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SCIENTIFIC ARTICLE

Predictive value of preoperative tests in estimating difficult intubation in patients who underwent direct laryngoscopy in ear, nose, and throat surgery

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KEYWORDS
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Abstract
Background and objectives: Predictive value of preoperative tests in estimating difficult intubation may differ in the laryngeal pathologies. Patients who had undergone direct laryngoscopy (DL) were reviewed, and predictive value of preoperative tests in estimating difficult intubation was investigated.
Methods: Preoperative, and intraoperative anesthesia record forms, and computerized system of the hospital were screened.
Results: A total of 2611 patients were assessed. In 7.4% of the patients, difficult intubations were detected. Difficult intubations were encountered in some of the patients with Mallampati scoring (MS) system Class 4 (50%), Cormack–Lehane classification (CLS) Grade 4 (95.7%), previous knowledge of difficult airway (86.2%), restricted neck movements (cervical ROM) (75.8%), short thyromental distance (TMD) (81.6%), vocal cord mass (49.5%) as indicated in parentheses ($p < 0.0001$). MS had a low sensitivity, while restricted cervical ROM, presence of a vocal cord mass, short thyromental distance, and MS each had a relatively higher positive predictive value. Incidence of difficult intubations increased 6.159 and 1.736-fold with each level of increase in CLS grade and MS class, respectively. When all tests were considered in combination difficult intubation could be classified accurately in 96.3% of the cases.
Conclusion: Test results predicting difficult intubations in cases with DL had observedly overlapped with the results provided in the literature for the patient populations in general. Differences in some test results when compared with those of the general population might stem from the concomitant underlying laryngeal pathological conditions in patient populations with difficult intubation.

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PALAVRAS-CHAVE
Intubação;
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Laringoscopia;
Otorrinolaringologia

Valor preditivo dos testes pré-operatórios para estimar a intubação difícil em pacientes submetidos à laringoscopia direta para cirurgia de ouvido, nariz e garganta

Resumo
Justificativa e objetivos: O valor preditivo dos testes pré-operatórios para estimar a intubação difícil pode diferir em patologias laríngeas. Foram feitas uma revisão dos prontuários de pacientes submetidos à laringoscopia direta (LD) e uma investigação do valor preditivo de exames pré-operatórios para estimar a intubação difícil.
Métodos: Triagem de prontuários dos períodos pré-operatório e intraoperatório e do sistema informatizado do hospital.
Resultados: Foram avaliados 2.611 pacientes. Em 7,4%, intubações difíceis foram detectadas. Intubações difíceis foram constatadas em pacientes com escore de Mallampati (EM), classe 4 (50%); classificação de Cormack-Lehane (CCL), grau 4 (95,7%); conhecimento prévio de via aérea difícil (86,2%); restrição da amplitude de movimentos (ADM) do pescoço (ADM cervical) (75,8%); distância tireomentoniana (DTM) curta (81,6%); e massa nas pregas vocais (849,5%) ($p < 0,0001$). O EM apresentou uma sensibilidade baixa, enquanto ADM cervical, presença de massa nas pregas vocais, DTM curta e EM apresentaram um valor preditivo positivo relativamente maior. A incidência de intubações difíceis aumentou 6.159 e 1.736 vezes com cada nível de aumento dos graus da CCL e da classe do EM, respectivamente. Quando todos os testes foram considerados em conjunto, a intubação difícil pôde ser classificada com precisão em 96,3% dos casos.
Conclusão: Os resultados dos testes que preveem intubações difíceis em casos com LD coincidiram claramente com os resultados previstos na literatura para as populações de pacientes em geral. As diferenças em alguns resultados dos testes, quando comparados com os da população em geral, podem ser por causa das condições patológicas subjacentes da laringe em populações de pacientes com intubação difícil.

Introduction

Many studies and meta-analyses have examined the predictive value of preoperative tests in determining difficult intubations. As laryngeal abnormalities are observed in direct laryngoscopic interventions in ear, nose, and throat surgery, the predictive values of these tests may differ. There appears to be no relevant studies in the literature in the patient population who had undergone direct laryngoscopy.

