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"Cannot intubate, cannot oxygenate" and eFONA: a narrative review

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Abstract

The "cannot intubate, cannot oxygenate" (CICO) event is a very rare airway crisis. The ensuing airway management is time-sensitive and if not managed promptly, CICO can lead to hypoxic brain injury or death. The identification of the cricothyroid membrane may be challenging when under stress, especially in certain patients, such as those with obesity and short neck. Thus, airway ultrasonography can be a useful aid in identifying the membrane. The emergency front of neck access (eFONA) rescue is performed using various methods, including needle cannula cricothyrotomy, scalpel-bougie method, traditional open cricothyrotomy, or using a commercial kit. The 4th National Audit Project reported a 60% failure rate of needle cricothyrotomy when it was the first eFONA choice, compared to 100% success rate when surgical cricothyrotomy was selected as the first airway rescue method. Thus, the Difficult Airway Society's recent guidelines recommend the scalpel-bougie technique. Apart from retaining the eFONA skills by training, education, and

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cognitive aids, patient safety can also be improved at the institutional administrative level by establishing airway equipment standardisation and a multidisciplinary airway management team.

Keywords: CICO, cricothyrotomy, difficult airway, eFONA

Introduction

"Cannot intubate, cannot oxygenate" (CICO) describes a life-threatening airway emergency encountered in anaesthesia and emergency medicine. This situation arises when attempts to secure the airway through conventional intubation techniques have failed and non-invasive methods to provide adequate oxygenation, such as mask ventilation or supraglottic airway devices, are also unsuccessful.[1] If not managed promptly, the CICO scenario, which represents one of the most feared complications in airway management due to its potential for catastrophic outcomes, can result in hypoxic brain injury or death.[1,2]

Incidence and outcomes

According to data from the 4th National Audit Project (NAP4), severe complications from CICO, including death, occur in roughly 1 in 180,000 anaesthetic cases, with poor preoperative airway assessment being a significant contributing factor.[1] In a developed Asian country such as Japan, the incidence of CICO has been well-documented. A multicentre study in Japan reported a CICO incidence of 3 cases out of 97,854, all occurring under general anaesthesia, corresponding to an incidence rate of 0.003%.[3] In each of these 3 instances, emergency tracheotomy was ultimately required to secure the airway. Two of the patients experienced full recovery without any neurological deficits; however, the third case resulted in severe and irreversible brain damage due to prolonged hypoxia. Data from the first National Audit on Anaesthetic Airway Management, conducted across 14 Malaysian Ministry of Health hospitals, provided a broader regional context. The audit found that the incidence of CICO necessitating an emergency surgical airway was 20 cases per 100,000 anaesthetic procedures, higher than in other developed countries.[4] Although the absolute risk of CICO is low, this data is alarming and should not be underestimated.

The outcomes of CICO can range from complete recovery to severe neurological impairment depending on the timeliness and effectiveness of the emergency

airway management. These severe critical incidents have prompted recommendations for rigorous preoperative assessment and adherence to protocols such as those of the Difficult Airway Society (DAS), which aim to mitigate such risks by outlining clear guidelines for emergency management.[5] Recent reviews highlight that, despite advances in technology and training, unanticipated difficult airways remain a challenge, emphasising the importance of immediate and decisive action in CICO scenarios.[6] As such, in a CICO scenario, emergency front of neck access (eFONA), also known as front of neck airway, is a definitive lifesaving intervention. When performed successfully, eFONA enables ventilation by accessing the anterior neck, thereby re-establishing alveolar oxygenation.[5]

Cricothyroid membrane identification

Fundamental to the successful outcome of any cricothyrotomy (cricothyroidotomy) technique is the accurate identification of the cricothyroid membrane (CTM). A clear knowledge of the percutaneous anatomical landmarks of the front of the neck is therefore essential. The conventional palpation method has been shown to be

