

Address for correspondence:

Rashid M Khan
Sr. Consultant Department of
Anaesthesia & ICU Khoula
Hospital, Muscat
E-mail: tuturashidmkhan@
gmail.com, seeras_alig@
rediffmail.com

Prophylactic catheter placement via cricothyroid membrane or trans-tracheally as a 'Safe Exit Strategy' for anticipated difficult airway patients: A review of literature and evidence

Rashid Manzoor Khan¹, Maher Al-Bahrani², Naresh Kaul¹

¹Senior Consultant, Department of Anaesthesia & ICU, Khoula Hospital, Muscat, Sultanate of Oman

²Senior Consultant, Department of Anaesthesia & ICU, Royal Hospital, Muscat, Sultanate of Oman

ABSTRACT

The objective of this review article is to increase awareness of the potential benefit from prophylactically placing an intravenous catheter or central venous catheter transtracheally or through cricothyroid membrane. This may serve as a temporary life saving route for oxygenation or jet ventilation in cases of anticipated difficult airway in the adult patients being undertaken under general anaesthesia and who have a high likelihood of ending in Cannot Intubate; Cannot Oxygenate (CICO) situation. Patients with severe difficult airway are at greatest risk of developing hypoxia especially where the patient despite best counseling denies awake airway management. In these patients, there is a high probability of ending in a CICO situation necessitating urgent cricothyroidotomy, trans-tracheal jet ventilation or other forms of surgical airway. Unfortunately, performing these procedures in precarious situation is not easy. Historically, literature is full of reports of successful trans-tracheal jet ventilation via needle or catheter when faced with CICO situation. However, last two decades have seen case reports and case series of prophylactic placement of intravenous catheter or central venous catheter in patients with predicted difficult airway in anticipation of failed intubation and oxygenation. All these reports favour taking this step as a planned 'Safe Exit Strategy' in the management of predicted difficult airway patient as it offers assurance of excellent oxygenation if the need arises. However, shortcomings have been reported with the use of catheters but fortunately taking simple appropriate measures can circumvent most of them. All these have been discussed with evidence to support the recommendations for this practice.

Key words: Anticipated difficult airway management, cannot intubate, cannot oxygenate, canula cricothyrotomy

Most patients with anticipated difficult airways are successfully managed with awake fiberoptic intubation or a tracheostomy under local anesthesia. However, no guidelines are available on planning and firm decision-making for patients with anticipated truly difficult airway particularly where the option of awake airway management does not exist either by force of circumstances or patient refusal. Such patients have the potentials to be the likely candidates to end in 'Cannot Intubate, Cannot Oxygenate' (CICO) situation when put to sleep prior to airway management. Unfortunately, it may be possible to reach a state of CICO after multiple futile attempts at tracheal intubation in such patients. Due to the rarity of this life-threatening scenario, clinicians often panic and become

fixated on further multiple attempts at achieving tracheal intubation with disastrous consequences. Part 1 advisory of the Canadian Airway Focus Group in an unconscious/induced patient with difficult airway has suggested three corrective measures to rapidly overcome CICO situation which includes: quick recognition, call for help, and

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immediately performing a surgical/trans-tracheal airway^[1]. This is most often cricothyrotomy in the adult patient.

Despite this recommendation by the Canadian Airway Focus Group, the CICO scenario is still encountered, though rarely, in clinical practice where in the absence of a safe pre-planned 'Exit Strategy', serious morbidity or mortality is the likely outcome.

When planning how to approach such an anticipated difficult airway patient, the primary focus needs to be on ensuring adequate oxygenation and preferably ventilation by adopting a safe 'Exit Strategy' rather than continue to focus on intubating the trachea^[2].

Cook et al had hinted this strategy earlier in 2011. They suggested that in appropriate circumstances placing a prophylactic catheter has numerous advantages, not least the potential to secure and check the 'rescue airway' in a calm and unhurried manner, without hypoxia, before an emergency arises^[3].

Two questions needs to be debated today while dealing with an anticipated truly difficult airway patient. First, whether application of a safe 'Exit Strategy' in the form of cricothyrotomy/trans-tracheal catheterization should be applied prophylactically prior to undertaking such high-risk airway management in these selected anticipated difficult patients? The second question is whether one should utilize prophylactic placement of commercial cricothyrotomy cannula that is pretty expensive and not readily available across hospitals in India or can use the easily available cannula or catheter while planning for such a safe 'Exit Strategy'?