Direct laryngoscopy (DL) is performed to evaluate laryngeal structures, including the glottis and the vocal cords, by direct inspection. Abnormalities of this region are diagnosed by examining biopsy specimens prior to performing therapeutic interventions if necessary.

During this procedure, the most fundamental duty of the anesthetist is to provide adequate ventilation. The prerequisite of adequate ventilation is to ensure a safe and patent airway. Preoperative prediction of a potentially difficult intubation is important to make proper preparations and to plan an appropriate intubation technique. In the preoperative evaluation of difficult intubation, the mouth opening, the state of the tongue and palate, the thyromental distance (TMD), the sternomental distance, the cervical ROM and the mandibular mobility are assessed, and evidence of difficult intubation (if any) is investigated. In DL, routine preoperative indirect laryngoscopic examination findings also provide important information.[1,2]

In this retrospective study, we evaluated the anesthesia records of patients who had received anesthesia between 2000 and 2012 because of DL to investigate the predictive value of preoperative tests in difficult intubation.

Materials and methods

In this study, pre- and intraoperative anesthesia records of patients who had received anesthesia because of DL in the Department of Anesthesiology and Reanimation, Ondokuz Mayis University Faculty of Medicine between 2000 and 2012 due to DL were examined after obtaining the approval of the ethics committee. We previously published epidemiological examination results of anesthetic applications in patients who underwent DL during 2000–2010. In the current study, data relating to 2010–2012 were also evaluated, and preoperative predictive test results related to difficult intubation procedures were statistically analyzed in detail. Data obtained from the medical files of patients in the hospital-based computerized system were screened.

The following parameters were evaluated:

1. Age distribution of the patients who had DL: 0–1, 1–5, 5–15, 15–45 and >65 years,
2. Gender distribution and the number of patients who had DL,
3. Indications for DL. As pre-2005 data on DL indications were not available in the medical files, the indications for DL performed between 2005 and 2012 were included,

4. Numbers of cases of DL evaluated separately in elective and emergency surgical settings,
5. American Society of Anaesthesiology (ASA) scores of the patients who underwent DL,
6. Rates of additional systemic diseases,
7. Mean anesthesia times,
8. Numbers of DL patients who had any of the following postoperative complication rates: cardiovascular, pulmonary, re-intubation, and delayed arousal from anesthesia,
9. Rates of difficult intubation,
10. Gender distribution of the difficult intubation cases,
11. Age distribution of the difficult intubation cases,
12. Numbers of the Mallampati scores (MS) of the intubated patients,
13. Rates of difficult intubation cases based on the Mallampati scoring classification criteria,
14. Rates of difficult intubation cases based on the Cormack–Lehane score (CLS),
15. Rates of the intubated cases with difficult intubation based on the CLS criteria,
16. Rates of intubated patients with a history of a difficult airway,
17. Rates of the intubated cases with difficult intubation based on the history of a difficult airway,
18. Rates of the intubated patients based on restricted cervical ROM,
19. Rates of the difficult intubation cases according to restricted cervical ROM,
20. Rates of the intubated patients according to TMD measurements,
21. Rates of the intubated cases with difficult intubation based on TMD measurements,
22. Rates of the intubated patients based on the presence of a vocal cord mass,
23. Rates of the difficult intubation cases with a vocal cord mass,
24. Logistic regression analysis of preoperative indicators of difficult intubation,
25. Predictive value of screening tests in the evaluation of difficult intubation.

The sensitivity, specificity, positive predictive values (PPV) and negative predictive values (NPV) were calculated according to the following formula:

$$\text{Sensitivity} = \frac{\text{Number of accurately predicted difficult intubations}}{\text{Number of difficult intubations encountered}}$$

$$\text{Specificity} = \frac{\text{Number of accurately predicted easy intubations}}{\text{Number of easy intubations encountered}}$$

$$\text{PPV} = \frac{\text{Number of accurately predicted difficult intubations}}{\text{Total of anticipated difficult intubations}}$$

$$\text{NPV} = \frac{\text{Number of accurately predicted easy intubations}}{\text{Total number of patients with unforeseen difficult intubations}}$$

Statistical analysis

The SPSS 21.0 statistical package program was used for the data analysis. The data are presented as mean ± SD (standard deviation), frequencies and percentages. For intergroup comparisons, chi-square and Mann–Whitney *U* tests were employed. $p < 0.05$ was considered to be significant. To determine the factors involved in difficult intubation, logistic regression analysis was performed.