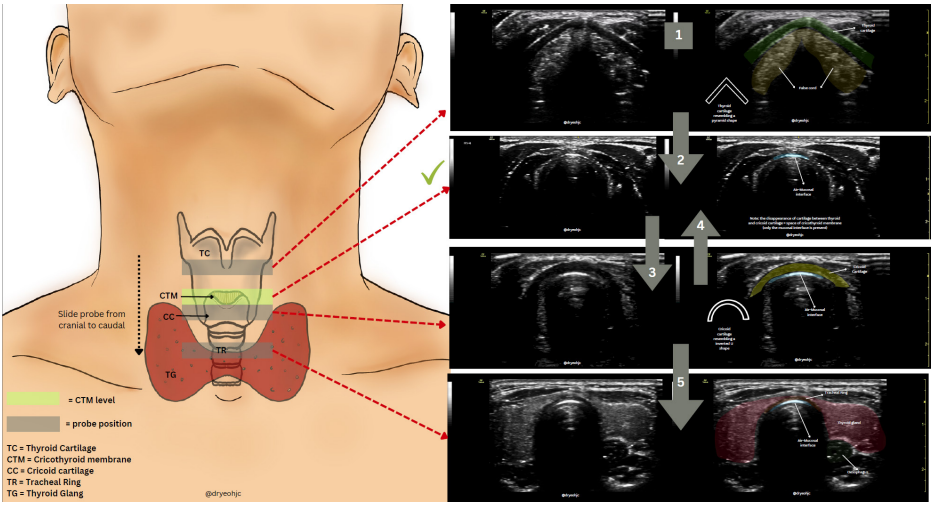

Fig. 1. The transverse approach of airway ultrasound. *(1)* Identify the thyroid cartilage (resembles a pyramid shape). *(2)* Slide down caudally until the thyroid cartilage disappears from sight, leaving the air mucosal interface alone. *(3)* Slide further down to view the cricoid cartilage (resembles an inverted U shape). *(4)* Slide cranially to visualise the space between the thyroid and cricoid cartilage, *i.e.*, cricothyroid membrane space. *(5)* Slide caudally to visualise the tracheal rings. The thyroid gland will appear as the probe moves more caudally to the sternal notch.

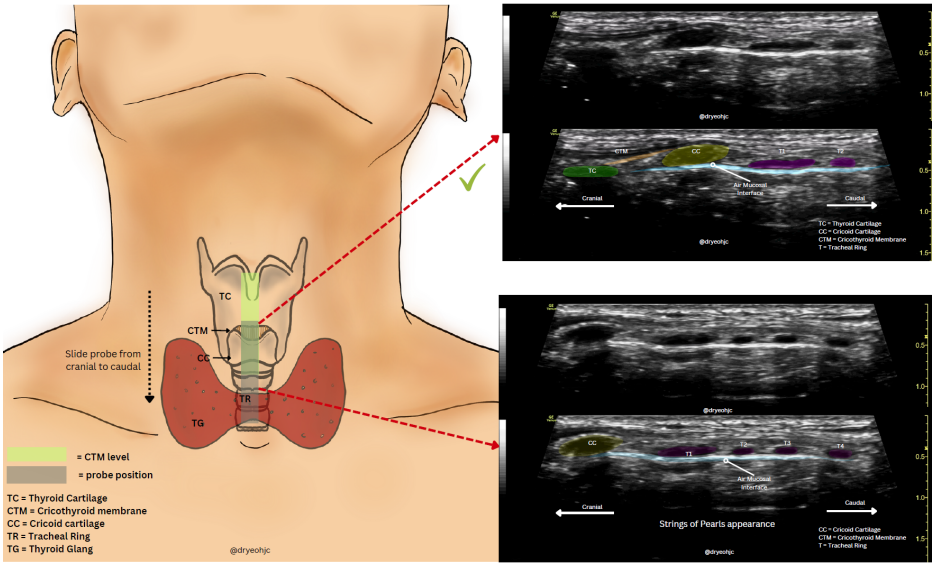

Fig. 2. The longitudinal approach of airway ultrasound. The thyroid cartilage, cricothyroid membrane, cricoid cartilage, tracheal rings, and air mucosal interface is visualised in a single view. Tip: Slide the probe left and right to obtain a true midline view, where the air mucosal interface appears as a straight hyperechoic line with its surrounding structures.

