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The great airway debate: is the scalpel mightier than the cannula?

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Although anaesthetists are experts at managing a patient with airway obstruction, most have never had to perform emergency front-of-neck access (FONA) procedures. The need to resort to an emergency FONA procedure is extremely rare and may occur only once in an anaesthetist's professional lifetime.[1] Despite the low incidence of a cannot intubate, cannot oxygenate (CICO) crisis, the outcome accounts for a large proportion of airway-related deaths and is often associated with very significant morbidity.[2 3]

There is ongoing debate about whether a scalpel or a cannula is the best device to access the airway when performing a FONA procedure for CICO.[4] Regardless of this debate, most anaesthestists would agree with the criteria for an ideal FONA technique for CICO: it should be a straightforward technique that is quick to perform, with a high success rate; it should be easy to master, with only a few steps; and it should protect against aspiration and allow adequate ventilation, regardless of upper airway obstruction.[5] These criteria are met only with a scalpel technique.

The 2015 Difficult Airway Society guideline for management of an unanticipated difficult intubation has recommended a scalpel–bougie FONA procedure.[6] This recommendation is evidence based and consistent with the criteria of an ideal FONA technique. There is no clinical evidence to support cannula cricothyroidotomy in preference to a scalpel technique. Furthermore, there is no evidence that a commercial large-bore cricothyroidotomy set is superior to a scalpel–tube technique.

A scalpel–bougie technique uses equipment familiar to every anaesthetist. It is suitable for a simple standard operating procedure, which can be learned easily and used in a CICO crisis by any practising anaesthetist. Use of a scalpel, bougie, cuffed tracheal tube, and self-inflating ventilation bag permits a rapid solution to a CICO crisis, providing definitive FONA, which may be important if urgent surgery is required. The technique includes a tracheal tube, which enables safe, secure ventilation even in the presence of regurgitation or upper airway obstruction. Furthermore, a scalpel is the appropriate instrument for an open procedure when neck anatomy is impalpable percutaneously.

A recent systematic review of transtracheal jet ventilation (TTJV) by Duggan and colleagues[7] highlighted four important issues concerning emergency airway management. First, the ventilation component of FONA using TTJV is associated with device failure, severe morbidity, and mortality. Unfortunately, the importance of ventilation after FONA is often ignored during the debate about scalpel *vs* cannula. Second, there is wide variability in TTJV technique. Third, there is a high failure rate to identify the cricothyroid membrane correctly by clinical means alone. Fourth, morbidity associated with TTJV during an emergency CICO crisis is significantly higher than that occurring during elective or non-emergency use of TTJV.

Although it may seem simpler and less daunting for anaesthetists to insert a cannula into the airway rather than placing a scalpel, evidence shows that the cannula option has a high failure rate in the clinical context. Furthermore, the potential ventilation techniques following emergency cannula cricothyroidotomy can be dangerous in the case of TTJV and three-way taps; and inadequate in the case of ventilation bags attached to the cannula.[7–9] Other options remain untested in the emergency setting; there are no clinical reports of successful emergency use of the Enk oxygen flow modulator or the Rapid-O2 device. Both of these devices are T-piece variants with equivalent side-port diameter. A small volume of forward gas flow continues during the expiratory phase when the side-port is open, aggravating the risk of barotrauma in the presence of upper airway obstruction.[10] The Ventrain shows promise as a mode of cannula ventilation. As yet, this device lacks clinical published results to support its use in FONA emergencies, but unpublished case reports do confirm the efficacy of the Ventrain in this scenario (personal communication from Professor Dietmar Enk). Any FONA option that relies solely on an uncuffed cannula affords no protection against aspiration and provides only a precarious temporary airway.[11] All of these options also carry a risk of causing barotrauma in the presence of operator error and significant upper airway obstruction.

The second matter put forward by Duggan and colleagues[7] concerned a lack of standardization of the TTJV technique. Cannula type and size, oxygen source, driving pressure, and jetting frequency all varied significantly. This indicates a lack of consistent training, confusion about optimal operation of the device, and potential dysfunction during a crisis. Using a complex device

or technique during a stressful event, such as CICO, when motor skills and cognitive processing can be impaired, will lead to frequent difficulties.

