Case Report

Cannula cricothyroidotomy and rescue oxygenation with the Rapid-O2™ oxygen insufflation device in the management of a can't intubate/can't oxygenate scenario

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Summary

We describe the successful use of cannula cricothyroidotomy and the Rapid-O2™ oxygen insufflation device (Meditech Systems Ltd, Dorset, UK) for rescue of a can't intubate/can't oxygenate (CICO) scenario in a patient with severe airway haemorrhage post-debridement of laryngeal amyloidosis. This case highlights the practical utility of a cannula technique for CICO rescue when appropriate equipment is used and when institutional measures are taken to prepare for this rare anaesthetic crisis.

Key Words: cricothyroidotomy, cannula, airway emergency, airway obstruction

A can't intubate/can't oxygenate (CICO) scenario arises when attempts at oxygenation of the patient via the anatomical conduits of the upper airway have failed. In such a scenario, the creation of a patent airway via the front of the neck by way of cricothyroidotomy or tracheotomy remains the only option for rescue oxygenation. A variety of rescue techniques are advocated, including cannula-, or scalpel-based techniques as well as wire-guided techniques, currently with no strong evidence to support the superiority of any given technique. Regardless of technique chosen, the CICO scenario in anaesthetic practice is often poorly managed with potentially catastrophic outcomes[1]. Important contributory factors include institutional ill-preparedness and equipment not fit-for-purpose. We report a case of successful CICO rescue with cannula cricothyroidotomy and re-oxygenation using the Rapid-O2™ oxygen insufflation device (Meditech Systems Ltd, Dorset, UK) at a hospital in which a systems approach to CICO preparedness had been adopted, including standardisation and point-of-care placement of equipment, multidisciplinary CICO training and adoption of an algorithmic approach to CICO rescue. The educational objective of this report is to highlight the importance of a systems-oriented and human factors approach to CICO management, and to increase awareness in the anaesthetic community of the potential merits of the Rapid-O2 oxygen insufflation device in cannula-based CICO rescue techniques. Consent for this publication was obtained from the patient.

Case history

A 53-year-old male with a locally aggressive form of laryngeal amyloidosis was admitted to hospital for periglottic debridement due to increasing dyspnoea, stridor and dysphonia. Over the preceding four years he had undergone multiple debridements for removal of amyloidosis-affected laryngeal tissue including a partial vocal cord resection. Prior anaesthetics were largely uneventful.

After induction of anaesthesia, attempts at bag–mask ventilation and intubation by direct laryngoscopy were unsuccessful. The patient was intubated by the ear, nose, and throat surgeon using a suspension laryngoscope and a size 5 microlaryngeal tube. In order to facilitate surgical access, airway management involved intermittent extubation and reintubation by the surgeon.

Intraoperative findings included infiltrative amyloidosis throughout the glottic and supraglottic regions. At case completion, significant bleeding was noted and measures were undertaken to achieve haemostasis with cautery and topical haemostatic agents. Once haemostasis and airway patency were achieved, the patient was transported to the recovery room where he was extubated.

Within minutes of extubation, copious amounts of fresh blood were observed in the oropharynx leading to complete upper airway obstruction and rapid desaturation. The

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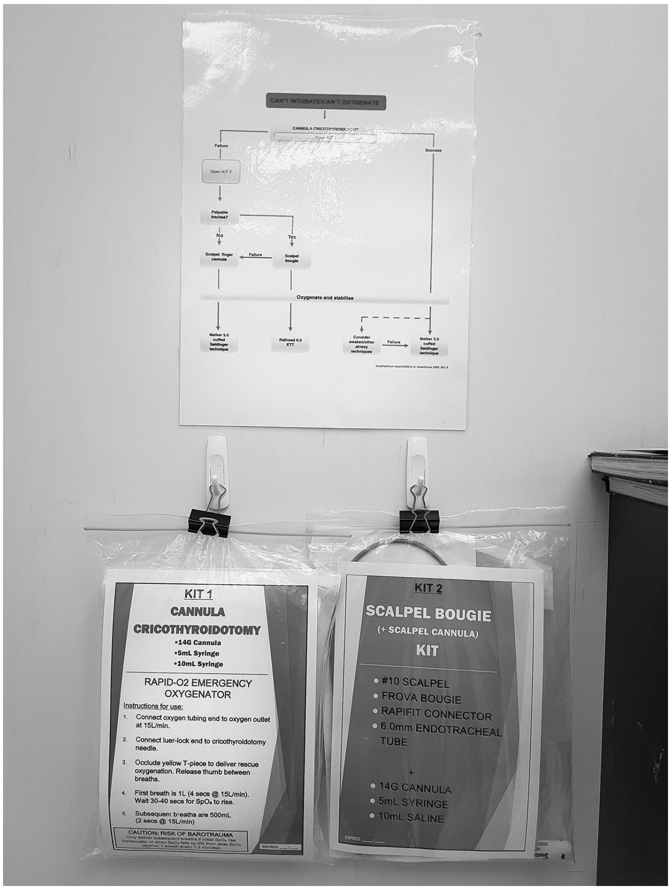

