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CASE REPORT

Awake percutaneous tracheostomy as an alternative to open emergency tracheostomy in a threatened airway

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Background: This case report details the management of a patient with a threatened airway booked for an emergency awake tracheostomy but successfully managed with a percutaneous tracheostomy technique. The case illustrates the challenges of managing a severely compromised airway and presents an alternative technique for consideration that may obviate the requirement for a challenging surgical attempt to secure the airway.
Methods: A 42-year-old male presented with a threatened airway as a consequence of complicated dental sepsis extending into the neck. Extensive head and neck swelling was assessed as severe enough to make bag-mask ventilation, direct laryngoscopy and rescue with a supraglottic airway (SGA) impossible. Critical narrowing of the pharynx, identified on CT scan, made fibre-optic intubation risky in terms of completely obstructing the airway during the attempt. The airway was secured by a percutaneous tracheostomy technique with local anaesthetic under ultrasound guidance with the patient awake and spontaneously breathing in the upright position.
Results and conclusions: Tracheostomy is a potentially hazardous procedure. The distortion of anatomy as occurs in severe forms of sepsis may complicate surgical approaches, increasing time to securing the airway and increasing the time under stress for the patient (and the anaesthetist). This case report demonstrates the utility of the percutaneous tracheostomy technique under ultrasound guidance for securing the airway in such cases.

Keywords: airway management, anaesthesia, difficult airway, percutaneous tracheostomy, tracheostomy

Introduction

The difficult airway is a problem regularly faced by anaesthesiologists. As the recognised expert in airway management, the anaesthesiologist is required to have a varied repertoire of airway management skills at his or her disposal.[1–3] Video-laryngoscopy and the wide variety of devices, including supraglottic airways (SGAs) and airway exchange catheters, receive much attention, while other techniques utilising the Seldinger technique such as percutaneous tracheostomy may be avoided, forgotten or considered very late. As a surgical intervention, tracheostomies are often left to surgeons to carry out but, with practice, the percutaneous tracheostomy is a useful addition in the skill set of any anaesthetist when the patient's condition makes surgical access difficult and/or dangerous.

The patient described gave no access to supraglottic interventions but infraglottic access was also problematic due to anatomical distortion and difficulty with positioning. This case report serves to draw attention to these challenges and provides some practical solutions.

Case report

On December 30, 2015, a 42-year-old male was admitted to Inkosi Albert Luthuli Central Hospital (IALCH), referred from a local secondary hospital with the following problems: (1) complicated neck abscess with necrotising fasciitis secondary to a dental infection presenting with a threatened airway, (2) severe bicytopenia (anaemia and thrombocytopenia) possibly due to a sepsis-related coagulopathy, and (3) raised liver enzymes and hypoalbuminemia.

Facial swelling progressed over a week following the onset of lower dental jaw pain. No nasal or ear symptoms were reported. The patient's human immunodeficiency virus (HIV) status was unknown and he had never had tuberculosis (TB). The patient was being evaluated and treated for a lower gastrointestinal (GI) bleed by the general surgeons in a local secondary hospital. When he developed stridor he was referred for ENT evaluation. Nasendoscopy showed a medialised right hemilarynx with significant airway narrowing. He was transferred to IALCH for further imaging and airway management.

On arrival at IALCH the patient was found to be obviously distressed, with laboured breathing, sitting up, unable to lie flat or recumbent for more than a few minutes, and biphasic stridor (Figures 1 and 2) He was pale, with a heart rate of 90–100 beats per minute, a blood pressure of 126/74 mmHg, a respiratory rate of 22 breaths per minute and saturation of 100% on pulse oximetry breathing 40% oxygen.

Examination of the head and neck showed marked swelling of the right face, neck and periorbital area, but no proptosis, and a fluctuant right submandibular and submental area with extensive surrounding induration. Drooling and trismus were noted. Auscultation of the chest revealed transmitted noises, normal hearts sounds and a possible flow murmur.

Chest X-ray showed an increased cardiothoracic ratio and prominent pulmonary vasculature. A CT scan of the neck showed a deep neck space abscess with gaseous fasciitis and air loculae in the neck extending to the upper mediastinum (Figure 3). Blood tests showed anaemia (Hb 4 g/dL), thrombocytopenia (PLT 33) and leucocytosis (WCC 49.9). Urea and electrolytes were normal, INR was 1.44 and a liver function test showed slightly raised transaminases and a low albumin (14 g/L).

