Academic Emergency Medicine
Official Journal of the Society for Academic Emergency Medicine

COMMENTARY

Evidence Is Important: Safety Considerations for Emergency Catheter Cricothyroidotomy

It is an unarguable truth that providing appropriate training and equipment leads to improved outcomes in emergencies. Unfortunately, all too often the training and equipment are suboptimal and designed without sufficient attention to current evidence or an appreciation of the context of the emergency. Perhaps the starkest of these examples is in the provision of equipment and training for performance of the emergency surgical airway. A large, nationwide, year-long audit in the United Kingdom has shown that success rates for emergency cricothyroidotomy are highly variable.[1] Singled out for particular criticism has been the catheter or "needle" method of accessing the airway and this is likely to be almost solely due to a lack of appropriate equipment and training. This commentary will outline the elements of safe practice of catheter cricothyroidotomy based on evidence from clinical and animal studies. The equipment, technique, and potential complications will be reviewed.

The provision of oxygen via a catheter placed through the front of the neck into the trachea was first described by Jacoby and colleagues some 60 years ago.[2] Although an inherently risky technique, in the past decade the technique has been scrutinized and refined based on data from elective head and neck surgery, animal, and mannequin-based simulation studies such that complication rates are now significantly lower.[3,4] Catheter cricothyroidotomy provides some advantages over scalpel techniques in terms of lower psychological barriers to perform them and the ability to proceed to other more aggressive techniques should they fail.[5] In the hands of appropriately trained practitioners it is likely that failure rates of emergency scalpel and catheter techniques for airway access are similar.[6]

TYPE AND SIZE OF CATHETER

Only large-bore catheters should be used for access to the airway as they are more resistant to occlusion and provide a more reliable flow of oxygen. A detailed analysis of intravenous catheters shows that smaller gauge devices are more likely to be compressed and to fail during emergency rescue techniques.[1,7] In the UK's 4th National Audit Project (NAP4) of airway management complications, failure occurred in 12 of the 19 attempts at rescue using cricothyroid membrane puncture with a narrow-gauge catheter (<2-mm diameter, equivalent to catheters smaller than 14 gauge).[1] Kinking of the device is the commonest complication of percutaneous approaches to the trachea. To prevent kinking the physical properties of the catheter that determine its "memory" (the property of the plastic to return to its original, straight, patent shape after kinking occurs) in addition to the size of the catheter need to be taken into account.[7] The use of an InSyte 14-gauge intravenous catheter (Becton Dickinson) as suggested by Heard and colleagues[8] has shown to have a lower incidence of occlusion than some purpose made catheters such as the Ravussin (VBM Medizintechnik GmbH-Germany) because of its ability to return to its original shape.

OXYGEN INSUFFLATION DEVICE

Lower-pressure devices such as connection to self-inflating bags provide insufficient pressure to reliably deliver enough oxygen to the alveoli. The success of any attempt at a catheter technique requires that the equipment for high-pressure oxygen insufflation is easy to assemble and predictable for the user. Hospitals in Australia and New Zealand are increasingly stocking prepackaged "can't intubate, can't oxygenate" (CICO) kits in critical care areas such as operating rooms and emergency departments. These kits include a cheap, easy to use device for oxygen delivery such as the RapidO2 (Meditech Systems Ltd) or Enk oxygen flow modulator (Cook Medical). Importantly, these devices also allow venting of insufflated gas via the catheter, even when the upper airway is completely obstructed, provided that adequate time is allowed between each insufflation.[8]

CATHETER PLACEMENT

The conventional caudal angulation of the catheter is advocated for cricothyroid puncture as it has been recognized for many years that angulation of the catheter from the cricothyroid membrane in a cephalad direction leads to a significant chance of damage to the vocal cords from the catheter. In a cadaveric model, vocal

Dr Marshall is in receipt of a research grant from the Australian and New Zealand College of Anaesthetists to explore decision-making in airway management that is unrelated to this submission.

ISSN 1069-6563
PII ISSN 1069-6563583

doi: 10.1111/acem.13037

cord damage was seen in 8% (3/37) of retrograde intubations and the figure in live patients is estimated to be substantially higher.[9] Placement of the catheter must be undertaken using an aspiration technique to ensure the catheter is within the trachea before insufflation occurs. Aspiration of air through a syringe half-filled with saline is preferred during and after placement of the catheter. This minimizes the chance of insufflation of gas into the tissues that will make further attempts at tracheal access more difficult.[7]

FREQUENCY AND DURATION OF GAS INSUFFLATION

The ability of gas to leave the airway and lungs is of critical importance to prevent barotrauma during catheter insufflation. An oxygen flow of 15 L/min equates to the insufflation of 250 mL/sec making the time required to produce dangerously high intrathoracic pressures if the upper airway is completely obstructed a matter of several seconds. It is highly likely in a true CICO emergency that the upper airway will be significantly if not completely obstructed, particularly when no active measures to keep it open are being implemented. While the obstruction may in the first instance be due to foreign material such as vomit or blood, it is also frequently aggravated by edema due to pathologies such as infection, tumor, anaphylaxis, or trauma that may be worsened by repeated attempts at airway instrumentation. The jet of oxygen from below cannot be relied upon to overcome difficult upper airway anatomy or obstruction. Guidelines produced by centers where transtracheal methods are used for elective surgery typically advocate that a second operator must actively take steps (such as jaw thrust, oropharyngeal airway, or supraglottic airway placement) to open the airway before gas is insufflated to minimize the risk of barotrauma.[3]

METHOD OF OXYGEN INSUFFLATION

Given the inability to rely on the patency of the upper airway to vent insufflated gas in the CICO scenario, safe practice of catheter insufflation requires meticulous attention to the volume and frequency of oxygen insufflation as well as the use of equipment that permits expiration via the catheter between inspiratory jets.

