Editorial

Time to abandon awake fibreoptic intubation?

The older generation of anaesthetists were taught direct laryngoscopy using the Macintosh blade, blind nasal intubation using red rubber tracheal tubes and, latterly, awake fibreoptic intubation in difficult airway situations. Today's generation of anaesthetists have a much broader selection of techniques at their disposal. Advances in regional anaesthetic techniques mean that they may choose not to administer a general anaesthetic at all; if they do choose a general anaesthetic, they may elect not to intubate the trachea, but rely on a supraglottic airway device (SAD) or they may intubate the trachea using the SAD as a conduit or they may intubate the trachea using newer equipment such as a videolarygoscope. However, awake fibreoptic intubation is still widely accepted as the gold standard in the management of the known difficult airway, yet in this month's issue of *Anaesthesia*, Lee et al. present a study that advances current practice for nasotracheal intubation in patients with limited mouth opening [1]. The conventional techniques used in these cases are fibreoptically-guided nasal intubation [2], blind nasal intubation [3], or lightwand-guided nasal intubation [4, 5]. In their study, Lee et al. randomised patients with mouth opening of <3 cm undergoing maxillofacial surgery into two groups; nasotracheal intubation using a fibrescope or a Trachway®-guided technique. The Trachway is a rigid video-intubating stylet with an adjustable distal portion. They concluded that the Trachway-guided technique for nasotracheal intubation is quicker and easier compared with fibreoptic intubation. With an increase in the number of airway devices now available, alternative techniques have recently been advocated in awake and anaesthetised patients [6–8]. Therefore, we propose that it is now time to adopt these newer techniques and reserve the use of the fibrescope for specific airway situations.

This editorial accompanies an original article by Lee et al., *Anaesthesia* 2016; 71: 31–8.

Training in fibreoptic intubation

Fibreoptic intubation (FOI) is a challenging technique to learn [9], and, even when mastered, requires regular practice in order to maintain skills [10]. Fitzgerald et al. [11] in a previous issue of this journal suggested that anaesthetists may avoid performing awake FOI in patients who would otherwise be suitable for the procedure for a number of reasons: fear of causing distress to the patient; operator diffidence; the worry of procedural failure; and possible complications such as over-sedation or bleeding.

There is evidence that the initial learning curve for fibreoptic intubation is steep, with the skill being learned after ten tracheal intubations in patients with normal laryngeal anatomy under general anaesthesia [12]. Training programmes for novices have demonstrated that FOI training can be safely accomplished in anaesthetised patients [13], while others have argued [14] that training devices can help novices better appreciate and learn the technical skills required for successful FOI.

In a survey of 132 residency programmes in America, Fellows were reportedly taught FOI in 64% of programmes, however, the average number of FOI procedures performed before graduation was estimated to be less than ten in 65% of trainees [15]. The results from a survey of Canadian anaesthetists (admittedly with a relatively low response rate of 47%), showed that, in a theoretically difficult tracheal intubation scenario, 45% preferred the lighted stylet, with only 26% preferring the fiberscope, which seems to imply that trainees are reluctant to use this technique [16]. Heidegger et al. [17] suggested that FOI is best accomplished by those clinicians who use it in their daily practice, and Difficult Airway Society (DAS) members revealed how they were equally divided

when it came to choosing between training in an awake FOI technique and training in videolaryngoscope use, despite fibrescopes being much more readily available than videolarygoscopes [18].

NAP4

The 4th National Audit Project (NAP4) [19] reported 18 cases (mostly anaesthetised by consultants) where the expert reviewers thought that an awake FOI might have offered advantages over airway management under general anaesthesia, and 15 cases where awake FOI was unsuccessful. They also reported that fibreoptic intubation under general anaesthesia was attempted in 20 cases, with 13 failures. These findings suggest that even experienced anaesthetists avoid awake FOI when it may be indicated, and choose fibreoptic intubation under general anaesthesia in patients with anticipated difficult airways, but also fail in this. Awake FOI is a procedure that necessitates experience with equipment, an understanding of airway endoscopic anatomy, and requires proficiency in providing effective local anaesthesia and sedation. The threshold for adopting awake FOI relies on the competence and confidence of the anaesthetist performing the procedure. It is likely some anaesthetists do not have the skills or confidence required to perform awake FOI and, for others, it may be difficult to maintain these skills.

Improved imaging techniques

Nørskov et al. [20] demonstrated that 93% of difficult tracheal intubations could not be predicted when routine bedside airway assessments were made. Recently, however, there has been an increase in the use of accurate pre-operative assessment tools such as nasendoscopy, virtual endoscopy and ultrasound [21–23], which contribute to better imaging and assessment of the difficult airway. These techniques help in pre-operative assessment and provide an improved overall picture of the airway, reducing the unknown elements and hence allow for more familiar techniques to be used safely.

Airway management under general anaesthesia

The administration of oxygen via nasal cannulae during conventional laryngoscopy or videolaryngoscopy extends the duration of safe apnoea [24–26], and is effective even in obese patients. For example, Ramachandran et al. [27] simulated difficult airways in obese patients and found that supplemental oxygen administration was associated with a significant increase in the duration and frequency of oxygen saturations >95% after induction of anaesthesia and neuromuscular blockade. Newer techniques such as THRIVE [28], where apnoeic oxygenation is combined with positive pressure ventilation through the delivery of trans-nasal high-flow warmed and humidified oxygen, have been shown to extend the apnoea times of patients with difficult airways. This has the potential to allow continuous oxygenation of the patient (provided the airway is patent) during airway management, where techniques such as videolaryngoscopy can be more safely employed. Alternative techniques for oxygenation during difficult laryngoscopy have also been suggested [29, 30], that do not require removal of the videolaryngoscope.

The widespread use of sugammadex [31, 32] facilitates almost immediate reversal of neuromuscular blockade following administration of rocuronium (and to a lesser extent, vecuronium). This also contributes to the safety of airway management during general anaesthesia, and allows the patient to regain consciousness with muscle tone.

Second generation supraglottic airway devices (SADs) with a gastric drain tube are recommended as a rescue device during failed tracheal intubation in obstetric patients [33]. They are relatively easy to insert, have higher oropharyngeal seal pressures and possibly reduce the risk of aspiration [34–36]. Cook [37] recently demonstrated that second generation SADs out perform first generation devices in terms of efficacy and are more suited for advanced uses such as rescue devices following failed rapid sequence induction and for tracheal intubation through the SAD. He also suggests that second generation devices should be used in routine practice, as this would enable anaesthetists to become more proficient and experienced and ensure that, when advanced use is required, anaesthetists feel comfortable. Certainly, second generation SADs can be used as rescue devices in failed tracheal intubation situations, either for oxygenation or as a conduit to

aid tracheal intubation [38–40], but we believe that blind tracheal intubation attempts cannot be recommended, and only fiberscope-guided techniques, or in combination with an Aintree Intubation Catheter (Cook Medical Inc, Bloomington, IN, USA) [41], should be attempted.