Figure 1: Preoperative view of the patient from the left.

Figure 2: Preoperative view of the patient from the right including monitoring.

The patient was cross-matched for four units of packed cells and two pooled units of platelets and urgently discussed with the anaesthesiologist on call for emergency awake tracheostomy. The cardiothoracic surgeons were consulted but upon review felt the sepsis did not extend below the clavicle, and was thus deemed to be a neck rather than mediastinal infection.

Anaesthetic assessment of the patient was that of difficult bag-mask ventilation, direct laryngoscopy and supraglottic rescue as well as a challenging standard surgical airway rescue due to tracheal deviation and overlying induration. Preoperative endoscopic airway assessment (PEAE), retrograde intubation and awake fibre-optic intubation were all considered. However, upon closer review of the CT scans these interventions were deemed unsuitable due to narrowing of the oro- and hypopharynx to a diameter of 2–3 mm over a length of 3–5 cm creating a very real risk of complete airway obstruction during airway manipulation above the larynx. Loculations of pus were also seen in close proximity to the airway with the likely possibility of rupture during airway manipulation with airway obstruction and aspiration, while completely obscuring any endoscopic view.

The revised plan was to perform an awake percutaneous tracheostomy to secure the airway. Theatre was prepared and the patient premedicated with 0.2 mg of glycopyrrolate. The patient was brought to theatre, positioned in a head-up position at 60 degrees, which he was able to tolerate. Standard ASA monitoring was attached, intravenous access confirmed, a pool of platelets and two packed cells commenced, and thereafter the patient was cleaned and draped. A senior ENT surgeon was scrubbed and ready to do an emergency open tracheostomy if needed. A mask was held over the patient's mouth with 60% oxygen administered at a flow of 8 l/min via a circle absorber system. Local infiltration with 0.5% bupivacaine with adrenaline was administered. Due to distortion and induration, tracheal location was achieved with the use of ultrasound. Ultrasound not only revealed the most superficial location of the trachea but prevented incision through a loculation. The trachea was cannulated with a 14G cannula on a saline-filled syringe. Thereafter the percutaneous tracheostomy kit (Portex® GRIGGS® PDT (Smiths Medical, Ashford, Kent, UK) was used, passing the guide wire through the cannula, and thereafter dividing the tissues with forceps and passing a size 7.0 tracheostomy tube (Figure 4). The cuff was inflated, circuit attached and capnography and clinical confirmation of tracheal placement established. The tracheostomy site was more lateral than the standard position with passage through the sternal head of the sternocleidomastoid muscle being required. The tube was secured, the patient anaesthetised and surgery proceeded.

A right neck submandibular and transcervical approach was used to access the superficial and deep neck spaces. Findings were of surgical emphysema and tissue plane distortion from oedema and pus. A pus collection was found to track up to the right parapharyngeal, retropharyngeal, submandibular and submental spaces extending toward the superior mediastinum. Necrotic neck tissue including sternocleidomastoid and strap muscle was found. The neck was washed out, the last right mandibular molar extracted, haemostasis achieved and corrugated drains placed into the mediastinum, retropharynx and submandibular areas. The tracheostomy was formalised with a Shiley size 8.0 (Covidien/Medtronic, Minneapolis, MN, USA), inserted over an airway exchange catheter. A nasogastric tube was inserted. Intraoperative specimens were taken for MCS, Gene Xpert and histology. Postoperatively the patient was taken to the intensive care unit (ICU) for further monitoring, ventilatory support, analgesia, antibiotics and daily dressings.

While in ICU, further packed cells were transfused, electrolytes replaced, nasogastric feeds commenced and ventilation weaned. Piperacillin/tazobactam with amikacin was initially commenced and later escalated to meropenem, vancomycin and fluconazole. The patient demonstrated high blood pressures, with SBPs > 150–200 mmHg and this was thought to be part of a withdrawal syndrome when collateral history revealed that the patient had been a long time IV drug and analgesic abuser. Microbiology samples showed a negative Gene Xpert and a pus swab revealed 3+ gram-positive cocci later identified as *Streptococcus anginosus*.