Figure 1: Contents of Kit 1—14G cannula, 5 ml syringe, ampoule of normal saline and Rapid-O2™ oxygen insufflation device (Meditech Systems Ltd, Dorset, UK). Contents of Kit 2—#10 scalpel, Frova Intubating Introducer (Cook Medical, Bloomington, IN, USA), Rapi-Fit® adaptor (Cook Medical, Bloomington, IN, USA), 6.0 mm endotracheal tube.

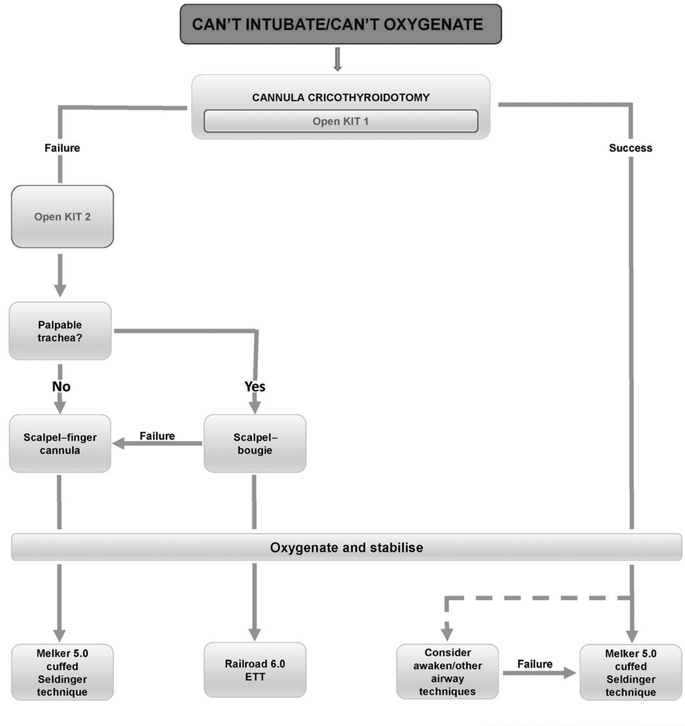

Figure 2: CICO algorithm. CICO, can't intubate, can't oxygenate; Melker, Melker™ Universal Emergency Cricothyrotomy Catheter Set (Cook Medical Inc, Bloomington, IN, USA); ETT, endotracheal tube.

anaesthetist and surgeon were recalled and preparations were made to reintubate the patient. After administration of propofol and suxamethonium, intubation attempts were unsuccessful due to copious bleeding, despite the use of two suction catheters.

A decision was made to perform cricothyroidotomy, for which a cannula cricothyroidotomy kit was requested. As part of recently implemented measures for preparedness for CICO crises, two pre-assembled CICO rescue kits ('kit one' for cannula cricothyroidotomy and 'kit two' for scalpel bougie) were available in a visible location on the walls of all operating theatres, recovery room and satellite locations in our hospital (Figure 1). A printed algorithm to aid in the management of CICO accompanies the kits and is based on the work of Heard et al[2] (Figure 2), whereby cannula cricothyroidotomy is recommended as the first-choice oxygenation conduit, followed by scalpel techniques in the event of cannula failure. Education on the use and location of these kits as well as the algorithmic approach to CICO is provided to anaesthetic and recovery room staff on a regular basis. Due to the proximity of the kits and high level of nursing staff awareness as to their location, a delay of only seconds occurred in delivering the necessary equipment to the bedside once a CICO crisis was declared.

