Macintosh Blade Videolaryngoscopy Combined With Rigid Bonfils Intubation Endoscope Offers a Suitable Alternative for Patients With Difficult Airways

Section Editor: **David Hillman**

Macintosh Blade Videolaryngoscopy Combined With Rigid Bonfils Intubation Endoscope Offers a Suitable Alternative for Patients With Difficult Airways

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BACKGROUND: In the armamentarium of an anesthesiologist, videolaryngoscopy is a valuable addition to secure the airway. However, when the videolaryngoscope (VLS) offers no solution, few options remain. Earlier, we presented an intubation technique combining Macintosh blade VLS and Bonfils intubation endoscope (BIE) for a patient with a history of very difficult intubation. In the present study, we evaluated this technique to establish whether it is a valuable alternative.

METHODS: In this single-blinded nonrandomized study, 38 patients with a history of difficult intubation or 1 or more predictors of difficult intubation, scoring a Cormack & Lehane (C&L) grade III or IV using Macintosh blade VLS, were included. Patients were intubated combining the VLS with the BIE. The C&L grade was scored 3 times during (1) direct laryngoscopy; (2) indirect videolaryngoscopy; and (3) using the combined technique (VLS + BIE). Afterward, 2 blinded anesthesiologists assessed the C&L grade using the pictures taken during the procedure.

RESULTS: Data of 38 patients were analyzed. An improvement of the C&L grade with the combined technique occurred in 33 of 38 patients (86.8%; 95% confidence interval, 71.9%–95.6%). Reviewer 1 reported an improvement of the C&L grade with the combined technique in 37 of 38 patients. Reviewer 2 reported improvement in 33 and deterioration in 2 of the patients. No complications occurred.

CONCLUSIONS: The combined use of a VLS with Macintosh blade and BIE gives the anesthesiologist a valuable alternative intubation option in patients with extremely difficult airways. (Anesth Analg 2018;126:988–94)

KEY POINTS

- **Question:** Does combining Macintosh videolaryngoscope (VLS) and Bonfils intubation endoscope (BIE) result in an improved glottic view for patients with difficult airways when the Macintosh VLS alone results in a Cormack & Lehane (C&L) grade ≥3?
- **Findings:** An improvement in C&L grade was achieved in the vast majority of patients and endured evaluation by 2 independent, blinded reviewers.
- **Meaning:** The combined use of a VLS with Macintosh blade and BIE gives the anesthesiologist a valuable alternative intubation option in patients with extremely difficult airways.

BACKGROUND AND RATIONALE

Earlier, Van Zundert and Pieters[1] reported on the successful application of a combined intubation technique (Figure 1), using indirect videolaryngoscopy and a rigid intubation endoscope, for a morbidly obese patient with a history of prolonged, very difficult intubation.[1] In most cases with a normal or difficult airway, using a videolaryngoscope (VLS) will result in an improved Cormack & Lehane (C&L) grade, compared with classic direct laryngoscopy. If, however, with the use of the VLS still only the epiglottis is to be seen, the VLS can be used to lift the epiglottis and combining its use with the rigid intubation endoscope may provide a valuable treatment option.

STUDY'S OBJECTIVES

The primary aim of this study was to assess visualization of the glottic entrance using the C&L grade scoring system in patients when indirect videolaryngoscopy failed to visualize the parts of the vocal cords. The combined technique (indirect Macintosh blade VLS and Bonfils intubation endoscope [BIE; Karl Storz, Tuttlingen, Germany]) was compared with the indirect Macintosh blade VLS alone. Secondary aims were the first-attempt successful intubation rate, time until successful intubation, number of attempts to successful intubation, trauma of the oral cavity, dental trauma, and the exploration of the effect of different predictors associated with difficult intubation on the intubation time.

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Accepted for publication November 2, 2017.

Funding: None of the study members has received funding from the device manufacturer of the Bonfils intubation endoscope. All devices used for the study were readily available from the department. No funding was obtained from the device manufacturers.