On day 3 in ICU his sedation was stopped and the patient was breathing comfortably on pressure support (Pressure support 6 cmH_2O and PEEP 6 cmH_2O). Wound inspection revealed reduced swelling, some pus still draining and no further necrosis. One failed T-piece trial resulted from thick secretions blocking the

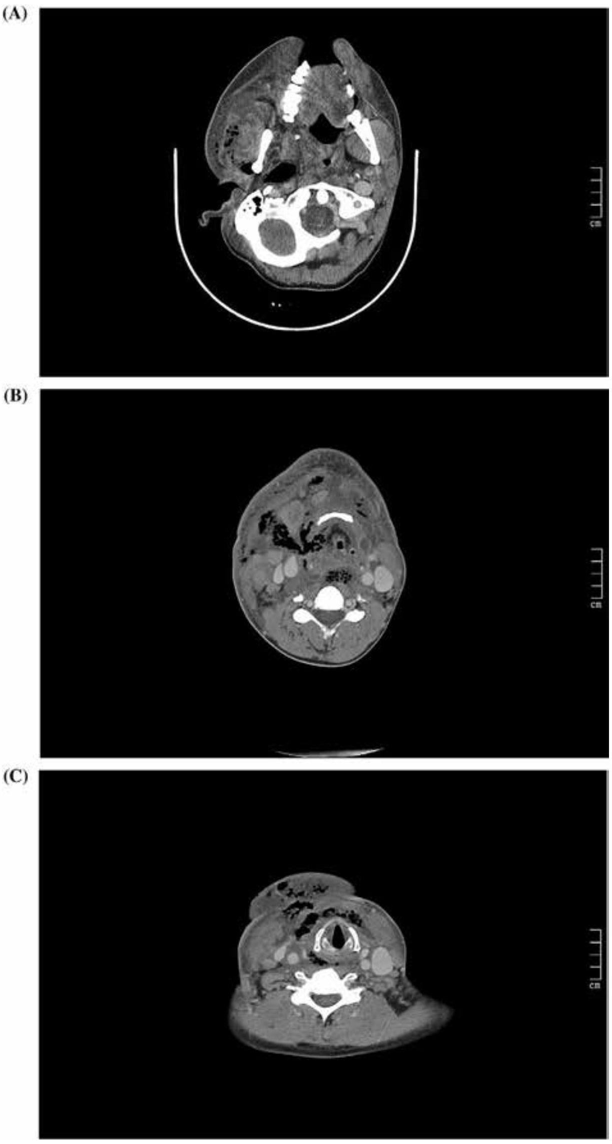

Figure 3: A–C: CT images of transverse sections through the floor of the mouth into the larynx.

tracheostomy tube. He was re-challenged and successfully weaned to a T-piece on day 6 in ICU. He was discharged to the high care unit, booked for washout in theatre and later referred back to his base hospital for further care.

Discussion

This case demonstrates the challenges of securing an airway in a patient with complicated facial and neck sepsis in an emergency setting. Deep neck-space infections like those that arise from neglected dental caries can lead to limited mouth opening due to trismus, anatomical distortion and pharyngeal and laryngeal oedema resulting in progressive airway narrowing and eventual loss.[2] In this instance bag-mask ventilation, laryngoscopy and supraglottic rescue were not considered feasible. Due to the length and small diameter of the narrowed airway with loculations of pus in close proximity, supraglottic airway interventions were considered dangerous. The FIS used for PEAE or awake intubation and the airway exchange catheter and guidewire required for retrograde intubation could easily have completely obstructed the airway with added risk of rupture of a loculation introducing pus into the airway. Consequently infraglottic options had to be considered.

The anticipation of a 'Can't Intubate, Can't Ventilate' scenario limits the available options in these situations to infraglottic approaches such as cricothyroidotomy and surgical tracheostomy. Cricothyroidotomy is generally reserved as the final recourse in an unanticipated 'failure to oxygenate' scenario. Here the principle of expeditious access to the airway via the cricothyroid membrane is based on the relatively superficial position of the larynx compared with the trachea.[5,6] Needle cricothyroidotomy may permit jet ventilation though carries the risk of barotrauma or ineffective ventilation. Surgical cricothyroidotomy will allow for a larger tube and more efficient ventilation but may result in damage to the cricoid cartilage and long-term complications such as subglottic stenosis and vocal cord dysfunction. Cricothyroidotomy does not provide a definitive airway, and would need to be revised to a tracheostomy.[7] Worryingly, however, the reported success rate of emergency airway access amongst anaesthetists is as low as 36% (in the non-obese population), with success in identifying the cricothyroid membrane highly dependent on physician experience and patient anatomy. Ultrasonography has been advocated as a superior means of locating the cricothyroid membrane over the traditional methods of inspection and palpation.[5]