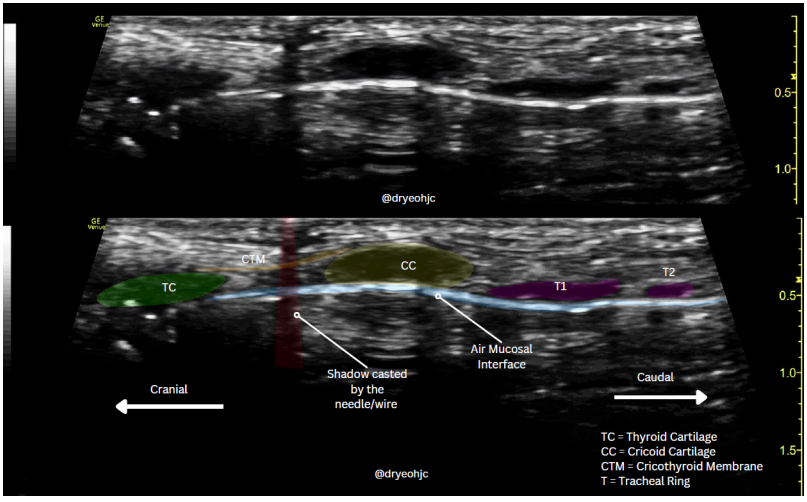

Fig. 3. A longitudinal approach of ultrasound probe shows a needle/wire casting a shadow and used to mark the location of the cricothyroid membrane.

inaccurate at determining not only the CTM, but also the midline in both obese and non-obese patients.[7-9] The more recent laryngeal handshake method, advocated by the 2015 DAS Guidelines, has been shown to be easy to learn as well as better at identifying the CTM.[5,10] However, this can also be challenging, particularly in patients with obesity, short necks, or difficult anatomy.

Ultrasound guidance is a valuable tool as it allows for real-time visualisation of the neck's anatomy and accurate identification of the CTM, which can improve the success rate and safety of this critical airway management.[11,12] The CTM can be identified using either a transverse or longitudinal approach with a high-frequency linear array transducer. The transverse view (Fig. 1) is beneficial for patients with short necks, while the longitudinal view (Fig. 2) enables the operator to visualise the thyroid cartilage, CTM, cricoid cartilage, and tracheal rings (also known as strings of pearls appearance) in a single view.[11] In addition to airway identification, both approaches allow for the identification of any major vessels or masses anterior to the CTM, further improving the safety during eFONA performance.[13]

In anticipated difficult airway cases, the surface landmarks of the neck, especially the CTM, can be marked with a marker under ultrasound guidance prior to managing the airway in case eFONA is necessary as a rescue method. Alternatively, a needle or wire can be used to identify the appropriate level of front of neck access by detecting the posterior acoustic shadowing (Fig. 3) in a longitudinal view of the airway.[12] Not only will this reduce the cognitive load on anaesthesiologists when an emergency situation arises, but a pre-procedural identification of the CTM will reduce the time to perform a cricothyrotomy whilst having a less rate of failure. Furthermore, ultrasound airway imaging can help avoid excessive deep penetration resulting in trauma to the posterior tracheal wall or creation of a false passage.[11]

Cricothyrotomy

The eFONA can be generally divided as needle cricothyrotomy (or cannula cricothyrotomy), scalpel (open) cricothyrotomy, or surgical tracheostomy. The needle cricothyrotomy involves passing an over-the-needle catheter through the CTM after bubbles are seen in a saline-filled syringe due to the needle entering the airway.[14] If successful, this provides an airway for oxygenating the patient, whereby ventilation is via a self-inflating bag-valve mask device or a low-pressure jet ventilation system (transtracheal jet ventilation).[15] Conversion to a wider, sturdier, and definitive airway, more efficient at oxygen delivery and carbon dioxide elimination is required after this initial rescue method.

While transtracheal jet ventilation (TTJV) is effective for short-term oxygenation in cases of upper airway obstruction, it is also not a long-term solution.[15] Duggan *et al.* identified significant complications with TTJV, such as barotrauma, pneumothorax, and inadequate ventilation, limiting its use in prolonged airway management.[16] Despite these drawbacks, TTJV remains a viable option primarily as a bridge to more definitive airway management strategies.[17]

The scalpel-bougie technique, endorsed by DAS in its 2015 guidelines, has become increasingly popular due to its simplicity and effectiveness in both pre-hospital and in-hospital settings.[5] This technique involves 5 simple essential steps: stabilising the larynx, identifying the CTM, making an initial horizontal incision which is widened by turning the scalpel 180°, bougie insertion into the trachea, and advancing a #6.0 endotracheal tube over the bougie. Finally, the correct tube placement is confirmed using capnography or capnometry. Its popularity arises from the minimal equipment required, making it ideal for emergency scenarios where advanced tools may not be available.