The authors declare no conflicts of interest.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's website (www.anesthesia-analgesia.org).

Clinical trial registration: ClinicalTrials.gov—NCT01691703.

Reprints will not be available from the authors.

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DOI: 10.1213/ANE.0000000000002739

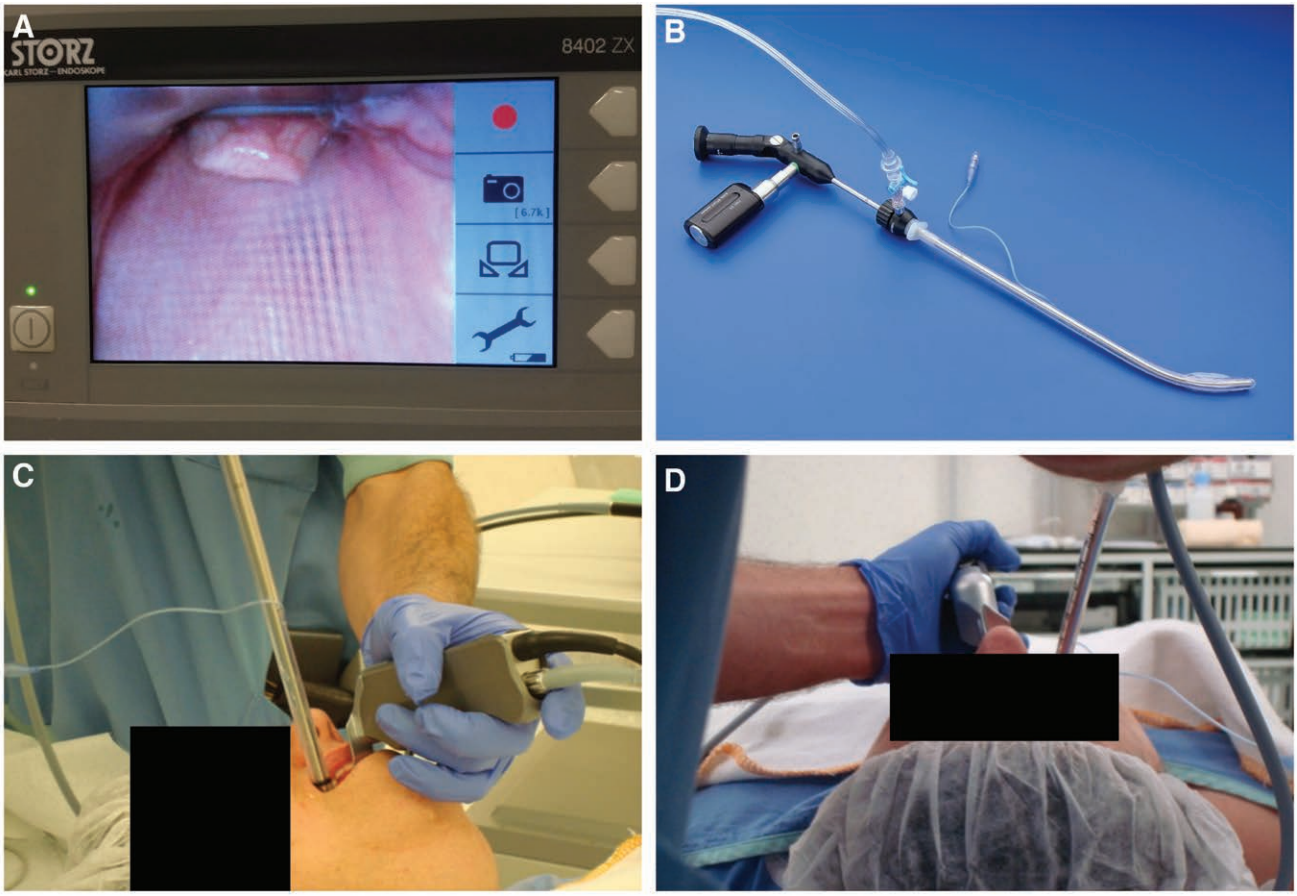

Figure 1. Application of the combination technique. A, Videoscreen of an indirect Macintosh videolaryngoscope showing a C&L grade III. B, Bonfils intubation endoscope loaded with a tracheal tube. C and D, Different angles of view showing the videolaryngoscope in the left hand and the Bonfils intubation endoscope in the right hand. C&L indicates Cormack & Lehane.

METHODS

Approval was obtained from the institutional review board of the Catharina Hospital Eindhoven, the Netherlands (Chairman Dr R. Grouls, COM 12.12–624). Written informed consent was obtained from all subjects. This single-blinded nonrandomized trial was registered at ClinicalTrials.gov (NCT01691703; principal investigator: B.M.P.; Date of registration: February 20, 2013) and adheres to the applicable Enhancing the QUAlity and Transparency Of health Research (EQUATOR) guidelines.

Patient Population and Inclusion/Exclusion Criteria

Patients, scheduled to undergo elective surgery under general anesthesia at the Catharina Hospital Eindhoven, the Netherlands, with a history of difficult intubation or 1 or more predictors of difficult intubation were selected for the study after obtaining written informed consent. Enrollment took place during the preanesthetic visit of the patient, performed by