Results

During the study period, a total of 2611 patients (females, $n = 333$; 12.8%; males, $n = 2278$; 87.3%) underwent DL in the ear, nose and throat (ENT) operative room ($p < 0.05$). The patients were aged 45–65 years ($n = 1417$; 54.3%) or older than 65 years ($n = 559$; 21.4%) ($p < 0.05$). Table 1 shows the indications for those who underwent DL between 2005 and 2012. The patients were operated on in an elective ($n = 2.557$; 97.9%) or emergency ($n = 54$; 2.1%) setting ($p < 0.05$). The ASA scores of the patients who underwent DL were as follows: ASA I, 38.3%; ASA II, 46.9%; ASA III, 13.9% and ASA IV, 0.9% (Fig. 1).

Concomitant systemic diseases were found in 50.4% of the patients (cardiovascular disease 11.6% and respiratory system disease 11.5%). The mean anesthesia time was 35.6 ± 13.6 min. Postoperative complications affecting the respiratory (19.2%) or cardiovascular system (72.4%) developed in 268 (10.3%) of the patients.

Difficult intubation was detected in 194 (7.4%) of the patients. Twenty-six (7.7%) women and 168 (7.4%) men could not be intubated. There was no statistically significant difference between the age groups with respect to difficult intubation ($p > 0.05$). Fiberoptic bronchoscopy ($n = 5$), surgical tracheotomy with mask ventilation ($n = 5$) and a fast-track laryngeal mask ($n = 1$) were used in the patients with difficult intubation. The other patients were intubated by experienced anesthetists using a stylet, a McCoy laryngoscope, a different size laryngeal blade and assisted techniques, such as backward-upward-rightward pressure maneuvers.

Table 1 Indications of direct laryngoscopies performed between 2005 and 2012 (*n*, %).

Indications of direct laryngoscopy	*n*	%
Benign diseases of the larynx	427	23%
Malignant diseases of the larynx	659	35.6%
Congenital defects of the larynx	14	0.7%
Laryngeal infections	85	4.5%
Tracheal, bronchial, and pulmonary diseases	32	1.7%
Oesophageal diseases	119	6.4%
Hypopharyngeal diseases	86	4.6%
Aspiration of a foreign substance	20	1%
Hoarseness	195	11%
Dyspnea	78	4.2%
Other	136	7.3%
Cumulative total	1.851	100%

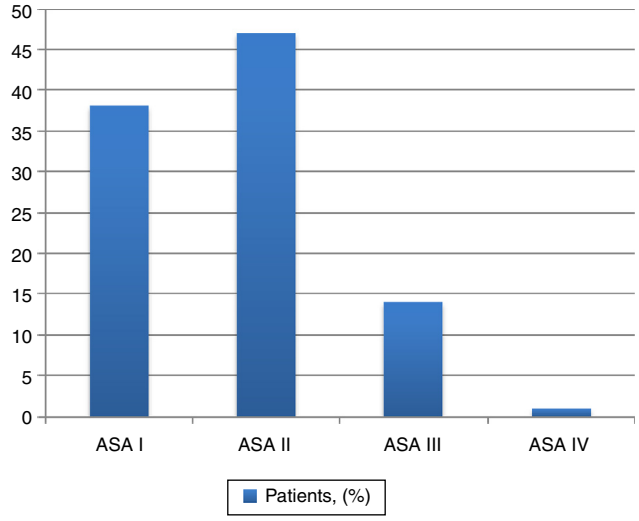

Figure 1 ASA scores of the patients (%).

In our study, 2045 patients were evaluated using MS criteria and classified as MS I (65.8%), MS II (29.9%), MS III (3.7%) and MS IV (0.4%) categories (Fig. 2). Difficult intubation procedures were detected in patients classified in MS I (2.6%), MS II (13.2%), MS III (60.5%) and MS IV (50%) categories ($p < 0.0001$).

