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ORIGINAL ARTICLE

Incidences and predictors of difficult laryngoscopy in adult patients undergoing general anesthesia

A single-center analysis of 102,305 cases

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Abstract
Background Hypoxemia caused by difficulties in airway management presents a major cause for perioperative morbidity and mortality. The ability to predict difficult laryngoscopy more accurately would enable anesthesiologists to take specific precautions to reduce airway risks and prevent patient-threatening events.
Methods Over a 6-year period of time, all anesthesia records with a documented direct laryngoscopic view were retrieved from the electronic data management system and statistically processed. The Cormack–Lehane four-point scale of grading laryngoscopy was used to assess visibility of the vocal cords.
Results Of 102,306 cases, the overall rate of difficult laryngoscopy was 4.9 %. Male gender (6.5 %), Mallampati score III and IV (17.3 %), obesity with a BMI $\geq$35 kg/m^2 (6.1 %), as well as physical status ASA III or IV (6.2 %), were identified as risk factors for difficult laryngoscopy. Patients undergoing surgery in the departments of oro-maxillofacial (8.9 %), ear nose throat surgery (ENT) (7.4 %), and cardiac surgery (7.0 %) showed the highest rates of difficult laryngoscopy.
Conclusions The results indicate that the risk for difficult airway situations might substantially differ between surgical patient groups. In hospitals with departmental structures and spatially separated operating rooms, the deduction might be increased awareness and particular structural preparation for difficult airway situations in the respective subspecialties.

Keywords Difficult airway · Poor laryngoscopic view · Airway management

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Introduction

Adverse events during difficult airway situations are the most common causes leading to adverse patient-threatening events in anesthesia. Failure to ventilate and to secure the airway with consecutive hypoxemia accounts for the most cases of death and brain damage in malpractice closed claims analysis [1]. Recommendations and practice guidelines that address both the expected and the unexpected difficult airway have been established by international and national anesthesiology societies [2–5]. The ability to predict and anticipate a difficult airway reliably would enable the anesthesiologist to take specific precautions such as have additional airway equipment, to reduce the risk of failure to secure the airway [2], or special training in the management of difficult airway situations [6]. Moreover, increased knowledge about predictors for the difficult airway could prevent devastating outcomes. Several studies have described various methods for the prediction of the difficult airway [7–10]. However, results have been inconsistent and ambiguous and have changed

over the years [8, 11]. The most common risk factors have been investigated in large meta-analyses [11, 12]. To our knowledge, there is no contemporary report that describes incidence, risk factors, and predictors of the difficult airway in a large population of patients. Additionally, data for the differences between gender und the surgical subspecialties are lacking.

Therefore, the aim of our study was to analyze the incidence and associated predictors of difficult direct laryngoscopy in a single tertiary university hospital, providing anesthesia for virtually all surgical, interventional, and diagnostic subspecialties.

Methods

Retrospectively, all anesthesia records from adult patients undergoing general anesthesia for any type of surgical or diagnostic intervention at the University Hospital Erlangen in a 6-year period of time (November 2005 to December 2011) were included. The University Hospital Erlangen is a tertiary hospital providing a full spectrum of surgical treatment in the following departments:

- Head surgery including neurosurgery, ophthalmology, ear-nose-throat, and oromaxillofacial surgery
- General surgery including visceral, vessel, thoracic, trauma, cardiac, and plastic surgery
- Gynecology and obstetrics

Beside the named surgical departments, anesthesiological care is also provided for diagnostic and interventional departments such as radiology or radiation therapy.

