

RESPIRATION AND THE AIRWAY

Airway Scope and gum elastic bougie with Macintosh laryngoscope for tracheal intubation in patients with simulated restricted neck mobility

R. Komatsu¹, K. Kamata¹, I. Hoshi², D. I. Sessler^{3*} and M. Ozaki²

¹Department of Anaesthesia, Kosei Hospital, Tokyo, Japan. ²Department of Anaesthesiology, Tokyo Women's Medical University, Tokyo, Japan. ³Department of Outcomes Research, The Cleveland Clinic, 9500 Euclid Avenue, P-77, Cleveland, OH 44195, USA

*Corresponding author. E-mail: ds@or.org

Background. Airway Scope is a new videolaryngoscope which requires less cervical movement during intubation than direct laryngoscopy. Thus, in patients wearing a rigid cervical collar, we compared the efficacy of the Airway Scope and the gum elastic bougie with Macintosh laryngoscope during tracheal intubation.

Methods. Anaesthesia was induced with propofol, fentanyl, and rocuronium. A rigid cervical collar was applied, and patients were randomly assigned to tracheal intubation with an Airway Scope ($n=48$) or multiple-use gum elastic bougie with Macintosh laryngoscope ($n=48$). Measurements included intubation time, gum elastic bougie insertion time, intubation success rate, and insertion and intubation attempts. Airway complications were also recorded.

Results. The time required for successful intubation was significantly shorter with the Airway Scope compared with the gum elastic bougie with Macintosh laryngoscope [mean (SD) 34 (13) vs 49 (27) s, $P=0.001$], although the overall success rate of the Airway Scope (100%) compared with the gum elastic bougie with Macintosh laryngoscope (90%) did not reach the statistical significance ($P=0.056$). Oesophageal intubation ($n=8$) occurred only with the gum elastic bougie with Macintosh laryngoscope. Incidence of mucosal trauma and lip injury was similar with each device. No dental injury or hypoxia occurred with either device.

Conclusions. The Airway Scope shortens intubation time, is less likely to result in oesophageal intubation, and may offer a marginally higher intubation success rate in patients with simulated restricted neck mobility.

Br J Anaesth 2008; **101**: 863–9

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

Accepted for publication: August 21, 2008

A number of devices have been developed to facilitate tracheal intubation of difficult airways, including Airway Scope[®] (Pentax, Tokyo, Japan) a new rigid video laryngoscope (Fig. 1). Airway Scope consists of three components: monitor, camera, and introducer blade or Intlock (Fig. 2). The camera is inserted into the introducer blade so that the camera eye is located 3 cm proximal from the tip of the blade. The tracheal tube can be attached to the right side of the introducer blade. The introducer blade is designed to be positioned posterior to the epiglottis and to slightly elevate it. This allows visualization of the glottic opening and insertion of the tracheal tube through the

vocal cords without alignment of the oral, pharyngeal, and tracheal axis. Studies show that the Airway Scope requires less cervical spine movement than conventional laryngoscopy with a Macintosh laryngoscope¹ and is effective when the neck is stabilized in the neutral position in manikins.^{2–4}

The gum elastic bougie is frequently used to facilitate tracheal intubation when the view of the glottic opening is restricted. Studies show that intubation with a gum elastic bougie and direct laryngoscopy in patients with a simulated Cormack–Lehane 3 laryngeal view is 94–100% successful.^{5–9}

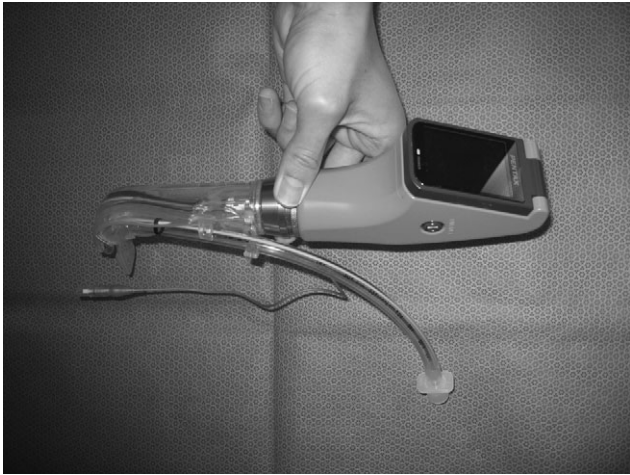


Fig 1 Airway Scope with attached Intlock blade and tracheal tube.