anesthesiologists not involved in the study. Evaluation of the patients included age, height, weight, body mass index (BMI), American Society of Anesthesiologists classification, maximum mouth opening, thyromental distance, Mallampati score, and dentition status. Inclusion criteria were elective surgery needing tracheal intubation, age ≥18 years old, a history of difficult intubation, or 1 or more predictors of difficult intubation[2,3]: Mallampati grade III and IV, interincisor distance <30 mm, restricted neck movement (<90°), thyromental distance <60 mm, or BMI >35 kg·m^{-2}. Exclusion criteria were no informed patient consent, age <18 years old, emergency surgery, a previous intubation stated as "easy"/C&L grade I–II, fasted <6 hours, and head or neck surgery.

Conduct of the Study

On arrival at the operating theater complex, patient characteristics were recorded, including all airway measurements mentioned above. Standard safety measures included monitoring of electrocardiography, noninvasive blood pressure, oxygen saturation, train-of-four (TOF) ratio, and intravenous access. Preoxygenation (3 minutes F_{IO_2} 1.0 by mask) was followed by induction of anesthesia while the patient was placed in the supine, sniffing (external auditory meatus at the level of the sternal notch) position. Sufentanil (1.5 μg·kg^{-1} lean body mass), propofol (2 mg·kg^{-1} lean body mass), and rocuronium (0.6 mg·kg^{-1} lean body mass) were administered to establish general anesthesia.

Before intubation, the patient's lungs were manually ventilated using bag-mask ventilation and 100% oxygen, while sevoflurane was added as required. Muscle paralysis