Anesthesiologists are faced with this comprehensive spectrum of surgical, diagnostic, and interventional specialties without being fixed to some specific subspecialty. General anesthesia is provided by anesthesiologists of varied levels of training under supervision of senior physicians. For preoperative evaluation and induction and maintenance of anesthesia, standard operating procedures (SOP) are preexisting. Preoperative evaluation for mobile patients was performed by anesthesiologists in a central anesthesia ambulance or, if patients could not be transferred to the ambulance, anesthesiologists visited the patients on the ward. Preoperative evaluation in scheduled surgery cases was performed by an anesthesiologist at least 12 h before the anesthesia including the determination of Mallampati score. SOPs are addressing both the conduction of anesthesia in general and important measures for specific operations. For anesthesia induction and maintenance, SOPs required a consistent approach using intravenous application of an opioid, a hypnotic drug, and a neuromuscular blocking agent. The "improved Jackson position" was the standard head positioning for direct laryngoscopy and endotracheal intubation according to the SOP. Every anesthesiologist was free to vary the position of the patient's head in adapting to the clinical situation, e.g., ramped position for obese patients [13]. Difficult airway management is addressed by two SOPs, one for the anticipated difficult airway and another for the unanticipated. Both SOPs are in line with the national and international guidelines for difficult airway management. For the unanticipated difficult airway management, endotracheal intubation over a flexible bronchoscope through a laryngeal airway mask was the standard approach. Patients with a preoperatively expected difficult airway were intubated exclusively with a flexible fiberoptic bronchoscope with topical anesthesia or in low-sedation-level, persistent spontaneous ventilation.

Direct laryngoscopy was performed with a standard cold light MacIntosh blade sized appropriately (Heine Optotechnik, Hersching, Germany). The direct laryngeal view was graded according to the Cormack and Lehane (CML) classification. Grade III and IV were assumed to be difficult laryngoscopic visualization.

The filed records were retrieved from an electronic anesthesia patient data management system (NarkoData; IMESO, Hüttenberg, Germany). For patients aged more than 18 years at the date of the intervention, data for age, height, weight, Mallampati score, Cormack and Lehane (CML) classification [14], priority of surgery, anesthesia drugs used for induction and maintenance, and type of airway device used were anonymized and transferred into an Excel datasheet (Microsoft, Redmond, WA, USA). Any individual case could be assigned to the surgical or medical department where the patient was treated. Further statistical processing was performed if direct laryngoscopic findings were documented.

The following patients were excluded from further statistical analysis because a direct laryngoscopy was not performed:

- Patients with exclusively regional anesthesia ($n = 12{,}537$)
- Exclusively sedated patients ($n = 3{,}042$)
- Patients already intubated when arriving at the operation theatre ($n = 5525$)
- Anesthesiological standby only ($n = 13{,}402$)
- Patients with supraglottic airway devices (e.g., laryngeal mask device) ($n = 27{,}408$)
- Patients intubated with videolaryngoscopic assistance without documentation of a direct laryngeal view ($n = 240$)
- Patients intubated with flexible fiberoptic bronchoscope without documentation of direct laryngeal view ($n = 1{,}964$)

- Direct laryngoscopy provided by surgical colleagues and trainees under close supervision of anesthesiologist without documentation of Cormack–Lehane grading ($n = 926$).

With respect to the retrospective, descriptive, and anonymous character of the study, the local ethics committee disclaimed the need for obtaining consent and the need for approval of the study.

Statistics

Statistical processing was performed as eligible, using SPSS (IBM, Armonk, NY, USA; significance level, $p < 0.05$). Elementary statistics, the chi square test, the Mann–Whitney U test, Pearson correlation, and a regression analysis were used for statistical testing.

Results

Overall, the database included 167,349 anesthesiological procedures for various types of surgery, diagnostic interventions requiring anesthesia, and emergency medical treatment with endotracheal intubation. After exclusion of patients who did not receive direct laryngoscopy, such as patients receiving exclusively sedation procedure or regional anesthesia, supraglottic airway device, and patients with fiberoptic or videolaryngoscopic airway management, 102,305 records were selected for further statistical processing.

The proportion of male to female patients was 50.5 % to 49.5 %. Demographic data of the cohort are shown in Table 1.

