Percutaneous emergency airway access; prevention, preparation, technique and training

M. S. Kristensen1*, W. H. L. Teoh2 and P. A. Baker3

1 Department of Anaesthesia, Centre of Head and Orthopaedics, Rigshospitalet, University Hospital of Copenhagen, Blegdamsvej 9 DK-2100, Denmark
2 Senior Consultant Anaesthesiologist, Wendy Teoh Pte.Ltd. Visiting Consultant, Department of Women’s Anaesthesia, KK Women’s & Children’s Hospital, Singapore
3 Department of Anaesthesiology, University of Auckland and Starship Children’s Hospital, Auckland, New Zealand

* Corresponding author: E-mail: michael.seltz.kristensen@regionh.dk

The study by Howes and co-workers in a recent issue of the British Journal of Anaesthesia gives us the opportunity to put the ‘Cannot Intubate Cannot Ventilate’ (CICV) situation and the percutaneous emergency airway access (PEAA) into context: how can we reduce the need for it and prepare for it? Which techniques should we use for it? And how do we teach it?

Prevention and preparation

We should be mindful that not every CICV situation occurs out of nowhere. Failure to intubate and ventilate can be predicted to some, useful, extent when preoperative airway assessments are performed, thereby allowing the clinician to choose an alternative approach to airway management, such as an awake intubation. The likelihood of having difficulty in locating the cricothyroid membrane (CTM) and in performing percutaneous emergency airway access must also be assessed before induction of anaesthesia. Should the need for an emergency percutaneous airway access arise, we can optimize the likelihood of success by identifying the trachea and the CTM before induction of anaesthesia. In slim patients, without airway pathology, this can be done by inspection and/or palpation alone, but in morbidly obese patients, clinical identification alone may be unreliable and ultrasonographic identification of the CTM offers an attractive alternative.

How to do it - which techniques should we use?

It is an interesting finding in the recent work of Howes and co-workers that the small-bore cannula had a strikingly low success-rate in the ‘morbidly obese’ manikin and, that when this technique failed, the majority of participants used a surgical approach as their second choice and succeeded. This suggests that no matter which approach is used initially, all anaesthetists should be able to perform a surgical technique and that the surgical approach should be considered as the first technique more often.

Since the first description of tracheostomy around 2000 BC many procedures and techniques have been described, lost and re-invented. Despite this long history, the optimum technique for PEAA is still debated. Ideally, PEAA should result in a high success rate and a low complication rate; it should be easy to master, involve only a few steps, provide protection against aspiration and allow adequate ventilation, regardless of upper airway obstruction. PEAA can be achieved by one of three techniques: surgical incision with a scalpel, narrow cannula-over-needle or large bore cannula (usually ≥4 mm) over a wire or trochar. Surgical tracheotomy was the norm until Toye and Weinstein described needle cricothyroidotomy and catheter ventilation in 1969. This technique was promoted as being faster and safer than surgical dissection. An algorithm for CICV proposed by Heard and colleagues promoted cannula cricothyroidotomy or tracheotomy as first-line treatment. The notion that a cannula is less invasive than a scalpel, that a cannula is familiar to all anaesthetists and is readily available, is appealing to many practitioners. It is also believed that anaesthetists feel more comfortable using a needle than a scalpel.