was measured using the TOF ratio; a TOF ratio of 0 was deemed as adequate for intubation. Depth of anesthesia had to be evaluated as adequate by the anesthesiologist before any intubation attempts were performed. The 2 anesthesiologists (investigators: B.M.P. and A.A.V.Z.) intubating the patients in this study both had extended experience with direct laryngoscopy as well as with videolaryngoscopy using a range of VLSs, including the C-MAC VLS (C-MAC; Karl Storz, Tuttlingen, Germany). They both use VLSs on a daily basis. A blade size 3 or 4 (left to the discretion of the anesthesiologist) Macintosh VLS was used to achieve the best possible laryngoscopy view and position in front of the laryngeal inlet. Once the anesthesiologist considered the achieved view of the glottis to be the best possible (eg, by applying, but not restricted to, external laryngeal pressure by an assistant), a picture was captured using the C-MAC secure digital (SD) card, not showing any part of the VLS. Keeping the Macintosh VLS in position using the left hand, the BIE preloaded with the tracheal tube (TT) (size 7 for women and 8 for men) was brought into position in the mouth next to the Macintosh VLS with the right hand, in front of the laryngeal inlet. The view obtained with the VLS and the view obtained with the BIE were projected next to each other on 1 video monitor screen in regular use by surgeons for laparoscopic procedures. In this way, the anesthesiologist was able to see both the views of the VLS and the BIE on 1 screen (Figure 2). An image of the laryngeal view obtained with the BIE, not showing any part of one of the 2 devices, was saved. Once the BIE was positioned in front of the tracheal entrance, the TT was passed into the correct position in the trachea. Subsequently, both the BIE and the Macintosh VLS were removed from the patient's mouth, and the TT was connected to the ventilator. Correct position of the TT was verified by normal capnogram, peripheral oxygen saturation (>95%), and auscultation of bilateral breathing sounds. The whole procedure was timed by the second investigator (not intubating the patient). Timing started when the Macintosh VLS was placed between the teeth and ended when the TT was in the correct position showing the first capnogram.

Outcome Measures

Primary outcome measure was the C&L grade, evaluating the glottis view during tracheal intubation using classification grades I–IV.[4] The C&L grade was scored 3 times during the intubation by the intubating anesthesiologist (investigators: B.M.P. and A.A.V.Z.). First, to obtain a baseline value, the anesthesiologist scored the C&L grade using the Macintosh VLS for (classic) direct laryngoscopy in the patient's mouth; second, using the Macintosh VLS for indirect (video)laryngoscopy without removing it from the patient's mouth on the monitor of the VLS; and finally, after the best possible view on the video monitor screen was achieved using the combination technique. To control for bias, after conclusion of the study, 2 independent anesthesiologists, blinded for the technique used, also scored the C&L grade (indirect and with the combination technique) using the pictures recorded during the procedure that were presented to them in randomized order. For the secondary outcomes, we collected data on the following: (1) the number of first-attempt successful intubations without the use of adjuncts; (2) time until successful intubation; (3) the number of attempts to successful intubation; and (4) predefined complications including soft tissue (mucosal) trauma to the oral cavity, defined as any amount of bright red blood in the oral cavity, dental and lip trauma, and regurgitation observed by the anesthesiologist. Furthermore, (5) the use of adjuncts (eg, gum elastic bougie, stylet, and the backward upward rightward pressure (BURP) maneuver [performed by a second operator]) was assessed.

Data Handling

Baseline and surgical data were retrieved from the patient's medical file, and data concerning the intubation procedure were recorded by A.A.V.Z. and B.M.P. All data were collected using case report forms and entered in an SPSS database (SPSS Inc, Chicago, IL) and checked by B.M.P. and M.T.