Cormack and Lehane (CML) III/IV findings were documented in 5,035 cases, which denotes an overall incidence of difficult laryngoscopy of 4.9 %. The predictors of CML III/IV findings are shown in Table 2.

Preoperative Mallampati (MLP) score was documented in 94.5 % of all cases. Patients with impaired view on the soft palate according to MLP score had a significantly increased rate of difficult laryngoscopy. The positive predictive value (PPV) of MLP III/IV finding is 0.17. Male patients had a significantly higher rate of MLP III or IV findings than female patients.

Of the operations, 15,544 (15.2 %) were performed unscheduled with an urgent or emergency priority. Figure 1 presents the influence of gender on the rates of CML III/IV findings for MLP and ASA score and elevated body mass index (BMI). The rate of difficult laryngoscopy in patients undergoing surgery with normal priority was significantly higher than in patients with urgent or emergency priority. In patients undergoing emergency surgery the use of neuromuscular blocking agents (NMBA) was more frequent than in patients with normal priority (95.7 % vs. 93.5 %, $p < 0.001$).

Rapid sequence induction (RSI) was performed in 11,515 patients (11.3 %). Patients undergoing RSI had a significantly lower incidence of CML III/IV findings than patients in the non-RSI group. The rate of patients undergoing RSI was significantly higher in procedures with emergency priority (41.8 % vs. 5.8 %, $p < 0.001$).

Table 1 Demographic data

	n	Age (years)	Height (cm)	Weight (kg)	Body mass index (BMI) (kg/m^2)
Overall	102,305	57 (42/69)	170 (164/177)	75 (65/87)	25.8 (23/29.4)
Male	51,697	58 (44/69)	176 (171/180)	82 (73/92)	26.2 (23.8/29.4)
Female	50,608	55 (40/70)	164 (160/168)	68 (60/80)	25.3 (22.2/29.4)

Age, height, weight, and body mass index (BMI) of the study population. Data are given as median (25 % quartile/75 % quartile)

Table 2 Rate of Cormack and Lehane (CML) III/IV findings

Number (rate) of CML III/IV		Odds ratio (95 % CI)	*p* value
MLP III/IV 2,101/12,149 (17.3 %)	MLP I/II 2,617/84,573 (3.1 %)	6.5 (6.16–6.96)	<0.001
Male 3,364/51,697 (6.5 %)	Female 1,671/50,608 (3.3 %)	2.0 (1.9–2.2)	<0.001
Without neuromuscular blocking agents (NMBA) 574/6,311 (9.1 %)	With NMBA 4,461/95,994 (4.6 %)	2.1 (1.87–2.24)	<0.001
ASA III/IV 1,823/29,348 (6.2 %)	ASA I/II 3,210/72,919 (4.4 %)	1.4 (1.36–1.53)	<0.001
BMI <18.5: 138/2,562 (5.4 %)	BMI >18.5 4,897/99,742 (4.9 %)	1.1 (0.92–1.31)	0.271
BMI >35: 414/6,334 (6.1 %)	BMI <35 4,621/95,556 (4.8 %)	1.3 (1.16–1.43)	<0.001
Scheduled 4,395/86,762 (5.1 %)	Unscheduled 640/155,44 (4.1 %)	1.24 (1.14–1.35)	<0.001
No RSI 4,731/90,790 (5.2 %)	RSI 304/11,515 (2.6 %)	2 (1.80–2.18)	<0.001

Rate of CML III/IV findings, odds ratio (OR), 95 % confidence interval (CI) and significance (p values)