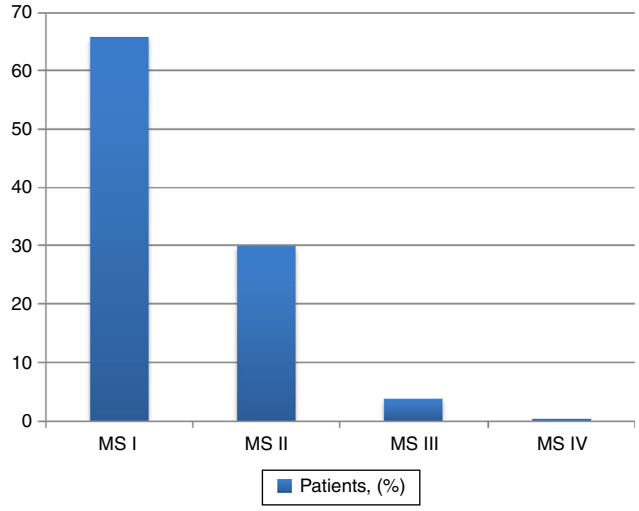

Figure 2 Mallampati scores of the patients (mallampati scores; MS, %).

Table 2 Logistic regression analysis of the preoperative screening tests performed for difficult intubation.

Difficult intubation	*p* value	Odds ratio
Mallampati score	0.003	1.736
Cormack–Lehane score	0.0001	6.159
History of difficult airway	0.011	2.887
Restricted cervical ROM	0.0001	6.518
Vocal cord mass	0.0001	2.968

Of the study group, 1910 of the patients were questioned about past experience of a difficult airway. Difficult intubations occurred in 25 (86.2%) of the 29 (1.5%) patients with a history of a difficult airway ($p < 0.0001$). Restricted cervical ROM was investigated in 1913 of the patients and detected in 3.2% ($n = 62$) of the cases. Forty-seven (75.8%) of these 62 patients had difficult intubation procedures ($p < 0.0001$). The TMD had been measured in 1913 of the patients. Among these, 49 (2.6%) of the patients had a short TMD, and 40 (81.6%) had a history of difficult intubation procedures ($p < 0.0001$). The presence of a vocal cord mass was assessed in 2588 patients. Of these, 279 (10.8%) of the patients had a vocal cord mass, and evidence of difficult intubation was present in 138 (49.5%) of the cases ($p < 0.0001$).

Logistic regression analysis of the preoperative screening tests performed for difficult intubation demonstrated that an increase of one level in the CL grade and the Mallampati class induced 6.159-fold and 1.736-fold increases, respectively, in the rate of difficult intubations (Table 2). When all the tests in Table 2 are considered as a whole, difficult intubation could be accurately classified (present or absent) in 96.3% of the cases. The predictive values for the preoperative screening tests used for the detection of difficult intubations in our patients are shown in Table 3.

Discussion

The retrieval of medical records of patients in an organized fashion is necessary to perform data analyses and to prepare monthly and yearly clinical study reports for the improvement of quality and the provision of health care services. The male/female ratio of our study population was

Table 3 Predictive value of preoperative screening tests for difficult intubation.

Screening tests	Screening tests, (%)			
	Sensitivity	Specificity	PPD	NPD
Mallampati score	30.5	97.9	59.3	93.6
Cormack–Lehane score	75.3	98	78.6	97.6
History of difficult airway	21.5	99.7	86.2	92.5
Restricted cervical ROM	28.1	99.1	75.8	92
Short thyromental distance	23.9	99.4	81.6	93.1
Vocal cord mass	71.1	94.1	49.4	97.5

nearly 1/7 ($p < 0.05$), a ratio between 1/5 and 1/20 has been reported in DL studies,[3,4] with DL being performed in all age groups but most frequently in those of advanced age (>45). In the present study, DL was also most common in patients aged 45–65 years and older ($p < 0.05$).

Laryngeal cancers constitute 45% of head and neck cancers and 1–2% of all types of cancers.[5] In our study, the most frequently encountered indications of DL were benign and malignant diseases of the larynx (58.6%).