Before answering the two questions above let us recall the historical application of trans-tracheal needle/catheter or cannula cricothyrotomy during difficult airway management.

HISTORICAL EVIDENCE OF TRANS-TRACHEAL PLACEMENT OF LARGE BORE NEEDLE OR CATHETER IN PATIENTS AFTER FACING CICO LIKE SITUATION

Nearly 75 years ago, Jacoby et al successfully resorted to the use of trans-tracheal oxygen insufflation via a 14-G needle as a bridge to achieving a definitive airway in 5 patients during difficult tracheal intubations^[4]. Two decades later, Spoeral et al in 1971, described the efficacy of trans-tracheal high-pressure jet ventilation in 12 patients during the course of elective anesthesia^[5]. They could

prove their point by demonstrating maintenance of normal blood gas when these paralyzed patients were ventilated transtracheally via a 16-G needle.

Till this time, all had used wide bore needle to administer Trans Tracheal Jet Ventilation (TTJV) or oxygenation. It was Yealy and colleagues in 1988 who demonstrated the use of a wider bore (12-16-G) angiocatheter for oxygenation and ventilation of their apneic patients instead of needle that had been used in the past^[6]. They were able to provide the desired tidal volume when using a 50-psi pressure via the angiocatheter.

However a year earlier, Weymuller et al did report few complications associated with percutaneous trans-tracheal jet ventilation during difficult airway management that included kinked catheters, lack of coordination of respiratory effort, acute hypoventilation, pneumothorax, and soft tissue emphysema^[7].

Patel in 1999 realized the potentials of this technique and wrote a review article wherein he reported the retrospective finding of the use of trans-tracheal catheter in the management of patients with unanticipated difficult mask ventilation and tracheal intubation^[8]. He gave details of 29 such patients that were managed by him with this technique after having faced CICO like situation. However, they adopted trans-tracheal catheterization after facing difficult facemask ventilation and difficult tracheal intubation rather than prophylactically.

All the above clinicians demonstrated the role of successful trans-tracheal jet ventilation via large bore needle or catheter after encountering a situation of failed tracheal intubation in the face of rapid desaturation. Evidence for pre-emptive or prophylactic placement of catheter prior to undertaking formal airway management of patients with anticipated difficult airways had yet to become popular.

EVIDENCE FOR THE ROLE OF PROPHYLACTIC OR PRE-EMPTIVE PLACEMENT OF TRANS-TRACHEAL OR CRICOTHYROTOMY CATHETER IN ANTICIPATED DIFFICULT AIRWAY PATIENT

The very idea of placing a trans-tracheal catheter prophylactically for the anticipated difficult airway patients before embarking on conventional or fiberoptic tracheal intubation was first thought about in an article written by Carden in 1976^[9].

It was six years later in 1982 that Miller et al reported a series of 4 cases having either massive facial trauma

or intra-oral abscess where trans-tracheal catheter was prophylactically placed^[10]. Subsequently these patients underwent induction of anesthesia and oral or nasal tracheal intubation. They reported that prophylactically placed trans-tracheal catheter offered them “assurance of airway maintenance and excellent oxygenation”.

Over the next 4 years it was realized that pre-placement of a trans-tracheal catheter provided safe and unhurried conditions for carrying out airway management in anticipated difficult airway patients. This advantage was put into practice by Anis Barakain 8 patients including a case of severe ankylosis of temporomandibular joint. 6 of these patients underwent oro-tracheal intubation while the other 2 were managed without tracheal intubation^[11,12].

Boucek, Gunnerson & Tullock took the cue from Anis Baraka and successfully employed prophylactic placement of trans-tracheal catheter in 3 patients with and in 1 patient without anticipated difficult airway. They reported their findings in 1987^[13]. Two years later, McLellan et al reported yet again the successful use of trans-tracheal catheter in a prophylactic manner^[14].

All along this period, emphasis was on placing trans-tracheal catheter and not via cricothyroid membrane. It was in 2002 that Bigeleisen reported having used a pre-placed cricothyrotomy catheter in a trauma patient with a suspected difficult airway^[15].

