Project of the Royal College of Anaesthetists. *Br J Anaesth* 2011; **107**: 978–82
3. Cook TM, Andrade J, Bogod DG, *et al*. The 5th National Audit Project (NAP5) on accidental awareness during general anaesthesia: patient experiences, human factors, sedation, consent and medicolegal issues. *Anaesthesia* 2014; **69**: 1102–16
4. NELA project team. First patient report of the National Emergency Laparotomy Audit RCoA London, 2015. Available from http://www.nela.org.uk/reports (accessed 27 January 2016)
5. Saunders DI, Murray D, Pichel AC, Varley S, Peden CJ. Variations in mortality after emergency laparotomy: the first report of the UK Emergency Laparotomy Network. *Br J Anaesth* 2012; **109**: 368–75
6. Clarke A, Murdoch H, Thomas MJ, Cook TM, Peden CJ. Mortality and postoperative care after emergency laparotomy. *Eur J Anaesthesiol* 2011; **28**: 16–9
7. Walder B. Improvement of perioperative care for better outcome after surgery: invited commentary. *Eur J Anaesthesiol* 2011; **28**: 7–9
8. EPOCH. Enhanced Peri-Operative Care for High-risk patients (EPOCH) trial site. Available from http://www.epochtrial.org/epoch.php?page=news (accessed 8 May 2016)
9. Iezzoni LI. Using risk-adjusted outcomes to assess clinical practice: an overview of issues pertaining to risk adjustment. *Ann Thorac Surg* 1994; **6**: 1822–6
10. Solberg LI, Mosser G, McDonald S. The three faces of performance measurement: improvement, accountability and research. *J Qual Improv* 1997; **23**: 135–47
11. Perla RJ, Provost LP. Judgement sampling: a healthcare improvement perspective. *Qual Manag Health Care* 2012; **21**: 169–75
12. Perla RJ, Provost LP, Murray SK. The run chart: a simple analytical tool for learning from variation in healthcare processes. *BMJ Qual Saf* 2011; **20**: 46–51
13. Jordan L. A quality improvement project: temperature on arrival in the post anasethesia care unit. In: Colvin J, Peden CJ, eds. *Raising the Standard: A Compendium of Audit Recipes for Continuous Quality Improvement in Anaesthesia*. London: Royal College of Anaesthetists, 2012. Available from https://www.rcoa.ac.uk/system/files/CSQ-ARB-2012_1.pdf (accessed 20 January 2016)
14. Donabedian A. The quality of medical care. *Science* 1978; **200**: 856–64
15. Agency for Healthcare Research and Quality. Selecting Process Measures for Clinical Quality Measurement. Available from http://www.qualitymeasures.ahrq.gov/tutorial/ProcessMeasure.aspx (accessed 20 January 2016)
16. Kalanuria AA, Zai W, Mirski M. Ventilator associated pneumonia in the ICU. *Crit Care* 2014; **18**: 208
17. Rosenbaum L. Scoring no goal — further adventures in transparency. *N Engl J Med* 2015; **373**: 1385–8
18. Walker K, Neuburger J, Groene O, Cromwell DA, van der Meulen J. Public reporting of surgeon outcomes: low numbers of procedures lead to false complacency. *Lancet* 2013; **382**: 1674–7
19. Perioperative medicine: the pathway to better care. London: Royal College of Anaesthetists. Available from https://www.rcoa.ac.uk/perioperativemedicine (accessed 20 January 2016)
20. Herridge M, Cox C. Linking ICU practice to long-term outcome. Fostering a longitudinal vision for ICU-acquired morbidity. *Am J Resp Crit Care Med* 2012; **186**: 299–305
21. Monk TG, Bronsert MR, Henderson WG, *et al*. Association between intraoperative hypotension and hypertension and 30-day postoperative mortality in noncardiac surgery. *Anesthesiology* 2015; **123**: 307–19
22. Porter ME. What is value in healthcare? *N Engl J Med* 2010; **26**: 2477–81
23. Khuri SF, Henderson WG, DePalma RG, Mosca C, Healey NA, Kumbhani DJ. Participants in the VA National Surgical Quality Improvement Program. Determinants of long-term survival after major surgery and the adverse effect of postoperative complications. *Ann Surg* 2005; **242**: 326–41
24. Moonesinghe SR, Harris S, Mythen MG, *et al*. Survival after postoperative morbidity: a longitudinal observational cohort study. *Br J Anaesth* 2014; **113**: 977–84
25. Health Services Research Centre. Perioperative Quality Improvement Programme (PQIP). Available from http://www.niaa-hsrc.org.uk/pqip (accessed 10 April 2016)
26. Pearse R, Moreno RP, Bauer P. Mortality after surgery in Europe: a 7 day cohort study. *Lancet* 2012; **380**: 1059–65
27. Simpao AF, Ahumada LM, Rehman MA. Big data and visual analytics in anaesthesia and healthcare. *Br J Anaesth* 2015; **115**: 350–6