Coincident with the receipt of the cannula cricothyroidotomy kit, the patient was observed to be in pulseless electrical activity (PEA) as evidenced by the absence of an arterial pulse or pulse oximetry trace. However, neither chest compressions nor adrenaline were commenced at this stage as the cause of the PEA was attributed to hypoxaemia and cannula cricothyroidotomy was set to be performed. After successful cannula cricothyroidotomy, oxygen insufflation via the Rapid-O2 oxygen insufflation device was commenced immediately, resulting in oxygen saturation increasing to 60% within seconds and the resumption of spontaneous circulation as evidenced by a palpable pulse. The patient was subsequently intubated successfully with the assistance of a bougie and was taken back to the operating theatre for formal tracheostomy formation. There was no neurological deficit upon wake-up and the patient was discharged home a few days later.

Discussion

This case demonstrates the successful use of cannula cricothyroidotomy and the Rapid-O2 insufflation device in CICO rescue and is, to our knowledge, the first such published report.

In preparing for CICO rescue at our institution, as per UK National Audit Project (NAP4) recommendations, our existing equipment, training and protocols were reviewed and a human factors approach adopted in developing a series of measures to optimise CICO preparedness[1]. This included adopting an agreed-upon approach to CICO rescue, and tailoring equipment and training to this approach. The CICO rescue algorithm and corresponding kits were then placed on walls in highly visible locations in all anaesthetising locations and in the recovery room. Education sessions in the use and location of the algorithm and CICO kits were also provided to all theatre and recovery room staff. Regular multidisciplinary crisis team training within the operating theatre was also provided. These measures enhance CICO awareness and ensure that, once a CICO crisis is declared, support staff can rapidly collect and deliver the appropriate equipment to the bedside with minimal delay. Ensuring CICO kits match the agreed-upon algorithm and contain all the essential equipment for a particular CICO rescue procedure, avoids loss of time or personnel caused by searching for separate pieces of equipment. Furthermore, as the equipment is placed in unsealed transparent plastic bags, nursing and medical staff can familiarise themselves regularly with the contents of the kits prior to a crisis. Finally, by designating an initial technique for CICO rescue, the risk of 'decision paralysis' may be reduced[3], whilst the addition of two backup tasks may assist teams to forward plan their response[4]. As the patient was already in a state of hypoxic cardiac arrest when CICO rescue commenced, any delay in delivering oxygen to the trachea would likely have led to death or brain injury, further highlighting the need for system measures which ensure rapid delivery of appropriate CICO rescue equipment to the bedside.

The 2015 Difficult Airway Society (DAS) guidelines endorse a scalpel-only technique for CICO rescue[5]. The evidence base for specific CICO rescue techniques is weak however, as much of the data comes from scenario-based studies on manikins, animals, or cadavers, or from case series in the pre-hospital or emergency department settings. Data from these sources are not necessarily transferable to the operating room where most CICO events are managed by anaesthetists. Data from NAP4[1], demonstrating a high failure rate of cannula techniques, also do not necessarily support the conclusion that cannula techniques are intrinsically less safe, as these were performed largely by anaesthetists who were untrained in this procedure[6].

At our institution the 'cannula first' approach has been chosen, with scalpel techniques reserved for failure of cannula technique. A number of technical and non-technical factors make cannula techniques more suitable for anaesthetists[7]. With regard to skill sets, anaesthetists are far more adept at using cannulas than scalpels and, as cannulas are less destructive, their use does not nullify the option of scalpel techniques. Once a scalpel is applied to the airway, significant tissue destruction occurs, making subsequent attempts, scalpel or cannula, difficult. For anaesthetists, a cannula technique presents a lesser mental hurdle than using a scalpel thereby favouring early or even prophylactic cannula insertion with minimal risk to the patient. Furthermore, because of its obvious endpoint of air aspiration, failure can be identified early prior to oxygenation attempts. This does not hold true for the scalpel–bougie technique whereby failure may be identified only after the occurrence of pneumomediastinum or significant subcutaneous emphysema, making subsequent rescue attempts difficult or impossible.

From a training perspective, cannula techniques can be performed on patients (e.g. transtracheal blocks for awake intubation) whereas scalpel technique training is largely limited to manikins. Cannula cricothyroidotomy also allows for rapid conversion to a definitive cuffed airway through guidewire-based techniques such as with the Melker™ Universal Emergency Cricothyrotomy Catheter Set (Cook Medical Inc., Bloomington, IN, USA).

