

RESPIRATION AND THE AIRWAY

Expected difficult tracheal intubation: a prospective comparison of direct laryngoscopy and video laryngoscopy in 200 patients

A. Jungbauer, M. Schumann, V. Brunkhorst, A. Börgers and H. Groeben*

Department of Anaesthesiology, Critical Care Medicine and Pain Therapy, Clinics Essen-Mitte, Henricistr. 92, 45136 Essen, Germany

*Corresponding author. E-mail: h.groeben@kliniken-essen-mitte.de

Background. The Berci–Kaplan video laryngoscope was developed to improve the visualization of the glottis and ease tracheal intubation. Whether this technique is also effective in patients with an expected difficult intubation is unclear. We have prospectively evaluated the conditions and success rate of tracheal intubation in patients with a Mallampati score of III or IV.

Methods. Two hundred patients, undergoing general anaesthesia, were randomized to be intubated using direct laryngoscopy ($n=100$) or video laryngoscopy ($n=100$). Visualization of the vocal cords, success rate, time for intubation, and the need for additional manoeuvres (laryngeal manipulations, head positioning, and Eschmann stylet) were evaluated.

Results. Video laryngoscopy produced better results for the visualization of the glottis using Cormack and Lehane criteria ($P<0.001$), success rate ($n=92$ vs 99 , $P=0.017$), and the time for intubation [60 (77) vs 40 (31) s, $P=0.0173$]. In addition, the number of optimizing manoeuvres was also significantly decreased [1.2 (1.3) vs 0.5 (0.7), $P<0.001$].

Conclusions. Video laryngoscopy, when compared with direct laryngoscopy for difficult intubations, provides a significantly better view of the cords, a higher success rate, faster intubations, and less need for optimizing manoeuvres. Therefore, we feel that the video laryngoscopy leads to a clinically relevant improvement of intubation conditions and can be recommended for difficult airway management.

Br J Anaesth 2009; **102**: 546–50

Keywords: airway; anaesthetic techniques, laryngoscopy; equipment, airway

Accepted for publication: January 11, 2009

Securing the airway with a cuffed tube in the trachea is still one of the most important skills in anaesthesia. However, the placement of a tracheal tube can be expectedly or unexpectedly difficult or even impossible.^{1–6} Difficult tracheal intubation still contributes to anaesthesia-related morbidity and mortality.^{7–10}

To minimize this risk due to difficult intubations, most of the national anaesthesia societies have developed guidelines for the management of expected and unexpected difficult intubations.^{11–13} At the same time, ‘blind techniques’ via laryngeal airways and video-assisted devices for tracheal intubation have been developed to ease difficult intubations.^{14–19} In addition, video-assisted techniques offer the opportunity to improve the teaching of airway management.²⁰ In general, these techniques offer the advantage of abandoning the need to align the

optical axis in the pharynx and mouth to visualize the entrance of the larynx.⁴

In 2003, Kaplan and Berci¹⁷ introduced the Storz video laryngoscope into clinical practice. The Storz video laryngoscope is built like a standard Macintosh laryngoscope with an integrated video camera. The camera projects the image to a portable screen. Besides the improved view for the anaesthesiologist, the system allows supporting staff to optimize their assistance (external manipulation of the larynx). The system has been shown to be very effective in a large study in patients with an expected normal intubation.²¹ Whether the Storz video laryngoscope can improve the intubating conditions and finally the success rate in difficult intubations remains unknown.

Therefore, the aim of this study was to compare the visualization of the glottis, the time for tracheal intubation, the

success rate of intubation, and the need for manoeuvres to optimize the view using direct laryngoscopy or video laryngoscopy in patients with expected difficult intubations.

Methods

After approval by the local Ethics Committee, 200 patients undergoing surgery under general anaesthesia with tracheal intubation gave their informed, written consent to participate in this study.

The patients were aged >18 yr, and were recruited if they had a modified Mallampati score of III or IV, or a history of a difficult intubation and a mouth opening of at least 2 cm.¹⁶ Patients who were ASA IV or higher and those undergoing rapid sequence induction were excluded.

The modified Mallampati score was assessed with the patient in sitting position, the mouth fully open and the tongue protruded.^{22 23} The patients were asked to phonate. Before induction of anaesthesia, the evaluation was confirmed by one of the two attending anaesthesiologists who performed the intubations. In cases where the anaesthesiologist could not confirm the scoring and found a Mallampati score of less than III, the patient was excluded from the study ($n=5$). Three patients with a Mallampati score of less than III were enrolled because of a documented history of difficult intubation.

