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Cervical spine motion during flexible bronchoscopy compared with the Lo-Pro GlideScope®

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Background. The most appropriate device for tracheal intubation in patients with potential cervical spine injury remains controversial. We hypothesized that the Lo-Pro GlideScope® (LP-G) videolaryngoscope would not cause significantly greater cervical spine movement than fibreoptic bronchoscopy even in the non-immobilized spine.

Methods. Twenty-eight healthy adults requiring intubation for radiographic procedures were randomized to either the LP-G or the flexible bronchoscope (FB) devices. Continuous fluoroscopy was used to assess cervical spine movement during tracheal intubation. The point of maximum movement was compared with baseline for change in angulation between Occiput (Occ)-C1, Occ-C2, Occ-C4, Occ-C5, C1–2, C2–4, and C4–5. Measurements were made by two independent observers. The change in angulation was also measured for tongue pull and jaw thrust, manoeuvres for enlarging the pharyngeal space, before FB intubation.

Results. LP-G resulted in greater cervical extension compared with FB for every angle calculated, statistically significant between Occ-C1 ($P<0.05$), Occ-C2 ($P<0.05$), and Occ-C4 ($P<0.01$). Tongue pull resulted in significantly less cervical spine motion than FB intubation at Occ-C1, Occ-C2, Occ-C4, and Occ-C5 ($P<0.05$). When jaw thrust was added to tongue pull, there was a tendency for greater movement than FB intubation at Occ-C1, Occ-C2, and Occ-C3. This was statistically significant at Occ-C1 and Occ-C3 ($P<0.05$) for one of the two observers.

Conclusions. During intubation under general anaesthesia, LP-G resulted in greater cervical movement than FB when no cervical immobilization was used in adults without cervical disease. Airway manoeuvres performed before FB, especially jaw thrust, also resulted in cervical spine movement.

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Cervical spine motion during intubation deserves particular attention in cases with cervical pathology. All types of devices and manoeuvres associated with airway management are associated with some degree of cervical spine motion.[1] Videolaryngoscopy is being used more commonly in difficult airway management and combines some advantages of traditional direct laryngoscopy and fibreoptic bronchoscopy.

The GlideScope videolaryngoscope (GVL) incorporates a high-resolution digital camera located in the laryngoscope blade allowing the glottis to be visualized on a dedicated LCD monitor. Although the GVL[2] is not specifically indicated in the management of the unstable cervical spine, it is possible that cervical spine motion may be minimized, since a direct line-of-sight is not required to visualize the larynx. Studies using continuous radiographic techniques have not demonstrated significant reduction in cervical spine movement when comparing the GVL with Macintosh direct laryngoscopy, despite the use of manual in-line stabilization.[3 4] These studies have used the older version of the GVL. A new lower vertical profile version (Lo-Pro GVL, LP-G) is 14.5 mm (compared with 18 mm for the original version), making insertion easier and providing more space in the oropharynx potentially reducing ventral force applied and cervical spine movement during intubation. No studies to date have compared the GVL with flexible bronchoscopy-assisted intubation.

Fibreoptic bronchoscopy or flexible videobronchoscopy (FB) is widely regarded as the gold standard for the intubation of patients with cervical instability.[5] However, its potential may be limited by lack of expertise, blood or secretions in the airway, lack of cooperation in awake patients, and the additional time required to prepare for and execute the procedure. Previous studies have demonstrated lesser movement using the FB in comparison with other devices. Furthermore, there are very little data evaluating the effects of a tongue pull and jaw thrust,[6 7] manoeuvres commonly used to enlarge the posterior pharyngeal space during FB intubation, on cervical spine motion.

In our prospective randomized controlled trial, we postulated that the LP-G would not cause significantly greater C-spine movement than fibreoptic bronchoscopy.