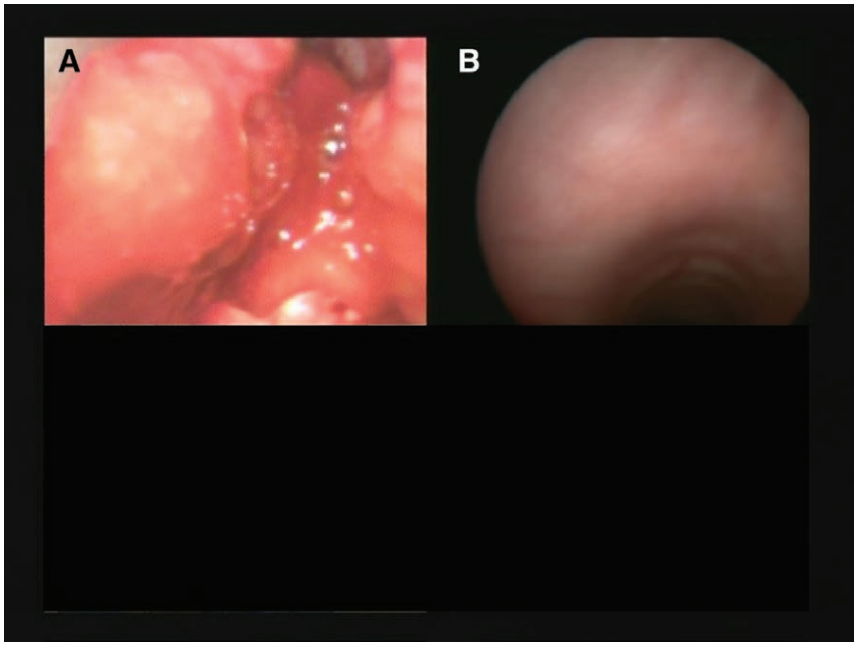

Figure 2. View of the VLS (A) and the BIE (B) as seen simultaneously on 1 video monitor screen. BIE indicates Bonfils intubation endoscope; VLS, videolaryngoscope.

All data and pictures were anonymized. Missing data were not imputed.

Statistical Analysis

Descriptive data analyses of baseline and outcome data were performed using mean (range), median (range), or number (%), where appropriate. For the primary outcome, a 95% confidence interval (CI) for the binomial probability (improved C&L score yes/no) was calculated according to the Clopper–Pearson method. The secondary assessment of C&L grade as defined by 2 independent anesthesiologists (change in C&L grade with combination technique versus indirect technique, improved/unchanged/deteriorated) after judging the pictures is presented using a 3 × 3 table. The amount of interrater agreement beyond that expected by chance was assessed using Cohen's κ coefficient.

For the secondary aim, the association between predictors of difficult intubation (eg, Mallampati grade III–IV scores, BMI >35 kg·m^{-2}) and time until successful intubation was assessed. Statistical testing was performed using the Mann-Whitney *U* test since the Shapiro-Wilk test revealed a nonparametric distribution. A significance level of $P < .008$ was used based on a Bonferroni correction (0.05/6) for multiple testing.

Based on the findings of an earlier study,[5] we estimated an improvement in C&L grade in 75% of the cases after using the combination technique, compared to the use of the VLS alone. With 38 evaluated patients, the hypothetical CI may vary between 54.1–84.6 (27 improved cases, 71.1%) and 75.2–97.1 (34 improved cases, 89.5%).

Analyses were performed using SPSS (IBM SPSS 23; IBM Corporation, New York, NY) and Stata 11.2 (StataCorp, College Station, TX).

RESULTS

After preoperative screening of 337 patients, a total of 42 patients with a history or 1 or more predictors of a difficult airway were included across a 6-month study period (Supplemental Digital Content, Figure 1, http://links.lww.com/AA/C173). Data of 38 patients were analyzed, while 4 patients were omitted because indirect laryngoscopy using the Macintosh VLS did not result in a C&L grade III or IV. All patients were successfully intubated.

Patient characteristics are depicted in Table 1. In total, 12 men (31.6%) and 26 women (68.4%) were included. Age (mean [standard deviation]) of these patients was 50.2 (15.4) years, and BMI was 35.6 (12.9) kg·m^{-2}. Concerning predictors of difficult intubation, 17 patients (44.7%) had a BMI >35 kg·m^{-2}, 7 (18.4%) lacked adequate neck movement, and a Mallampati score III/IV was scored in 19 (50%)/8 (21.1%) patients. Five patients (13.2%) had a history of difficult intubation, and in 21 patients (55.3%), external features predicting a difficult intubation were present. In 23 patients, 1 predictor of difficult intubation was present, 7 had 2 predictors, 8 had 3 predictors, 4 predictors were present in 4 patients, and 1 patient showed 5 predictors.

All patients, except 1, were successfully intubated using the combination technique. For the patient in which the combination technique was not successful, intubation was achieved using the C-MAC D-Blade (Karl Storz, Tuttlingen, Germany) instead of the Macintosh blade VLS combined with the BIE.