In reviews of studies concerning emergency cricothyroidotomy, the authors concluded that there was insufficient
evidence to conclude that any one technique was better than another, due to the low or very low quality of the evidence in many of the studies. A meta-analysis of pre-hospital airway control techniques looked at 35 studies, involving 2005 patients, and found that of those, 27 patients who received a needle cricothyroidotomy, the overall success rate was 65.8%. In the 485 patients who received a surgical cricothyroidotomy, the pooled success rate was 90.5%. In 28,939 patients who received pre-hospital physician care, 48 received a surgical airway (primary and rescue) with 100% success. In 72 surgical airways from the battlefield performed by army medics and military doctors the success rates were 67% and 85% respectfully. In 19,831,189 Emergency Medical Service activations in the USA by paramedics there were 1332 cricothyroidotomies (needle and surgical) with a success rate of 34.3%. There are no human series of needle cricothyroidotomies with a high success rate, and the low overall success rate (34.3%) in this series may reflect the inclusion of needle cricothyroidotomies, along with the inexperience of the providers. There is little evidence to support the view that cannula cricothyroidotomy is the best option. Percutaneous identification of landmarks for cricothyroidotomy by anaesthetists is poor. In the NAP4 audit, 15 out of 29 (52%) cannula cricothyroidotomies performed by anaesthetists failed, compared with surgical cricothyroidotomy or tracheotomy performed by surgeons with a success rate of 100%. There may have been a reporting bias in NAP4 towards unfavourable outcomes and, therefore, successful cannula cricothyroidotomy might not have been reported. Failure could be attributed to patient factors affecting the identification of anatomical landmarks, such as neck positioning or obesity or to equipment issues, poor insertion techniques, incorrect cannula ventilation methods and inadequate training. Inexperience and psychological stress may also contribute to poor outcome due to a tendency to fixate on supraglottic airway management. Stress with increasing heart rate has a deleterious effect on vision, cognitive processing and motor skill performance. Anaesthetists are certainly less practised at performing PEAA compared with non-anaesthetists who work in emergency medicine, retrieval and military environments. In these groups, surgical techniques predominate, with success rates consistently higher than cannula techniques. There is insufficient evidence to support the third option of cricothyroidotomy kits. These devices are associated with multiple steps, prolonged insertion times and more complications than a standard surgical technique.

Most current guidelines recommend that practitioners involved in airway management should be proficient in surgical and cannula cricothyroidotomy. The Canadian Airway Focus Group guidelines now limit treatment options to large bore cannula or scalpel techniques for cricothyroidotomy, unless the practitioner is very experienced with translational jet ventilation (TTJV). Serious morbidity and mortality can arise from failed ventilation, often due to inexperience or inappropriate ventilation in the presence of upper airway obstruction. In a review of claims concerning management of the difficult airway in the ASA Closed Claims study, 26 needle cricothyroidotomy cases were reported and all had a poor outcome. Where TTJV was used, 89% developed pneumothorax, pneumomediastinum or subcutaneous emphysema. Alternative ventilation techniques have been promoted to mitigate these risks using flow regulated volume ventilation such as the Enk oxygen flow modulator, Y connectors and the Ventrain. Regardless of the ventilation technique, the use of a small-bore cannula results in a temporary airway, which is vulnerable to displacement, kinking and aspiration and which needs to be converted to a larger-diameter cuffed tube before surgery or ventilator treatment can be initiated.

Surgical techniques vary in complexity. The simplest approach is the ‘scalpel-finger-tube’ method involving a stab incision through the CTM, removal of the scalpel, insertion of a finger to dilate the wound and advancement of a tracheal tube into the airway. Two techniques have been developed to prevent the loss of the incision during the tube insertion: the ‘rapid 4-step technique’ involving a tracheal hook and ‘the scalpel bougie technique’. This requires very little equipment and can be completed rapidly with a high success rate. A third and simpler variant involves a horizontal scalpel stab incision through the CTM, rotation of the scalpel into a vertical plane, insertion of the bougie down the trachea to stabilise the airway, removal of the scalpel and railroad of a cuffed 6.0 tracheal tube. If the anatomical landmarks cannot be identified percutaneously in a timely manner, the first step involves a vertical midline anterior neck incision followed by blunt digital dissection to identify the CTM or trachea prior to a scalpel-bougie or a hook-tube technique. The endpoint of these techniques is a cuffed tracheal tube that protects the airway from aspiration and facilitates ventilation with an anaesthetic circuit or ventilation bag, even in the presence of upper airway obstruction (Fig. 1). For PEAA in smaller children a tracheal access is necessary and a surgical scissors-based technique had a high success rate in an animal model.

How should we teach?