Methods

After approval from the University Health Network Research Ethics Board (Toronto) and the University Health Network Radiation Protection Subcommittee, informed written consent was obtained from all patients before participating in the trial. Adult patients with no known cervical pathology, undergoing neuroradiological procedures under general anaesthesia with endotracheal intubation, were enrolled. Patients were excluded if they had clinical or radiographic evidence of cervical spine abnormality, increased risk of aspiration (e.g. full stomach or gastro-oesophageal reflux disease), or lack of informed consent. Patients with Mallampati scores of $\geq$3 or those with an el-Ganzouri simplified risk index[8] $>$5 were also excluded.

Twenty-eight recruited adults completed the study between December 2005 and June 2006. A computer-generated randomization was placed in sealed envelopes that were opened on the day of the scheduled procedure. Fourteen patients were randomized to receive an asleep flexible bronchoscopic intubation (FBI) and 14 were randomized to a Lo-Pro GVL intubation (LP-GI).

Awake full-flexion and extension lateral images were obtained in the supine position, as indicators of physiological range of motion. A 7 cm thick foam pad was placed under the head, and adjusted if necessary to obtain a neutral head and neck posture. The C-arm of the fluoroscope was placed laterally and centred on the cervical spine before induction of anaesthesia.

Standard monitoring was used. Anaesthesia was induced with midazolam 1–2.5 mg i.v., fentanyl 3 μg kg^{-1}, and propofol 2.5–3.5 mg kg^{-1}. Rocuronium 0.6 mg kg^{-1} was given for muscle relaxation. Facemask ventilation and propofol boluses for anaesthesia maintenance were continued until complete neuromuscular block was demonstrated using a peripheral nerve stimulator. Patients were randomized to large-sized LP-GI (Verathon Inc., Bothell, WA, USA) or an FBI using a 5.2 mm video-bronchoscope (Porta-View LF-TP, Olympus Optical Co. Ltd, Japan). Successful tracheal intubation was confirmed by auscultation of breath sounds and by end-tidal CO_2 tracing. The duration of LP-GI was recorded from the loss of motor twitch until both the GVL and the stylet were fully withdrawn. For FBI, the clock was started after tongue pull and jaw thrust were performed and stopped after the bronchoscope was removed from the tracheal tube.

Biplanar fluoroscopic recording of the cervical spine continued at 3.8 frames s^{-1} throughout the intubation sequence as illustrated in Figure 1 (General Electric Medical Systems monitor, ADVANTX, model LCLP 416369). A neuroradiologist (S.C.) analysed the fluoroscopic video using an eFilm PACS workstation (FUSION eFilm 2.1, Merge Healthcare 2006) to determine the point of maximum change in angulation and to measure the relative change in angulation between cervical spine vertebrae. A spinal surgeon (G.C.) made independent measurements to allow us to calculate the inter-observer variability.

FBI was divided into two phases: (i) 'pre-FB manoeuvres' (tongue pull and jaw thrust) and (ii) 'intubation' phases (Fig. 1). 'Tongue pull' required gentle traction on the tongue by an assistant, who was either a nurse or a respiratory therapist, using a small piece of gauze to hold the tongue. 'Jaw thrust' required a second assistant to place both hands behind the angle of the mandible bilaterally and gently pull forward. The goal was to demonstrate visible displacement of the chin forward ($\sim$1 cm) using minimal force and without moving the head or neck where possible. The intubation began with both tongue pull and jaw thrust in place and also continued and finished with both of these in place. By separating this intubation phase from the 'pre-FB' phase, we were able to separate out the cervical motion caused by the intubation from that caused by tongue pull and jaw thrust manoeuvres. Fibreoptic intubations were performed via the oral route without the use of an intubating airway (such as an Ovassapian airway).