Visualization of the laryngeal inlet was assessed according to the classification of Cormack and Lehane: I, vocal cords visible; II, less than half of the glottis or only the posterior commissure is visible; III, only the epiglottis is visible; and IV, none of the foregoing is visible.²⁴

All intubations were performed by two experienced anaesthesiologists with 13 and 17 yr of experience in clinical anaesthesia and at least 3 yr of experience in difficult intubations.

The video laryngoscope (Karl Storz Endoskope, Tuttlingen, Germany) was introduced into clinical practice by Kaplan and Berci.¹⁷ The video laryngoscope is built like a standard Macintosh laryngoscope with fiberoptic fibres built into the end of the blade. This way the video laryngoscope allows at the same time a direct view, like the view with a normal Macintosh blade, and the view of the camera at the end of the blade projected on a monitor. The camera projects the image in real time to a portable video system with the option to record sequences or pictures. For the study, blades Macintosh size three and four were used. Size of the blades and tracheal tubes (7.0–8.0 mm ID) were used to the discretion of the intubating anaesthesiologists.

After having obtained the consent, the patient was assigned to tracheal intubation via direct laryngoscopy or video laryngoscopy according to a computer-based randomization list. Before induction of anaesthesia, the anaesthesiologist performing the tracheal intubation confirmed the Mallampati score and started preoxygenation.

The patients were placed in the supine position with their head on a 7 cm headrest. General anaesthesia was

Table 1 Anthropometric data and dose of medication for anaesthesia induction of 200 patients [mean (sd) or mean (range)] randomized for direct laryngoscopy ($n=100$) or video laryngoscopy ($n=100$) with expected difficult intubation

	Direct laryngoscopy	Video laryngoscopy	P-value
Height (cm)	172 (9)	172 (10)	0.8351
Weight (kg)	78.7 (19.4)	83.2 (20.8)	0.1073
Age (yr)	54.2 (18–94)	56.8 (18–88)	0.2411
Mallampati score (I/II/III/IV)	0/2/87/11	0/1/76/23	0.0703
Thyromental distance	6.8 (1.5)	7.0 (1.4)	0.4653
Sternomental distance	14.3 (2.0)	14.1 (2.4)	0.5155
Interincisor gap	3.7 (0.9)	3.7 (0.9)	0.9880
Propofol (mg kg ⁻¹)	2.4 (0.6)	2.4 (0.5)	0.6639
Remifentanyl (µg kg ⁻¹)	0.87 (0.16)	0.81 (0.21)	0.0186
Succinylcholine (mg)	87 (21)	91 (23)	0.1535

induced according to the preference of the attending anaesthesiologist (Table 1). The attending anaesthesiologist decided when to start the intubation attempt and the time for the procedure was then noted.

The time for an attempt was defined from when the patient's mouth was opened until the cuff of the tube was inflated. The attending anaesthesiologist noted the laryngoscopic view according to Cormack and Lehane.²⁴ Always the best view and the number of manoeuvres to optimize this view were noted. In the case of video laryngoscopic intubations, both views (direct view with the blade and the view on the screen) were recorded.

Optimizing manoeuvres were the external manipulation of the larynx (BURP manoeuvre), use of a gum elastic bougie (Eschmann stylet), and changes in head positioning. A number of zero optimizing manoeuvres meant that the patient was intubated in neutral position without any manipulations. In cases where the anaesthesiologist could not intubate a patient despite all manoeuvres, the intubation attempt was declared as failed.

During the tracheal intubation, standard monitoring, i.e. non-invasive arterial pressure measurement, heart rate, and arterial oxygen saturation (pulse oximeter), was performed and the results were recorded before induction of anaesthesia and at the end of the intubation.

Data are presented as mean (sd). The following null hypotheses were tested: first, time for tracheal intubation using video laryngoscopy was significantly longer than using direct laryngoscopy. Secondly, the view at the larynx according to Cormack and Lehane was not different for the two techniques. Thirdly, the number of optimizing manoeuvres was not different for the two techniques. Fourthly, the success rate for tracheal intubation was not different for the two techniques. Hypotheses were tested using χ^2 test (classification according to Cormack and Lehane, number of optimizing manoeuvres, and success rate) and Student's *t*-test (time for intubation). Differences were considered significant for $P<0.05$. Bonferroni's correction for multiple testing was applied for significance testing, when multiple tests for one parameter (time for tracheal intubation) were performed.

