopy and passage of the tube more technical. We investigated whether or not the site of the tumour on the mandible, maxilla or tongue and the intraoral position of the tumour i.e. anteriorly, mid-way or

posteriorly influence the difficulty of achieving endotracheal intubation differently. The usual practice in our centre is to routinely use nasotracheal intubation for all oral and maxillofacial tumour surgery because of the extensive surgery that is often done intraorally and the placement of intermaxillary fixations on most occasions. However when this route appear impracticable, orotracheal intubation is sometimes adopted with some compromise on the part the surgeons. Hence this study was based on difficulty of direct nasotracheal or orotracheal intubation.

The LEMON score is a tool described and validated for predicting endotracheal intubation difficulty in emergency situation [14]. Although a few authors [14,15] have alleged the limitations to the guidelines as an assessment tool for emergency intubation. The reasons provided is that some of the parameters like the Mallampatti score, evaluation of the interincisal gap, thyromental distance, neck mobility may be impossible during life-threatening emergency because to a large extent, these require some degree of co-operation from patients. Nevertheless, we thought it may be useful in non-emergent situations. A significant correlation between the LEMON score and actual intubation difficulty was observed in the present study suggesting that the tool could be useful for assessing patients with orofacial tumours. However, since the protocol involves five different factors, a regression test was conducted to determine the concurrent effect of the multiple factors in determining the actual difficulty as well as to identify which of the five items made the most significant contributions in the collective equation. A significant regression coefficient ($R=0.62$) was observed but this value suggests that some other factors apart from the those included in this LEMON method contribute to the actual difficulty. These may include some physical characteristics of the patients and some limitations posed by the tumour mass in the jaws or tongue.

The Mallampatti score and neck mobility appeared to be the most important predictor variables when the LEMON method was used in this study. This differs from a previous observation in a study to validate the LEMON scoring system whereby of the five criteria, only inter-incisor distance <3 fingerbreadths, and thyro-mental distance <2 fingerbreadths were associated significantly with difficult intubation [14]. It also contradicts the

assertion made by Tse et al. [16] who concluded that Mallampatti score and neck mobility were of little value in predicting difficult airway. Could the Mallampatti score and neck mobility have been significantly affected by the clinical condition of the group of patients under study?

The Mallampatti score is a known important entity for assessing difficult airway [5,15,16]. It is derived by having a patient sit up and fully open the mouth with the tongue maximally protruded, in order to view the extent of the palate and oropharyngeal structures that is immediately visible. This is potentially compromised among these patients because tumours involving the jaws are often associated with varying degree of trismus and the intraoral component of the tumour often obstruct direct visualization of the oropharyngeal structures. Although, the Mallampatti score has been consistently found to correlate with laryngoscopic view [9,16,17], it actually failed to reach high sensitivity and Positive Predictive Value (PPV) as a predictive risk factor for difficult intubation in a previous study [7]. The implication of the current finding is that the Mallampatti score in patients with orofacial tumours might be more predictive of difficult intubation than it is in the general surgical patients' population. It must be noted however, that it is not the Mallampatti score alone that produced the significant regression coefficient but its simultaneous interplay with other items in the LEMON protocol.

During intubation some degree of simultaneous extension at the atlanto-occipital joints and cervical flexion is required so that the pharyngeal and laryngeal structures are put in alignment (The McGill or modified Jackson's position) [18]. Therefore limited neck mobility could be a potential cause of difficult intubation. These may be consequent on some underlying diseases such as Insulin Dependent Diabetes Mellitus (IDDM), rheumatoid arthritis, ankylosing spondylitis, Kippel-Feil Syndrome [19] which was not observed among the subjects in this study. Nevertheless, it is not unlikely that massive mandibular tumour may have affected the assessment of some of the parameters measured when using the LEMON method. Such indices as thyromental distance, hyomental distance and even neck mobility could be affected by tumour mass giving a false positive or false negative impression. The strong impact of neck mobility in the

regression equation for the LEMON criteria may have resulted from a sizable number of patients with difficult airway who had apparent limitation to neck flexion/extension probably as a result of the site, size and growth pattern of the tumour mass. Undoubtedly, some of these could have been false positive impressions.