With the development of these devices and drugs, there is a strong argument that the improved safety they provide during difficult airway management under general anaesthesia reduces the need to rely on an awake FOI technique.

The rise of the videolaryngoscope

The availability and use of videolaryngoscopes (VL) is increasing [18]. Studies that included both novices and experienced anaesthetists have suggested that approximately 20 uses are required in order to gain competence with an individual VL [42]. This can be achieved in a relatively short period of time and the skills can be maintained. NAP4 mentions the theoretical benefit of VLs in converting 'blind' intubations into 'visualised' tracheal intubations [43]. Indeed, there is growing evidence that VLs are more effective than conventional laryngoscopy using a Macintosh blade [44–47].

Awake FOI has also been challenged by videolaryngoscopy. Rosenstock et al. [48] compared FOI with the McGrath VL for awake oral tracheal intubation in adult patients with an anticipated difficult intubation. There was no difference found between the two techniques in time to intubation or success rate. Zaouter et al. [49] have gone so far as to suggest that VLs should be used for all tracheal intubations and replace direct laryngoscopy. However, concerns have been raised, as with the increasing availability of this new technology, there is a risk that trainees will progressively lose their skills in conventional laryngoscopy [50]. In addition, the process of placing a tracheal tube with a VL can take longer than conventional laryngoscopy [51], and is another argument against the use of VL for all intubations. But there is an increasing body of evidence to support the use of VLs in unanticipated, difficult, or failed intubations compared with direct laryngoscopy [52–54]. Provided these devices are readily available, operators are competent in their use and they are shown to be effective in difficult airway scenarios, then they will be used more often compared with the less familiar and more technically complicated technique of awake FOI.

It must be noted that there are a bewildering array of VLs available [55], with different user interfaces, blade shapes and blade and tracheal tube insertion techniques. A trainee may become proficient using one type of VL only to find it unavailable at a subsequent hospital due to local preference or financial constraints. Their shorter working week and reduced training opportunities may also result in a lack of experience with different VLs. However,, we believe that the knowledge and clinical skills required to master videolaryngoscopy can be acquired and embedded.

In conclusion, provided accurate pre-operative imaging has been obtained and a multidisciplinary discussion has taken place, then awake FOI performed by a competent operator still has a role. If an airway is unexpectedly difficult, it is more prudent to use a technique that is more familiar to the anaesthetist, and there is growing evidence that this is more likely to be a videolaryngoscope. We believe that awake FOI is increasingly becoming obsolete in the management of difficult airways and should not now be considered the 'gold standard' for managing the difficult airway.

Competing interests

IA is a committee member of the Difficult Airway Society and has received funding for travel from Fischer and Pykel to give talks at international meetings. CB is an Editor of *Anaesthesia*, and this article was therefore sent out for additional review. No other external funding or competing interests declared.

I. Ahmad
C. R. Bailey
Consultants
Department of Anaesthesia
Guys and St. Thomas' Hospitals
London, UK
Email: drimranahmad1@gmail.com

References

1. Lee MC, Tseng KY, Shen YC, et al. Nasotracheal intubation in patients with limited mouth opening: a comparison between fibreoptic intubation and the Trachway®. *Anaesthesia* 2016; **71**: 31–8.
2. Sun Y, Liu JX, Jiang H, Zhu YS, Xu H, Huang Y. Cardiovascular responses and airway complications following awake nasal intubation with blind intubation device and fibreoptic bronchoscope: a randomized con-

