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The occasional bougie-assisted cricothyroidotomy

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Management of the difficult airway may be anxiety provoking for any clinician. Furthermore, predicting 'difficulty' can be problematic as endotracheal intubations that appear difficult (i.e. from an anatomic perspective) often proceed without complication, while seemingly simple intubations prove challenging.[1] Fortunately, most airways can be effectively managed by focusing on oxygenation, ventilation and basic techniques (i.e. effective bag-valve-mask ventilation [BMV] or extra-glottic device [EGD] placement) and not by focusing on 'putting a piece of plastic in the trachea' above all else (Dr George Kovacs, Personal Communication 4th June 2019). Still, emergency department intubation is successful the vast majority of the time, although, complications increase significantly with multiple attempts.[2,3] Nonetheless, there are situations, most notably in case of upper airway obstruction (e.g. trauma, anaphylaxis, epiglottitis and mass), where BMV and EGDs may prove to be unsuccessful rescue techniques for failed intubation. In these 'can't intubate – can't oxygenate' (CICO) scenarios, the ability to perform a surgical airway is an essential skill for anyone called upon to perform airway management.[1,4]

The cricothyroidotomy is the most common emergent surgical airway management technique for non-surgeons. Classically, two techniques have been described:

1. An 'open' surgical technique
2. The needle cricothyroidotomy performed using the Seldinger technique.[1,4-8]

Both techniques can be technically challenging in the highly charged CICO scenario. More recently, the bougie-assisted cricothyroidotomy (BAC) has been described.[5-7] The advantages of this technique include relatively few, straightforward steps that do not require as much fine motor control as other techniques.[1,5-7] Some authors have also argued that the use of bougie as a tracheal introducer facilitates true endotracheal placement in front of the neck access (FONA) avoiding the creation of a false passage and facilitates passage of the endotracheal tube cuff through the tight stoma created by the open technique.[7] The BAC uses materials that should be available in every environment where airways are managed (10 blade scalpel, bougie, #6 or #6.5 endotracheal tube). Further, in

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rural environments, where back-up (i.e. surgery and anaesthesia providers) and advanced technologies (i.e. flexible fibre-optic endoscopes) are often less available, a simple technique for the surgical airway, using readily available materials, is desirable. There remains some debate among clinicians as to supremacy of the BAC technique versus the needle cricothyroidotomy in the CICO situation.[1,8] Nonetheless, in controlled trials using animal models, the BAC has been reported to be faster, and preferred, with a similar failure rate among novice providers, and preferred with a lower failure rate and lower complication rate than other techniques (i.e. the Portex Cricothyroidotomy Kit) among experienced providers.[7,9] Still, clinicians should perform the technique with which they are most comfortable, with the BAC providing a simple, fast and potentially more reliable option for this rarely performed procedure.

INDICATIONS

1. 'CICO scenario'
2. Glottic or supra-glottic airway obstruction
3. Three failed intubation attempts without adequate oxygenation and ventilation by other means
4. Semi-elective indications: Massive facial trauma, maxilla-mandibular fixation (i.e. jaw wired shut).

CONTRAINDICATIONS

1. Absolute: <8 years old or airway anatomy not conducive to cricothyroidotomy
2. Relative: expanding neck hematoma, massively distorted anatomy and lack of appropriate skill.

ANATOMY

In the anterior midline neck, the cricothyroid membrane (CTM) is a thin, subcutaneous structure approximately 1 cm in length, stretching from the inferior thyroid cartilage to the cricoid cartilage [Figures 1 and 2]. Few critical structures (e.g. blood vessels, thyroid) overlie it in its most central and anterior positions.[4,10,11] The thyroid typically lies inferiorly and laterally to the CTM, and major blood vessels (e.g. carotid artery) also tend to lie relatively lateral. Smaller blood vessels (e.g. anterior jugular vein and cricothyroid artery) and the vertically oriented pyramidal lobe of the thyroid may often be found more centrally and superiorly and may be injured during FONA.[10] As such, the operator should expect bleeding once a vertical incision is made.[10,12]

MATERIALS

1. Gloves, personal protective equipment, chlorhexidine if time permits
2. #10 Scalpel blade and handle – Pre-loaded scalpels are helpful in the stressful case of CICO [Figure 3]
3. Bougie tracheal introducer – A variety of different kinds can facilitate this technique
4. 6.0 or 6.5 Endotracheal tube – The smallest that will fit over the bougie at your institution
5. 10 cc syringe
6. Self-inflating bag connected to an oxygen source
7. End-tidal CO_2 detection – Either colorimetric or continuous quantitative.