In assessing the effect of demographic indices, variables which include sex, age, weight, body mass index, body surface area and optimal interincisal distance showed a strong concurrent effect on intubation difficulty. Although increasing weight and body mass index have been previously implicated; [19–21] BMI>32kgm² was considered a risk factor, very few patients exceeded this cut-off point in the present study. None of the variables could individually account for the collective impact observed on actual difficulty but the optimal interincisal distance (OID) appears to be the most important factor in the interaction. However, this does not imply a direct causal relationship because when tested in a univariate regression analysis (unpublished data), the OID was unable to produce a significant regression coefficient. Hence, it is deducible that all these variables interact to produce the observed impact and should all be considered when assessing patients for airway difficulty.

Interestingly, there was no observable statistical difference in intubation difficulty based on the jaw on which the tumour is located. However, there is a need for caution in the clinical interpretation of this finding, considering that there were only three tongue tumors involved which is a small number relative to the other sites. Similarly, the position of the intraoral component did not make significant statistical difference. It follows therefore that both mandibular, maxillary and tongue tumours have similar potential for causing difficulty. We had thought that the anterior, mid-way or posterior position of intraoral tumour could have varying effect on direct laryngoscopy and intubation; the present findings do not support this idea. That jaw tumours affect face mask seal during ventilation, laryngoscopy and tube passage is already known but in terms of the features that have potential for causing a prolonged and difficult process, it may be that the size, pattern of growth and nature of tumours (hemorrhagic or non-hemorrhagic) could be more differentiating than the mere tumour sites and intraoral position.

It is noteworthy that 32% (9/28) of the patients involved in this study had definitely difficult to extremely difficult

airway. This underscores the high incidence of difficult airway in elective oral and maxillofacial surgery. Anaesthesiologists who would work in this field must therefore be vast in difficult airway management. Whenever a difficult airway is anticipated, a properly planned intubation sequence must be developed; the personnel must be armed with versatile armamentaria and expertise in alternative techniques [18]. Techniques such as retrograde intubation, submental intubation, fiberoptic bronchoscopy, fiberoptic laryngoscopy and ventilation techniques such as percutaneous transtracheal jet ventilation, the use of laryngeal masks airway, cuffed oropharyngeal airway and the combitube must be prepared for difficult airway intubation [18,19,22,23].

Although, this study has not pointed out any new parameter for assessing intubation difficulty peculiar to oral and maxillofacial tumour patients, it does establish that the jaw site of tumour (whether mandible, maxilla or tongue) and the IOP (whether anterior, middle or posterior) do not influence the difficulty of intubation exercise differently. It supports the use of the LEMON criteria for difficult airway assessment in elective oral and maxillofacial surgery and suggests that patients demographic indices are important in airway assessment. Three variables were particularly important and should be given greater value among orofacial tumour patients, these are, neck mobility, Mallampatti score and optimal interincisal distance.

Conclusion

No single airway test can provide a high index of sensitivity and specificity for prediction of difficult airway [19]. Therefore a comprehensive evaluation of multiple factors is advocated including the demographic indices of patients. The LEMON criteria is concise and easy to use. In this study, it is of significant statistical value as a predictor of difficult intubation, however, further validation study is necessary before adopting LEMON scores in the routine practice. We advocate its routine application in elective general anesthesia for oral and maxillofacial surgery. However, despite the most careful preoperative airway evaluation, some patients will remain undetected especially in such fields as oral and maxillofacial surgery and allied specialities. Thus, anaesthesiologists must always be prepared

with a variety of pre-formulated and practiced plans for airway management in the event of an unanticipated difficult airway.

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