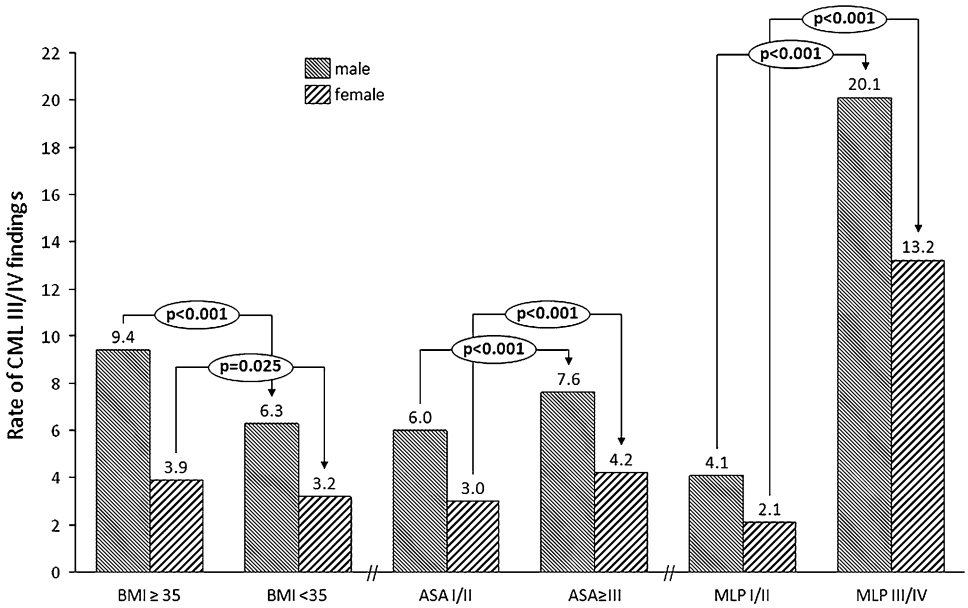

Fig. 1 Influence of gender on predictors of difficult laryngoscopy

Patients who did not receive NMBA showed a higher incidence of CML III/IV views than patients who received NMBA. The preoperatively documented American Society of Anesthesiologists Physical Score (ASA) had a significant influence on the rate of difficult laryngoscopy. Patients with a documented ASA I or II score showed a significant lower rate of CML III/IV findings than patients with ASA III score or higher. The BMI of patients classified as ASA III/IV was significantly higher than in ASA I/II patients (27.9 vs. 26.4 kg/m^2, $p < 0.001$).

In our study, being underweight (BMI <18.5 kg/m^2) had no significant influence on the rate of difficult laryngoscopy, whereas obese patients in our cohort (BMI ≥35 kg/m^2) showed a significant increase in the rate of CML III or IV findings compared to patients with BMI less than 35 kg/m^2. However, the receiver operating curve showed only a poor correlation between BMI and laryngoscopic view. The highest sensitivity (0.55) and specificity (0.53) were found for a BMI of 26 kg/m^2. Female patients showed a significant higher rate of obesity (BMI ≥35 kg/m^2) than male patients (8.2 % vs. 5.2 %, $p < 0.001$).

Regression analysis including MLP score, gender, avoidance of NMBA, ASA score, BMI higher than 35, priority of surgery, and RSI showed only a poor fitting of the statistical model, as R^2 was given as 0.05. Calculated correlation coefficients showed the highest correlation for MLP III/IV (0.21) followed by male gender (0.074), avoidance of NMBA (0.049), ASA III/IV (0.038), and BMI >35 (0.014). For surgery with emergency priority (−0.016) and RSI (−0.038), the analysis showed negative correlations.

Patients of surgical subspecialties treating neoplasms of the upper airway showed the highest incidences of difficult laryngoscopy. In patients undergoing oromaxillofacial (OMF) surgery, ENT surgery, and cardiac surgery we found rates of difficult laryngoscopy to be 8.9, 7.4, and 7 %, respectively. Rates of difficult laryngoscopy in the other surgical departments were neurosurgery 4.3 %, ophthalmology 4.2 %, visceral surgery 4.2 %, trauma surgery 3.5 %, plastic and reconstructive surgery 3.5 %, and gynecology and obstetrics 2.4 %. The proportions of difficult laryngoscopy in the different surgical subspecialties with the highest incidences of CML III or IV findings and gender differences are shown in Table 3. OMF, ENT, and cardiac surgery contributed cumulatively to 31.6 % of the cohort, whereas their contribution to patients with difficult laryngoscopy is 48.8 %.