The third finding confirms previous studies that have shown the difficulty of successfully identifying the cricothyroid membrane by clinical means alone.[1 12] The outcome of an emergency FONA is likely to be improved by preparation before induction of anaesthesia in all patients.[13] Identification of the trachea and the cricothyroid membrane should be an intrinsic part of any airway evaluation.[14] In many patients, this can be done by inspection, palpation, or both.[12] In the remaining patients, confirmation of anatomical landmarks can be aided by adding ultrasound-guided identification.[15] In patients for whom percutaneous access to the cricothyroid membrane might be difficult or impossible, the airway management strategy can be modified accordingly; for example, by performing an awake intubation.

The fourth finding concerned the significant difference in outcome when TTJV was used in a CICO emergency compared with elective or non-emergency use. It was found that nearly all problems associated with TTJV occur during the stressful event of a CICO emergency. Even experienced users of this technique demonstrate technical problems when exposed to stress. Other seemingly simple procedures, such as percutaneous identification of the cricothyroid membrane, reveal poor success rates of 30–40% during relatively low levels of stress. This problem highlights the difficulty of translating laboratory CICO performance using manikins, animals, or cadavers to a real clinical crisis. Performance in an unstressed environment is different from performance during a real CICO situation.

Timmermann and colleagues[4] make an important point in their defence of cannula techniques. A major determinant of outcome in severe hypoxaemic events is the decision-making that leads to decisive use of a rescue technique. It may be that anaesthetists are more comfortable with cannula techniques, although there is little evidence to support this concept. However, the high failure rates of cannula techniques and high success of scalpel techniques mean that we are obliged to address decision-making in emergency anaesthetic training to ensure that the effective intervention is carried out when indicated. The concept that an unreliable and ineffective intervention should be carried out because it is more comfortable for operators cannot be supported.[16]

Performance during stressful events has been studied for more than a century, looking at skill acquisition, fine motor control, and cognition, and their relationship to muscle size, severity of stress, task difficulty, and increasing heart rate.[17] Numerous studies have confirmed that maintenance of fine motor skills requiring accuracy and cognition demand conditions of low stress; the threading of, for example, a Seldinger wire through a Melker cricothyroidotomy set may well require such accuracy and cognition. It was found that the performance of subjects' fine motor skills deteriorated with heart rates >115 beats min^{-1}, and complex motor skills began to deteriorate above 145 beats min^{-1}. Extreme stress is associated with cognitive deterioration, perceptual narrowing, and a state of hypervigilance. At this level of stress, when heart rates can accelerate above 175 beats min^{-1}, subjects display irrational behaviour, decreased reaction times, and may freeze in place (hypervigilance). These behaviours can be identified in practitioners involved in numerous reported airway management catastrophes.

An understanding of the physiological response to stressful situations has allowed other professions to adapt their behaviour and training to minimize the impact of stress. As it is recognized that any stressful situation is likely to increase a subject's heart rate >145 beats min^{-1}, training is designed, whenever possible, to focus on gross motor skills rather than fine motor skills. Breath control and visualization techniques are practised by athletes and soldiers to control heart rate. Rehearsing performance outside the static atmosphere of a classroom helps to develop situational confidence. By training in simulated conditions of stress, a student's reaction and response times are dramatically reduced.[17]

The CICO situation is so rare in anaesthesia that there is a shortage of clinical evidence specific to the specialty. Critical events are rarely reported, and conclusions have inevitably been drawn from anecdotal human evidence, expert opinion, and non-human data, such as animal laboratories. Large series have been reported from other specialties, but these are often dismissed because they are not anaesthesia related. Rather than rejecting the observational results of performance by retrieval, emergency medicine, and military personnel, lessons should be learned from these valuable human data on emergency airway management. Understanding the impact of stress on performance might help to explain the poor results reported when anaesthetists operate jet ventilators during a CICO crisis. The outcome of the Fourth National Audit Project of the Royal College of Anaesthetists and Difficult Airway Society (NAP4) highlighted the impact of stress on anaesthetists during CICO crises while practising cannula cricothyroidotomy. An overall success rate of 37% by anaesthetists was in sharp contrast to 100% success by surgeons who used scalpels.[2] Many theories have been proposed to explain this disparity, but it is likely that the confidence and lower stress level associated with being a second responder was a factor in their success.