trolled study. *European Journal of Anaesthesiology* 2010; **27**: 461–7.
3. Chung YT, Sun MS, Wu HS. Blind nasotracheal intubation is facilitated by neutral head position and endotracheal tube cuff inflation in spontaneously breathing patients. *Canadian Journal of Anesthesia* 2003; **50**: 511–3.
4. Cheng KI, Chang MC, Lai TW, et al. A modified lightwand-guided nasotracheal intubation technique for oromaxillofacial surgical patients. *Journal of Clinical Anesthesia* 2009; **21**: 258–63.
5. Dong Y1, Li G, Wu W, Su R, Shao Y. Lightwand-guided nasotracheal intubation in oromaxillofacial surgery patients with anticipated difficult airways: a comparison with blind nasal intubation. *International Journal of Oral and Maxillofacial Surgery* 2013; **42**: 1049–53.
6. Kajekar P, Mendonca C, Danha R, Hillermann C. Awake tracheal intubation using Pentax airway scope in 30 patients: a Case series. *Indian Journal of Anaesthesia* 2014; **58**: 447–51.
7. Gaszynska E, Gaszynski T. The King Vision™ video laryngoscope for awake intubation: series of cases and literature review. *Therapeutics and Clinical Risk Management* 2014; **10**: 475–8.
8. Dotson M. Awake video laryngoscope intubation: case report of a patient with a nasopharyngeal mass. *Journal of the American Association of Nurse Anesthetists* 2012; **80**: 347–53.
9. Fiadjoe JE, Litman RS. Difficult tracheal intubation: looking to the past to determine the future. *Anesthesiology* 2012; **116**: 1181–2.
10. Rose DK, Cohen MM. The airway: problems and predictions in 18,500 patients. *Canadian Journal of Anesthesia* 1994; **41**: 372–83.
11. Fitzgerald E, Hodzovic I, Smith AF. 'From darkness into light': time to make awake intubation with videolaryngoscopy the primary technique for an anticipated difficult airway? *Anaesthesia* 2015; **70**: 387–92.
12. Johnson C, Roberts JT. Clinical competence in the performance of fiberoptic laryngoscopy and endotracheal intubation: a study of resident instruction. *Journal of Clinical Anesthesia* 1989; **1**: 344–9.
13. Cole AF, Mallon JS, Rolbin SH, Ananthanarayan C. Fiberoptic intubation using anesthetized, paralyzed, apneic patients. Results of a resident training program. *Anesthesiology* 1996; **84**: 1101–6.
14. Rosenblatt W. The fiberoptic training jig. *Anaesthesia* 2007; **62**: 201–2.
15. Joffe AM, Liew EC, Olivar H, et al. A national survey of airway management training in United States internal medicine-based critical care fellowship programs. *Respiratory Care* 2012; **57**: 1084–8.
16. Wong DT, Lai K, Chung FF, Ho RY. Cannot intubate–cannot ventilate and difficult intubation strategies: results of a Canadian national survey. *Anesthesia and Analgesia* 2005; **100**: 1439–46.
17. Heidegger T, Gerig HJ, Ulrich B, Kreienbühl G. Validation of a simple algorithm for tracheal intubation: daily practice is the key to success in emergencies–an analysis of 13,248 intubations. *Anesthesia and Analgesia* 2001; **92**: 517–22.
18. Gill RL, Jeffrey AS, McNarry AF, Liew GH. The availability of advanced airway equipment and experience with videolaryngoscopy in the UK: two UK surveys. *Anesthesiology Research and Practice* 2015. http://www.hindawi.com/journals/arp/2015/152014/ (accessed 23/10/2015).
19. Popat M, Woodall N. Fibreoptic intubation: uses and omisions. In: Cook TM, Woodall N, Frerk C, eds. *Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society: Major Complications of Airway Management in the UK Report and Findings*. London, UK: Royal College of Anaesthetists, 2011: 114–120.
20. Nørskov AK, Rosenstock CV, Wetterslev J, Astrup G, Afshari A, Lundstrøm LH. Diagnostic accuracy of anaesthesiologists' prediction of difficult airway management in daily clinical practice: a cohort study of 188 064 patients registered in the Danish Anaesthesia Database. *Anaesthesia* 2015; **70**: 272–81.
21. Pearce A, Shaw J. Airway assessment and planning. In: Cook TM, Woodall N, Frerk C, eds. *Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society: Major Complications of Airway Management in the UK Report and Findings*. London, UK: Royal College of Anaesthetists, 2011: 135–142.
22. Ahmad I, Millhoff B, John M, Andi K, Oakley R. Virtual endoscopy-a new assessment tool in difficult airway management. *Journal of Clinical Anaesthesia* 2015; **27**: 508–13.
23. Hui CM, Tsui BC. Sublingual ultrasound as an assessment method for predicting difficult intubation: a pilot study. *Anaesthesia* 2014; **69**: 314–9.
24. Levitan RM. NO DESAT! Nasal oxygen during efforts securing a tube. *Emergency Physicians Monthly*. December 9, 2010. http://www.epmonthly.com/features/currentfeatures/no-desat-/ (accessed 23/10/2015).
25. Taha SK, Siddik-Sayyid SM, El-Khatib MF, Dagher CM, Hakki MA, Baraka AS. Nasopharyngeal oxygen insufflation following pre-oxygenation using the four deep breath technique. *Anaesthesia* 2006; **61**: 427–30.
26. Baraka AS, Taha SK, Siddik-Sayyid SM, et al. Supplementation of preoxygenation in morbidly obese patients using nasopharyngeal oxygen insufflation. *Anaesthesia* 2007; **62**: 769–73.
27. Ramachandran SK, Cosnowski A, Shanks A, et al. Apneic oxygenation during prolonged laryngoscopy in obese patients: a randomized, controlled trial of nasal oxygen administration. *Journal of Clinical Anaesthesia* 2010; **22**: 164–8.
28. Patel A, Nouraei SA. Transnasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE): a physiological method of increasing apnoea time in patients with difficult airways. *Anaesthesia* 2015; **70**: 323–9.
29. Ungureanu N, Mendonca C. Oxygenation during difficult videolaryngoscopy. *Anaesthesia* 2015; **70**: 1216–7.
30. Khan RM, Haris A, Sharma P, Kaul N. Oxygenating patients during difficult videolaryngoscopy. *Anaesthesia* 2015; **70**: 1214.
31. Paton L, Gupta S, Blacoe D. Successful use of sugammadex in a 'can't ventilate' scenario. *Anaesthesia* 2013; **68**: 861–4.
32. Welliver M, Cheek D, Osterbrink J, McDonough J. Worldwide experience with sugammadex sodium: implications for the United States. *Journal of the American Association of Nurse Anesthetists* 2015; **83**: 107–15.
33. Mushambi MC, Kinsella SM, Popat M, et al. Obstetric Anaesthetists' Association and Difficult Airway Society guidelines for the management of difficult and failed tracheal intubation in obstetrics. *Anaesthesia* 2015; **70**: 1286–306.
34. de Montblanc J, Ruscio L, Mazoit JX, Benhamou D. A systematic review

and meta-analysis of the i-gel vs laryngeal mask airway in adults. *Anaesthesia* 2014; **69**: 1151–62.
35. Cook TM, Lee G, Nolan JP. The ProSealTM laryngeal mask airway: a review of the literature. *Canadian Journal of Anesthesia* 2005; **52**: 739–60.
36. Maitra S, Khanna P, Baidya DK. Comparison of laryngeal mask airway Supreme and laryngeal mask airway Pro-Seal for controlled ventilation during general anaesthesia in adult patients: systematic review with meta-analysis. *European Journal of Anaesthesiology* 2014; **31**: 266–73.
37. Cook TM, Kelly FE. Time to abandon the 'vintage' laryngeal mask airway and adopt second-generation supraglottic airway devices as first choice. *British Journal of Anaesthesia* 2015; **115**: 497–9.
38. Ferson DZ, Rosenblatt WH, Johansen MJ, Osborn I, Ovassapian A. Use of the intubating LMA-Fastrach in 254 patients with difficult-to-manage airways. *Anesthesiology* 2001; **95**: 1175–81.
39. Pandit JJ, MacLachlan K, Dravid RM, Popat MT. Comparison of times to achieve tracheal intubation with three techniques using the laryngeal or intubating laryngeal mask airway. *Anaesthesia* 2002; **57**: 128–32.
40. Joo HS, Kapoor S, Rose DK, Naik VN. The intubating laryngeal mask airway after induction of general anesthesia versus awake fiberoptic intubation in patients with difficult airways. *Anesthesia and Analgesia* 2001; **92**: 1342–6.
41. Cook TM, Silsby J, Simpson TP. Airway rescue in acute upper airway obstruction using a ProSeal Laryngeal mask airway and an Aintree Catheter: a review of the ProSeal Laryngeal mask airway in the management of the difficult airway. *Anaesthesia* 2005; **60**: 1129–36.
42. Falcetta S, Pecora L, Orsetti G, et al. The Bonfils fiberscope: a clinical evaluation of its learning curve and efficacy in difficult airway management. *Minerva Anestesiologica* 2012; **78**: 176–84.
43. Bogod D, Popat M. Tracheal intubation. In: Cook TM, Woodall N, Frerk C, eds. *Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society: Major Complications of Airway Management in the UK Report and Findings*. Royal College of Anaesthetists: London, UK, 2011: 96–104.
44. Aziz MF, Healy D, Kheterpal S, Fu RF, Dillman D, Brambrink AM. Routine clinical practice effectiveness of the Glidescope in difficult airway management: an analysis of 2,004 Glidescope intubations, complications, and failures from two institutions. *Anesthesiology* 2011; **114**: 34–41.
45. Aziz MF, Dillman D, Fu R, Brambrink AM. Comparative effectiveness of the C-MAC video laryngoscope versus direct laryngoscopy in the setting of the predicted difficult airway. *Anesthesiology* 2012; **116**: 629–36.
46. Su YC, Chen CC, Lee YK, Lee JY, Lin KJ. Comparison of video laryngoscopes with direct laryngoscopy for tracheal intubation: a meta-analysis of randomised trials. *European Journal of Anaesthesiology* 2011; **28**: 788–95.
47. Marrel J, Blanc C, Frascarolo P, Magnusson L. Videolaryngoscopy improves intubation condition in morbidly obese patients. *European Journal of Anaesthesiology* 2007; **24**: 1045–9.
48. Rosenstock CV, Thogersen B, Afshari A, Christensen AL, Eriksen C, Gatke MR. Awake fiberoptic or awake video laryngoscopic tracheal intubation in patients with anticipated difficult airway management: a randomized clinical trial. *Anesthesiology* 2012; **116**: 1210–6.
49. Zaouter C1, Calderon J1, Hemmerling TM. Videolaryngoscopy as a new standard of care. *British Journal of Anaesthesia* 2015; **114**: 181–3.
50. Cavus E, Thee C, Moeller T, Kieckhaefer J, Doerges V, Wagner K. A randomised, controlled crossover comparison of the C-MAC videolaryngoscope with direct laryngoscopy in 150 patients during routine induction of anaesthesia. *BMC Anesthesiology* 2011; **11**: 6.
51. Platts-Mills TF, Campagne D, Chinnock B, Snowden B, Glickman LT, Hendey GW. A comparison of GlideScope video laryngoscopy versus direct laryngoscopy intubation in the emergency department. *Journal of the Academy of Emergency Medicine* 2009; **16**: 866–71.
52. Niforopoulou P, Pantazopoulos I, Demestiha T, Koudouna E, Xanthos T. Video-laryngoscopes in the adult airway management: a topical review of the literature. *Acta Anaesthesiologica Scandinavica* 2010; **54**: 1050–61.
53. Griesdale DEG, Liu D, McKinney J, Choi PT. Glidescope® video-laryngoscopy versus direct laryngoscopy for endotracheal intubation: a systematic review and meta-analysis. *Canadian Journal of Anesthesia* 2012; **59**: 41–52.
54. Agro' FE, Doyle DJ, Vennari M. Use of GlideScope® in adults: an overview. *Minerva Anestesiologica* 2015; **81**: 342–51.
55. Paolini JB1, Donati F, Drolet P. Review article: video-laryngoscopy: another tool for difficult intubation or a new paradigm in airway management? *Canadian Journal of Anesthesia* 2013; **60**: 184–91.