It is crucial to appreciate that the goal of insufflation is oxygenation not ventilation. Consequently, the numerical value of normal minute ventilation has no relevance to determining the required oxygen delivery when insufflating 100% oxygen via a cricothyroid catheter. Heard and colleagues have, via thousands of trials on a live sheep model, determined that an initial 4-second initial insufflation (1 L at 15 L/min oxygen flow) is sufficient to provide initial recovery of oxygenation.[7,8] Having restored oxygen saturation to safe levels, subsequent insufflations of 2 seconds′ duration (500 mL at 15 L/min) should only be delivered once oxygen saturations measurements begin to decline. In practice, the oxygen saturation levels may take in excess of 1 or 2 minutes to fall, meaning the insufflations need not be as frequent and risk of barotrauma further minimized even in a completely obstructed upper airway.[7,8] Any practitioner using this technique must still be vigilant for chest rise and fall with insufflation and signs of subcutaneous emphysema or pneumothorax and cease insufflation immediately if these occur.

EVIDENCE OF SAFETY AND NEED FOR ONGOING TRAINING

As already noted, transtracheal ventilation has been used and refined for decades in elective and emergency settings. Emergency use of transtracheal ventilation is difficult to study because of the rarity and unpredictability of the need for the technique. Nevertheless, substantial numbers of cases on anesthetized sheep have been performed in simulated conditions. A surgical airway program has been run in Western Australia since 2003 where over 10,000 surgical airways have been performed by anesthesiologists, emergency physicians, and others in a simulated operating theater. These observations have led to an evidenced-based algorithm for cricothyroidotomy access,[10] freely available instructional videos,[8] and a book describing the evidence in detail.[7] This method is the most commonly taught in Australia and New Zealand because of the substantial evidence behind it and its applicability to the operating room context. Training is now also mandated for anesthesiologists once during their training and for attendings every 3 years to maintain currency. There are now many anecdotal reports where this technique was successful, with few reports of complications from barotrauma or surgical emphysema when the prescribed technique was employed.

CONCLUSION

As with all emergency procedures such as cardiac arrest or trauma management, success is dependent on an evidence-based technique that is trained and supported by the correct equipment. Recent research has demonstrated that with the appropriate equipment and training catheter cricothyroidotomy can be safe and effective in rescuing patients from CICO situations. The equipment need not be expensive but should be preprepared and immediately available. The training need not be onerous, but should be standardized and in keeping with the evidence of what equipment and techniques work safely from clinical and simulation experience.

I thank Dr. Nicholas Chrimes and Dr. Andrew Heard for their advice and for sharing their experience in the preparation of this article.

Stuart Duncan Marshall, MB.ChB, PhD, M.Human Fact., MRCA, FANZCA
(stuart.marshall@monash.edu)
Department of Anaesthesia and Perioperative Medicine
Monash University
Australian Centre for Health Innovation
Melbourne, Australia

Supervising Editor: John H. Burton, MD.

References

1. Cook T, Woodall N, Frerk C. 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.
2. Jacoby JJ, Hamelberg W, Ziegler CH, Florey FA, Jones RJ. Transtracheal resuscitation. J Am Med Assoc 1956;162:625–8.
3. Cook TM, Alexander R. Major complications during anaesthesia for elective laryngeal surgery in the UK: a national survey of the use of high-pressure source ventilation. Br J Anaesth 2008;101:266–72.
4. Ross-Anderson DJ, Ferguson C, Patel A. Transtracheal jet ventilation in 50 patients with severe airway compromise and stridor. Br J Anaesth 2010; 106:140–4.
5. Watterson L, Rehak A, Heard A, Marshall S. Transition from supraglottic to infraglottic rescue in the "can't intubate can't oxygenate" (CICO) scenario. Melbourne: Australian and New Zealand College of Anaesthetists, 2014.
6. Langvad S, Hyldmo PK, Nakstad AR, Vist GE, Sandberg M. Emergency cricothyrotomy–a systematic review. Scand J Trauma Resusc Emerg Med 2013;21:43.
7. Heard AM. Percutaneous Emergency Oxygenation Strategies in the "Can't Intubate, Can't Oxygenate" Scenario. Perth, Western Australia: Smashwords, 2013.
8. Heard AM. CICO airway management: percutaneous emergency oxygenation techniques. 2013. Available from: https://www.youtube.com/user/DrAMBHeardAirway. Accessed May 28, 2016.
9. Shantha TR. Retrograde intubation using the subcricoid region. Br J Anaesth 1992;69:542–5.
10. Heard AM, Green RJ, Eakins P. The formulation and introduction of a 'can't intubate, can't ventilate' algorithm into clinical practice. Anaesthesia 2009;64: 601–8.