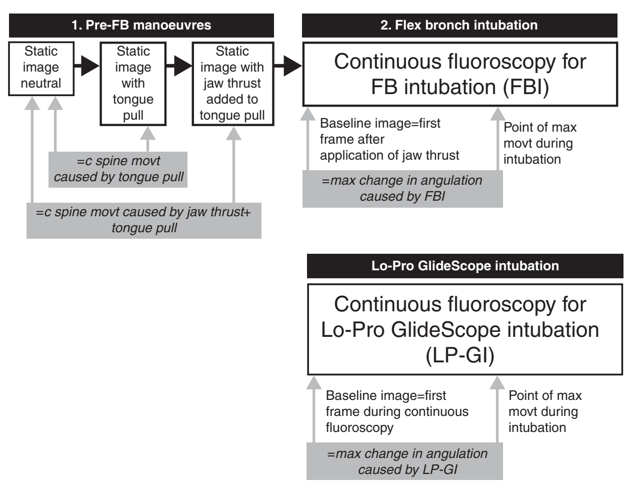

Fig 1 The protocol was slightly more complicated for patients randomized to FB intubations. Measurements are shown in italics.

The LP-G was used in a manner as previously described;[2] however, the forces applied were only sufficient to provide a view of the larynx adequate to permit visualized tracheal intubation.

The University Health Network Radiation Protection Subcommittee placed tight restrictions on the radiation exposure of patients and staff. An 'intubation failure' occurred, if the intubation was not close to completion after 45 s of continuous fluoroscopy. No more than two attempts were made with the bronchoscope or GlideScope®. We recorded details concerning 'failed attempts' for each patient.

Two experienced neuroanaesthesiologists (A.P. and D.M.W.), familiar with both techniques, performed all the intubations. Although neither manual in-line stabilization nor a cervical collar was used, head movements were avoided as much as possible during the intubation sequence. The primary endpoint was the maximal angulation of the cervical segments [(Occiput) Occ-C1, C1–2, C2–4, and C4–5] relative to the neutral position over the entire intubation sequence (Fig. 2A and B). All subjects had normal cervical spines, so vertebral angulation and rotation, but not displacement or translation, were the only measured variables. Absolute rotation of the vertebrae was considered less important than the change in angulation between vertebrae. The range of flexion and extension was measured in all patients and defined as the change in angulation from flexion to extension from the occiput to the lowest seen cervical vertebra (usually C5).

Using data for Occ-C1 change in angulation estimated from the graphs in Rudolph and colleagues[9] [Bonfils fibreoptic intubation change from baseline of 5° extension (1.4 SD)] and defining 'no significant difference' as a mean value within 1.5° of this (similar to the expected inter-observer variability), the sample size was calculated to be 14 patients for each group (P=0.05, power=0.80). The 1.5° assumed inter-observer difference was slightly more generous than that calculated by Sawin and colleagues[10] (within 1° inter-observer variability), since our methodology required less standardization of intersecting lines and a subjective estimate of the exact frame capturing maximum global change in cervical spine motion by each observer (radiologist and surgeon). Statistical analysis was performed using Stata version 8.2 software (Stata Corporation, College Station, TX, USA). Data for maximal change in angulation (FB *vs* LP-G) were compared using the Mann–Whitney U-test. Non-parametric, paired data were compared using the Wilcoxon signed-rank test (for inter-observer differences, tongue pull *vs* intubation, and jaw thrust *vs* intubation). Other data were compared using Student's t-test and Fisher's exact test as appropriate.

Results

A total of 28 patients completed the study. There were no significant differences in baseline variables between the two groups (Table 1). Normal physiologic range on motion was observed in the flexion and extension views of all patients and there was no difference in maximal angulations.