Discussion

Generally, the data from our study confirmed several results from prior work, but added some new associations with difficult laryngoscopy. The overall incidence of difficult laryngoscopy in our study was 4.9 %, confirming the estimates of previous multicenter studies and meta-analysis [12, 15].

In our study, MLP III or IV score was associated with a significantly increased rate of difficult laryngoscopy. Since Mallampati and colleagues described the relationship between the size of the tongue and the oral cavity [8] in 1985, the Mallampati test has been modified by Samsoon and Young [16] from a three-scale to a four-scale test. This modified Mallampati test is usually referred to when referring to the Mallampati test, which was established as a clinical standard screening tool to evaluate the possibility

Table 3 Departments with high rates of CML III/IV findings

	Contribution to cohort, *n* (%)	CML III or IV overall, *n* (rate)	Male/female, *n* (%)	CML III or IV male, *n* (%)	CML III or IV female, *n* (%)
OMF	5,755 (5.6 %)	513 (8.9 %)	3,609 (62.7 %)/2,146 (37.3 %)	364 (10.1 %)	149 (6.9 %)
ENT	19,939 (19.5 %)	1.478 (7.4 %)	12,790 (64.1 %)/7,149 (35.9 %)	1,161 (9.1 %)	317 (4.4 %)
Cardiac surgery	6,606 (6.5 %)	465 (7.0 %)	4,565 (69.1 %)/2,041 (30.9 %)	376 (8.2 %)	89 (4.4 %)

Incidences and gender differences of difficult laryngoscopy in the different surgical departments with the highest rate of CML III or IV findings: oromaxillofacial surgery (OMF), ear nose throat (ENT), and cardiac surgery

of difficult intubation. Previous meta-analysis including 177,088 patients showed only a poor prognostic value of the Mallampati score [11]. Lundstrom and coworkers estimated the pooled odds ratio of MLP III/IV in their meta-analysis of 55 different studies to be 5.89 (CI, 4.74–7.32) [11]. In our cohort, we found an odds ratio of MLP III or IV finding of 6.5 (CI, 6.16–6.96). As per the findings of other authors, our results suggest that the Mallampati test alone is of limited value [11, 17, 18]. Alternative tests such as the upper lip bite test [19], the ratio of thyromental distance and patient's height [20], thyromental distance [21], hyomental distance ratio [22], interincisor gap [23], and their combination have been suggested, but because of its simplicity and well-known feasibility, the Mallampati test is still an essential part of preoperative evaluation. Recognizing the limited prognostic value of the Mallampati test alone, it is even more important to know other risk factors predicting a poor laryngoscopic view such as gender, surgery of the upper airway, cardiac surgery, elevated BMI, and avoidance of NMBA.

Our analysis identified male gender as a risk factor for CML III/IV findings. Male patients showed a highly significant increased rate of CML III/IV findings compared to female patients. Analyzing other predictors that contribute to an increased rate of CML III/IV findings shows that male patients have a significantly increased rate of MLP III/IV findings and ASA III/IV classification. Male gender is also identified to be a risk factor for CML III/IV findings by other authors [9, 12]. Moreover, male gender as well as MLP III/IV was also identified as predictors for difficult mask ventilation by Kheterpal and coworkers [24].

Patients undergoing RSI showed a significant lower incidence of CML III/IV findings than patients of the non-RSI group (2.6 % vs. 5.2 %). As an underlying cause, the dosage of rapid-onset NMBA used in RSI procedures is much higher than in non-RSI inductions. Unfortunately, our database had no specific information about the dosage of NMBA. However, the avoidance of NMBA was correlated with a significantly increased rate of CML III/IV findings in our study database. This result agrees with the findings of the Danish Anesthesia Database cohort of 103,812 patients where the avoidance of NMBA increased the CML findings (OR 1.52, 95 % CI 1.43–1.61) [25]. The influence of NMBA on the efficiency of mask ventilation is reported to be limited [26].