PROCEDURAL STEPS

1. Position yourself *facing the patient* at the level of the *shoulders* on the *same side of the patient as your dominant hand* (R-handed clinician on the R side of the patient)[12]
2. Lay the patient flat and *hyperextend the neck* [Figure 2]
   Note: In trauma, you should not vigorously hyperextend the neck due to concerns about cervical spine control, but gentle extension to access the anatomy is indicated. Success in this procedure is paramount[12]
3. Landmark by placing the thumb and middle finger of your non-dominant hand on opposite sides of the thyroid cartilage and *place your index finger on the CTM* [Figure 4]. Palpating down from thyroid notch and up from the sternal notch can be helpful to confirm CTM position. If time permits, ultrasound may be used to assist with land-marking, but this is probably best done as part of the operator's preparation before intubation[4,12-15] [Figures 5-7]
4. Make a 3–5 cm vertical incision across the *CTM* [Figure 8].[4,12] Cut from just below the thyroid notch to the cricoid ring. Blunt, dissect

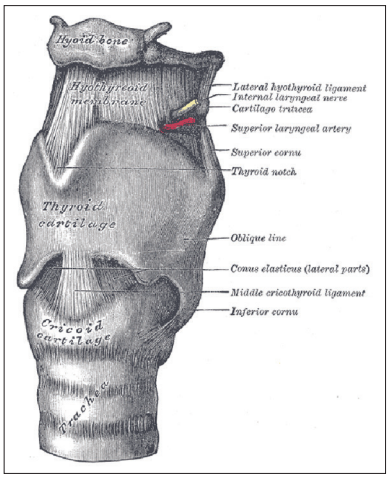


Figure 1: Source: Gray's Anatomy. Henry Gray (1918) anatomy of the human body.

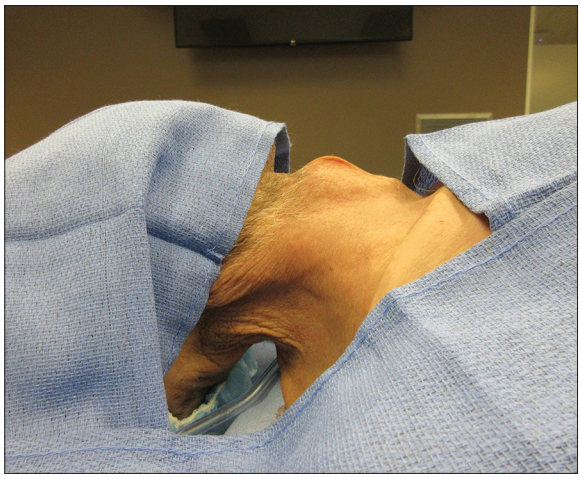


Figure 2: Surface anatomy: neck extended-thyroid cartilage, cricothyroid membrane, cricoid ring.

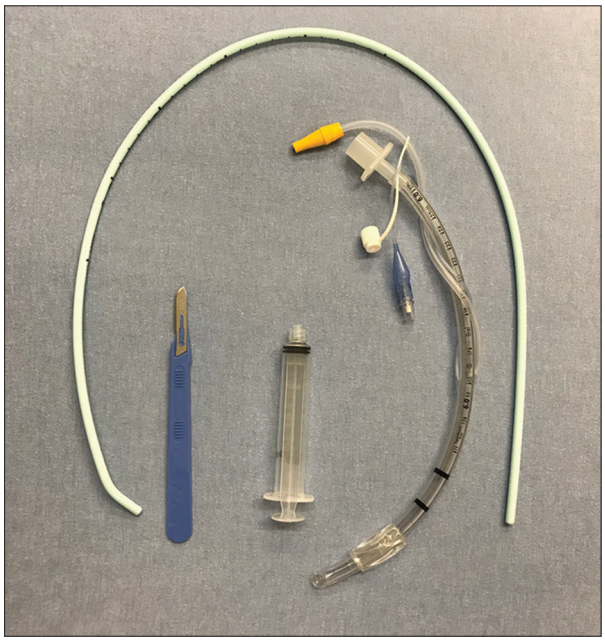


Figure 3: The minimal materials required to perform a bougie-assisted cricothyroidotomy.