Table 1. Patient Characteristics and Intubation Parameters

Parameter	Results
Age (y)	50.2 (15.4)
Sex (male/female), n	12/26
Height (cm)	169.6 (7.6)
Weight (kg)	102.8 (37.9)
BMI (kg·m^{-2})	35.6 (12.9)
Thyromental distance (mm)	60.8 (19.8)
Interincisor distance (mm)	37.1 (7.4)
ASA class (n)	
I/II/III	11/23/4
Mallampati score (n)	
I/II/III/IV	6/5/19/8
Restricted neck movement <90°, n (%)	7 (18.4)
History of difficult intubation, n (%)	5 (13.2)
External features difficult intubation, n (%)	16 (42.1)
Dentition status (n)	
None/upper–lower/complete	5/3/30

Total number of patients: 38.
Data represented as mean (SD) or n (%).
Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index.

Table 2. C&L Grades Scored by the Intubating Anesthesiologist With Classic Direct Laryngoscopy, Indirect Videolaryngoscopy, and Combination Technique

C&L Grade	Direct, n (%)	Indirect, n (%)	Combination, n (%)
1	0	0	32 (84.2)
2	0	0	1 (2.6)
3	16 (42.1)	34 (89.5)	3 (7.9)
4	22 (57.9)	4 (10.5)	2 (5.3)

Total number of patients: 38. Data represented as n (%).
Abbreviation: C&L, Cormack & Lehane.

Concerning the primary outcome, C&L grades that were scored by the intubating anesthesiologist are presented in Table 2. When comparing indirect laryngoscopy with the combined technique, we found an improvement of the C&L grade with the combined technique in 33 of 38 patients (86.8%; 95% CI, 71.9%–95.6%). The other 5 patients showed no improvement of the C&L grade, nor did it worsen. The C&L grade significantly improved when comparing direct to indirect laryngoscopy using the Macintosh VLS. However, the improvement was, as hypothesized, even more when the combination technique was applied. As shown in Table 2, there were no C&L grade I and II scores with indirect (video)laryngoscopy, in contrast to the combination technique, where 86.8% of laryngoscopies resulted in a C&L grade I or II.

Scores given by the independent, blinded reviewers concerning improvement of the C&L grade are depicted in Table 3. The proportion of cases in which both reviewers noted an improved C&L score was 84.2% with a further 10.5% rated as unchanged or improved by one or other of the reviewers. In the remaining 5.3% of cases, one of the reviewers noted a deterioration, while the other rated the view improved. While observed agreement between reviewers was very good, the agreement expected by chance was also high, resulting in a very low κ statistic of −0.036 (−0.098 to 0.025).

Table 3. Change in C&L Grade With Combination Technique Versus Indirect Technique, Scored by Independent, Blinded Reviewers

		Change C&L Grade Reviewer 1			
		Deteriorated	Unchanged	Improved	Total
Change C&L Grade Reviewer 2	Deteriorated	0	0	2[a]	2
	Unchanged	0	0	3[a]	3
	Improved	0	1[a]	32	33
	Total	0	1	37	38

Data represented as n.
Proportion of positive agreement, 84.2%; proportion of expected agreement, 84.8%; κ, −0.036 (95% confidence interval, −0.098 to 0.025).
Abbreviation: C&L, Cormack & Lehane.
[a]Disagreement between reviewers.