The first large series of the use of preemptive or prophylactic placement of trans-tracheal catheter came from Gerig, Schnider & Heidegger in 2005^[16]. Over a 22-month period they had 11 patients with very difficult airways. Majority of these patients had large intra oral tumors or massive facial trauma. In all these 11 patients, they successfully avoided primary tracheostomy by prophylactically placing a 13-G trans-tracheal catheter and instituting jet ventilation of the lung. This ensured an adequate oxygenation in all their patients while tracheal intubation was attempted with standard laryngoscope or fiberoptic intubation technique. They reported that in addition to providing oxygen insufflation, when correctly used, it resulted in the opening of the airway by the insufflated gas, and facilitated location of the glottis when using conventional or fiberoptic intubation technique. They reported no complication in any of their patients.

All the above literature goes on to prove that there is a definite role of prophylactic use of trans-tracheal jet ventilation or cricothyrotomy in patients with anticipated difficult airway. This brings us to the second question i.e., whether one should utilize pre-emptive placement

of commercial cricothyrotomy cannula that is pretty expensive and not readily available across hospitals in India or use the easily available Central Venous Cannula/ catheter (CVC) or thin walled intravenous catheter while planning for such a safe ‘Exit Strategy’?

EVIDENCE FOR THE EFFICACY OF CVC OR THIN WALLED INTRAVENOUS CATHETER DURING THEIR PROPHYLACTIC PLACEMENT VIA TRANS-TRACHEAL OR CRICOTHYROID MEMBRANE IN ANTICIPATION OF TRULY DIFFICULT AIRWAY:

Choi et al in 2008 reported a 33-year-old female patient with a polyp arising from the posterior one third of her vocal cord. The patient was scheduled for laser laryngomicro surgery to remove a polyp. They inserted a 7 Fr 20-cm double lumen CVC (Arrow International Inc., Reading, PA, USA) through the cricothyroid membrane and carried out high frequency jet ventilation at the rate of 120 breathe/min via the distal 14-G lumen. They used the proximal 18-G lumen of the CVC for capnographic readings, enabling breath-by-breath monitoring of end-tidal CO₂. The surgery was successfully completed in 10 minutes time. Though Choi et al used the CVC to avoid tracheal intubation as this would interfere surgical access to the lesion site, they could demonstrate the efficacy of using a double lumen CVC via cricothyroid membrane for maintaining ventilation and oxygenation^[17].

Placing a double lumen conventional CVC through the cricothyroid membrane offers several advantages. These include: 1. CVC is readily available in the operation theatre/ critical care area and is easy to insert via the cricothyroid membrane, 2. the first of the two lumens of the CVC can be used to monitor capnographic tracings and the other for high frequency ventilation, and lastly 3. One of the lumens can be used to continuously or intermittently monitor the airway pressures to minimize barotrauma and pneumothorax. However, using CVC for this purpose is not without its share of potential problems. There are two shortcomings of using CVC technique. One such problem includes the trauma caused by the whipping movement of the relatively soft CVC in the trachea. Adopting two strategies can circumvent this: first, leave a short length of the catheter within the trachea and second, use lowest possible driving pressure. The second problem is the probability of blockage of the lumen of the catheter by mucus plug. If this is suspected, pass the guide wire into the CVC and try to clear the plug.

Using an ordinary intravenous catheter is an attractive

choice for using it as a channel for jet ventilation or simply oxygenation in situations where lungs cannot be ventilated via facemask or whose trachea cannot be intubated. These are not only much cheaper than a CVC but are available at all medical centers even in peripheral areas with very little resources. Unfortunately, they are prone to kinks. There is nothing in literature to suggest the incidence of this problem. However it is felt that kinking of the catheter is most likely to occur as the shaft of the plastic catheter turns from a predominantly posteriorly directed axis to a predominantly caudad-directed axis. It has been observed that if at the time of placement of the catheter, the greater the caudad orientation of the shaft of the intravenous catheter, the smaller will be the risk of kinking. In fact, suggestion has been made to create a small 15-degree angle bend approximately 2.0-2.5 cm at its distal end by Sdrales & Benumof^[18]. This bend reduces the initial insertion caudad-directed orientation requirement for rest of the intravenous catheter shaft, resulting in zero incidences for any kinks. In addition, in their experimental study, Sdrales & Benumof noted that all kinks might not be of same severity. Jet ventilation via these intravenous catheters has a tendency to unkink them^[18]. In deciding on intravenous catheter size, Yealy et al suggested that size 16-G or bigger should be used^[19].