Because time for preparation is limited, one might expect that urgent and emergency priority surgery would lead to a higher incidence of poor laryngoscopic view. In our study, the contradictory finding that patients undergoing unscheduled surgery showed a significant lower rate of CML III/IV findings could be observed. Thus, we found a significantly lower rate of avoidance of NMBA in this patient group. These findings suggest that the usage of NMBA reduces the risk of poor laryngeal visualization.

ASA III/IV classification was positively correlated with poor laryngoscopic view in our patient cohort. Although Pearson's correlation coefficient shows only a poor grade of correlation, the incidence of CML III/IV was significantly increased in the ASA III/IV patients. This correlation was found independently from patient gender (Fig. 1). Patients of ASA group I/II have a RSI rate of 9.3 % and that of patients of the ASA group III/IV is 16 %, so the different rate of RSI is also not useful to explain why patients with high ASA classification have such an increased rate of poor laryngoscopic view. In pediatric patients, a correlation between high ASA scores and an increased rate of CML III/IV findings is explained by the younger age of ASA III/IV scored patients [27]. Review of the literature shows that the correlation of high ASA scores and poor laryngoscopic view has not been investigated in adult patients until now.

Regarding BMI as a possible predictor of poor laryngoscopic view, the threshold level needs further discussion. On the one hand, we calculated a BMI of 26 kg/m^2 as the threshold level for the highest sensitivity and specificity, and on the other hand we used a BMI of 35 kg/m^2 as the cutoff for statistical processing. In favor of a better comparability to other studies, we choose a BMI of 35 kg/m^2 as our cutoff. Other studies addressing BMI as predictor for a poor laryngoscopic view reported different results. Although Juvin et al. [28] reported an increased rate of CML III/IV findings in obese patients, Ezri and coworkers [29] declined this correlation. In a much larger cohort,

Lundstrom et al. [12] found that the BMI is only a weak predictor of CML III/IV findings but that it is much more useful than weight or height alone. In our study, obesity (BMI >35 kg/m^2) is associated with a significant increased rate of poor laryngoscopic view. Interestingly, this effect is much more pronounced in male patients than in female patients (Fig. 1). In female patients, the effect does not reach the same high statistical level as in male patients. Besides the patient factors discussed, other predictors such as type of surgery might also contribute to the risk of poor laryngoscopic view. In departments treating neoplasms and malformations of the upper airway, the increased rate of CML III/IV findings is not surprising (Table 3). The increased rate of poor laryngeal visualization in cardiac surgery is a well-known phenomenon [30]. However, not cardiac surgery per se but specific patient characteristics seem to be responsible for this observation [30]. It is remarkable that in all three surgical departments previously mentioned the rate of CML III/IV findings is much higher in male patients than in female patients (Table 3). It seems obvious that especially in the oromaxillofacial and ENT departments the higher rate of poor laryngeal visualization is related to disease-specific changes of the anatomy of the upper airway, but additionally this effect is more pronounced in male patients. The increased rate of laryngeal and parapharyngeal neoplasm in male patients likely contributed to this result [31].

It is remarkable that in all three departments with the highest rates of CML III/IV findings, i.e., ENT, oromaxillofacial, and cardiac surgery, male patients represent nearly two-thirds of the patients. The department with the lowest rate of CML III/IV findings (2.4 %) is the department for gynecology and obstetrics where almost exclusively female patients are represented. In the trauma and plastic surgery departments, where we also found low rates of CML III/IV findings (3.5 %, respectively), female patients represent the majority of patients (53 %, respectively).

These results indicate that the high proportion of male patients might have contributed to the high rates of poor laryngeal visualization in the ENT, oromaxillofacial, and cardiac surgery departments.