A large series of surgical cricothyroidotomies performed by army medics and army doctors in the field shows overall success rates of 67% for the medics and 85% for the army doctors; this, despite the fact that they are operating in conditions of extreme stress and personal danger.[18] Standard operating procedures are applied with a simple scalpel technique. This reduces the need for fine motor control. Training is designed to inspire confidence and emphasize simplicity. Equipment is standardized, and complex algorithms with multiple choices and alternative devices are eliminated. The benefit of reducing choice is consistent with several studies that have shown a significant increase in reaction time when subjects are confronted with multiple alternatives.[17] These principles have been adopted by recent airway management anaesthetic guidelines, which have moved away from the traditional menu philosophy. Instead of suggesting a range of options for CICO management, these guidelines have opted for a scalpel technique. This recommendation is based on clinical evidence, simplicity, and the ability to open the neck if necessary.

The largest single reported series of scalpel–bougie technique came from the London Air Ambulance Service. In 2014, Lockey and colleagues[19] reported 98 scalpel–bougie cricothyroidotomies with 100% success. These procedures were performed by anaesthetists and emergency medicine doctors on patients with a range of pathology and morphology. This success rate was attributed to the following factors: development of a positive mental attitude; immediate availability of equipment; the presence of a trained paramedic assistant; and a simple, well-practised technique.[20]

Several initiatives have been proposed to advance patient care during a CICO crisis. NAP4 recommended that each UK anaesthetic department should have a nominated airway lead (AWL),[21] and this was endorsed by the Royal College of Anaesthetists and Difficult Airway Society.[22] The main roles of the AWL include: (i) overseeing local airway training for anaesthetists and assisting in airway training more widely; and (ii) ensuring that

local policies exist and are disseminated for predictable airway emergency procedures included in the Difficult Airway Society guidelines.[6] A recent editorial in the *BJA* (in press) entitled, 'Surgical intervention during a CICO event: emergency FONA?' by Pracy and colleagues stresses that departments should plan multidisciplinary team rehearsals, and the AWL should be responsible for the coordination of such multidisciplinary rehearsals.

The Royal College of Anaesthetists have now appointed AWLs in ~ 94% of all hospitals in the UK. It is further envisaged that their role will be to get involved in the collection of quality data through a reporting system along the lines of NAP4. Good outcome data are necessary if we are to progress on this issue. In addition, the Royal College of Anaesthetists are working on a FONA database. The latter is essential if we are to re-audit the impact of an initiative by the Difficult Airway Society to introduce a didactic approach to the management of the rare event that is CICO. The results should help to inform the ongoing re-evaluation of the guidelines using the best evidence available.

Existing human evidence supports the use of a scalpel FONA technique. Published case reports suggest that anaesthetists are able and willing to pick up a scalpel and successfully perform a scalpel–bougie technique.[19] Fears of extensive bleeding and trauma are unfounded, and reports of significant morbidity associated with a scalpel–bougie technique are acceptably rare.[19 23]

The emergency nature and infrequency of CICO and invasive rescue techniques make it unlikely that high-quality human studies will ever be available to support our choice of techniques. However, what is clear from observational studies is that cannula techniques cannot be relied upon to save lives and prevent severe morbidity. With appropriate training, scalpel techniques are reliable and easy to perform and have the potential to reduce mortality and morbidity in time-critical airway emergencies.

Declaration of interest

None declared.