Cannula techniques have a high success rate when the correct equipment and technique is used[2,7]. Much of the concern in the literature regarding safety and success of cannula techniques relates to the subsequent step of attempting to ventilate with a pressure-regulated device such as a jet ventilator[8]. Jet ventilation in the setting of upper airway obstruction may result in dangerously high intrathoracic pressures leading to barotrauma, volutrauma and a reduction in cardiac output[9,10]. We believe that such devices are inappropriate for use in a CICO event due to their attendant risks. Newer oxygenation devices such as the Rapid-O2 are now available, which provide safe rescue oxygenation even in the setting of complete upper airway obstruction.

The Rapid-O2 is a simple apparatus that connects at one end to a standard oxygen flowmeter and at the other end to a Luer Lock cannula. Thumb occlusion of the T-piece allows for oxygen to flow from the flow meter to the cannula, whilst releasing the thumb allows for flow meter gas to vent to the atmosphere, and passive expiration (Figure 3).

Successful use of the Rapid-O2 insufflation device in our case demonstrates many of the ideal features of a CICO rescue oxygenation device[7] (see Table 1). The need to occlude only one hole by using your thumb, ensures the device is simple and intuitive to use even under stress. As opposed to pressure-regulated devices, the Rapid-O2 allows for delivery of a known volume of oxygen. Knowing the precise volume being insufflated into the lungs is crucial in avoiding the aforementioned complications of over-insufflation. Data from Heard et al's animal wet lab studies demonstrate that by extrapolation to humans, only 1,000 ml of oxygen is needed for initial rescue of an adult which, at 15 litres per minute, equates to only four seconds of oxygenation. A further 500 ml of oxygen is adequate once oxygen saturation begins to

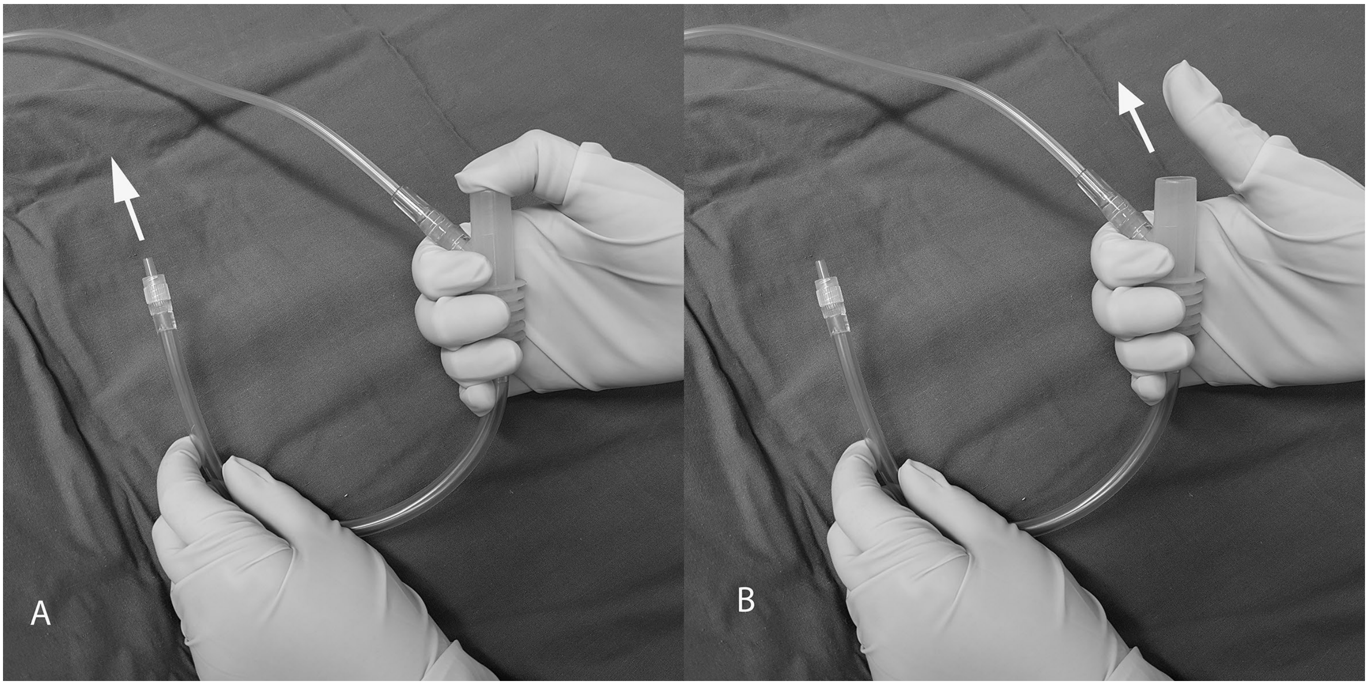

Figure 3: Rapid-O2™ oxygen insufflation device (Meditech Systems Ltd, Dorset, UK) in the 'on' (A) and 'off' (B) positions. Arrow denotes direction of gas flow.