Our study has certain limitations, mainly associated with the retrospective design. The CML findings especially are based on the subjective view of the attending anesthesiologist. Unfortunately, our database does not contain any information about positioning of the head, number of intubation attempts, or the experience of the attending anesthesiologist: all three factors would have been of certain interest and could have affected our results. Some results, especially the Mallampati test, are not based on a standardized conduction; in particular, investigator and patient positioning was not standardized.

The general incidence of our cohort is comparable to those of other contemporary studies. Beside male gender, Mallampati III/IV, avoidance of NMBA, and BMI >35 kg/m^2, we also found ASA III/IV classification as predictor of difficult laryngoscopy. Negative correlations were found for RSI and emergency priority. Most likely, more frequent use of rapid-onset and higher-dose NMBA in RSI and emergency procedures might be the cause. These results could support the thesis that the use of NMBA improves laryngeal view. A particular level of airway management precautions and special equipment might be useful for departments with elevated CML III/IV findings such as oromaxillofacial surgery, ENT, and cardiac surgery.

Conflict of interest No external funding and no competing interests are declared.

References

1. Peterson GN, Domino KB, Caplan RA, Posner KL, Lee LA, Cheney FW. Management of the difficult airway: a closed claims analysis. Anesthesiology. 2005;103(1):33–9.
2. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. Anesthesiology 2003;98(5):1269–77.
3. Airway management. Guidelines of the German Society of Anesthesiology and Intensive Care Medicine. Anesth Intensivmed 2004;45:302–6.
4. Henderson JJ, Popat MT, Latto IP, Pearce AC. Difficult Airway Society guidelines for management of the unanticipated difficult intubation. Anesthesia. 2004;59(7):675–94.
5. Barron FA, Ball DR, Jefferson P, Norrie J. 'Airway Alerts.' How UK anesthetists organise, document and communicate difficult airway management. Anaesthesia. 2003;58(1):73–7.
6. Stringer KR, Bajenov S, Yentis SM. Training in airway management. Anaesthesia. 2002;57(10):967–83.
7. Deller A. Incidence and predictability of difficult intubation. Anaesthesiol Intensivmed Notfallmed Schmerzther. 1995;30(3):169–71.
8. Mallampati SR, Gatt SP, Gugino LD, Desai SP, Waraksa B, Freiberger D, Liu PL. A clinical sign to predict difficult tracheal intubation: a prospective study. Can Anesth Soc J. 1985;32(4):429–34.
9. Rose DK, Cohen MM. The airway: problems and predictions in 18,500 patients. Can J Anesth. 1994;41(5 pt 1):372–83.
10. Safavi M, Honarmand A, Zare N. A comparison of the ratio of patient's height to thyromental distance with the modified Mallampati and the upper lip bite test in predicting difficult laryngoscopy. Saudi J Anesth. 2011;5(3):258–63.
11. Lundstrom LH, Vester-Andersen M, Moller AM, Charuluxananan S, L'Hermite J, Wetterslev J. Poor prognostic value of the modified Mallampati score: a meta-analysis involving 177 088 patients. Br J Anaesth. 2011;107(5):659–67.
12. Lundstrom LH, Moller AM, Rosenstock C, Astrup G, Wetterslev J. High body mass index is a weak predictor for difficult and failed tracheal intubation: a cohort study of 91,332 consecutive patients scheduled for direct laryngoscopy registered in the Danish Anesthesia Database. Anesthesiology. 2009;110(2):266–74.
13. Heinrich S, Horbach T, Salleck D, Birkholz T, Irouschek A, Schmidt J. Perioperative anesthesiological management in 167