Sample size was based on an α -error of 0.05 and a β -error of 0.2 with a minimal time difference for intubation of 20 s and a standard deviation of 45 s. The resulting minimal number per group was 79 and was rounded to 100 for each group.

Results

The patients were recruited from the departments of oral and maxillo-facial surgery ($n=126$), general surgery ($n=50$), and urology ($n=24$). The patients were evenly distributed for the two groups. Anthropometric data of the patients were presented in Table 1.

Video laryngoscopy provided a significantly better view of the laryngeal structures than direct laryngoscopy ($P<0.0001$). Direct laryngoscopy with a standard Macintosh blade showed a distribution of the classification grades from I to IV of: 23/41/26/10, whereas video laryngoscopy showed a distribution of: 45/45/10/0 (Fig. 1). Besides, video laryngoscopy also allows a direct view which is similar to a

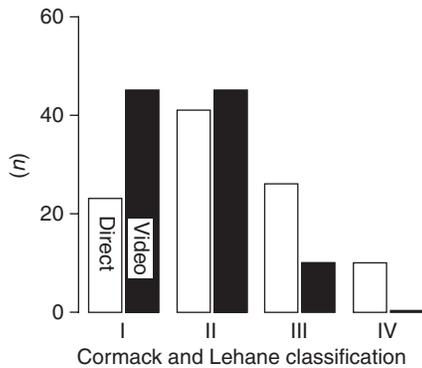


Fig 1 Number of patients according to the classification of Cormack and Lehane. Laryngoscopy with the video laryngoscope facilitated a significantly better view of the glottis compared with direct laryngoscopy with a Macintosh blade ($P<0.0001$).

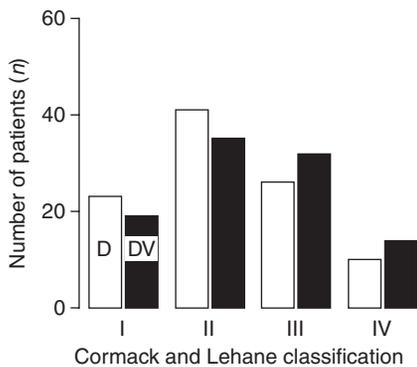


Fig 2 Number of patients according to the classification of Cormack and Lehane. The direct view with the video laryngoscope through the mouth (DV) did not reveal any significant difference compared with direct laryngoscopy with the Macintosh laryngoscope (D; $P=0.54$). The equivalent direct view with the Berci–Kaplan laryngoscope compared with that with the Macintosh laryngoscope provides the rationale for a subanalysis of patients with a Cormack and Lehane class III and IV airway.

Macintosh blade. This direct view with the video laryngoscope provided a view of: 19/35/32/14. This direct view was not statistically different from that of the controls ($P=0.54$, Fig. 2).

The time for tracheal intubation (from opening of the mouth to inflating the cuff) was significantly shorter for video laryngoscopy compared with direct laryngoscopy with a standard Macintosh blade [40 (31) s video laryngoscopy vs 60 (77) s direct laryngoscopy; $P=0.017$, Fig. 3].

Overall, 200 attempts at tracheal intubation were made with 100 attempts for each technique. Video laryngoscopy led to 99 successful intubations, whereas direct laryngoscopy was successful in 92 attempts ($P=0.017$). These results were achieved in 61 vs 41 cases (video