doi:10.1111/anae.13333

Anaesthesia 2016, 71, 31–38 doi:10.1111/anae.13232

Original Article

Nasotracheal intubation in patients with limited mouth opening: a comparison between fibreoptic intubation and the Trachway®

M. C. Lee,[1] K. Y. Tseng,[1] Y. C. Shen,[2] C. H. Lin,[1] C. W. Hsu,[3] H. J. Hsu,[3] I. C. Lu[1] and K. I. Cheng[4,5]

1 Visiting Staff, 2 Nurse Anaesthetist, 4 Director, Department of Anesthesiology, 3 Visiting Staff, Division of Oral Maxillofacial Surgery, Department of Dentistry, Kaohsiung Medical University Hospital, Kaohsiung Medical University, Kaohsiung, Taiwan
5 Professor, Department of Anesthesiology, College of Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan

Summary

In patients with limited mouth opening, traditional laryngoscopy and videolaryngoscopes are not useful when performing nasotracheal intubation. Eighty patients with limited mouth opening who required nasotracheal intubation were randomly assigned to either fibreoptic intubation (n = 40) or the Trachway® (n = 40). Using the modified nasal intubation difficulty scale, 22 (55%) patients who received fibreoptic intubation were categorised as no difficulty compared with 40 (100%) patients in the Trachway group ($p < 0.001$). Mean (SD) total intubation time was 71.8 (23.3) s in patients who received fibreoptic intubation compared with 35.4 (9.8) s in the Trachway group ($p < 0.001$). We conclude that the Trachway technique for nasotracheal intubation is quicker and easier compared with fibreoptic intubation in patients with limited mouth opening.

Correspondence to: K. I. Cheng
Email: 770234kmuhanesthesia@gmail.com
Accepted: 10 August 2015
*This original article is accompanied by an editorial by Ahmad and Bailey, Anaesthesia 2016; **71**: 12–6.*

Introduction

In patients with limited mouth opening who are scheduled to undergo oro-maxillofacial surgery, traditional laryngoscopy or videolaryngoscopy to aid nasotracheal intubation is difficult, if not impossible [1]. Use of a fibreoptic intubation technique is considered the 'gold standard' for difficult laryngoscopy [2]; however, the flexible portion of the fibrescope is easily damaged, expensive to repair and this in turn may lead to a decrease in its routine use [3, 4]. Although a lightwand-guided nasotracheal intubation technique has been developed [5–8], this blind technique may cause tissue damage and is not useful if illumination is sub-optimal, for example in the obese or patients with short necks [9].

The Trachway® is a video intubating stylet for tracheal intubation. It has a rigid intubating stylet with an adjustable distal portion. At the proximal end is a light source and a camera. It has proved useful to novices in both easy and difficult laryngoscopy scenarios [10, 11]. Successful oral tracheal single- and double-lumen tube intubations using the Trachway have been reported [12, 13]. The Trachway has been used for nasotracheal intubation with a pre-formed double-curved tracheal tube in patients with normal anatomy [14] and we hypothesised that the Trachway technique would be practical for patients with limited mouth opening. We therefore decided to compare the intubating characteristics of fibreoptic intubation with the Trachway technique in patients with limited mouth opening.

Methods

Following local research ethics committee approval and written informed consent, adult patients of ASA physical status I or II with limited mouth opening (< 3 cm) and scheduled to undergo oro-maxillofacial surgery requiring nasotracheal intubation were recruited. Exclusion criteria included fixed, or limited, neck movement, obstructive sleep apnoea, bilateral nasal obstruction or patients with an abnormal coagulation status.