Fig 2 Disposable Intlock blade.

We compared the Airway Scope and the gum elastic bougie with Macintosh laryngoscope in patients with simulated restricted neck mobility.

Methods

With the approval from the Human Research Committee at Kosei Hospital (Tokyo, Japan) and written informed consent, 96 patients undergoing various surgical procedures and requiring tracheal intubation as part of their anaesthesia were enrolled. Exclusion criteria included increased risk of pulmonary aspiration, cervical spine pathology, anticipated airway difficulties (i.e. Mallampati grade IV or thyromental distance of <6 cm), and ASA $>III$.

Before induction of anaesthesia, the patients' heads were elevated (7 cm) with a pillow. Anaesthesia was induced with fentanyl $2 \mu\text{g kg}^{-1}$, propofol 2 mg kg^{-1} , and after confirmation of facemask ventilation, rocuronium

0.6 mg kg^{-1} was given for muscle relaxation. Anaesthesia was maintained with 2% sevoflurane in oxygen during the study period.

After full muscle relaxation was confirmed with a nerve stimulator, the pillow was removed and an appropriately sized rigid Philadelphia collar (Tracheostomy Philadelphia Collar, Philadelphia Cervical Collar Co., Thorofare, NJ, USA) was positioned around the neck. Patients were then randomly allocated to tracheal intubation with an Airway Scope loaded with a tracheal tube or gum elastic bougie with Macintosh laryngoscope. Randomization was based on the computer-generated codes that were maintained in sequentially numbered opaque envelopes.

For patients allocated to the Airway Scope group, an Airway Scope with a preloaded curved tracheal tube (7 mm internal diameter for women and 8 mm for men) was inserted in the mouth and the Airway Scope was positioned at the glottis where this could be seen at the centre of the cross-mark on the scope's monitor. The tracheal tube was then advanced into the trachea, and the scope was detached and removed from the mouth. Finally, the respiratory circuit was connected and ventilation confirmed with capnography.

For patients assigned to the gum elastic bougie with Macintosh laryngoscope group, the best possible view of the glottis using a #3 Macintosh laryngoscope was obtained. If the glottic view was a modified Cormack–Lehane grade 1, 2a, or 2b,¹⁰ the gum elastic bougie (Eschmann Tracheal Tube Introducer, SIMS Portex, Hythe, UK) with preshaped curve was inserted into the glottis under direct laryngoscopic vision. If the glottic view was a modified Cormack–Lehane grade 3a, the gum elastic bougie was inserted beneath the epiglottis and advanced to the presumed location of the glottis. If the glottic view was a grade 3b, the intubating investigator tried to create a space between the epiglottis and the posterior pharyngeal wall with the tip of the gum elastic bougie or he tried to slip the tip from the side and under the epiglottis. And, if the glottic view was a grade 4, the gum elastic bougie was inserted blindly. Proper placement was indicated by clicks or vibrations as the bougie passed along the tracheal rings or by distal hold-up as it entered a small bronchus.^{11 12} If clicks were felt, the investigator proceeded with the intubation. In the absence of clicks, the bougie was advanced to the maximum distance (45 cm) to seek hold-up. If hold-up was perceived, the patient was intubated. In the absence of clicks and hold-up, the gum elastic bougie was removed and another insertion was attempted. A maximum of three attempts were permitted. With the gum elastic bougie properly positioned, a tracheal tube (7 mm internal diameter for women and 8 mm for men) was advanced over the bougie into the trachea with the intubating investigator maintaining laryngoscopy and an assistant steadying the gum elastic bougie. Before passing the vocal cords, the tracheal tube was rotated in a counterclockwise direction by 90° , so

that the bevel was oriented posteriorly¹³ and then the tube was advanced into the trachea. Finally, the gum elastic bougie was removed, the respiratory circuit was connected, and correct ventilation was confirmed.