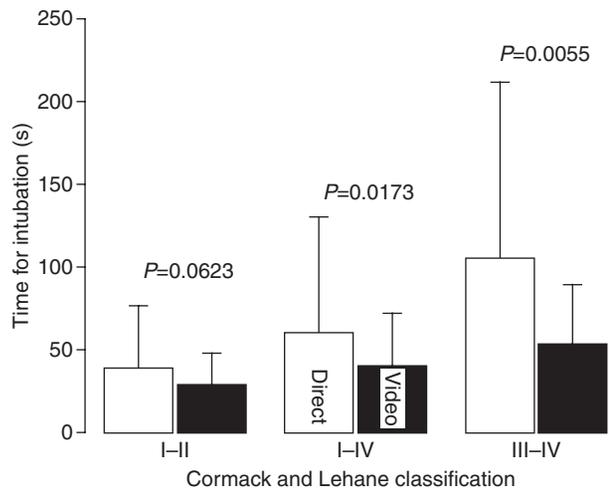


Fig 3 Time for intubation with respect to the classification of Cormack and Lehane. On the left, a subanalysis of patients with a Cormack and Lehane class I and II airway ($n=118$), in the middle all patients ($n=200$), and on the right, a subanalysis of patients with a Cormack and Lehane class III and IV airway ($n=88$), judged from the direct view with both techniques. The difference in time for intubation increased between video laryngoscopy and direct laryngoscopy with the increase in the classification of Cormack and Lehane.

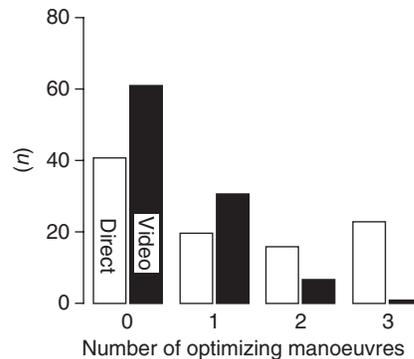


Fig 4 Number of optimizing manoeuvres (external manipulation of the larynx, gum elastic bougie, and change in head positioning) to achieve the best view at the glottic structures. There was significantly less need for supportive manoeuvres to optimize the view with the video laryngoscope ($P<0.0001$).

laryngoscopy vs direct laryngoscopy) from neutral position without manipulations, in 31 vs 20 cases with external manipulation of the larynx, in 7 vs 16 cases with additional use of a gum elastic bougie, and finally with additional change in head position in 1 vs 23 cases ($P < 0.001$, Fig. 4).

The dose of remifentanyl was significantly lower for the patients intubated via video laryngoscopy (Table 1). There were no differences for arterial pressure, heart rate, and the measurements of pulse oximetry between the two groups. Overall, systolic arterial pressure and heart rate decreased significantly ($P < 0.001$), whereas oxygen saturation significantly increased ($P < 0.001$).

Because direct view with the video laryngoscopy was not different from that with the standard Macintosh blade, a subanalysis of the patients with a classified airway according to Cormack and Lehane grade III and IV was performed. There were 46 patients with a direct laryngoscopic view of III and IV in the video laryngoscopy group and 36 in the group randomized for direct laryngoscopy.

In contrast to patients with Cormack and Lehane class I and II, who did not show a significant difference for the time for intubation, the time for intubation in patients with Cormack and Lehane class III and IV was significantly different [53 (38) s video laryngoscopy and 105 (112) s direct laryngoscopy, $P < 0.01$; Fig. 3], respectively. The need for optimizing manoeuvres was 0.8 (0.8) for video laryngoscopy and 2.2 (1.1) for direct laryngoscopy ($P < 0.001$), respectively. Finally, the rate of successful intubations was 45 of 46 attempts for video laryngoscopy and 28 of 36 attempts for direct laryngoscopy ($P < 0.01$).

Discussion

In patients with an expected difficult intubation, video laryngoscopy leads to a better view of the laryngeal structures, facilitates faster intubations with a higher success rate and less need for optimizing manoeuvres.

These results could have been influenced by the selection of the patients and differences in the depth of anaesthesia as important determinants of the intubation conditions.^{2-4 25} Therefore, we analysed the anthropometric data of the patients (Table 1) and the medication used for induction of anaesthesia.

Concerning the induction of general anaesthesia, we found a significantly lower induction bolus of remifentanyl, which was 0.06 μg lower in the video laryngoscopy group (Table 1). However, the decrease in arterial pressure and heart rate in both groups demonstrates that there was no clinically relevant difference in depth of anaesthesia. Moreover, if this difference had influenced our results, it would have had an influence in favour of the direct laryngoscopy. Overall, the condition for tracheal intubation should not have influenced our results.