Un-premedicated patients were brought to the operating room, intravenous access was obtained and standard AAGBI monitoring (ECG, oxygen saturation and non-invasive blood pressure) applied. Patients received intravenous fentanyl 1 $\mu g.kg^{-1}$ and a selected nostril was sprayed with 4% cocaine 0.5 $mg.kg^{-1}$ using an atomisation device (MADgic™; Wolfe Tory Medical Inc., Salt Lake City, UT, USA) to shrink and anaesthetise the mucosa. Patients were asked to lie supine with their head in a neutral position and the neck flexed on a pillow at a height of 7 cm. General anaesthesia was induced with fentanyl 1 $\mu g.kg^{-1}$, thiamylal 5 $mg.kg^{-1}$, propofol 1 $mg.kg^{-1}$ and cisatracurium 0.2 $mg.kg^{-1}$. A pre-formed double-curved nasotracheal tube (RAE Nasal; Mallinckrodt Medical, Athlone, Ireland) of 7.0 mm internal diameter for men and 6.5 mm internal diameter for women was used for tracheal intubation. Patients were randomly assigned to either the fibreoptic intubation group or the Trachway group and all intubations were performed by anaesthetists with more than 20 years experience who were familiar with both techniques.

In the fibreoptic intubation group, a 3.5-mm diameter, 600-mm long fibreoptic scope (Pentax FI-10RBS; HOYA Corporation, Tokyo, Japan) was used for nasotracheal intubation. The appropriately sized warmed and softened nasotracheal tube was loaded onto the fibrescope, which was introduced into the selected nostril and down into the trachea. After the fibrescope tip was seen to enter the trachea, the nasotracheal tube was railroaded over the fibrescope into the trachea and the fibrescope withdrawn. If resistance was felt while advancing the nasotracheal tube, then it was withdrawn slightly, rotated counter-clockwise between 90° and 180°, and then re-advanced. The nasotracheal tube was connected to a circle breathing system and successful tracheal intubation confirmed by the presence of three consecutive capnography waveforms.

In the Trachway group, a video-stylet (Trachway® video intubating stylet, Biotronic Instrument Enterprise Ltd., Tai-Chung, Taiwan) was used. It is 5 mm in diameter and 425 mm in length, with a 100 mm anteriorly curved distal portion of 60–70°. A warmed and softened nasotracheal tube was loaded onto the video-stylet. The distal tip was positioned proximal to the Murphy eye of the tracheal tube in order that the distal end and side holes of the tracheal tube were visible on the camera screen. The tube-stylet assembly was inserted into the selected nostril with the anteriorly curved part of the stylet introduced at a sharp angle into the nasal cavity. The assembly was advanced under direct vision through the nasal cavity to the nasopharynx (Figs. 1a–c). Subsequently, with cephalad movement of the Trachway handle, the tube-stylet assembly was advanced to the glottis (Fig. 1d,e). With the right hand holding the handle, the left hand threaded the tube over the stylet and into the trachea (Fig. 1f). The stylet was then removed. Successful tracheal intubation was confirmed by the presence of three consecutive capnography waveforms. The assembly was manoeuvred counterclockwise 30–45° back to the sagittal plane if the stylet was in the left nostril or clockwise 30–45° to the sagittal plane if it was in the right nostril (Fig. 1g).

Total intubation time was from removal of the facemask until the appearance of three consecutive capnography waveforms. Total intubation time was divided into Time A and Time B. Time A was from removal of the facemask until threading of the nasotracheal tube into the trachea in the fibreoptic intubation group or until advancement of the tube-stylet assembly into the trachea in the Trachway group. Time B was from withdrawal of the fibrescope insertion cord or Trachway stylet from the nasotracheal tube, connection to the ventilator circuit, manual ventilation at a frequency of 18–20 $breaths.min^{-1}$, and the presence of three consecutive capnography waveforms.

To score intubating conditions, a modified nasal intubation difficulty scale (NIDS) was used [14–16] (Table 1). The total NIDS score was categorised as no

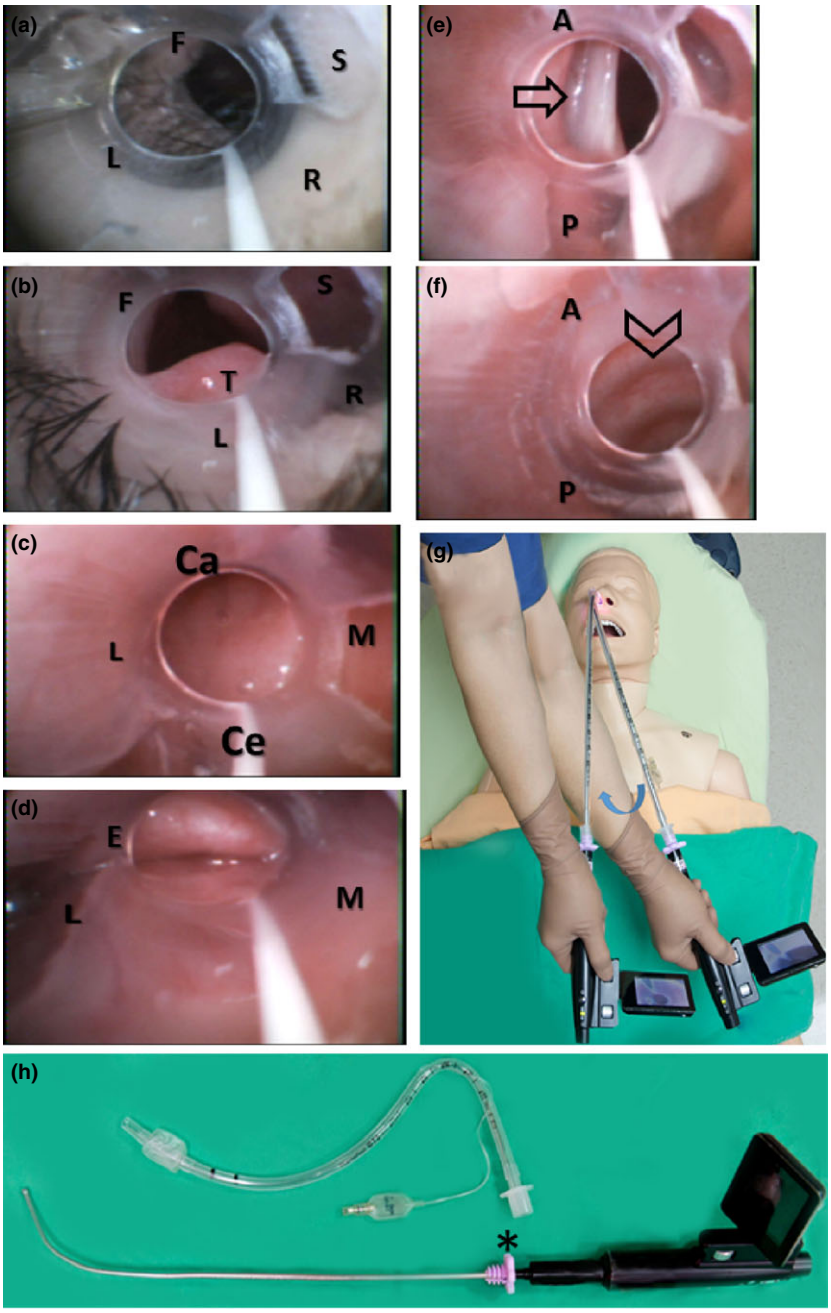

Figure 1 Trachway assembly and its advancement. (a) the assembly tip inserted into selected nostril, (b) into nasal cavity, (c) in nasopharyngeal space, (d) in oropharynx space with epiglottis visible, (e) chin elevated and glottic inlet visible (f) into trachea and tracheal rings visible, (g) the assembly tip advances in a sharp angle into the right nasal cavity and then clockwise shift to mid-sagittal line while the tip is in the nasal cavity, (h) a pre-formed double-curved nasotracheal tube and Trachway with stopper (*). F, floor of nose; S, septum of nose; L, lateral side; R, roof of nose; T, turbinate; Ca, caudal; Ce, cephalad; M, medial; E, epiglottis; A, anterior; P, posterior; arrow, left vocal cord; arrowhead, tracheal rings.