drop[7]. At these flow rates intrathoracic pressures and risk of barotrauma are low. Furthermore, as a true on/off device, passive expiration occurs and flow meter oxygen can vent to the atmosphere when the thumb is removed from the jet oxygenation hole, thereby ensuring breath stacking is avoided.

Cannula kinking or misplacement is an additional concern with cannula techniques. The Rapid-O2 is especially effective at providing feedback in this regard and this manifests as palpable resistance against the thumb. The operator is thus able to detect early failure of the technique. From a cost perspective, the Rapid-O2 is inexpensive and therefore its placement in all anaesthetising locations, even in large theatre complexes, is affordable.

Despite the successful outcome in our case and the aforementioned advantages of our technique, success can by no means be guaranteed even with adequate training and equipment availability. Therefore, an institutionally-adopted CICO rescue strategy, which incorporates a variety of first-line and back-up techniques, should be in place. We favour the approach of Heard et al[2], the efficacy of which has been demonstrated in the wet lab setting involving thousands of stressed anaesthetists. This strategy calls for an initial rescue oxygenation attempt with cannula cricothyroidotomy and the Rapid-O2 in both the palpable and impalpable anterior neck anatomy patient, followed by scalpel techniques in case of failure. In those patients in whom anterior neck anatomy is palpable a scalpel bougie technique is suggested whilst in the impalpable anatomy patient a scalpel–finger–cannula technique is advocated. The latter technique is also recommended in the event of a failed scalpel–bougie technique and involves an 8 cm midline vertical incision through skin and subcutaneous tissue followed by blunt dissection to locate the trachea at which point a cannula technique is performed.

From a human factors perspective, adopting a single initial rescue technique with two back-up techniques reduces operator stress and facilitates a more efficient and timely transition to contingency plans, should failure occur. Furthermore, it can be argued that as the approach graduates from a less invasive (and, for most anaesthetists, less daunting) technique to progressively more invasive (and psychologically more challenging) techniques, the anaesthetic team is more likely to initiate rescue early whilst retaining the option of escalating their efforts in a timely fashion. However

Table 1

Features of the Rapid-O2™

Requires only one thumb for oxygen insufflation
Allows for passive expiration when thumb port not occluded
Can be used with a standard flow meter
Affordable
Intuitive and quick to set up
Safe to use
True on/off device
Delivers a known and accurate flow
Provides feedback if flow is not delivered

Rapid-O2 oxygen insufflation device (Meditech Systems Ltd, Dorset, UK).

more studies are required to better define the psychological barriers to surgical front-of-neck airway access among anaesthetists.

Whilst at our institution a cannula-first approach has been adopted, the primary aim of this report is not to advocate for a cannula technique over scalpel-based techniques, nor to provoke debate on which technique may be superior. In our view, it is more important that whatever algorithm is adopted, it be underpinned by a systems approach to CICO preparedness, which optimises the interaction between the airway rescue team (by increasing CICO awareness and familiarity with equipment through multidisciplinary team training), the environment (point-of-care poster and standardised CICO rescue kits with equipment fit-for-purpose) and clinical decision-making (agreed-upon CICO rescue algorithm).

In summary, this case demonstrates the practical utility of the Rapid-O2 oxygen insufflation device for rescue oxygenation in the CICO scenario and the greater level of safety its use can add to cannula techniques in this setting. As ours is the first report on the use of the Rapid-O2 oxygen insufflation device for rescue oxygenation in humans, further reports are needed in order to monitor its utility and safety in the management of CICO events. Nonetheless, as the features of the Rapid-O2 oxygen insufflation device are in keeping with human factors engineering principles, institutions that include a cannula technique as part of their approach to CICO rescue should consider its use. Finally, this report emphasises the importance of adopting a systems approach to CICO preparedness in order to ensure the correct equipment (be it scalpel-, or cannula-based) is delivered to the bedside and deployed appropriately with minimal delay.

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