In each group, tracheal intubation was considered a failure if it could not be accomplished within three attempts or 3 min. Any forward movement of the Airway Scope and any forward advancement of the gum elastic bougie itself or the tracheal tube over the gum elastic bougie were considered intubation attempts. In the event of an intubation failure, the Philadelphia collar was removed, and patients were intubated under direct vision using a #3 Macintosh blade. All intubations were performed by a single anaesthesiologist (R.K.) whose previous experience included >50 intubations with the Airway Scope, and more than 3 yr of frequent use with the gum elastic bougie.

Morphometric data, Mallampati score, mouth opening (inter-incisor distance), thyromental distance, and sternomental distance (with head extended in upright position) were measured by an observer blinded to group assignment. With the patient in the supine position and cervical collar in place, the mouth opening was measured before intubation by an observer blinded to group assignment.

The following outcomes were recorded by an unblinded observer: (i) overall intubation success rate; (ii) number of gum elastic bougie insertion attempts; (iii) number of intubation attempts; (iv) gum elastic bougie insertion time (defined as the time from picking up the laryngoscope to the gum elastic bougie insertion in the trachea); (v) gum elastic bougie intubation time (defined as the time from the gum elastic bougie insertion until first appearance of the capnograph wave form); (vi) total intubation time (defined, in the Airway Scope group, as the time from picking up the Airway Scope until first appearance of the capnograph wave form, and in the gum elastic bougie with Macintosh laryngoscope group as insertion time plus intubation time); (vii) frequency of oesophageal intubation; (viii) mucosal trauma (e.g. blood detected on the Airway Scope, gum elastic bougie, or Macintosh laryngoscope); (ix) lip or dental injury; and (x) hypoxia ($Sp_{O_2} < 95\%$). Further modified Cormack–Lehane laryngoscopy grade with the #3 Macintosh blade was reported in the gum elastic bougie with Macintosh laryngoscope group. Finally, reasons were recorded for any failed intubation attempt or overall unsuccessful intubation.

In a preliminary experiment by the authors, intubation with the Airway Scope did not result in oesophageal intubation in patients with a rigid cervical collar. Assuming that no oesophageal intubation occurs in the Airway Scope group, 48 patients per group would detect a 14% difference in the occurrence of oesophageal intubation between the groups ($\alpha=0.05$, one-tailed) with a power of 82%.

Non-parametric data were compared with the Mann–Whitney *U*-test. The incidence of intubation complications and overall intubation success rate between the groups

were tested by Fisher's exact or χ^2 tests as appropriate. Parametric data were compared using unpaired Student's *t*-test. To evaluate learning during the study period, we compared the time required for the first and the last 10 intubations for each device.

Statistical analysis was performed using StatView version 5.0 (SAS Institute Inc., Cary, NC, USA) and Sample Power 2.0 (SPSS, Chicago, IL, USA). Values are expressed as mean (SD) unless otherwise specified; $P < 0.05$ was considered statistically significant.

Results

Morphometric and patient characteristics and airway assessments are described in Table 1. Patients were aged 21–86 yr and were ASA I, II, or III.