Most anaesthetists acquire their procedural skills at work using the traditional apprenticeship model described by William Halstead over 100 years ago. That form of experiential learning works well for techniques which can be applied regularly, using methods of deliberate practice and distributed learning. The skill of cricothyroidotomy, however, cannot be acquired in this way and, therefore, the majority of anaesthetists lack the skill and experience to perform this technique proficiently. Evidence from the NAP4 study suggests that anaesthetists perform poorly when required to achieve PEAA. This is not surprising, considering that the average anaesthetist may perform this procedure only once in their professional lifetime. Unfamiliarity with PEAA leads to hesitancy and delays. This was shown in the ASA Closed Claims study where a surgical airway was achieved too late to avoid a poor outcome in two thirds of claims. Simulation training can help compensate for this inadequate clinical experience and offers an obvious alternative to the Halstead method for learning PEAA.
A key issue in simulation training is the transfer of simulator learning to clinical performance. To maximize this transfer, educational goals and learner ability should be aligned with the type of simulator in order to reduce the gap between simulation and clinical reality. Research has repeatedly shown that the transfer of learning from one entity to another depends on the overlapping conditions between those two entities. In a recent issue of the British Journal of Anaesthesia, Howes and colleagues describe the modification of a model to replicate a thick or burnt neck for PEAA training. In this example the educational goal is to prepare anaesthetists to manage PEAA on normal anatomy, a very simple model will suffice. Friedman and colleagues compared the cricothyroidotomy performance of two groups of anaesthetic trainees using either a high fidelity full-scale Sim-Man (Laerdal Medical, Stavanger, Norway) or a homemade model made out of tape and anaesthetic circuit. A subsequent cricothyroidotomy performed by both groups on a cadaver with normal anatomy found no difference in performance between the two groups. Simple models are particularly helpful to the novice learner to establish basic skills, but do not improve learning curves or skill retention for more advanced procedures such as an obese or distorted neck. Furthermore, advanced learners will benefit more from higher fidelity simulators, which can reproduce more complex tasks. Therefore, the experience of the learner and the associated educational goal should match the fidelity of the simulator.

The fidelity of many commercially available airway manikins has come under scrutiny. While nominally, airway manikins are based on normal anatomy, anatomical dimensions of the upper airway deviate significantly from human anatomy. These issues highlight the need to improve the fidelity of PEAA simulators, to mimic our real-life patients, as done by Howes and co-workers, to meet the educational goals of instructors and enhance the expertise and learning opportunities of trainees.

The concept of regular compulsory training for clinical competence requires robust assessment to ensure an adequate standard of comprehension and performance. Each clinical fundamental should be teachable, learnable and measurable but a training programme, which does not close the loop by being measurable, potentially exposes patients to suboptimal care. In the case of CICV, this could result in brain damage or death. The Australian and New Zealand College of Anaesthetists (ANZCA) recently introduced a new competency-based medical education curriculum which includes a CICV module that must be repeated at regular intervals. A minimum of two of these modules must be completed, per triennium. Procedural skill will inevitably decay without regular practice, but the rate of skill decay and the interval between cricothyroidotomy training, needs to be determined. Limited research has been directed toward these questions but studies suggest that cricothyroidotomy skill could be retained for at least one year. Simple attendance at a course does not guarantee learning and performance. If performance during training is to become a requirement for on-going certification, it is essential that a valid and reliable form of assessment is used.

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**Flowchart for performance of the default percutaneous emergency airway access.**

Always attempt to identify the cricothyroid membrane before induction of anaesthesia

**Fig 1**

**Can you identify the cricothyroid membrane?**

**YES**

Use a horizontal scalpel stab incision through the cricothyroid membrane, stabilise with a hook or a bougie, advance a 6.0 mm cuffed ET tube

**NO**

Make a longitudinal midline scalpel neck incision. Use digital blunt dissection. Palpate the cricothyroid membrane or trachea

Ventilate through a size 6.0 mm ET tube with a ventilation bag or an anaesthetic circuit