An open, surgical tracheostomy, while considered the gold standard for establishing definitive long-term airway access, is time consuming and is challenging in cases where sepsis results in distorted anatomical planes and where dyspnoeic anxious patients are unable to lie flat.[1]

Percutaneous tracheostomy (PT) has been validated largely in the ICU literature as a means to electively secure an infraglottic airway and increasingly shown in several case reports to be a viable option even in the emergency setting.[1,8] Ciaglia and colleagues first described the Seldinger-based dilatational PT method in 1985, which has been widely implemented. The past decade has seen the development of modified methods of insertion, with improved procedural times, safety profiles and complication rates, reflecting a better understanding and execution of the procedure. Familiarity with the procedure, a good grasp of anatomy and adequate preparation are prerequisites to improve the chances of success.[8,9]

Various percutaneous tracheostomy kits are commercially available. The different techniques employed for dilatation and insertion include the classical sequential dilatational method, guide-wire dilating forceps (GWDF) and single hydrophilic dilatation devices.[1,4]

The dilatational forceps method as was used in this case was described by Griggs, whereby specialised grooved dilating forceps are advanced over the inserted guide wire into the trachea. These forceps are then opened, dilating the tracheal wall to the required diameter to permit insertion of the tracheostomy tube.[4]

Listed contraindications to percutaneous tracheostomy include patients younger than 15 years, uncorrected bleeding disorders, gross anatomical distortion and the inability to appropriately extend the neck. However, greater proficiency with the procedure has resulted in it being utilised successfully in numerous circumstances previously thought unsuitable.[1] Emerging case reports have demonstrated the efficacy of this technique for rapid tracheal access, showing it to be cost effective, quick and with few complications in experienced hands.

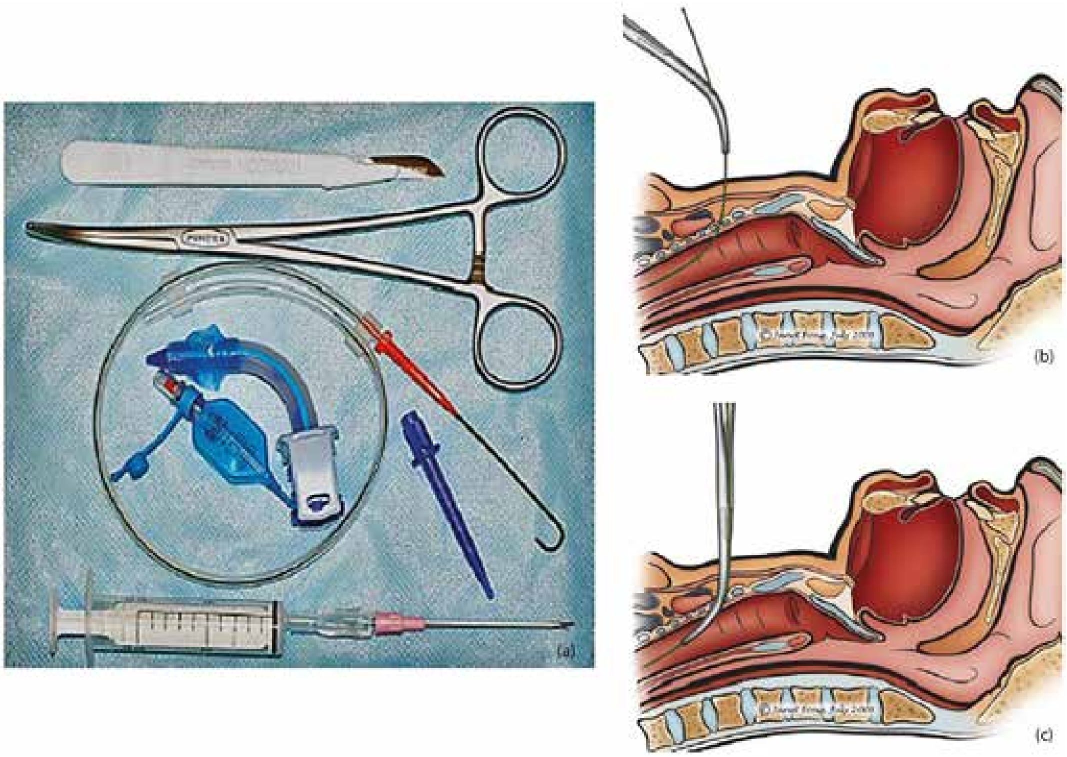

Figure 4: Percutaneous tracheostomy kit with Griggs forceps with depiction of insertion alongside.[4]