British Journal of Anaesthesia **117** (2): 148–50 (2016)
Advance Access publication 1 June 2016 · doi:10.1093/bja/aew122

Limitations of videolaryngoscopy

A. Norris[1,*] and T. Heidegger[2]

[1] Anaesthetic Department, Nottingham University Hospital NHS Trust, C Floor East Block, Nottingham NG7 2UH, UK, and [2] Department of Anaesthesia, Intensive Care & Resuscitation, Spitalstrasse 44, Spitalregion Rheintal Werdenberg Sarganserland, Switzerland, Grabs, CH 9472

*Corresponding author: E-mail: anorris@nhs.net

Increasing use of camera images and wireless communication is changing the way laryngoscopy and intubation is taught, learned, recorded, and even remotely supervised. Since 2003, when this journal published an evaluation of the GlideScope in cervical spine immobilization,[1] many other devices have been introduced: the search term ‘videolaryngoscopy’ in Google Scholar now returns >5000 references and recent guidance from the Difficult Airway Society incorporates videolaryngoscopy for

management of the unpredicted difficult airway.[2] These videolaryngoscope devices differ widely and classification is based on optical technology, blade shape and guiding channels.[3] The development of these devices has been driven by the need to improve the view with laryngoscopy, improve initial success rates, and aid the management of difficult intubations, aiming to improve care and reduce harm to patients.

There is now convincing evidence in some of these areas. An improved laryngeal view with most current devices has been demonstrated.[4–6] Several authors have found improved success rates, particularly among less experienced practitioners.[6–8] Improved performance in known difficult laryngoscopy by experienced practitioners has also been shown, and last year this journal went so far as to publish an editorial proposing videolaryngoscopy as a standard of care.[9 10]

However, important questions regarding the limitations of these devices in specific circumstances and their comparative performance remain unanswered. The question presents several problems: we continue to lack adequate definitions of difficult laryngoscopy and intubation, the utility of the Cormack and Lehane system is much less relevant to videolaryngoscopy, the low frequency and identification of true difficulty makes recruitment difficult, and 'difficulty' itself comes in many forms [nature and site of pathology, anatomical changes, mouth opening, failure despite good view (you see that you fail) and environment]. Second, although some studies have been performed, we lack evidence of comparative performance of all these devices.

Adequate clinical trials to address these questions are challenging to design and perform, and their absence has led to several attempts at systematic reviews or meta-analysis of the evidence that is available. Unfortunately, these have resulted in some conflicting results, and efforts have been hampered by poor quality underlying trial design, differing groups of patients (particularly 'normal' as opposed to a known or anticipated difficult airway), experienced *vs* novice practitioners, differing endpoints and the 'moving target' represented by ongoing evolution of available devices.[3 4 11] These reviews have called for prospective multicentre studies in specific populations.

Kleine-Brueggeney and colleagues[12] have addressed the question of comparative performance. They describe a three-centre prospective randomized trial involving 720 patients and six videolaryngoscopes in a controlled model of difficult intubation using a stiff cervical collar and head fixation, with the first success rate of intubation as the primary outcome. They chose three unchannelled and three channelled devices. Of the three unchannelled devices, only the McGrath did not have an acutely angled blade. The results are plausible, with significant and important differences between devices that were mirrored across the three sites and maintained after correction for multiple analyses. In their model, they found that the unchannelled, modestly curved, McGrath Series 5 performed best and was the only device with a 95% confidence interval for success >90%. They chose not to make a comparison with conventional direct laryngoscopy, maintaining that the case for superior conditions in their model was already made, although others might disagree. If, as seems likely, these results are genuine, we need to consider why they differ from those of other studies, predominantly the systematic reviews, as well as what clinical significance they have and how generalizable they are.

How do these results differ from those of others to date? There have been few studies in patients involving multiple device comparisons. Regarding the results of the systematic reviews, there is little evidence for the McGrath, but very few studies involving it were available until recently, in contrast with the GlideScope. A systematic review from 2008 essentially declared a lack of data to support any recommendations of particular devices.[4] A recent large multicentre study comparing the GlideScope with the C-MAC D-blade in 1100 patients with predicted difficult airways showed a first-attempt intubation success of 96% and 93%, respectively.[13] Although patients with limited mouth opening were included the majority were primarily obese with an increased neck circumference. It therefore seems that angled videolaryngoscopes can also perform well in some selected situations with predicted difficult airways (not perfectly, as the worst failure rate we can expect, corresponding to the upper limit of the 95% confidence interval, is higher[14]). In the paper by Kleine-Brueggeney and colleagues,[12] the authors suggest that videolaryngoscope performance may be situation specific. Clearly this has significant implications for future research. Furthermore, although limited mouth opening and restricted neck movement are common causes of difficulty, mimicking this by means of a hard, well-fitting cervical collar and stabilization is a rather specific example of these problems, so generalizing the results even to other patients with this combination may not be justified.

The authors suggest that their model is relevant to trauma, however, the time taken for intubation is a concern. If we take 60 s as a reasonable cut-off time for first-attempt success rate, none of the six devices really satisfied the requirements (success rate <70%).