patients undergoing bariatric surgery. Zentralbl Chir. 2011; 136(6):604–11.
14. Cormack RS. Cormack–Lehane classification revisited. Br J Anesth. 2010;105(6):867–8.
15. Shiga T, Wajima Z, Inoue T, Sakamoto A. Predicting difficult intubation in apparently normal patients: a meta-analysis of bedside screening test performance. Anesthesiology. 2005; 103(2):429–37.
16. Samsoon GL, Young JR. Difficult tracheal intubation: a retrospective study. Anaesthesia. 1987;42(5):487–90.
17. Lee A, Fan LT, Gin T, Karmakar MK. A systematic review (meta-analysis) of the accuracy of the Mallampati tests to predict the difficult airway. Anesth Analg. 2006;102(6):1867–78.
18. Adamus M, Fritscherova S, Hrabalek L, Gabrhelik T, Zapletalova J, Janout V. Mallampati test as a predictor of laryngoscopic view. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub. 2010;154(4):339–43.
19. Tremblay MH, Williams S, Robitaille A, Drolet P. Poor visualization during direct laryngoscopy and high upper lip bite test score are predictors of difficult intubation with the GlideScope videolaryngoscope. Anesth Analg. 2008;106(5):1495–500.
20. Schmitt HJ, Kirmse M, Radespiel-Troger M. Ratio of patient's height to thyromental distance improves prediction of difficult laryngoscopy. Anesth Intensive Care. 2002;30(6):763–5.
21. Butler PJ, Dhara SS. Prediction of difficult laryngoscopy: an assessment of the thyromental distance and Mallampati predictive tests. Anesth Intensive Care. 1992;20(2):139–42.
22. Jin Huh H-YS, Kim S-H, Yoon T-K, Kim D-K. Diagnostic predictor of difficult laryngoscopy: the hyomental distance ratio. Anesth Analg. 2009;108:544–8.
23. Naguib M, Scamman FL, O'Sullivan C, Aker J, Ross AF, Kosmach S, Ensor JE. Predictive performance of three multivariate difficult tracheal intubation models: a double-blind, case-controlled study. Anesth Analg. 2006;102(3):818–24.
24. Kheterpal S, Martin L, Shanks AM, Tremper KK. Prediction and outcomes of impossible mask ventilation: a review of 50,000 anesthetics. Anesthesiology. 2009;110(4):891–7.
25. Lundstrom LH, Moller AM, Rosenstock C, Astrup G, Gatke MR, Wetterslev J. Avoidance of neuromuscular blocking agents may increase the risk of difficult tracheal intubation: a cohort study of 103,812 consecutive adult patients recorded in the Danish Anesthesia Database. Br J Anesth. 2009;103(2):283–90.
26. Goodwin MW, Pandit JJ, Hames K, Popat M, Yentis SM. The effect of neuromuscular blockade on the efficiency of mask ventilation of the lungs. Anesthesia. 2003;58(1):60–3.
27. Heinrich S, Birkholz T, Ihmsen H, Irouschek A, Ackermann A, Schmidt J. Incidence and predictors of difficult laryngoscopy in 11,219 pediatric anesthesia procedures. Paediatr Anesth. 2012;22(8):729–36.
28. Juvin P, Lavaut E, Dupont H, Lefevre P, Demetriou M, Dumoulin JL, Desmonts JM. Difficult tracheal intubation is more common in obese than in lean patients. Anesth Analg. 2003;97(2): 595–600.
29. Ezri T, Medalion B, Weisenberg M, Szmuk P, Warters RD, Charuzi I. Increased body mass index per se is not a predictor of difficult laryngoscopy. Can J Anesth. 2003;50(2):179–83.
30. Ezri T, Weisenberg M, Khazin V, Zabeeda D, Sasson L, Shachner A, Medalion B. Difficult laryngoscopy: incidence and predictors in patients undergoing coronary artery bypass surgery versus general surgery patients. J Cardiothorac Vasc Anesth. 2003;17(3):321–4.
31. Arsenijevic S, Pantovic V, Gledovic Z, Stojanovic J, Belic B. Demographic characteristics of patients with laryngeal cancer and their socioeconomic status. J BUON. 2010;15(1):131–35.