We chose a modified Mallampati classification to predict difficult intubations. Difficult intubations were

defined as an intubation with the best obtainable laryngoscopic view of III or IV according to the classification of Cormack and Lehane. The Mallampati classification has been criticized multiple times, because of a high number of false positive ratings and a low predictive value.²⁵⁻²⁷ In 2005, Eberhart and colleagues²⁷ found a positive prediction value of 19.5% for true difficult intubations with a Mallampati class of III and IV. That our positive prediction value was 36% for the patients randomized for direct laryngoscopy has at least three reasons. First, Lewis and colleagues²⁵ have demonstrated that the way the Mallampati test is performed has a significant influence on the prediction of a difficult intubation. According to these findings, the way we performed the test should yield the best predictive value. Secondly, the result of the Mallampati test is strongly influenced by an inter-observer variability. Therefore, we decided that the grade of the Mallampati classification had to be confirmed by a second observer.⁴ Consequently, five patients with a false high Mallampati score were excluded. Thirdly, the Mallampati classification is mainly determined by soft tissue, which in many cases can be pushed away with the laryngoscope to reveal a view of less than III according to Cormack and Lehane. In our study, more than 60% of all patients and more than 70% of the patients with a class III and IV laryngeal view were patients undergoing oral and maxillofacial surgery. These patients underwent surgery, because of tumours, infections, or anatomical variations in the oral, pharyngeal, or both regions. In most of these patients, the tongue is not as mobile as in normal patients and the tissue gives much more resistance and cannot be pushed away. Therefore, the Mallampati classification has such a high predictive value in our study. Ayuso and colleagues⁶ published similar results in patients who underwent intubation for tumour-related surgery.

As a limitation of the study, we have to state that despite all efforts to avoid any bias by the selection of the patients and the standardization of the anaesthesia technique and technique of intubation, we cannot exclude an unintended bias due to the fact of an unavoidable unblinded study design.

Depending on the management, tracheal intubation in patients with difficult airways can lead to airway trauma or even a life-threatening disaster.^{10 11} Therefore, on the one hand, difficult airway management guidelines have been developed and, on the other hand, video-assisted devices have been developed to ease tracheal intubation.¹²⁻²² The rationale behind the development of these devices is to abandon the need for the alignment of the optical axis to receive a direct view of the glottis.⁴

In a multi-centre trial enrolling 867 patients, Kaplan and Berci found a significantly improved view using the Storz video laryngoscope view on the monitor compared with the direct 'naked' view by the same laryngoscope.¹⁷ Overall, they found that the video laryngoscopy can be used safely and this technique seems to provide better

intubation conditions.²¹ However, their study design did not include a control group of patients, who were randomized for intubation with a standard Macintosh laryngoscope, and it remains unclear whether these improved conditions are clinically relevant.

Since the higher costs and logistic requirements for such a system have to be justified, the next step was to show that patients can be intubated with the new technique, who could not be intubated with the standard technique or only with more effort and time. Therefore, we performed this study and found again an improved laryngoscopic view and even more important a higher success rate of tracheal intubation in patients with an expected difficult airway, compared with a standard control group. Moreover, intubations with the video laryngoscope required less time and effort in terms of optimizing manoeuvres. These results were even clearer when the focus of the analysis was set on the data of patients with a 'class III and IV' airway, according to Cormack and Lehane.

In addition, Low and colleagues used the option of the Berci–Kaplan laryngoscope to provide a direct view through the mouth and the extended view projected on a monitor, for teaching novices with minimal experience in tracheal intubation. The trainee used the standard view of a Macintosh blade and the trainer supervised the procedure via the picture on the monitor.²⁰

In conclusion, the use of the video laryngoscope eases tracheal intubations in patients with expected difficult intubations. The view of the laryngeal entrance is significantly improved, with a decreased number of optimizing manoeuvres and in less time. Overall, these improvements of the conditions for tracheal intubations result in a significantly higher success rate of tracheal intubations.

Funding

All funding was from departmental resources.