Table 4. Time to Successful Intubation in Seconds Taking Into Account the Different Factors Associated With Difficult Intubation

	Time (s), Median (Range)	*P* Value
Mallampati		.844
I–II	25 (19–58)	
III–IV	25 (14–58)	
Interincisor distance (mm)		.851
<30	24 (21–58)	
≥30	25 (14–58)	
Adequate neck movement		.002[a]
No	44 (32–58)	
Yes	24 (14–58)	
Thyromental distance (mm)		.031
<60	32 (20–58)	
≥60	23 (14–58)	
BMI ($kg \cdot m^{-2}$)		.851
≤35	24 (14–58)	
>35	26 (21–49)	
History of difficult intubation		.029
No	24 (14–58)	
Yes	40 (32–58)	

Total number of patients: 38. Data represented as median (range).
Abbreviation: BMI, body mass index.
[a]Significant result after Bonferroni correction (0.05/6) for multiple testing ($P < .008$).

Mean (range) time to successful intubation was 30 seconds (14–58). Time to successful intubation was analyzed in 37 instead of 38 patients. For 1 patient, instead of time to successful intubation, time of the complete surgical procedure was recorded. Time to successful intubation was evaluated taking into account the different factors associated with difficult intubation: Mallampati grade I and II versus III and IV, interincisor distance <30 vs ≥30 mm, restricted neck movement (<90°) (no versus yes), thyromental distance <60 vs ≥60 mm, BMI >35 vs ≤35 $kg \cdot m^{-2}$, and a history of difficult intubation (no versus yes). Median (range) insertion time for patients without adequate neck movement was 44 seconds (32–58), compared with 24 seconds (14–58) for patients with adequate neck movement ($P = .002$). Insertion time for patients with a history of difficult intubation was 40 seconds (32–58), for patients without a history of difficult intubation was 24 seconds (14–58), and for patients with a thyromental distance <60 mm was 32 seconds (20–58) compared with 23 seconds (14–58) for patients with a thyromental distance ≥60 mm (Table 4). The rates for number of attempts until successful intubation were as follows: 1 attempt 30 (78.9%), 2 attempts 5 (13.2%), and 3 attempts 3 (7.9%).

No soft tissue trauma to the oral cavity, dental or lip trauma, and regurgitation occurred during the study period. Also, no adjuncts (eg, gum elastic bougie, stylet, and BURP maneuver) were used. All surgical interventions were uneventful.

DISCUSSION

This is the first trial to investigate a tracheal intubation technique aimed at a group of patients presenting with a C&L grade III or IV while using indirect videolaryngoscopy. The combined technique presented reduced the intubation difficulty and resulted in improved laryngoscopy with a high first-attempt and overall intubation success rate in the vast majority of cases, the mean time to successful intubation being no >30 seconds. The obtained improvement in the glottis view, as scored by the intubating anesthesiologist, was corroborated by 2 independent, blinded reviewers in nearly all cases.

Since its introduction, videolaryngoscopy has proven to be advantageous in a broad range of clinical situations and patients.[5–12] However, occasionally, intubation will fail with a VLS.[12] In this case, the suggested combined intubation technique provides the anesthesiologist with an alternative option.

The combined technique provides the anesthesiologist with an alternative technique to awake fiberoptic intubation to intubate the patient with an (expected) difficult airway. Similar to both videolaryngoscopy and awake fiberoptic intubation, the combined technique and awake fiberoptic intubation should exist alongside and supplement each other.[13] Furthermore, although this method was not specifically tested in emergency situations, it may also be considered a rescue approach. Finally, the avoidance of the use of different adjuncts for multiple attempts lowers the risk of complications.

Other research supports techniques combining 2 devices. Lenhardt et al[14] intubated 4 patients with cervical spine pathology who could not be intubated with VLS and rigid stylet using an alternative method including a flexible fiberscope. There is an important difference between our technique and the technique described by Lenhardt et al.[14] According to the technique by Lenhardt et al,[14] 2 people are necessary to keep a good glottis view: 1 to hold the VLS in place and the second person to proceed with the actual intubation with the flexible fiberscope, since it is extremely difficult to manage a flexible fiberscope using only 1 hand. This means that even a third person is needed to pass the tube loaded on the flexible fiberscope, while the other 2 providers

have to work together to keep a good view of the glottis. In the technique we describe, 2 people have to be involved, similar to the ideal situation for direct laryngoscopy. One anesthesia provider, however, is able, without aid, to keep a good view of the glottis. Therefore, the combined technique makes keeping a good view of the glottis far easier.