difficulty (score = 0), mild difficulty (score between 0 and 5), moderate difficulty (score between 6 and 11) and profound difficulty (score of 12 or more). Three minutes after intubation, a separate anaesthetist assessed anterior bleeding from the selected nostril and posterior bleeding by grading blood in the oropharynx

Table 1 The modified nasal intubation difficulty scale (NIDS) [14–16].

Parameters	Score
N1: intubation attempts	Each additional intubation attempt after the first one adds 1 point
N2: operators to attempt intubation	Each additional operator required to attempt intubation adds 1 point
N3: alternative intubation techniques or change head position	Each alternative technique or change of head position adds 1 point
N4: glottic exposure	0 = good visualisation of vocal cords with little manipulation 1 = tools manipulated in all directions to identify the vocal cords 2 = tools extensively manipulated in all directions to identify the vocal cords
N5: lifting force required to expose the vocal cords	0 = lifting without assistance 1 = lifting required by an assistant to improve view of the vocal cords
N6: optimise glottic exposure with BURP (backward, upward, and right ward pressure)	0 = none 1 = BURP applied
N7: techniques to aid intubation	0 = none 1 = cuff inflation or use of Magill forceps

(0 = none; 1 = minimal, blood-tinged oropharynx, entire nasotracheal tube segment visible in oropharynx; 2 = slight, blood covering the nasotracheal tube segment, > 1/2 of its length visible; 3 = moderate, blood covering the nasotracheal tube segment, < 1/2 of its length visible; 4 = severe, blood covering the nasotracheal tube and part of tube segment invisible) [17]. Postoperative sore throat, pain on swallowing and hoarseness were categorised as none, mild, moderate or severe by an independent anaesthetist who was blinded as to group allocation.

The primary outcome was intubation time and, based on a pilot study [17], it took a mean (SD) time of 32 (5) s. We assumed a difference of 10% would be significant and with a power of 0.8 at an α-level of 0.05, we required 39 patients in each group. Two-sample t-test (for numerical variables) and Chi-square test (for categorical variables) were performed. We used the Spearman rank correlation to test the association between one ranked variable (modified NIDS score) and one measurement variable (total intubation time). SPSS software (IBM Corp., IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY, USA) was used for statistical analysis and a p value of < 0.05 was considered statistically significant.

Results

Eighty patients were enrolled and Fig. 2 shows the CONSORT flow diagram for patients included in the study.

Patient characteristics are shown in Table 2. Thirty-six patients in the fibreoptic intubation group were successfully intubated at the first attempt. The four failed first attempts were due to the presence of nasal secretions or a blood-stained lens preventing adequate vision. Mean (SD) total intubation time was significantly longer in the fibreoptic intubation group compared with the Trachway group; 71.8 (23.3) s vs 34.3 (11.1) s, respectively, $p < 0.001$ (Table 3).

With regard to the modified NIDS score, 22 (55%) patients in the fibreoptic intubation group and 40 (100%) patients in the Trachway group were categorised as having no difficulty with intubation. Eighteen (45%) patients in the fibreoptic intubation group were categorised as mildly difficult intubating conditions. None were categorised as moderate or profound difficulty with intubation. There was a significant difference in modified NIDS scores between the groups ($p < 0.001$, Table 3).

Figure 3 shows the relationship between total intubation times and modified NIDS scores. There was a strong positive correlation between modified NIDS scores and total intubation times ($r = 0.586$, $p < 0.001$) with further analysis of the fibreoptic intubation group showing a positive correlation between modified NIDS scores and total intubation time ($r = 0.475$, $p = 0.002$).

Eleven (28%) patients in the fibreoptic intubation group and 15 (38%) patients in the Trachway group had bleeding from the nostril, whereas 11 (28%) patients in the fibreoptic intubation group and 14 (35%) in the Trachway group had mild accumulation of blood in the oropharyngeal space. There were no statistically significant differences between the groups. Postoperative sore throat with none/mild/moderate/

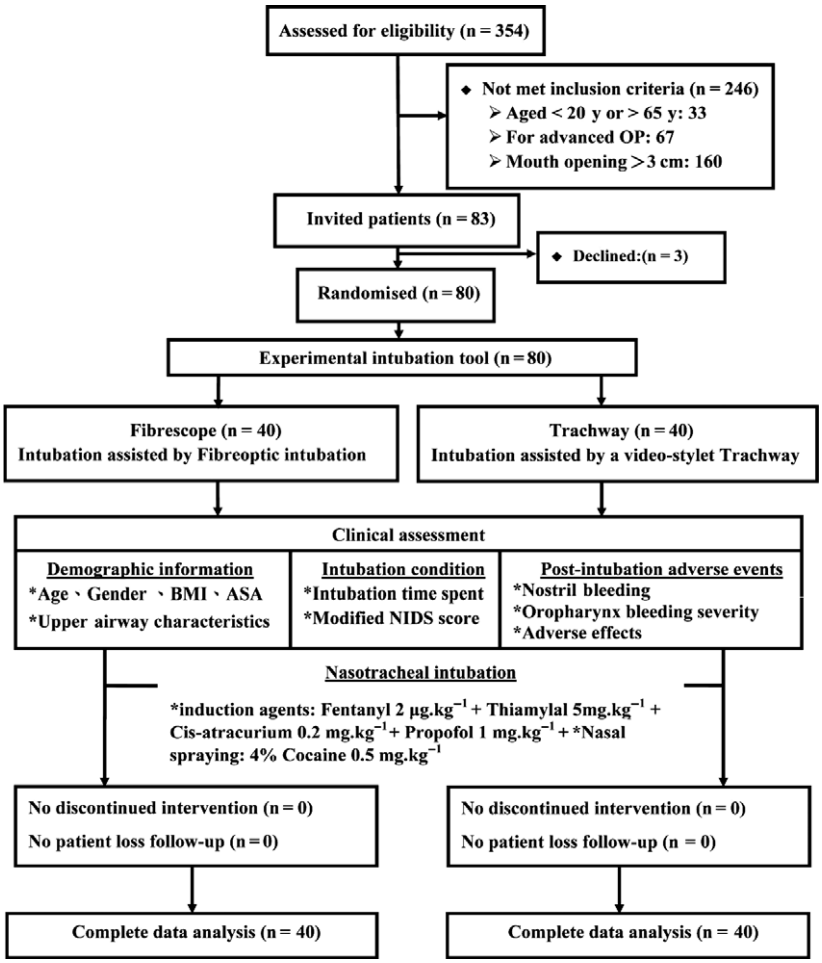

Figure 2 CONSORT flow diagram of nasotracheal intubation with either the fibreoptic scope or the Trachway in patients with limited mouth opening patients undergoing oro-maxillofacial surgery. BMI, body mass index; NIDS, nasal intubation difficulty scale.