**Cannot intubate, cannot ventilate**

Can you identify the cricothyroid membrane?
Within the framework of competency based medical education, a syllabus needs to be defined in order to ensure completeness and consistency of training. In the context of PEAA, ANZCA have stipulated familiarity with procedures and equipment using simulation training. Human factor training is also specified to address issues surrounding transition from supraglottic to infraglottic rescue and other aspects of crisis resource management. Uncertainty when diagnosing and declaring a CICV emergency, fixation with supraglottic care, and team management are included in the syllabus. In the open-for-all-nationalities Scandinavian ‘airway-management-for-anaesthesiologists’ non-profit training (www.airwaymanagement.dk), all anaesthetists must obtain both theoretical and hands-on competence in all three (small bore cannula, large bore cannula and scalpel-based) ways of performing PEAA, so that they can choose the technique that suits the clinical situation best.

In conclusion, the need for PEAA should be reduced by the performance of an airway evaluation and subsequent awake securing of the airway in high-risk patients. The likelihood of successful PEAA should be enhanced by locating the trachea and CTM in all patients before airway management and by regular training with a PEAA technique that is simple to learn and has the highest chance of a successful outcome for the patient. Training should emphasize rapid diagnosis and transition from supraglottic to a PEAA technique. A small bore/needle technique is a temporary airway with a high failure rate, as seen in a realistic training setting, whereas a simple surgical technique has a high success rate, and results in a cuffed tube in the trachea that allows the continuation of surgery and ventilator treatment. A surgical technique must be mastered by all anaesthetists and should be considered the default technique. We should develop, and train on, manikins that mimic difficult patients, such as those described by Howes and colleagues.

**Declaration of interest**

None declared.

**References**

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Peripheral neuropathic pain: signs, symptoms, mechanisms, and causes: are they linked?

L. A. Colvin1* and P. M. Dougherty2

1 Department of Anaesthesia, Critical Care and Pain Medicine, University of Edinburgh, Western General Hospital, Crewe Rd, Edinburgh EH4 2XU, UK
2 Department of Anesthesiology and Pain Management, The University of Texas M.D. Anderson Cancer Center, 1400 Holcombe Boulevard Unit 409, Houston, TX 77030, USA

* Corresponding author. E-mail: lesley.colvin@ed.ac.uk

Neuropathic pain is a particularly distressing chronic pain syndrome, affecting between 2% and 8% of people with a major impact on quality of life.1 2 Peripheral neuropathic pain, defined as ‘Pain caused by a lesion or disease of the peripheral somatosensory nervous system’ (IASP, 2011), is a common and challenging chronic pain syndrome, with a range of diverse aetiologies. Broadly speaking, these can be divided into neural damage as a result of systemic processes such as disease, toxins, or drugs, often with a classical ‘glove and stocking’ distribution; or secondary to local damage such as trauma, surgery, or locally invasive malignancy.

The diagnosis of neuropathic pain can be difficult, particularly for non-specialists, with new diagnostic criteria developed recently.1–5 It is well recognized that there are several symptoms typically associated with neuropathic pain, leading to the development of a number of screening tools.6 While many of the tools have similar components, there are some differences that are likely, at least in part, to be due to development in patient populations with different types of neuropathic pain.7

There are two important questions: first, how does the clinical presentation (signs and symptoms) correlate with the underlying neurobiology and secondly, what influence does the aetiology have on these neurobiological changes that may occur? The ongoing challenge for clinicians (and patients) remains the frustration of not being able to determine which treatment is most likely to work for any one individual.

Neurobiology and translation to clinical presentation

Much of our understanding of the neurobiological changes in neuropathic pain has come from the study of animal models, although there has been significant recent debate over the utility of these.8 This has centred on a perceived failure of translation of basic science data into effective new medications, which may have several possible reasons.9 One concern is the reliance of preclinical studies on reflexive measures, while human pain includes higher order processes that may not be captured in these types of assays. Another is that animal models of disease may not adequately recapitulate the physiological basis of nociception, led to the identification of neurotransmitters, receptors, intracellular messengers, and genes involved in pain signalling; and in understanding the basic mechanisms of many effective pain treatments.10 31

The majority of clinical trials have previously relied solely on subjective pain intensity rating measures. Given the wide-ranging spectrum of factors that this type of rating might encompass...