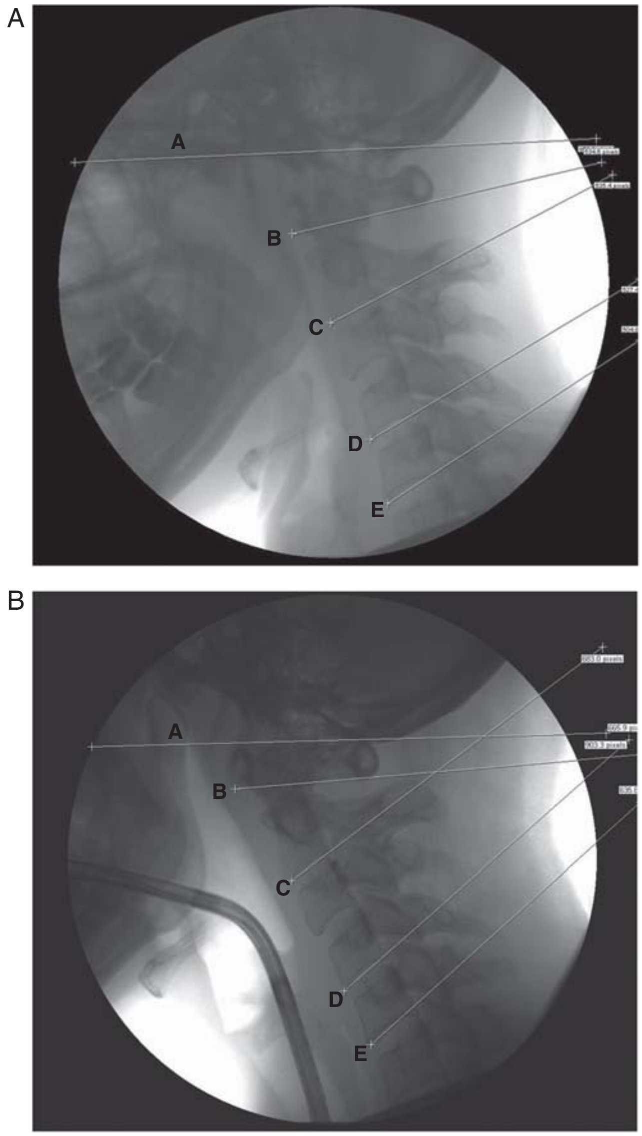

Fig 2 Lines intersecting through occiput, C1, C2, C4, and C5. Baseline angles (A) are compared with maximum movement during intubation (B) to determine maximum *change* in angulation. The relative change in angles rather than the absolute angles were taken as primary endpoints. A, The line extending from the posterior margin of the hard palate to the opisthion (occiput). B, C1 level defined by a line joining the inferior margins of anterior and posterior arches of atlas. C, C2 level defined by a line joining the antero-inferior margin of C2 vertebral body with anterior point of the C2 spinous process. D, C4 level defined by a line joining the antero-inferior margin of C4 vertebral body with anterior point of the C4 spinous process. E, C5 level defined by a line joining the antero-inferior margin of C5 vertebral body with anterior point of the C5 spinous process.

The two groups were compared for maximum change in angulation from baseline between adjacent vertebrae (Occ-C1, C1-2, C2–4, and C4–5) and non-adjacent vertebrae (Occ-C2, Occ-C4, and Occ-C5). The additive effects of extension across more than two vertebrae

Table 1 Baseline characteristics. Values are mean (range) or mean (SD). *Max range of motion for the angle between occiput and the lowest vertebra seen (usually C5) calculated as the difference between full flexion and full extension (in the supine position—immediately before induction). Details of the el-Ganzouri score are found in Ref. 8

	Lo-Pro GlideScope	Flexible bronchoscope	*P*-value	Statistical test
Number of patients	14	14		
Age (yr)	46.5 (19–83)	48.6 (30–89)	0.74	Student's *t*-test
Sex (M/F)	4/10	5/9	0.61	Fisher's exact
BMI	27.8 (5.95)	29.4 (5.46)	0.46	Student's *t*-test
Mallampati score				
One	5	8		
Two	9	6	0.45	Fisher's exact
Three or four	0	0		
el-Ganzouri score				
Zero	4	6		
One	1	3		
Two	3	1		
Three	0	3	0.17	Mann–Whitney *U*
Four	4	0		
Five	2	1		
Six or more	0	0		
Max range of motion*	29.0 (9.7)	26.57 (11.0)	0.54	Student's *t*-test