severe grading was 11/20/7/2, respectively in the fibreoptic intubation group and 20/18/1/1 in the Trachway group. Postoperative hoarseness with none/mild/moderate/severe grading was 33/6/1/0, respectively in the fibreoptic intubation group and 34/6/0/0 in the Trachway group. Pain on swallowing with none/mild/moderate/severe grading was 32/7/1/0, respectively in the fibreoptic intubation group and 37/3/0/0 in the Trachway group. There were no statistically significant differences between the groups.

Discussion

Using the Trachway to perform nasotracheal intubation resulted in a quicker intubation time and better intubating conditions compared with fibreoptic intubation, and the incidence of adverse effects were comparable between the groups. Nasotracheal intubation is complicated because the tracheal tube is blindly inserted through the nasal cavity and turns a sharp angle from the nasopharynx into the oropharynx whatever technique is used. In our study, Trachway-assisted nasotracheal intubation overcomes the hazard of blind advancement by visualising the anatomy via the stylet tip while the whole assembly is passed through the nasal cavity. Furthermore, the Trachway stylet tip can be positioned proximal to the side hole of the nasotracheal tube in order that its softened tip prevents the stylet from damaging surrounding tissues. Trachway-assisted nasotracheal intubation easily facilitates tube tip advancement into the trachea by its levering effect and does not require accessory tools such as Magill forceps [18] or cuff inflation [7].

Table 2 Characteristics of patients in the fibreoptic intubation and Trachway groups. Values are mean (SD) or number (proportion).

	Fibreoptic intubation n = 40	Trachway group n = 40
Age; years	52.2 (8.6)	50.6 (10.3)
Gender; male:female	39:1	36:4
Body mass index; $kg.m^{-2}$	23.9 (3.4)	21.2 (4.0)
ASA physical status		
Class 1	1 (2.5%)	1 (2.5%)
Class 2	25 (62.5%)	26 (65.0%)
Class 3	14 (35.0%)	13 (32.5%)
Upper airway characteristics		
Thyromental distance; cm	7.6 (0.8)	7.4 (1.1)
Inter-incisor gap; cm	2.2 (0.8)	2.2 (0.7)
Mouth opening; cm		
0–1 cm	3 (7.5%)	1 (2.5%)
1–2 cm	17 (42.5%)	17 (42.5%)
2–3 cm	20 (50.0%)	22 (55.0%)

Table 3 Comparison of intubation attempts, intubation times and modified nasal intubation difficulty scales (NIDS) between patients in the fibreoptic intubation and Trachway groups. Values are number (proportion) or mean (SD).

	Fibreoptic intubation n = 40	Trachway group n = 40	p value
Intubation attempts			
One	36 (90%)	40 (100%)	0.314
Two	4 (10%)	0 (0%)	
Fail	0 (0%)	0 (0%)	
Intubation times			
Time A	54.1 (21.9)	21.7 (8.5)	< 0.001
Time B	17.5 (4.8)	13.7 (4.3)	< 0.001
Total time	71.8 (23.3)	35.4 (9.8)	< 0.001
Modified NIDS score			
0 (no difficulty)	22 (55%)	40 (100%)	< 0.001
1–5 (minor difficulty)	18 (45%)	0 (0%)	
6–11(moderate difficulty)	0 (0%)	0 (0%)	
≥ 12 (profound difficulty)	0 (0%)	0 (0%)	

The scope-first technique that we used for fibreoptic intubation was superior to a tube-first technique because tube advancement through the nasopharynx prevents the insertion cord tip from being misplaced into the Murphy eye of the tracheal tube [19]. Using this technique for nasotracheal intubation may take a mean intubation time of 3 min in an emergency [20], although one study found that the intubation time could be shortened to less than 1 min using a two-person intubation technique [21]. In our study, in 13 of 40 patients, it was not possible to perform fibreoptic intubation using a one person technique and an assistant was required to elevate the patients chin in order to open up the airway space. This is probably the reason why the mean total intubation time was more than a minute in the fibreoptic intubation group.

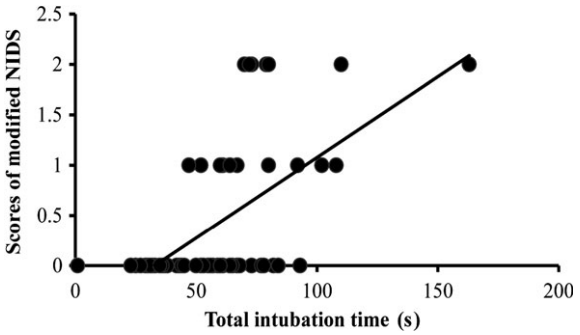

Figure 3 Correlation between modified NIDS scores and total intubation time.

Various intubation times have been described, such as from when the laryngoscope blade passes the incisors until successful nasotracheal tube placement [22], from opening of the mouth until inflation of the tracheal tube cuff [23], from when the nasotracheal tube is inserted into a selected nostril until withdrawal of the laryngoscope blade from the mouth [24] or from insertion of the fibrescope into the selected nostril until removal of the insertion cord of the fibrescope [21]. We chose from when the facemask was removed from the patient's face until the presence of three consecutive capnography waveforms because this is effectively the apnoeic time and seems to be the most objective endpoint [25]. The mean total intubation time was 35.4 s in the Trachway group compared with 71.8 s in the fibreoptic intubation group, a statistically, and clinically significant, difference between the groups.

The modified NIDS was determined as the N1, N2, N3, N5 and N6 items originally described by Adnet et al. [14], the N4 grading of glottic opening

described by Ovassapian et al. [16] and the N7 item as described by Ono et al. [15]. We found that the scores had a high positive correlation with total intubation time and believe this demonstrates that the modified NIDS is reliable in the assessment of difficult nasotracheal intubation.