Compared to the scalpel-bougie technique, the traditional open cricothyrotomy is more equipment-intensive and is often reserved for cases involving complex anatomical challenges, such as facial trauma, extensive soft tissue injuries, or haematoma.[18] This method requires making vertical and horizontal incisions over the CTM using a tracheal hook for traction, dilating the incision, and placing a tracheostomy tube. Compared to the above techniques, the traditional open cricothyrotomy is more invasive, time-consuming, and carries a higher risk of trauma to the surrounding tissues, including haemorrhage.

The Seldinger technique, featured in several of the pre-packed commercial kits, such as the Cook Melker kit, involves inserting a needle into the CTM, verifying tracheal entry, placing a guidewire, and dilating the tract to insert the tube. It is particularly favoured in intensive care due to its lower complication rates, especially for its reduced risk of bleeding and tracheal injury.[19] Despite being less invasive than the traditional open cricothyrotomy method, the Seldinger technique is more suited to a controlled environment than the time-sensitive CICO situation.[18] Compared to the scalpel-bougie technique, Nakstad *et al.* reported the Seldinger technique poses higher risks of tube misplacement, making it less ideal in rapid high-stakes settings.[20]

The commercial kits provide the convenience of having all required components available during a critical emergency situation, rather than having to gather each separate component. However, one should be familiar with the kits, which may very well differ from one to another in terms not only of content but also as to usage instructions. Heymans *et al.* conducted a study involving 20 medical

students without prior surgical airway training who were randomly selected and trained to perform cricothyrotomy using the surgical cricothyrotomy methods and 2 different commercial kits.[21] The study concluded that surgical airway-naïve medical personnel established emergency cricothyrotomy more efficiently and safely with the surgical technique than with the commercial kits. Each institution can also assemble their own pre-packed rescue kits that can be easily accessed during a CICO event.[22]

The NAP4 reported an unexpectedly high (60%) failure rate of needle cricothyrotomy when performed as the initial CICO rescue method.[23] In contrast, there was a 100% success when surgical cricothyrotomy was the first choice of rescue method, which led to the recommendation of the scalpel-bougie technique by DAS as the rescue technique of choice. The failure of needle cricothyrotomy during the audit period was reported to have stemmed from various factors, which included the cannula directed cephalad, mechanical failure, and failure to oxygenate, among others. A recent systematic review and meta-analysis found scalpel cricothyrotomies to be quicker, have fewer complications, and superior first pass success rate compared to cannula cricothyrotomies.[24] Another advantage of the surgical airway over the needle cricothyrotomy is the provision of a definitive airway by the presence of a cuffed tube.[15] On the other hand, Heard *et al.* found scalpel-finger-cannula cricothyrotomy preferrable to scalpel-finger-bougie in simulated impalpable anatomy.[25] Nevertheless, needle cricothyrotomy is preferred over surgical cricothyrotomy in the paediatric population until age 12 due to the smaller CTM size and adjacent vascularity.

Since cricothyrotomy is a rare but critical procedure, frequent hands-on practice is also crucial for maintaining proficiency. Simulation training is especially useful for mastering any technique, allowing practitioners to refine their skills when put under pressure.[26] Interdisciplinary training is also on the rise, with many institutions offering collaborative airway management workshops for anaesthesiologists, emergency physicians, and trauma surgeons to practice cricothyrotomy and other emergency airway techniques.[27,28] The DAS guidelines recommend that all airway management personnel be trained in cricothyrotomy to ensure a coordinated and swift response during emergencies.[5]

Cricothyrotomy has a high complication rate as it is performed on patients who have had their airway possibly injured from multiple failed attempts at intubation under very stressful conditions.[15] The complications can be due to problems related to insertion or subsequent ventilation. Open cricothyrotomy is associated with complications of insertion, such as haemorrhage, whereas needle cricothyrotomy is associated with ventilation problems, which are hypercapnia, barotrauma, subcutaneous emphysema, and kinking of the cannula.[14,15] Mid to

longer term complications necessitating further intervention include subglottic stenosis, tracheocutaneous fistula, and tracheomalacia.[14] Ultrasound guidance may reduce the incidence of airway damage.