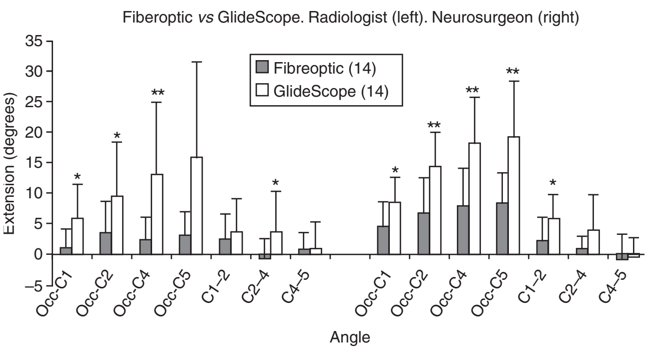

Fig 3 Maximum change in angulation during intubation. *$P<0.05$, **$P<0.01$, mean (SD) shown.

(Occ-C2, Occ-C4, and Occ-C5) were measured to demonstrate changes that may not have been as noticeable between adjacent vertebrae. LP-GI resulted in a greater extension compared with FBI for every angle calculated. This was statistically significant for both observers for movements between adjacent upper cervical spine vertebrae (Occ-C1) and compounded movements across more than two vertebrae (Occ-C2 and Occ-C4). The results are displayed in Figure 3 for both the observers (radiologist and spinal surgeon).

Inter-observer differences between radiologist and spinal surgeon (Fig. 4) were statistically significant for both devices, though these differences were generally $<3–4°$. The inter-practitioner differences were also limited to 3–4°.

The change in angulation of cervical segments caused by the tongue pull and jaw thrust was compared with that caused by the maximal change in angulation during FBI.

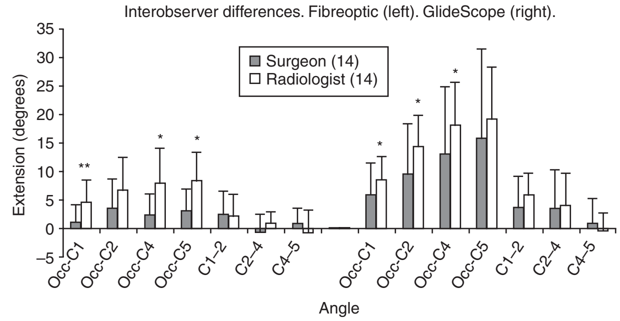

Fig 4 Inter-observer variability. *$P<0.05$, **$P<0.01$, mean (SD) shown.

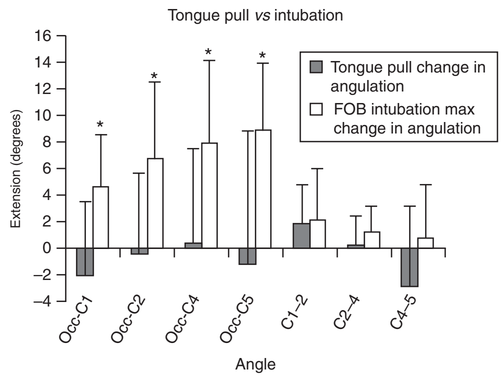

Fig 5 Cervical movement associated with tongue pull during FB intubation (measured by radiologist). *$P<0.05$, mean (SD) shown. Maximal change during intubation refers to the period after application of pharyngeal opening manoeuvres.

Tongue pull resulted in significantly less cervical spine motion than FBI, statistically significant for the angles Occ-C1, Occ-C2, Occ-C4, and Occ-C5 (Fig. 5). There was a trend for jaw thrust to cause greater cervical spine motion than the FBI, although there was slight discrepancy between observers as to its significance (Fig. 6A and B).

Intubation times are shown in Table 2. A 'failed attempt' occurred if the intubation was not near completion after 45 s in order to minimize radiation exposure. This resulted in a relatively short average intubation time and a high number of 'failed attempts'.

Discussion

Our study showed that in non-immobilized, fully anaesthetized adults LP-GI produced significantly more cervical spine movement than FBI.