Table 2 shows the comparison between the two intubation techniques. For the Airway Scope group, 22 patients required one attempt, 19 required two attempts, and seven required three attempts of intubation before the intubation

Table 1 Morphometric characteristics and airway assessments. Data are mean (range), mean (SD) or number of patients

	Airway Scope (<i>n</i> =48)	Gum elastic bougie with Macintosh laryngoscope (<i>n</i> =48)
Age (yr)	60 (22–86)	55 (21–79)
Sex (M/F)	26/22	27/21
Height (cm)	160 (9)	163 (11)
Weight (kg)	60 (10)	58 (12)
Body mass index (kg m ⁻²)	23.1 (2.8)	21.8 (3.3)
Mallampati score (I/II/III/IV)	21/18/9/0	20/18/10/0
Mouth opening (cm)	4.9 (0.7)	4.7 (0.7)
Mouth opening with collar (cm)	2.0 (0.3)	2.0 (0.3)
Thyromental distance (cm)	8.7 (1.3)	8.3 (1.3)
Sternomental distance (cm)	17.4 (1.7)	17.0 (2.2)

Table 2 Intubation results. Data are presented as mean (SD) (range), number of patients, or (per cent). NA, not applicable

	Airway Scope (<i>n</i> =48)	Gum elastic bougie with Macintosh laryngoscope (<i>n</i> =48)	<i>P</i> -value
Insertion time (s)	NA	21 (11) (9–66)	
Intubation time (s)	NA	27 (20) (15–122)	
Total intubation time (s)	34 (13) (18–105)	49 (27) (29–177)	0.001
Modified Cormack– Lehane score (1/2a/2b/3a/ 3b/4)	—	0/2/10/36/0/0	
Insertion attempts (1/2/3)	NA	35/8/5	
Intubation attempts (1/2/3)	22/19/7	40/6/2	
Overall intubation success	48 (100%)	43 (89.6%)	0.056

was eventually successful. In contrast, for the gum elastic bougie with Macintosh laryngoscope group, 35 patients required one attempt, eight required two attempts, and five required three attempts of insertion before the gum elastic bougie was deemed to be inserted in the trachea. Subsequently, 40 patients required one attempt, six required two attempts, and two required three attempts of intubation before the intubation was eventually successful or failed in the gum elastic bougie with Macintosh laryngoscope group. 'Clicks' and 'distal hold-up' were detected in 36 and nine patients, respectively, but neither indication was perceived in three patients. Times for gum elastic bougie insertion and intubation were 21 (11) and 27 (20) s, respectively; total intubation time was 49 (27) s. Intubation required less time in patients assigned to the Airway Scope [34 (13) s] than those assigned to the gum elastic bougie with Macintosh laryngoscope ($P=0.001$). Further, the range of total time taken for intubation was narrower with the Airway Scope (18–105 s) compared with the gum elastic bougie with Macintosh laryngoscope (29–177 s). The overall intubation success rate was 100% in the Airway Scope group compared with 90% in the gum elastic bougie with Macintosh laryngoscope group ($P=0.056$).

Total time taken for the first and the last 10 intubations with the Airway Scope was 39 (10) and 39 (25) s ($P=0.99$), respectively, and that with the gum elastic bougie with Macintosh laryngoscope was 59 (26) and 45 (20) s ($P=0.21$), respectively. Intubation time between the first and the last intubations did not differ significantly, and thus learning did not influence the outcomes. In the gum elastic bougie with Macintosh laryngoscope group, no intubations failed during the first 10 intubations, but two failures occurred among the last 10 intubations.

In the gum elastic bougie with Macintosh laryngoscope group, the laryngoscopic view was graded according to the modified Cormack–Lehane classification (Table 2). Under direct laryngoscopy with a rigid collar in place, two patients with a modified Cormack–Lehane grade 2a view, 10 patients with a grade 2b view, and 36 patients with a grade 3a view had total intubation times of 34 (3), 49 (17), and 49 (29) s, respectively. None of the patients had modified Cormack–Lehane 1, 3b, or 4 views.

Intubation or gum elastic bougie insertion failed at the first, second, or third attempt for various reasons. In the Airway Scope group, intubation failed due to advancement of the Intlock tip into the vallecula rather than the glottis ($n=32$) or tactile resistance to the tracheal tube as it progressed towards the trachea ($n=1$). In the gum elastic bougie with Macintosh laryngoscope group, insertion of the bougie failed as a result of oesophageal insertion, which was subsequently recognized upon oesophageal intubation ($n=9$), absence of 'clicks' or 'distal hold-up' ($n=7$), or tactile resistance to the bougie ($n=2$); and the intubation failed due to oesophageal intubation ($n=9$) or tactile resistance to the tracheal tube ($n=1$).