Guidelines and standardisation

Guidelines are crucial in assisting proper patient management during emergency situations. Although invasive airway access for CICO has existed for many years in these guidelines, the choice of method was not fixed and left to the rescuer.[29,30] Based on the findings of NAP4, the scalpel-bougie method was stated as the eFONA technique of choice by DAS when they updated their guidelines in 2015, which was also mentioned by the Canadian Airway Focus Group a few years later.[23,5,31] As of the time of writing, many of the other major difficult airway management guidelines remain neutral on the cricothyrotomy option, and a few recommend the eFONA method the rescuer is most familiar with.[22,32-34]

We have mentioned regular simulation as a way of becoming proficient when faced with a rare incident such as CICO. A recent review of human factors in anaesthesia described 4 controls involved in improving patient safety and staff well-being, which are design, barriers, mitigations, and the medical practitioners' education and training.[35] It was noted that although the medical practitioners' education and training, such as simulation, are the most frequent measures in the healthcare system, in the long run, these had the least effective control for improving patient safety and staff well-being. Meanwhile, design, which involves managerial tasks such as medical equipment, equipment procurement, drug packaging, and working environment, is the least frequent control in relation to human factors. Yet, when properly implemented, design turned out to be most effective control at improving patient safety, making it as equally important as education and training. In terms of difficult airway management, healthcare design translates into the adequacy and standardisation of proper airway equipment, together with the setup not only within a single department, but also throughout an institution.[23,35] The guidelines on human factors recommend input from human factor experts at the medical equipment procurement stage, together with designing a safe work environment, preferably led by an airway lead.[28,35]

An airway lead, first described in 1996, was one of many recommendations in the NAP 4 report, which states that each anaesthesiology department should have an anaesthesiologist responsible for difficult airway management.[22] The airway lead would head a multidisciplinary hospital airway committee incorporating key departments, namely anaesthesiology, intensive care, emergency

medicine, otorhinolaryngology, and other disciplines such as respiratory therapists and nursing.[28] The responsibilities for hospital leads include promotion of education, audit, standardised hospital-wide airway trolleys, and adherence to current guidelines, which can lead to better and effective difficult airway management.[23,28,35]

When one is faced with CICO, the stress during the event is likely to impair judgement and thought processes. Easily accessible or prominently displayed cognitive aids such as algorithms and checklists, which fall under the barriers category, are also recommended to improve difficult airway management flow and efficacy.[35] Finally, staff well-being should not be forgotten, whereby adequate time is allocated for debriefing following traumatising events such as CICO and eFONA.

Summary

As prevention is better than cure, proper pre-anaesthetic airway assessment may alert the practitioner to potential CICO, leading to adequate preparation and a tailored airway management approach. Poor or absent airway assessment and planning are the 2 main factors contributing to failed airway management.[22] In the anticipated difficult airway, it is worthwhile to identify and mark the surface anatomy of the CTM prior to airway management. While there are a few options of eFONA, when faced with CICO, the fastest and effective rescue method is preferred as the crisis is time-sensitive. At present, the scalpel-bougie method, which utilises minimal steps, is the fastest rescue technique to achieve a definitive airway, as advocated by DAS, while many of the other major guidelines remain neutral regarding cricothyrotomy options. In terms of preparation, we as anaesthesiologists can obtain and retain eFONA skills by attending regular simulation sessions. At the institutional level, easily accessible cognitive aids to assist during emergency and airway equipment standardisation are also essential keys to managing difficult airway scenarios, which ultimately improve patient outcomes.

Declarations

Ethics approval and consent to participate

This is a review article and as such does not require ethical approval and informed consent.

Competing interests
Dr. Muhammad Maaya, Dr. Ina Ismiarti Shariffuddin, and Dr. Shahridan Mohd Fathil serve as Section Editor, Chief Editor, and Deputy Chief Editor, respectively, of Malaysian Journal of Anaesthesiology. They have not been involved in any part of the publication process prior to manuscript acceptance; peer review for this journal is double blind. The remaining authors have no competing interests to declare.

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