References

1. Elliott DS, Baker PA, Scott MR, Birch CW, Thompson JM. Accuracy of surface landmark identification for cannula cricothyroidotomy. *Anaesthesia* 2010; **65**: 889–94
2. Cook TM, Woodall N, Frerk C; Fourth National Audit Project. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 1: anaesthesia. *Br J Anaesth* 2011; **106**: 617–31
3. Peterson GN, Domino KB, Caplan RA, Posner KL, Lee LA, Cheney FW. Management of the difficult airway: a closed claims analysis. *Anesthesiology* 2005; **103**: 33–9
4. Timmermann A, Chrimes N, Hagberg CA. Need to consider human factors when determining first-line technique for emergency front-of-neck access. *Br J Anaesth* 2016; **117**: 5–7
5. Hamaekers AE, Henderson JJ. Equipment and strategies for emergency tracheal access in the adult patient. *Anaesthesia* 2011; **66**(Suppl 2): 65–80
6. 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
7. Duggan LV, Ballantyne SB, Law JA, Morris IR, Murphy MF, Griesdale DE, *et al*. Transtracheal jet ventilation in the 'can't intubate, can't oxygenate' emergency: a systematic review. *Br J Anaesth* 2016; **117**(Suppl. 1): i28–i38
8. Hamaekers AE, Borg PA, Enk D. A bench study of ventilation via two self-assembled jet devices and the Oxygen Flow Modulator in simulated upper airway obstruction. *Anaesthesia* 2009; **64**: 1353–8
9. Hooker EA, Danzl DF, O'Brien D, Presley M, Whitaker G, Sharp MK. Percutaneous transtracheal ventilation: resuscitation bags do not provide adequate ventilation. *Prehospital Disaster Med* 2006; **21**: 431–5
10. Baker PA, Brown AJ. Experimental adaptation of the Enk oxygen flow modulator for potential pediatric use. *Paediatr Anaesth* 2009; **19**: 458–63
11. Nolan JP, Soar J, Zideman DA, *et al*. European Resuscitation Council Guidelines for Resuscitation 2010 Section 1. Executive summary. *Resuscitation* 2010; **81**: 1219–76
12. Bair AE, Chima R. The inaccuracy of using landmark techniques for cricothyroid membrane identification: a comparison of three techniques. *Acad Emerg Med* 2015; **22**: 908–14
13. Siddiqui N, Arzola C, Friedman Z, Guerina L, You-Ten KE. Ultrasound improves cricothyrotomy success in cadavers with poorly defined neck anatomy: a randomized control trial. *Anesthesiology* 2015; **123**: 1033–41
14. Kristensen MS, Teoh WH, Baker PA. Percutaneous emergency airway access; prevention, preparation, technique and training. *Br J Anaesth* 2015; **114**: 357–61
15. Kristensen MS, Teoh WH, Rudolph SS. Ultrasonographic identification of the cricothyroid membrane: best evidence, techniques, and clinical impact. *Br J Anaesth* 2016; **117** (Suppl. 1): i39–i48
16. Asai T. Surgical cricothyrotomy, rather than percutaneous cricothyrotomy, in "cannot intubate, cannot oxygenate" situation. *Anesthesiology* 2016; **8**: 8
17. Siddle BK. Sharpening the Warrior's Edge: the Psychology and Science of Training. Millstadt, IL, USA: PPCT Management Systems Inc., 1995
18. Mabry RL. An analysis of battlefield cricothyrotomy in Iraq and Afghanistan. *J Spec Oper Med* 2012; **12**: 17–23
19. Lockey D, Crewdson K, Weaver A, Davies G. Observational study of the success rates of intubation and failed intubation airway rescue techniques in 7256 attempted intubations of trauma patients by pre-hospital physicians. *Br J Anaesth* 2014; **113**: 220–5
20. London Air Ambulance's approach to advanced airway management. Available from http://oupacademic.tumblr.com/post/92431206171/podcast-bja-special-issue (accessed 14 June 2016). 2014
21. Cook TM, Woodall N, Frerk C. The College Department Airway Lead and NAP4 follow-up surveys: an announcement. *Bull R Coll Anaesth* 2012; **76**: 37–8
22. Royal College of Anaesthetists-Difficult Airway Society Airway Leads. Available from http://www.rcoa.ac.uk/clinical-standards-quality/rcoa-das-airway-leads (accessed 14 June 2016)
23. Paix BR, Griggs WM. Emergency surgical cricothyroidotomy: 24 successful cases leading to a simple 'scalpel–finger–tube' method. *Emerg Med Australas* 2012; **24**: 23–30