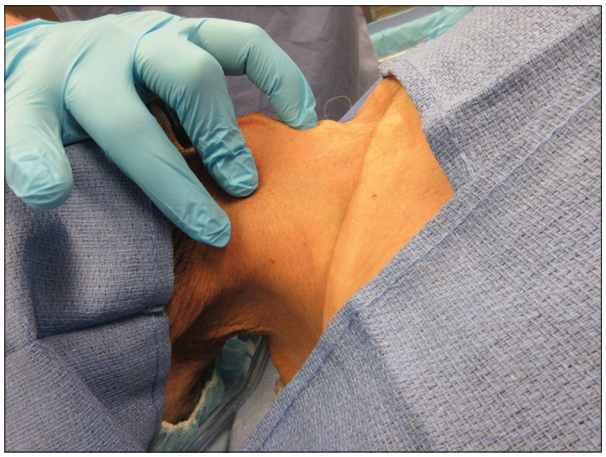


Figure 4: Primary palpation: index finger of non-dominant hand palpates cricothyroid membrane.

and *re-palpate the CTM* with the index finger of your non-dominant hand [Figure 9]. Some experts suggest omitting this step, if the CTM is readily identifiable, to prevent bleeding, *but this is generally a blind palpation-based technique not based on visualisation*. A single horizontal incision may result in inappropriate land-marking and extra-tracheal incision

5. Make a *horizontal stab incision in the middle of the CTM* [Figure 10]. *Leave the blade in place*. Rotate it 90' so the sharp end is caudad and *sweep it gently to each side of the trachea* in lieu of a dilator. Hold it firmly on the side of the trachea opposite of you to maintain access to the stoma and facilitate bougie passage into the lumen [Figure 11]. You may choose to carefully re-palpate with your dominant index finger to ensure endotracheal position
6. Once confident you are in the tracheal lumen, use your non-dominant hand to pass the bougie (Coude tip down) into the trachea, approximately 10–12 cm until it stops or meets resistance [Figure 12]. You may feel tracheal clicks
7. 'Railroad' the 6.0 or 6.5 endotracheal tube over the bougie until the thick black markings just above the balloon (usually denoting the level of the vocal cords) are a few centimetres inside the trachea [Figure 13]. Make sure you do not unilaterally intubate one of the lungs. The surgical stoma can be tight. *Some pressure, rotation and gentle wiggling* may be required to



Figure 5: Ultrasound-guided identification of the cricothyroid membrane using a linear array probe in the midline between the thyroid notch and cricothyroid membrane. Probe indicator is aimed cephalad.



Figure 7: The asterisk indicates the area palpated by the surgeon to find the cricothyroid membrane. The red circle shows the cricothyroid membrane identified by ultrasound. Source: Okano *et al*.[15]

get the endotracheal tube cuff to pass into the trachea[8]

8. Once the tube is appropriately positioned, blow up the cuff until the pilot balloon is firm
9. Apply a self-inflating bag with end-tidal CO_2 detection. Confirm intubation with colorimetric or continuous end-tidal CO_2 detection, symmetric chest rise and auscultation
10. In most cases, it is recommended that the operator simply holds the 6.0 endotracheal tube in place at the level of the stoma until oxygenation and ventilation have been corrected [Figure 14] (Dr George Kovacs, Personal Communication, 4th June 2019). Once corrected and relative calm is restored, secure the endotracheal tube in place using sutures, tape or twine. A large amount of endotracheal tube will be left outside the patient. Consider cutting the tube, or securing it along the neck, with a leash similar to a chest tube. A commercial endotracheal tube securing device may be particularly useful if available [Figure 15]
11. Initiate usual post-intubation care, including sedation and titration of the ventilator.