Boker[15] recently published a case series of 4 patients using the technique of combining a Macintosh VLS with the BIE. None of these patients, however, are scored a C&L grade III or IV using indirect videolaryngoscopy, and it is possible that they would have been successfully intubated when an indirect Macintosh VLS was used alone.

The major strength of the present study is that we address a category of patients with a suspected difficult airway in which the Macintosh VLS does not offer the solution. The anesthesiologist can decide to use this technique at any time during the intubation when confronted with an unexpectedly difficult intubation. No special measures have to be taken, except that the BIE needs to be connected to a separate video screen (eg, a monitor normally used for minimally invasive surgery), although the image can also be viewed directly through the BIE, and no extra anesthesia provider is needed.

Our study also has limitations. First, the BIE is not readily available in every center. Second, because we only evaluated 1 type of VLS, we cannot draw any conclusion for other VLSs. The use of, for example, an acutely angled VLS (eg, C-MAC D-Blade) could have resulted in a better C&L grade in some patients. Third, we used the Mallampati score as one of the several predictors for difficult intubation although we were aware of the fact that this score has limited predictive value. Nonetheless, our recruitment methods resulted in a high proportion of patients with the desired C&L grade of III or IV at baseline. Also, it is arguable if the C&L grading system is suitable for videolaryngoscopy. The C&L grading system was originally developed to support decision making during direct laryngoscopy.[4] It was not developed for videolaryngoscopy. There are, however, no other good options. Alternatives would have been the intubation difficulty scale proposed by Adnet et al[16] or the percentage of glottic opening (POGO) score. However, for this study, use of the POGO score would imply a serious limitation, since all POGO scores with the VLS would have been 0%. A solution is to refer to the quality of the view of laryngoscopy in terms of improvement or not. The cases in which there is no improvement of view with indirect videolaryngoscopy are the cases addressed in this study. Fourth, blinding of the intubating anesthesiologist was impossible. Bias of the intubating anesthesiologist was a possibility, since worsening of the laryngeal view was scored twice by one of the 2 reviewing anesthesiologists. However, given the fact that it only occurred in 2 of 38 evaluations, while at the same time the other reviewer and the intubating anesthesiologist judged these 2 cases as improved, we consider this a small influence. Finally, it is hard to deduct anything regarding the learning curve for the technique presented. The use of the BIE is not readily intuitive, so we advocate gaining experience using the combined intubation technique. Simulation on manikins is warranted and since the extra impact of the combination technique on the patient and the risk for complications are low, it is a technique that can be used even when the intubation is unexpectedly difficult, offering a steep learning curve. Although no complications occurred during the present study, mechanical (equipment) failure, psychological factors (eg, blood, fogging, or secretions blurring the view), and trauma (eg, sore throat, laceration of oral mucosa) could result in failure of the combination technique.

In conclusion, our results provide evidence that the combined use of indirect videolaryngoscopy with Macintosh blade and BIE can be a promising alternative technique for successful intubation of anesthetized patients with a difficult airway.

DISCLOSURES

Name: Barbe M. Pieters, MD, PhD.
Contribution: This author helped design the study, write the study protocol, conduct the study, analyze the data, write the manuscript, critically revise the manuscript, and read and approve the final version.
Name: Maurice Theunissen, MSc, PhD.
Contribution: This author helped design the study, write the study protocol, analyze the data, write the manuscript, critically revise the manuscript, and read and approve the final version.
Name: Andre A. van Zundert, MD, PhD, FRCA, EDRA, FANZA.
Contribution: This author helped design the study, write the study protocol, conduct the study, write the manuscript, critically revise the manuscript, and read and approve the final version.
This manuscript was handled by: David Hillman, MD.

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