Table 3 Explanation of intubation failures with the gum elastic bougie with Macintosh laryngoscope. Data are presented as number of occurrences. *Patient intubated successfully at 196 s

Patient no.	Absence of 'clicks' or 'hold-up'	Tactile resistance to GEB	Tactile resistance to tracheal tube	Oesophageal intubation	Time >3 min
1	0	1	1	1	0
2	2	0	0	1	0
3	2	0	0	0	1*
4	0	0	0	2	1
5	2	0	0	1	0

Overall, intubation failed within three attempts or 3 min in five patients assigned to the gum elastic bougie with Macintosh laryngoscope. All patients had a modified Cormack–Lehane 3a view with the cervical collar in place. Explanations of these failures are summarized in Table 3. After removal of the collar from Patients 1, 2, 4, and 5, all, except Patient 5, were easily intubated with a #3 Macintosh laryngoscope. The laryngeal views of Patients 1, 2, and 4 were modified Cormack–Lehane grade 1; no unusual upper airway anatomical characteristics were observed. In Patient 5, the laryngeal view was modified Cormack–Lehane 3a even after removal of the collar. Attempted intubation with a #3 Macintosh laryngoscope failed; however, the trachea was eventually intubated with the Airway Scope without difficulty. No unusual anatomical characteristics were observed on the Airway Scope monitor. The collar was not removed from Patient 3, because intubation with the collar in place was ultimately successful, although it required slightly more than 3 min.

Intubation complications are listed in Table 4. Oesophageal intubation occurred only with the gum elastic bougie with Macintosh laryngoscope ($n=8$) and not with the Airway Scope ($P=0.0057$). The incidence of mucosal trauma and lip injury was not statistically different between the two groups. Neither dental injury nor hypoxia ($Sp_{O_2}<95\%$) was experienced by any patient in either group.

Discussion

Although the Airway Scope is reportedly effective when the neck is stabilized in the neutral position in

Table 4 Incidence of complications. Data are presented as number of patients

	Airway Scope ($n=48$)	Gum elastic bougie with Macintosh laryngoscope ($n=48$)	<i>P</i> -value
Mucosal trauma	5	6	>0.99
Dental injury	0	0	
Lip injury	4	5	>0.99
Hypoxia ($Sp_{O_2}<95\%$)	0	0	
Oesophageal intubation	0	8	0.0057

manikins,^{3 4 14} studies assessing its usefulness in difficult airways have been limited to case reports and case series involving small numbers of patients.^{15–18} Thus, we compared the Airway Scope and the gum elastic bougie with Macintosh laryngoscope in patients with simulated restricted neck mobility that was generated by a rigid cervical collar. Our results show that the overall intubation success rate was 100% in the Airway Scope group and 90% in the gum elastic bougie with Macintosh laryngoscope group, a difference that failed to reach statistical significance ($P=0.056$). Additionally, total time to intubation was ~ 15 s less with the Airway Scope than the gum elastic bougie with Macintosh laryngoscope, a statistically significant difference ($P=0.001$). And finally, the incidence of intubation complications was comparable in the two groups, except for oesophageal intubation which occurred only with the gum elastic bougie with Macintosh laryngoscope. The Airway Scope therefore provided shorter intubation times than the gum elastic bougie with Macintosh laryngoscope in patients with restricted neck mobility. Currently, retail prices for the Airway Scope and the gum elastic bougie are \$6000 and \$80, respectively.