What are the implications? The results, though disappointing, are important in so far as they clearly demonstrate the limits of the technology in this clinical scenario. Whether the solution is to further improve designs and use the right videolaryngoscope for the right airway scenario, as proposed by the authors, or whether these airways should be managed differently in principle, must be discussed. Recently, success with 'awake' videolaryngoscopy, with its lack of emphasis on apnoeic time, has been reported but deserves more extensive evaluation.[15–17] The possibilities around extending the safe apnoeic window and reducing the pressure on clinicians to secure an airway rapidly by use of high-flow oxygen techniques is also an area of promise.[18]

Videolaryngoscopes have been shown to improve the laryngeal view and improve the success rate of tracheal intubation, although the optimal device for specific patients and groups varies, and in genuinely difficult cases, intubation time may be prolonged. The study by Kleine-Brueggeney and colleagues[12] sets a standard for others in addressing the comparative performance of these devices in specific situations. The availability of videolaryngoscopes and skills to use them has significantly improved the options in difficult airway management, but they are not a panacea. Maximum benefit may yet come from matching difficulty with the type of device, always keeping in mind their respective limitations.

Authors' contributions

Preparation, writing and submission of the manuscript: A.N.
Preparation and writing of the manuscript: T.H.

Declaration of interest

A.N. is clinical advisor to the Centre for Healthcare Technologies, University of Nottingham and Nottingham University Hospitals NHS Trust. T.H. declares no conflicts of interest.

References

1. 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

2. Frerk C, Mitchell VS, McNarry AF, *et al*. Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. *Br J Anaesth* 2015; **115**: 827–48
3. Healy DW, Maties O, Hovord D, Kheterpal S. A systematic review of the role of videolaryngoscopy in successful orotracheal intubation. *BMC Anesthesiol* 2012; **12**: 32
4. Mihai R, Blair E, Kay H, Cook TM. A quantitative review and meta-analysis of performance of non-standard laryngoscopes and rigid fibreoptic intubation aids. *Anaesthesia* 2008; **63**: 745–60
5. 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. *Eur J Anaesthesiol* 2011; **28**: 788–95
6. Griesdale DE, Liu D, McKinney J, Choi PT. GlideScope® videolaryngoscopy versus direct laryngoscopy for endotracheal intubation: a systematic review and meta-analysis. *Can J Anaesth* 2012; **59**: 41–52
7. Nouruzi-Sedeh P, Schumann M, Groeben H. Laryngoscopy via Macintosh blade versus GlideScope: success rate and time for endotracheal intubation in untrained medical personnel. *Anesthesiology* 2009; **110**: 32–7
8. Howard-Quijano KJ, Huang YM, Matevosian R, Kaplan MB, Steadman RH. Video-assisted instruction improves the success rate for tracheal intubation by novices. *Br J Anaesth* 2008; **101**: 568–72
9. Zaouter C, Calderon J, Hemmerling TM. Videolaryngoscopy as a new standard of care. *Br J Anaesth* 2015; **114**: 181–3
10. Asai T, Liu EH, Matsumoto S, *et al*. Use of the Pentax-AWS in 293 patients with difficult airways. *Anesthesiology* 2009; **110**: 898–904
11. Suppan L, Tramer MR, Niquille M, Grosgurin O, Marti C. Alternative intubation techniques vs Macintosh laryngoscopy in patients with cervical spine immobilization: systematic review and meta-analysis of randomized controlled trials. *Br J Anaesth* 2016; **116**: 27–36
12. Kleine-Brueggeney M, Greif R, Schoettker P, Salvodelli G, Nabecker S, Theiler L. Evaluation of six videolaryngoscopes in 720 patients with a simulated difficult airway -a multicentre randomised controlled trial. *Br J Anaesth* 2016; **116**: 670–9
13. Aziz MF, Abrons RO, Cattano D, *et al*. First-attempt intubation success of video laryngoscopy in patients with anticipated difficult direct laryngoscopy: a multicenter randomized controlled trial comparing the C-MAC D-blade versus the GlideScope in a mixed provider and diverse patient population. *Anesth Analg* 2016; **122**: 740–50
14. Pandit JJ. If it hasn't failed, does it work? On 'the worst we can expect' from observational trial results, with reference to airway management devices. *Anaesthesia* 2012; **67**: 578–83
15. Asai T. Pentax-AWS videolaryngoscope for awake nasal intubation in patients with unstable necks. *Br J Anaesth* 2010; **104**: 108–11
16. Kramer A, Muller D, Pfortner R, Mohr C, Groeben H. Fibreoptic vs videolaryngoscopic (C-MAC® D-blade) nasal awake intubation under local anaesthesia. *Anaesthesia* 2015; **70**: 400–6
17. 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
18. Patel A, Nouraei SAR. Transnasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE): a physiological method of increasing apnoea time in patients with difficult airways. *Anaesthesia* 2015; **70**: 323–9