In 2011, Bishop et al wrote an interesting article titled- Difficult airways: a reliable 'Plan B'. In this article they reported the prophylactic insertion of a single-lumen CVC to establish a means for TTJV or oxygen insufflation prior to induction of anaesthesia in an 18-year old patient with anticipated difficult airway due to a progressively enlarging tumor leading to complete nasal obstruction and facial distortion. The patient had totally refused awake airway management and hence they adopted this prophylactic CVC technique for use as a conduit for oxygenation during induction of general anesthesia in case of airway obstruction. They reported that using a single lumen CVC results in being cost effective, easy availability in operation theatres/ critical care areas and minimized risk of kinking as that seen with ordinary intravenous catheters^[20].

Most recently, a 20-year-old male patient sustained splinter injury to the face in the ongoing Yemen war. He had undergone four reconstructive surgeries at our trauma center in Muscat. It involved debridement, free osteocutaneous fibular flap and pectoralis major myocutaneous flap cover for reconstruction of the defect of the floor of mouth. During all these procedures Percutaneous Tracheostomy (PCT) was used as the definitive airway in the operation theatre and ICU. The patient was now posted for flap readjustment and rotation of musculomucosal flap nearly

three weeks after the closure of the PCT. On examination, an exposed fibular bone as well as myocutaneous flap on the left inside of the oral cavity was noted with several adhesions of soft tissue (Figure 1). Mouth opening was less than 3 cm.



Figure 1. Showing the reconstructed oro-facial defect needing re-adjustments.



Figure 2. Showing light wand intubation in progress after placing an IV catheter transtracheally.

Patient was extremely anxious and rejected any plea for awake airway management. After achieving adequate depth of anaesthesia with sevoflurane, a 16-G conventional intravenous catheter was placed via the previous PCT site for oxygenation and if required passages of a guide wire for tracheostomy in the event of rapid desaturation- an Exit Strategy. Flexible fiberoscopy via the nostril failed to negotiate towards the glottis even in expert hand. Before resorting to tracheostomy, it was decided to give a try with a lightwand [Trachlight[™]]. Prior to undertaking nasal lightwand aided tracheal intubation; patency of the preplaced catheter in the trachea was verified by noting CO₂ elimination on the capnograph. The lightwand-endotracheal tube assembly was successfully negotiated into the glottis in the second attempt by seeing a bright red glow in front of the neck (Figure 2) while patient received 2 liter oxygen via the pre-placed catheter. A totally unexpected finding was the illumination seen via the preplaced intravenous catheter confirming tracheal

entry of lightwand-tracheal tube assembly (Figure 3). This was not seen when the first lightwand attempt passed into the esophagus. Thus, the pre-placed intravenous catheter not only guided lightwand-assisted intubation but also was a source of great re-assurance for ongoing oxygenation and its ready availability in the rare event of CICO^[21].



Figure 3. Showing illumination over front of the neck as well as hub of the intravenous catheter (Arrow).

In conclusion, there should always be a primary and a backup plan for airway management in every patient with predicted difficult airway. It should take into consideration readily available equipment, drugs, monitoring and help as required. Most importantly, one should have a ‘Safe Exit Strategy’ for continuous oxygen administration irrespective of intubation technique used where the likelihood of CICO is strong especially in patients who deny awake airway management. However, it is a well-accepted fact that rapid cricothyrotomy after facing a CICO like situation is unlikely to succeed and cannot be regarded a prudent rescue option especially if access to the cricothyroid membrane is likely to be difficult^[22]. Thus, in selected circumstances placing an intravenous catheter or a CVC transtracheally or via cricothyroid membrane offers several advantages. One of them is their life-saving potential to secure and check the ‘rescue airway’ in a calm and unhurried manner, without hypoxia, before an emergency arises.

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