By applying a rigid cervical collar, both mouth opening and neck mobility were decreased, effectively simulating the anatomy of difficult laryngoscopy. The average 20 mm mouth opening in the current study was 9 mm smaller than that reported by Goutcher and Lochhead,¹⁹ even though each study used the same rigid cervical collar. In other studies, a cervical collar generated Cormack–Lehane grade 3/4 laryngeal views with a reported frequency of 64–65%.^{20 21} In the current study, however, the frequency of a modified Cormack–Lehane 3a view was 75%, and no modified Cormack–Lehane 3b or 4 views were observed. Small differences in these frequencies may be related to minor differences in the collars that were used in each of these studies, or how they were positioned.

Gum elastic bougie has been tested in a number of difficult airway scenarios with excellent rates of intubation, including manual in-line stabilization and cricoid pressure (100% intubation rate),⁵ intentional suboptimal laryngoscopy generating a Cormack–Lehane grade 3 view (94–100% intubation rate),^{6–9} and in 75 patients presenting with modified Cormack–Lehane 2b and 3a views (100% intubation rate).¹⁰ In our patients, the overall intubation success rate was only 90%, which included patients with modified Cormack–Lehane grade 2a and 2b views. This lower success rate is likely to be due to the restricted mouth opening (≈ 20 mm) and the consequent difficult manipulation of the gum elastic bougie in patients wearing a cervical collar. In contrast, manual in-line stabilization or intentional suboptimal laryngoscopy presumably resulted in little, if any, restriction in mouth opening. Intubation with the Airway Scope was successful in all our patients, although multiple attempts were required in half. All failed attempts with the Airway Scope (except one which failed due to tactile resistance of the tracheal tube

against the arytenoid cartilage) resulted from the Intlock tip advancing into the vallecula rather than underneath the epiglottis. However, this was easily corrected by partially withdrawing the device, and with a subsequent scooping movement of the Intlock, lifting the epiglottis, and advancing the tracheal tube into the trachea. Only a few seconds were required for this manoeuvre, which helps to explain the faster intubation time with the Airway Scope compared with the gum elastic bougie with Macintosh laryngoscope. The gum elastic bougie insertion times for modified Cormack–Lehane grade 2a and grade 2b–3 were 13 (1) and 22 (11) s, respectively. These were shorter than the total intubation time in the Airway Scope group. This implies that even in grade 2b–3a patients, an object could be inserted into the trachea quicker with the gum elastic bougie with Macintosh laryngoscope than with the Airway Scope, although intubation itself was quicker with the Airway Scope.

Patients in the Airway Scope group did not experience oesophageal intubation. The Airway Scope provided a nearly complete view of the larynx and allowed the clinician to observe advancement of the tube into the trachea from outside of the larynx. This continuous view allowed detection of inaccurate tube advancement which can then be corrected before oesophageal intubation. Although we were concerned that the camera and thus the view might become obstructed by mucosal secretion or fogging, neither problem was observed. In fact, the camera is protected by the Intlock and does not directly contact mucosal tissue. In spite of the relative bulky Intlock, the Airway Scope could be used in patients with a mouth opening as small as 20 mm.

Two videolaryngoscopes with the operating principle similar to the Airway Scope are the GlideScope and the McGrath videolaryngoscope. The GlideScope was reported to reduce Cormack–Lehane grading by 1 when compared with direct laryngoscopy with the Macintosh laryngoscope in 93% of patients wearing a rigid cervical collar.²² In an article by Shippey and colleagues,²³ it was reported that patients who had Cormack–Lehane grade 3 and 4 views were easily intubated using the McGrath laryngoscope. Difference between these two devices and the Airway Scope is that the former do not accommodate a tracheal tube, thus a tracheal tube needs to be advanced into the glottis with the other hand of the intubator, which might require some hand–eye co-ordination. Hence, intubation with these devices might be more difficult than with the Airway Scope which requires only pushing a tracheal tube forward once the cross-mark on the monitor captures the glottis.