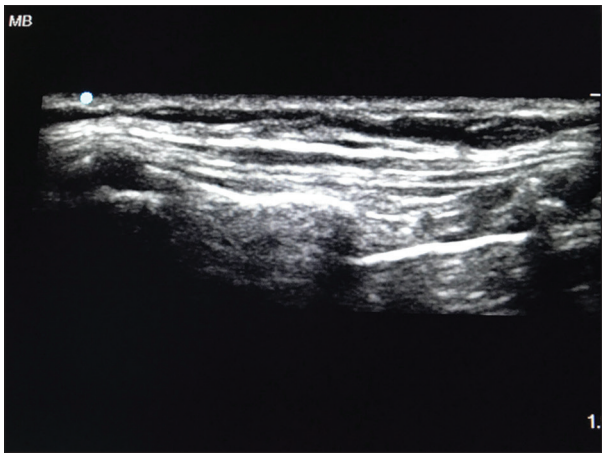


Figure 6: Ultrasound-guided image of the cricothyroid membrane. The cricothyroid membrane is the higher, mildly angulated hyperechoic structure just left of the midline on this image. It is between the thyroid cartilage (the hypoechoic circular structure on-screen left) and the cricoid cartilage (the small circular structure in the middle of the image with ring-down artefact). The small semi-circular structure with ring-down artefact on the extreme right of the screen is characteristic of tracheal rings.

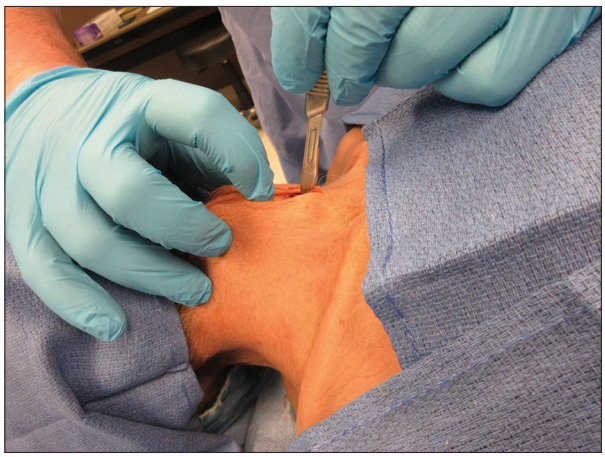


Figure 8: A 3–5 cm vertical incision is made over the cricothyroid membrane.

COMPLICATIONS

- Common: failure or incorrect tube placement, bleeding, thyroid or cricoid cartilage fracture, tracheal laceration/perforation, airway obstruction and subcutaneous emphysema



Figure 9: Secondary Palpation: Re-palpate the cricothyroid membrane after the vertical incision. This is crucial to ensure appropriate land-marking in obese, bearded, bleeding patients or those with distorted neck anatomy (e.g. abscess, mass).



Figure 11: Maintain the stoma and facilitate bougie passage by gently anchoring the 10-blade opposite of the operator.

- Uncommon: Oesophageal injury, pneumothorax, pneumomediastinum, aspiration.

TIPS AND TROUBLESHOOTING

Making the decision to perform a surgical airway

It has been said that 'the most difficult thing about a surgical airway is the decision to perform it'. (Dr George Kovacs, Personal Communication, 4th June 2019). This may be the case and the decision will depend on many factors, including recognition and declaration of the CICO situation, the availability of alternate providers and techniques, as well as provider confidence in success. Numerous things may assist with

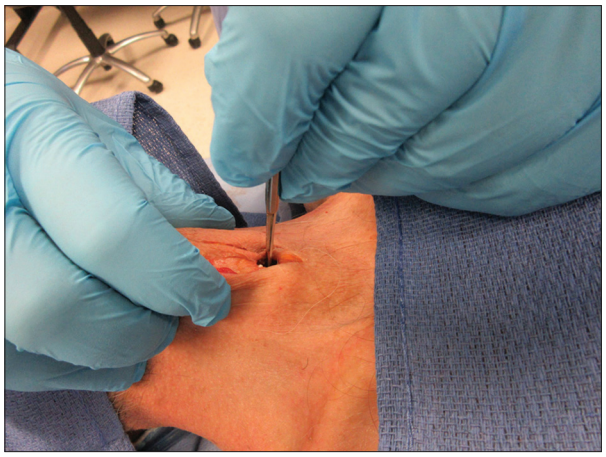


Figure 10: Horizontal stab incision through the cricothyroid membrane. Rotate so that the sharp end of the blade is caudad.