The patients were mostly (97.9%) scheduled for elective surgery ($p < 0.05$). This finding is in agreement with that of other studies that investigated the type of the surgery.[6,7] ASA II patients were more numerous in the current study. We attribute this finding to the more frequent application of DL in advanced age groups and the increasing frequency of concomitant diseases with aging. The mean anesthesia time was 35.6 ± 13.6 min. This was affected by various factors, such as the surgical procedure applied, the skill and talents of the anesthetist and the surgeon and the general status of the patient.

Cardiac complications are usually the most frequently encountered problem during the postoperative period (16–62%).[8,9] This was also the case in the current study, with cardiac complications seen more frequently (7.3%) than other types of problems.

According to a report published by the ASA in 2013 on the management of a difficult airway, difficult intubation is defined as the requirement for recurrent interventions for intubation in the presence or absence of tracheal pathology.[10] The overall incidence of difficult intubation has been reported as 1–3% in the general population.[11,12] In the present study, the incidence was 7.4%. This higher rate might stem from the presence of laryngeal pathologies in these cases. According to the literature, difficult intubations are more frequently encountered in male patients.[13,14] In the current study, difficult intubation procedures were found in 7.4% of males and 7.7% of female patients, without any statistically significant difference between genders ($p > 0.05$).

Most aetiological factors for difficult intubation can be determined with careful preanaesthetic evaluation, and steps can be put in place to prevent difficult intubation. To predict difficult intubation beforehand, the TMD, the sternomental distance and the extension of the neck have been used, as well as the MS and the CLS.[15–17]

To obtain anticipated benefits from the tests used, they should have higher sensitivity specificity and PPV.[18,19] The application of these tests will allow time for the required preparations for potentially difficult intubations and avoid unnecessary preparations for easy intubations.

Similar to our study, a retrospective study that analyzed 2733 patients revealed that most of the cases with difficult intubation were in MS III and MS IV categories.[20] Another study investigated 1200 patients and detected 78% sensitivity, 85% specificity, 19% PPV and 99% NPV for MS. In the present study, the sensitivity, specificity, PPV and NPV of the MS were 30.5%, 97%, 59.3% and 93.6%, respectively. The lower sensitivity of the MS, with an increased MS found in only 30.5% of cases with difficult intubations, may stem from the presence of laryngeal pathologies in our study population. The results demonstrate that MS III and MS IV are less effective in the prediction of difficult intubations in a general patient population.

Frerk et al. reported 81.2% sensitivity and 81.5% specificity for the CLS.[21] We determined corresponding values of 75.3% and 98% for the CLS. The higher sensitivity and specificity values found in our study indicate that the CLS can predict difficult intubation procedures.

A TMD shorter than 6 cm can lead to difficult intubations for anesthesia.[22] Jimson et al. reported that the sensitivity, specificity, PPV and NPV of a short TMD were 32%, 80%, 20% and 89%, respectively.[23] Our corresponding values for the sensitivity, specificity, PPV and NPV of a short TMD were 23.9, 99.4, 81.6 and 93.1% respectively. Our study indicates that a short TMD is an important predictor of difficult intubation procedures. A higher PPV might be related to laryngeal pathology associated with a short TMD.

Many authors have evaluated patients undergoing surgical interventions with respect to restricted cervical ROM. Arne et al. detected restricted cervical ROM in 4.2% of patients and observed difficult intubation procedures in 54% of these cases.[24] However, we detected restricted cervical ROM in 3.2% of our patients and difficult intubation procedures in 75.8% of these cases. Cattano et al. reported that the sensitivity, specificity, PPV and NPV of restricted cervical ROM were 17%, 91.8%, 5% and 98%, respectively.[19] Jimson et al. found corresponding percentages for sensitivity, specificity, PPV and NPV of 10%, 93%, 18% and 87%, respectively.[23] In our study, the sensitivity, specificity, PPV and NPV of restricted cervical ROM were 28.1%, 99.1%, 75.8% and 92%, respectively. These results indicate a marked correlation between restricted cervical ROM and difficult intubation. The higher PPV in our study might be due to the presence of laryngeal pathologies, in addition to restricted cervical ROM.