Our study design did not permit correlation between Airway Scope efficacy and the modified Cormack–Lehane laryngeal view because direct laryngoscopy was not required with the Airway Scope. However, assuming that laryngeal view grades were similar between the randomized groups, it is reasonable to speculate that the Airway

Scope is effective for a grade 3a laryngeal view. A second limitation is that grade 3b and 4 views were not observed, thus prohibiting evaluation of these devices under those conditions. A third limitation is that the intubating investigator had more experience with the gum elastic bougie with Macintosh laryngoscope than with the Airway Scope. However, there was no evidence of learning with the Airway Scope as the first and last 10 intubations required similar amounts of time. For the gum elastic bougie with Macintosh laryngoscope, the last 10 intubations took 14 s less than the first 10 intubations, but two failed intubations, which were not included in the calculation of mean intubation time, occurred among the last 10. Thus, it is also unlikely that learning occurred during the use of the gum elastic bougie with Macintosh laryngoscope. Another limitation is that the use of the gum elastic bougie in modified Cormack–Lehane grade 1 and 2a views was clinically unnecessary and might have slowed intubation time of the gum elastic bougie with Macintosh laryngoscope group. However, in the current study, only two patients in the gum elastic bougie with Macintosh laryngoscope group had a grade 2a view and no patients had a grade 1 view. Therefore, the use of the gum elastic bougie in these two grade 2a patients would have little impact on the mean intubation time of the group.

The current study did not include a comparison of other intubation modalities which are recommended in difficult airway scenarios, such as the intubating laryngeal mask airway (ILMA) or the Bullard laryngoscope. Yet, other studies have demonstrated that neither device is particularly effective in patients wearing a cervical collar. For example, we showed that ILMA required an average intubation time of 60 s and resulted in a 96% success rate in patients wearing a cervical collar,²⁴ and due to this relatively slow intubation time, ILMA was not included in the current study. Furthermore, the Bullard laryngoscope offered a <90% intubation success rate in patients with a cervical collar,²¹ and for this reason was not included in the current study. The McCoy laryngoscope has been reported as improving the Cormack–Lehane laryngoscopic view by at least one grade in 45.1% of patients wearing a rigid cervical collar,²⁵ and in 49% of patients whose neck was stabilized with manual in-line stabilization.²⁶ Considering intubation with the McCoy laryngoscope does not require a time-consuming process aside from direct laryngoscopy; this device might offer a high success rate and a short intubation time in patients wearing a rigid cervical collar.

In conclusion, the use of the Airway Scope for tracheal intubation in patients wearing a rigid cervical collar resulted in a 100% success rate and was faster than the gum elastic bougie with Macintosh laryngoscope in establishing the airway. Therefore, it is likely to be preferred in emergency settings where accidental oesophageal intubation is best avoided.

Funding

No corporate funds supported this project; the Airway Scope was loaned to the investigators by the manufacturer. The multiple-use gum bougies used for the study were the department's property. None of the authors has a personal financial interest related to this research. Dr D.I.S.'s time is supported by the Joseph Drown Foundation (Los Angeles, CA, USA).

Acknowledgement

Philip G. Woost, PhD, Department of Outcomes Research, Cleveland Clinic, Cleveland, OH, edited the manuscript.