References

- Yentis SM. Predicting trouble in airway management. *Anesthesiology* 2006; **105**: 871–2
- Shiga T, Wajima Z, Inoue T, Sakamoto A. Predicting difficult intubation in apparently normal patients. *Anesthesiology* 2005; **103**: 429–37
- Rose DK, Cohen MM. The airway: problems and prediction in 18,500 patients. *Can J Anaesth* 1994; **41**: 372–83
- Randell T. Prediction of difficult intubation. *Acta Anaesthesiol Scand* 1996; **40**: 1016–23
- Savva D. Prediction of difficult tracheal intubation. *Br J Anaesth* 1994; **73**: 149–53
- Ayuso M, Sala X, Luis M, Carbo J. Predicting difficult orotracheal intubation in pharyngo-laryngeal disease: preliminary results of a composite index. *Can J Anaesth* 2003; **50**: 81–5
- Domino KB, Posner KL, Caplan RA, Cheney FW. Airway injury during anesthesia. *Anesthesiology* 1999; **91**: 1703–11
- Asai T, Koga K, Vaughan RS. Respiratory complications with tracheal intubation and extubation. *Br J Anaesth* 1998; **80**: 767–75
- Schwartz DE, Matthay MA, Cohen NH. Death and other complications of emergency airway management in critically ill adults. *Anesthesiology* 1995; **82**: 367–76
- Rahman K, Jenkins JG. Failed tracheal intubation in obstetrics: no more frequent but still managed badly. *Anaesthesia* 2005; **60**: 168–71
- Peterson GN, Domino KB, Caplan RA, Posner KL, Lee LA, Cheney FW. Management of the difficult airway. *Anesthesiology* 2005; **103**: 33–9
- Report by the ASA Task Force on the Management of the Difficult Airway: practice guidelines for management of the difficult airway. *Anesthesiology* 2003; **98**: 1269–77
- Henderson JJ, Popat MT, Latto IP, Pearce AC. Difficult airway society guidelines for management of the unanticipated difficult intubation. *Anaesthesia* 2004; **59**: 675–94
- Timmermann A, Russo SG, Crozier TA, *et al.* Novices ventilate and intubate quicker and safer via intubating laryngeal mask than by conventional bag-mask ventilation and laryngoscopy. *Anesthesiology* 2007; **107**: 570–6
- Doyle DJ. Miniaturizing the GlideScope video laryngoscope system: a new design for enhanced portability. *Can J Anaesth* 2004; **51**: 642–3
- Lim TJ, Lim Y, Liu EHC. Evaluation of ease of intubation with the GlideScope or Macintosh laryngoscope by anaesthesiologists in simulated easy and difficult laryngoscopy. *Anaesthesia* 2005; **60**: 180–3
- Kaplan MB, Ward DS, Berci G. A new video laryngoscope—an aid to intubation and teaching. *J Clin Anesth* 2003; **14**: 620–6
- Henthorn RW, Reed J, Szafranski JS, Ganta R. Combining the fiberoptic bronchoscope with a laryngoscope blade aids teaching direct laryngoscopy. *Anesth Analg* 1995; **80**: 427–34
- Enomoto Y, Asai T, Arai T, Kamishima K, Okuda Y. Pentax-AWS, a new videolaryngoscope, is more effective than the Macintosh laryngoscope for tracheal intubation in patients with restricted neck movements: a randomized comparative study. *Br J Anaesth* 2008; **100**: 544–8
- Low D, Healy D, Rasburn N. The use of the BERIC DCI laryngoscope for teaching novices direct laryngoscopy and tracheal intubation. *Anaesthesia* 2008; **63**: 195–201
- Kaplan MB, Hagberg CA, Ward DS, *et al.* Comparison of direct and video-assisted views of the larynx during routine intubation. *J Clin Anesth* 2006; **18**: 357–62
- Mallampati SR, Gatt SP, Gugino LD, *et al.* A clinical sign to predict difficult tracheal intubation: a prospective study. *Can Anaesth Soc J* 1985; **32**: 429–34
- Samsoon GLT, Young JRB. Difficult tracheal intubation: a retrospective study. *Anaesthesia* 1987; **42**: 487–90
- Cormack RS, Lehane J. Difficult tracheal intubation in obstetrics. *Anaesthesia* 1984; **39**: 1105–11
- Lewis M, Keramati S, Benumof JL, Berry CC. What is the best way to determine oropharyngeal classification and mandibular space length to predict difficult laryngoscopy? *Anesthesiology* 1994; **81**: 69–75
- Lee A, Fan LTY, Gin T, Karmakar MK, Ngan Kee WD. A systematic review (meta-analysis) of the accuracy of the Mallampati tests to predict the difficult airway. *Anesth Analg* 2006; **102**: 1867–78
- Eberhart LHJ, Arndt C, Cierpka T, Schwanekamp J, Wulf H, Putzke C. The reliability and validity of the upper lip bite test compared with the Mallampati classification to predict difficult laryngoscopy: an external prospective evaluation. *Anesth Analg* 2005; **101**: 281–9