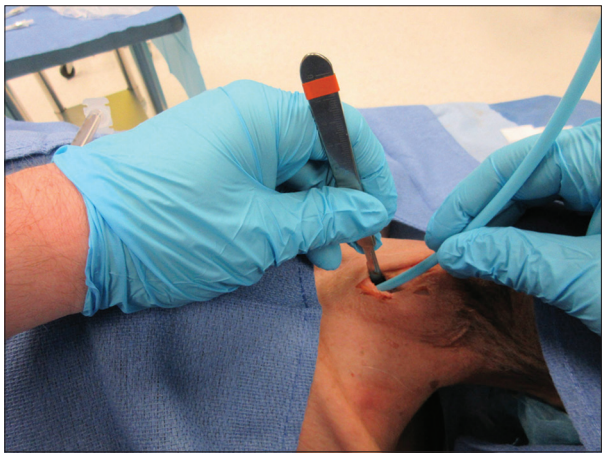


Figure 12: Pass the bougie into the trachea until 'hold up' is appreciated.

appropriate decision-making and successful performance of a surgical airway, including 'overlearning' (i.e. practising until procedure or thought process is automatic) the cognitive and procedural skills required to recognise the need for a BAC and the technical skills to perform it.[16] In addition, *cognitive aids* (e.g. checklists) and a *declared airway plan* that creates a 'shared mental model' (i.e. make sure your nurses and respiratory therapists know the plan and will speak up to remind you!) may assist with recognition of the need to perform this procedure. A pre-made surgical airway kit located prominently in your resuscitation bay may also prompt providers to think of performing this procedure and decrease the time and stress associated with gathering materials [Figure 16].

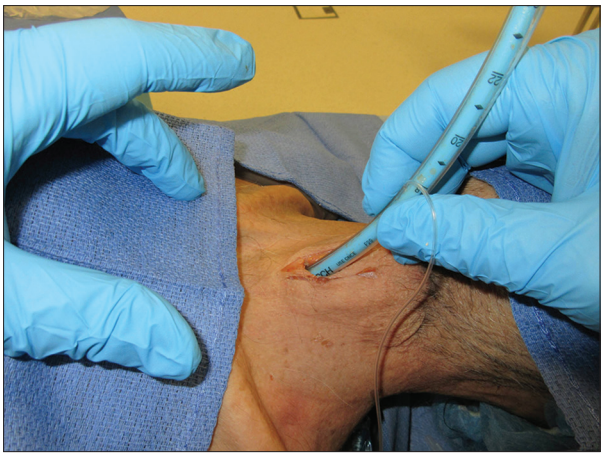


Figure 13: Railroad the 6.0 endotracheal tube over the bougie until vocal cord line above the cuff is a few centimetres into stoma. Be careful not to put the tube in too deep (i.e. mainstem the endotracheal tube).



Figure 15: A commercial endotracheal tube securing device holding the endotracheal tube post-bougie-assisted cricothyroidotomy (The AnchorFast by Hollister Incorporated. No conflicts of interest, e.g., financial).

Stabilising the larynx and finding the midline – 'The laryngeal handshake'?

A recent consensus article sourced from airway experts suggests the popular term, 'laryngeal handshake', is non-specific and not helpful in teaching the BAC.[6,17] The Laryngeal handshake involves a provider taking a firm grasp of the larynx with the non-dominant middle finger and thumb, and gently rocking it from side to side. We believe this manoeuvre can be helpful to ensure an operator is in fact grasping the larynx, that the larynx itself is held in the midline and that subsequent incisions are also made in the midline in order to avoid critical structures. A trial among anaesthesiologists showed that the laryngeal handshake method

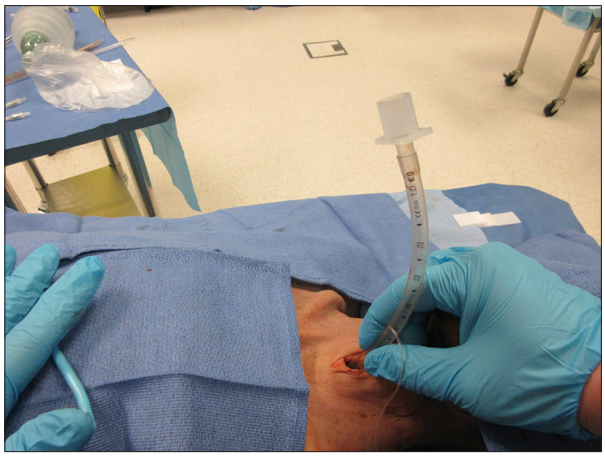


Figure 14: Remove the bougie and firmly hold the tube in place while restoring oxygenation and ventilation.