References

- Hirabayashi Y, Fujita A, Seo N, Sugimoto H. Cervical spine movement during laryngoscopy using the Airway Scope compared with the Macintosh laryngoscope. *Anaesthesia* 2007; **62**: 1050–5
- Hirabayashi Y. Airway Scope versus Macintosh laryngoscope: a manikin study. *Emerg Med J* 2007; **24**: 357–8
- Hirabayashi Y. In-line head and neck positioning facilitates tracheal intubation with the Airway Scope. *Can J Anaesth* 2007; **54**: 774
- Koyama Y, Inagawa G, Miyashita T, *et al.* Comparison of the Airway Scope, gum elastic bougie and fiberoptic bronchoscope in simulated difficult tracheal intubation: a manikin study. *Anaesthesia* 2007; **62**: 936–9
- Nolan JP, Wilson ME. Orotracheal intubation in patients with potential cervical spine injuries. An indication for the gum elastic bougie. *Anaesthesia* 1993; **48**: 630–3
- Gataure PS, Vaughan RS, Latto IP. Simulated difficult intubation. Comparison of the gum elastic bougie and the stylet. *Anaesthesia* 1996; **51**: 935–8
- Marfin AG, Pandit JJ, Hames KC, Popat MT, Yentis SM. Use of the bougie in simulated difficult intubation. 2. Comparison of single-use bougie with multiple-use bougie. *Anaesthesia* 2003; **58**: 852–5
- Nolan JP, Wilson ME. An evaluation of the gum elastic bougie. Intubation times and incidence of sore throat. *Anaesthesia* 1992; **47**: 878–81
- Harvey K, Davies R, Evans A, Latto IP, Hall JE. A comparison of the use of Trachlight and Eschmann multiple-use introducer in simulated difficult intubation. *Eur J Anaesthesiol* 2007; **24**: 76–81
- Cook TM. A new practical classification of laryngeal view. *Anaesthesia* 2000; **55**: 274–9
- Kidd JF, Dyson A, Latto IP. Successful difficult intubation. Use of the gum elastic bougie. *Anaesthesia* 1988; **43**: 437–8
- Cossham PS. Difficult intubation. *Br J Anaesth* 1985; **57**: 239
- Dogra S, Falconer R, Latto IP. Successful difficult intubation. Tracheal tube placement over a gum-elastic bougie. *Anaesthesia* 1990; **45**: 774–6
- Hirabayashi Y. Ease of use of the Airway Scope vs the Bullard laryngoscope: a manikin study. *Can J Anaesth* 2007; **54**: 397–8
- Asai T, Enomoto Y, Okuda Y. Airway Scope for difficult intubation. *Anaesthesia* 2007; **62**: 199
- Kurihara R, Inagawa G, Kikuchi T, Koyama Y, Goto T. The Airway Scope for difficult intubation. *J Clin Anesth* 2007; **19**: 240–1
- Suzuki A, Hayashi D, Toyama H, Minami S, Iwasaki H. Use of the pentax-AWS in a patient with Cormack 3a difficult airway. *Masui* 2007; **56**: 341–4

- 18 Suzuki A, Toyama Y, Katsumi N, et al. Pentax-AWS improves laryngeal view compared with Macintosh blade during laryngoscopy and facilitates easier intubation. *Masui* 2007; **56**: 464–8
- 19 Goutcher CM, Lochhead V. Reduction in mouth opening with semi-rigid cervical collars. *Br J Anaesth* 2005; **95**: 344–8
- 20 Heath KJ. The effect of laryngoscopy of different cervical spine immobilisation techniques. *Anaesthesia* 1994; **49**: 843–5
- 21 MacQuarrie K, Hung OR, Law JA. Tracheal intubation using Bullard laryngoscope for patients with a simulated difficult airway. *Can J Anaesth* 1999; **46**: 760–5
- 22 Agro F, Barzoi G, Montecchia F. Tracheal intubation using a Macintosh laryngoscope or a GlideScope in 15 patients with cervical spine immobilization. *Br J Anaesth* 2003; **90**: 705–6
- 23 Shippey B, Ray D, McKeown D. Use of the McGrath videolaryngoscope in the management of difficult and failed tracheal intubation. *Br J Anaesth* 2008; **100**: 116–9
- 24 Komatsu R, Nagata O, Kamata K, Yamagata K, Sessler DI, Ozaki M. Intubating laryngeal mask airway allows tracheal intubation when the cervical spine is immobilized by a rigid collar. *Br J Anaesth* 2004; **93**: 655–9
- 25 Gabbott DA. Laryngoscopy using the McCoy laryngoscope after application of a cervical collar. *Anaesthesia* 1996; **51**: 812–4
- 26 Laurent SC, de Melo AE, Alexander-Williams JM. The use of the McCoy laryngoscope in patients with simulated cervical spine injuries. *Anaesthesia* 1996; **51**: 74–5