There are some limitations to our study. Firstly, the Trachway does not have a facility to provide suction or oxygen supplementation. Using the Trachway in patients with secretions or accumulated blood in the nasopharynx or oropharynx may be a problem. Secondly, the Trachway technique in patients with limited mouth opening combined with limited neck movement is worthy of further investigation. Thirdly, it is relatively easy with a 3.5 mm diameter insertion cord to load a pre-formed double-curved nasotracheal tube and to withdraw from within it. Whether a larger 5.0-mm diameter cord is preferable is still to be determined.

We conclude that, compared with fibreoptic intubation, the Trachway allows for a quicker nasotracheal intubation time with a similar incidence of adverse effects. Trachway-assisted nasotracheal intubation is a feasible and efficient method that we recommend in patients with limited mouth opening undergoing oromaxillofacial surgery.

Acknowledgements

We thank Richard H. Davis for reviewing the English translation of this manuscript.

Competing interests

No external funding and no competing interests declared.

References

1. Sakles J, Brown C, Bair A. Video Laryngoscopy. In: Walls R, Murphy M, eds. *Manual of Emergency Airway Management*. Philadelphia, PA: Lippincott Willians & Wilkins, 2012: 139–57.
2. Ovassapian A. Failure to withdraw flexible fiberoptic laryngoscope after nasotracheal intubation. *Anesthesiology* 1985; **63**: 124–5.
3. Sloan T, Ovassapian A. The principals of fiberoptic endoscopes. In: Ovassapian A, ed. *Fiberoptic Endoscopy and the Difficult Airway*. Philadelphia, NY: Lippincott-Raven, 1996: 1–16.
4. Tvede MF, Kristensen MS, Nyhus-Andreasen M. A cost analysis of reusable and disposable flexible optical scopes for intubation. *Acta Anaesthesiologica Scandinavica* 2012; **56**: 577–84.
5. Cheng KI, Chang MC, Lai TW, et al. A modified lightwand-guided nasotracheal intubation technique for oromaxillofacial surgical patients. *Journal of Clinical Anesthesia* 2009; **21**: 258–63.
6. Xue FS, Yang QY, Xu YC, Liao X. A simple method to use the preformed nasotracheal tube during the lightwand-guided awake nasal intubation in the patients with difficult airways. *Chinese Medical Journal* 2009; **122**: 599–600.
7. Chung YT, Sun MS, Wu HS. Blind nasotracheal intubation is facilitated by neutral head position and endotracheal tube cuff inflation in spontaneously breathing patients. *Canadian Journal of Anaesthesia* 2003; **50**: 511–3.
8. Favaro R, Tordiglione P, Di Lascio F, et al. Effective nasotracheal intubation using a modified transillumination technique. *Canadian Journal of Anaesthesia* 2002; **49**: 91–5.
9. Agro F, Hung OR, Cataldo R, Carassiti M, Gherardi S. Lightwand intubation using the Trachlight: a brief review of current knowledge. *Canadian Journal of Anaesthesia* 2001; **48**: 592–9.
10. Tseng KY, Chau SW, Su MP, Shih CK, Lu IC, Cheng KI. A comparison of Trachway intubating stylet and Airway Scope for tracheal intubation by novice operators: a manikin study. *Kaohsiung Journal of Medical Science* 2012; **28**: 448–51.
11. Hung KC, Tan PH, Lin VC, Wang HK, Chen HS. A comparison of the Trachway intubating stylet and the Macintosh laryngoscope in tracheal intubation: a manikin study. *Journal of Anesthesia* 2013; **27**: 205–10.
12. Lee AR, Yang S, Shin YH, et al. A comparison of the BURP and conventional and modified jaw thrust manoeuvres for orotracheal intubation using the Clarus Video System. *Anaesthesia* 2013; **68**: 931–7.
13. Hsu HT, Chou SH, Chen CL, et al. Left endobronchial intubation with a double-lumen tube using direct laryngoscopy or the Trachway(R) video stylet. *Anaesthesia* 2013; **68**: 851–5.
14. Adnet F, Borron SW, Racine SX, et al. The intubation difficulty scale (IDS): proposal and evaluation of a new score characterizing the complexity of endotracheal intubation. *Anesthesiology* 1997; **87**: 1290–7.
15. Ono K, Goto T, Nakai D, Ueki S, Takenaka S, Moriya T. Incidence and predictors of difficult nasotracheal intubation with airway scope. *Journal of Anesthesia* 2014; **28**: 650–4.
16. Ovassapian A, Yelich SJ, Dykes MH, Brunner EE. Fiberoptic nasotracheal intubation–incidence and causes of failure. *Anesthesia and Analgesia* 1983; **62**: 692–5.
17. Hsu HT, Lin CH, Tseng KY, et al. Trachway in assistance of nasotracheal intubation with a preformed nasotracheal tube in patients undergoing oral maxillofacial surgery. *British Journal of Anaesthesia* 2014; **113**: 720–1.
18. Staar S, Biesler I, Muller D, Pfortner R, Mohr C, Groeben H. Nasotracheal intubation with three indirect laryngoscopes assisted by standard or modified Magill forceps. *Anaesthesia* 2013; **68**: 467–71.
19. Ovassapian A. Fiberoptic tracheal intubation in adults. In: Ovassapian A, ed. *Fiberoptic Endoscopy and the Difficult Airway*. Philadelphia, New York: Lippincott-Raven, 1996: 71–104.
20. Delaney KA, Hessler R. Emergency flexible fiberoptic nasotracheal intubation: a report of 60 cases. *Annals of Emergency Medicine* 1988; **17**: 919–26.
21. Xue FS, Li CW, Sun HT, et al. The circulatory responses to fibreoptic intubation: a comparison of oral and nasal routes. *Anaesthesia* 2006; **61**: 639–45.
22. Suzuki A, Onodera Y, Mitamura SM, et al. Comparison of the Pentax-AWS airway scope with the Macintosh laryngoscope

for nasotracheal intubation: a randomized, prospective study. *Journal of Clinical Anesthesia* 2012; **24**: 561–5.
23. St Mont G, Biesler I, Pfortner R, Mohr C, Groeben H. Easy and difficult nasal intubation – a randomised comparison of Macintosh vs Airtraq(R) laryngoscopes. *Anaesthesia* 2012; **67**: 132–8.
24. Xue F, Zhang G, Liu J, et al. A clinical assessment of the Glidescope videolaryngoscope in nasotracheal intubation with general anesthesia. *Journal of Clinical Anesthesia* 2006; **18**: 611–5.
25. Jones PM, Armstrong KP, Armstrong PM, et al. A comparison of glidescope videolaryngoscopy to direct laryngoscopy for nasotracheal intubation. *Anesthesia and Analgesia* 2008; **107**: 144–8.