In a study that evaluated patients for any previous evidence of a difficult airway, a history of a difficult airway was noted in 0.6% of the patients and 77.8% of these had experienced difficult intubation procedures.[24] We noted a history of a difficult airway in 1.5% of the patients, of whom 86.2% had undergone difficult intubation procedures. In the abovementioned study, the sensitivity, specificity, PPV and NPV of a history of a difficult airway was 14%, 99%, 78% and 96%, respectively. We determined corresponding rates of 21.5%, 99.7%, 86.2% and 92.5% for the sensitivity, specificity, PPV and NPV, respectively. Similar to the abovementioned study, our study also revealed a distinct correlation between a history of a difficult airway and difficult intubation procedures.

A separate study reported the presence of a vocal cord mass in 3% of patients who had undergone surgical interventions, with 19.2% of these having difficult intubations.[24] We detected a vocal cord mass in 10.8% of our patients, 49.5% of whom experienced intubation difficulties. The sensitivity, specificity, PPV and NPV of the presence of a vocal cord mass were 70%, 87%, 19% and 99%, respectively.[24] The corresponding estimates of the sensitivity, specificity, PPV and NPV in the current study were 71.1%, 94.1%, 49.4% and 97.5%, respectively. Diverse PPV might stem from variations in the sizes of vocal cord masses and different laryngeal pathologies. Both the literature data and the outcomes of our study emphasize the importance of a vocal cord mass in the prediction of difficult intubation.

Arne et al. performed a logistic analysis of indicators of difficult intubation and calculated the odds ratios and P values, respectively for the MS (2.52 and $p < 0.0001$), a

short TMD (1.36 and $p < 0.0001$), restricted cervical ROM (1.46 and $p < 0.0149$) and any previous evidence of difficult intubation (3.28 and $p < 0.0084$).[24] However, Sheff et al. reported odds ratios for MS of 2.75 and *P* values of < 0.035 and odds ratios and *P* values of .17 and <0.002, respectively, for a history of difficult intubation.[14] Our odds ratios and *P* values, respectively, for these predictors were as follows: MS (1.736 and <0.003) CLS (6.159 and <0.0001), restricted cervical ROM (6.518 and <0.0001), history of difficult intubation (2.887 and <0.011) and presence of a vocal cord mass (2.968 and <0.0001). According to this analysis, the MS, the CLS, restricted cervical ROM, a history of difficult airway, a short TMD and the presence of a vocal cord mass are statistically significant predictors of difficult intubation. However, when compared with the combined assessment of all the predictors, the predictive value of a short TMD did not appear to be statistically significant predictor of difficult intubation.

As most patients are not at risk for difficult intubation, abnormally high rates of PPV cannot be possibly encountered. The only way to increase the PPV is by using a combination of diagnostic tests.[23,25] Many authors have reported increased PPV with the combined use of the MS and measurements of the TMD.[24] An ideal test should predict all potential cases of difficult intubations and detect all easy ones. However, thus far, neither meta-analyses nor the ASA has defined an ideal predictive test.[26] Meta-analyses have demonstrated great differences among data retrieved from various medical centers and indicated that individually these tests had minor or moderate predictive values for potentially difficult intubation procedures. Studies that compared ENT patients with the general patient population reported that predictive values in ENT patients were comparable with those found in the general patient population with a 1–2% intergroup difference in the NPV.[18,27]

Even if patients are evaluated by preoperatively medical anamnesis, physical examination, and tests, difficult intubation cannot be accurately predicted. Nevertheless, preoperative application of the aforementioned tests is useful and necessary for preintubation preparation and prediction of potentially difficult intubation procedures. Precise selection criteria are not available for the numerous preoperative tests. Different levels of expertise among anesthetists and diverse intubation techniques further complicate the selection process. However, the combined use of several bedside tests, such as the MS and the TMD tests can be recommended.[28] In cases where the preliminary evaluation reveals a slight suspicion, preintubation preparation will be beneficial for the successful management of difficult intubation.

In conclusion, preoperative tests predictive of difficult intubation procedures performed in cases with DL in ENT surgery have greatly overlapped with those reported for the general patient population. Laryngeal pathologies explain the differences between the patients in the current study and those in the general population. They also explain the lower sensitivity of the MS test results.

Conflicts of interest

The authors declare no conflicts of interest.

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