The effect of FBI on cervical spine motion has previously been evaluated on cadavers.[11 12] Brimacombe and colleagues concluded that the nasal fibreoptic intubation produced the least cervical spine movement in cadavers with artificially created cervical spine instability. A recent study by Rudolph and colleagues[9] assessed the effect of Bonfils rigid fibreoptic intubation on cervical spine movement in live patients using single exposure X-rays. It was concluded that the Bonfils fibrescope caused less cervical

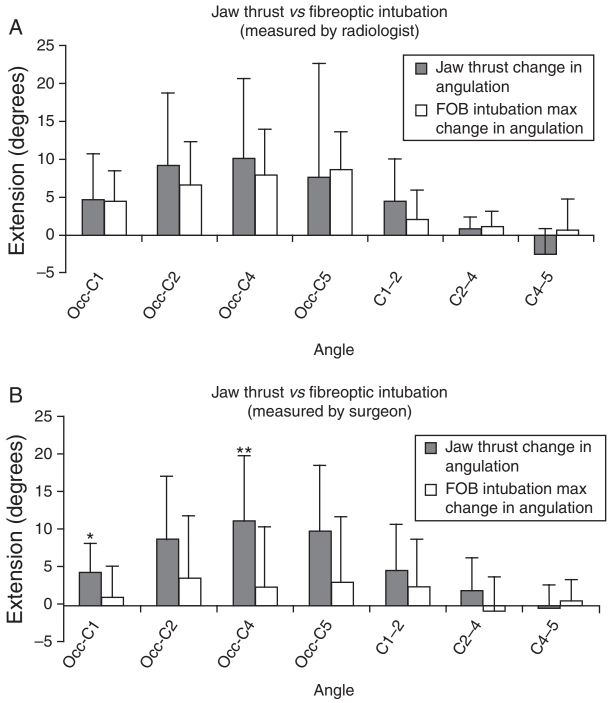

Fig 6 Cervical movement from a jaw thrust during FBI measured by (A) radiologist and (B) surgeon. *$P<0.05$, **$P<0.01$, mean (SD) shown. Maximal change during intubation refers to the period after application of pharyngeal opening manoeuvres.

Table 2 Radiation exposure times [mean (SD)] during intubation using Glidescope (LP-GI) or fibreoptic bronchoscope (FBI). An attempt was considered a 'failed attempt', if the anaesthetist was not close to completing the intubation after 45 s of radiation exposure, which explains the relatively short intubation times and high number of second attempts

	Time (s)	Second attempt	Procedure completed within two attempts
LP-GI	31.2 (2.61)	6/14	14/14
FBI	30.7 (3.34)	3/14	14/14

movement than the Macintosh laryngoscope. However, it is difficult to predict exactly when maximum movement is likely to occur during FBI. For this reason, we used continuous fluoroscopy and we believe that this is the first study to assess FBI in this way. It should be noted, however, that our assessment of this device relates to asleep FBI and we cannot make any assumptions about the effects of awake FBI on cervical spine motion. The cervical spine motion that we observed with asleep FBI was not due to any one manoeuvre but resulted from several factors including movement of the assistant's hands with the release of jaw thrust at the completion of the intubation, opening the mouth, or pressure on the chin.

In contrast, it was easier to predict when movement occurred during LP-GI. Significant movement was most often associated with even small degrees of ventral lifting force applied to the blade of the GVL in order to expose the glottis. In theory, non-line-of-sight laryngoscopy should reduce the ventral force, clearly demonstrated by previous radiographic studies to be responsible for significant degrees of movement during Macintosh laryngoscopy.[10] However, even studies using cervical immobilization have not demonstrated a significant reduction in cervical spine motion when the GVL was compared with Macintosh direct laryngoscopy.[3 4]

Turkstra and colleagues[3] studied adult patients with normal cervical spines, immobilized in a Mayfield horseshoe. They demonstrated no significant difference between the original GVL and a Macintosh laryngoscope. Using similar measuring techniques, we demonstrated less movement in our LP-GI (e.g. 6–8 *vs* 12.5° average extension for Occ-C1). It is unclear whether this resulted from differences in the patients studied, the device (classic GVL *vs* LP-GVL), measurement, or operator techniques.