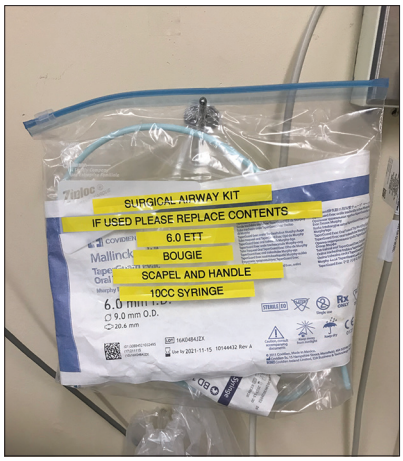


Figure 16: A pre-collected bougie-assisted cricothyroidotomy kit can ensure all materials are readily available and be a cognitive cue to perform the procedure under the appropriate circumstances.

took slightly longer for land-marking but was more accurate.[18]

Expect bleeding

Bleeding is an expected effect of the vertical incision made to facilitate secondary land-marking by palpation.[10,12] Although 4 × 4 gauze should be available for assistance with momentary compression and bleeding control in between the vertical and horizontal incision, the clinician is reminded that this is largely a blind, palpation-based technique and that relying on visualisation may be problematic.

Securing the tube

In performing FONA using a typical endotracheal tube, the clinician performing a BAC has skipped

the length of the oropharynx and the tube needs only to be inserted 5–10 cm depending on neck depth. This can leave a considerable length of endotracheal tube emanating from the stoma. The excess tube can be cut pre- or post-insertion, be secured with a leash in a longitudinal fashion along the neck (similar to a chest tube) or simply be secured using a commercial tube securing device [Figure 15]. However, simply holding the tube at the stoma until oxygenation and ventilation have been corrected has face validity and is recommended by airway experts (Dr George Kovacs, Personal Communication, 4th June 2019).

Paediatric patients

Remember that the BAC can only be performed on patients with adequately developed CTMs and enough space to safely and successfully pass a bougie and endotracheal tube through the stoma created.[4,12] This generally means that patients must be at least 8 years old and sometimes older. Transtracheal jet insufflation along with optimising other techniques (BVM and EGD) and/or a reattempt at orotracheal intubation should be considered for children without the cricothyroid complex development necessary to perform a BAC.

Procedural competency and skill maintenance

The CICO scenario, necessitating emergent surgical airway management, is a rare, stressful and high-risk situation.[1,4,6,9,12,19,20] It is unlikely that clinicians will perform sufficient *in-vivo* procedures to be competent or display mastery of the emergent surgical airway by accumulated clinical experience alone.[6,19-22] As such, 'deliberate practice' (iterative, structured, practice with feedback and subsequent skill refinement) and 'mastery learning' (iterative practice of progressive 'microskills' - e.g. mastering CTM identification before practising the vertical incision in BAC) involving task trainers and cadaveric models may represent an important way to achieve procedural competency with the BAC.[16,20-22] This is currently under study.[22] 'Mental rehearsal' (i.e. mentally reviewing the procedural steps, visualising the procedure) and 'overlearning' (i.e. practising until procedural steps are automatic and require minimal cognitive effort) may also represent ways to maintain competency and improve performance of the BAC.[16,21-23] As cadavers may be difficult to access (i.e. increased cost, limited availability and travel to institutions capable of cadaveric preparations), open-source 3D-printed task trainers represent a viable alternative [Additional Resources] for practising the BAC.

CONCLUSION

The surgical airway is a rare, but life-saving procedure performed in high-stress situations. Regardless of the chosen technique, considerable cognitive and psychomotor skill, as well as situational awareness, is required to perform it effectively. The BAC is a relatively simple technique that de-emphasises fine motor control compared to other techniques and takes advantage of a commonly used tracheal introducer device (i.e. the bougie). This technique, combined with appropriate training and practice, provides an attractive option for FONA in the case of CICO, or significant upper airway obstruction.

Additional resources

For full-length videos of the procedure see:

Trauma Nova Scotia Procedure Videos: https://www.trauma-ns.com/trauma-procedure-videos.

AIME Airway YouTube Channel: https://www.youtube.com/watch?v=8XDE9pBdrqU.

To practice the BAC with an open-source 3D Printed Task Trainer see here: https://www.thingiverse.com/thing:2530474 or here http://www.airwaycollaboration.org.

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