Inter-observer differences were apparent. The radiologist consistently detected ~3° greater extension than the surgeon. In contrast, Sawin and colleagues[10] reported inter-observer variability of <1°. However, our measurement protocol was quite different and several factors may explain our higher inter-observer variability. We required both observers to independently select the frame capturing the greatest global change in cervical spine motion during intubation, which is somewhat subjective. We did this to simplify the primary endpoint, since the phases of LP-GI are completely different from those of FBI. Secondly, our software could only detect angles to the closest 1°, whereas Sawin and colleagues[10] were able to detect angles to 0.01°. A 1° error for each line can produce a 2° error each way for each angle. Thirdly, we did not use a standardized set of reference lines to measure angles between vertebrae. This was not necessary because we were interested in the change in the angles from baseline to maximum cervical spine movement rather than absolute angles during intubation. Sawin and colleagues[10] measured rotation of vertebrae, whereas we measured angles between adjacent vertebrae. We considered this to be more important since angles can be added to reveal the compounded effects of movement across more than two adjacent vertebrae. Our methodology was similar to Turkstra and colleagues,[3] though they did not use a second independent observer for radiographic measurements. Our inter-observer variability demonstrates the potential for erroneous conclusions in these studies.

FBI is not always possible without the aid of manoeuvres to enlarge the posterior pharyngeal space. For this reason, we were interested in assessing the effect of such manoeuvres on cervical spine motion and comparing them with those produced by the FBI itself. We found that pulling on the tongue alone, which may sometimes be sufficient to open the posterior pharyngeal space, caused significantly less movement than the FBI *per se*. This was not the case when a jaw thrust was added to tongue pull. The addition of jaw thrust caused as much movement as the FBI itself (after application of the pharyngeal opening manoeuvres). It should be acknowledged that jaw thrust is not unique to fibreoptic intubation and may form part of the airway management in all patients regardless of the device. The fact that this may cause significant cervical spine motion is not a new concept and has been shown to occur in cadaver models.[6 7] Tongue pull, on the other hand, is a manoeuvre we frequently use during oral FBI, as an alternative to using an intubating airway, and is usually sufficient on its own to open up the posterior pharyngeal space. It appeared to cause less cervical spine motion that jaw thrust and our study raises the possibility that tongue pull alone may be preferable to the routine use of jaw thrust during oral FBI without an intubating airway. However, further research is required to make such a conclusion as we did not directly examine both manoeuvres in isolation and it is possible that, in some individuals, oral FBI may be more difficult without jaw thrust.

The endpoint of *maximum relative angulation* during each intubation sequence is helpful because it is quantitative and proportional to the movement caused by an intubating device. We found a difference between the LP-G and the FB using this approach. However, it is difficult to say whether these differences are clinically important and it may not be possible to assess the effect of airway devices on neurological outcome in controlled clinical trials. It is also difficult to compare the cervical movement between studies involving different intubation devices because of differences between patients and measurement techniques.

Our study supports the view that when the appropriate equipment and personnel are available and the clinical setting permits, FBI may be a safer approach than the LP-GI for patients with cervical instability.[5] However, it is the practitioner rather than the device that performs the intubation and perhaps the 'best device' is the one most familiar to the care provider.[5]

Major study limitations include the absence of blinding of the operators, the number of 'failed attempts', and the lack of manual in-line stabilization. Clearly, it is not possible to prevent the laryngoscopist from knowing what technique is being used and this does permit bias. The number of failed attempts and lack of stabilization were related to the need to minimize radiation exposure to patients and staff. A 'failed attempt' was defined as the probable inability to complete an intubation within 45 s and does not reflect clinical practice. Likewise, the lack of manual in-line stabilization does not reflect routine management of patients where cervical motion is a concern. We chose not to use in-line stabilization in order to minimize intubation times, avoid radiation exposure to an extra pair of hands (considering that the assessment of tongue pull and jaw thrust already required a second pair of hands), and to reduce radiographic masking of the cervical spine. It is possible that our findings might have differed had we used in-line stabilization.

We chose to exclude patients with predicted airway difficulties, as this would have increased radiation exposure times and heterogeneity between the groups. Airway difficulties are common, particularly in the acute situation, and are likely to result in increased cervical spine motion for all devices during intubation. Another concern is that our study used adults without cervical spine disease. Many previous clinical studies on the effects of airway devices on cervical spine motion have also used healthy adults and the authors have noted the need for caution in extrapolating the results to the unstable cervical spine.[3 4 9] The same caution should be taken with this study.

In conclusion, we demonstrated that in adult patients lacking cervical spine pathology and in whom cervical stabilization was not provided, the Lo-Pro GlideScope® produced greater cervical spine movement than intubation using the flexible bronchoscope. We also conclude that the manoeuvres to facilitate FBI—the *jaw thrust* in particular—results in movement of the cervical spine.

Acknowledgements

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References

1 Crosby ET. Considerations for airway management for cervical spine surgery in adults. *Anesthesiol Clin* 2007; **25**: 511–33
2 Cooper RM. Use of a new videolaryngoscope (GlideScope) in the management of a difficult airway. *Can J Anaesth* 2003; **50**: 611–3
3 Turkstra TP, Craen RA, Pelz DM, Gelb AW. Cervical spine motion: a fluoroscopic comparison during intubation with lighted stylet, GlideScope, and Macintosh laryngoscope. *Anesth Analg* 2005; **101**: 910–5
4 Robitaille A, Williams SR, Tremblay MH, Guilbert F, Theriault M, Drolet P. Cervical spine motion during tracheal intubation with manual in-line stabilization: direct laryngoscopy versus GlideScope(R) videolaryngoscopy. *Anesth Analg* 2008; **106**: 935–41
5 Crosby ET, Lui A. The adult cervical spine: implications for airway management. *Can J Anaesth* 1990; **37**: 77–93
6 Donaldson WF, 3rd, Towers JD, Doctor A, Brand A, Donaldson VP. A methodology to evaluate motion of the unstable spine during intubation techniques. *Spine* 1993; **18**: 2020–3
7 Donaldson WF, 3rd, Heil BV, Donaldson VP, Silvaggio VJ. The effect of airway maneuvers on the unstable C1–C2 segment. A cadaver study. *Spine* 1997; **22**: 1215–8
8 el-Ganzouri AR, McCarthy RJ, Tuman KJ, Tanck EN, Ivankovich AD. Preoperative airway assessment: predictive value of a multivariate risk index. *Anesth Analg* 1996; **82**: 1197–204
9 Rudolph C, Schneider JP, Wallenborn J, Schaffranietz L. Movement of the upper cervical spine during laryngoscopy: a comparison of the Bonfils intubation fibrescope and the Macintosh laryngoscope. *Anaesthesia* 2005; **60**: 668–72

10 Sawin PD, Todd MM, Traynelis VC, *et al*. Cervical spine motion with direct laryngoscopy and orotracheal intubation. An in vivo cinefluoroscopic study of subjects without cervical abnormality. *Anesthesiology* 1996; **85**: 26–36

11 Brimacombe J, Keller C, Kunzel KH, Gaber O, Boehler M, Puhringer F. Cervical spine motion during airway management: a cinefluoroscopic study of the posteriorly destabilized third cervical vertebrae in human cadavers. *Anesth Analg* 2000; **91**: 1274–8

12 Hauswald M, Sklar DP, Tandberg D, Garcia JF. Cervical spine movement during airway management: cinefluoroscopic appraisal in human cadavers. *Am J Emerg Med* 1991; **9**: 535–8