PT-related complications rates range from 2.1% to more than 20%. These are usually early and minor, but significant complications related to haemorrhage, false tract formation and hypoxia from airway obstruction can occur. The incidence of major complications as derived from large cohort studies is reported to be around 5% and may be higher in emergency cases.[8] Three retrospective studies looking at PT in the emergency setting included 18, 12 and 10 cases respectively.[10–12] Emergency PT was performed for varying indications, from anaphylaxis with respiratory failure and upper airway obstruction from bleeding or oedema to trauma and burns to the head and neck. All cases in these studies were managed successfully, no major complications occurred, and no cases required conversion to an open technique. Further emerging case studies show encouraging results with the Griggs technique in the setting of angioedema, burns and malignancies of the upper airway.[7]

A vital contributor to success in the context of airway crisis management, which is reiterated by all authors on the subject, is that it requires appropriate and frequent training and honing of skills, and experience with the technique.[1,3]

Intra-procedural bronchoscopic guidance during PT has already been widely accepted as a standard of care, helping to define the appropriate site, guide needle entry, avoid injury to the posterior tracheal wall and confirm endotracheal placement. Limitations of bronchoscopy include the possibility of complete airway obstruction prior to airway control and inability to assess overlying vascular or anatomical structures like the thyroid gland and thus the inability to predict or pre-empt procedural trauma to these structures.[13–15] It may also cause acute increases in intracranial pressure, which is undesirable in certain patient groups (neurosurgical).[13]

Advances in the field of ultrasound technology have made reliable bedside sonographic assessment accessible, easier to use and more affordable, with ever expanding applications in theatre and critical care. Ultrasound-guided techniques have shown the potential to improve efficacy and safety by improving the accuracy of needle placement and averting injury to neighbouring structures.[6,16]

These characteristics affirm its role as a valuable adjunct in airway assessment, particularly in the setting of cricothyroidotomy and PT, with roles in the pre-, intra- and post-procedural period.[5,14,17] This modality may provide important information less evident on clinical examination, especially in challenging cases (obesity, unfavourable anatomy/obscured landmarks, cervical spine precautions).[13,14] These factors most likely prompted the recent recommendation of ultrasound in both the Australian/New Zealand and Danish intensive care practice guidelines as a means of improving the safety of the technique.[18,19]

Observational data suggests a 10 times higher incidence of complications in conventional groups when compared with ultrasound guidance.[20] A study reviewing procedure-related mortality estimated that one in 600 patients who undergo PT may die as a result of it, the most frequent causes of death being PT-related haemorrhage (38%) and airway complications (29.6%).[21]

Few prospective randomised controlled trials (RCTs) exist but have suggested improved rates of first-pass punctures, midline location and trends towards fewer procedure-related complications, when compared with anatomical landmark-based PT.[14,16,22,23]

In direct comparison with bronchoscopy-aided PT, Ravi *et al*. in a prospective, single-centre randomised control trial (RCT) of 74 consecutive patients found real-time ultrasound-guided PT to result in significantly shorter procedural time, lower rate of multiple punctures and fewer episodes of hypoxia and minor and major bleeding.[13]

Most recently, the Trachus study, a single-centre open-label, parallel, non-inferiority RCT involving 118 patients (60 patients ultrasound group and 58 patients bronchoscopy) in eight ICUs found procedural ultrasound-guided PT to be non-inferior to bronchoscopy-guided PT. They showed no significant difference in a primary composite outcome (conversion to surgical tracheostomy, switching groups or major complication) with similar subjective procedural difficulty, similar procedure durations and ultrasound information effecting a change of puncture site in 23.3% of patients. Minor complications were higher (33.3% vs. 20.7%) in the ultrasound group, though not significantly ($p = 0.122$) though the study may have been underpowered for these secondary outcomes. Patients were not followed long enough to assess for late complications such as tracheal stenosis, vocal abnormalities or scar characteristics.[14] Limitations to most of the above studies include small sample sizes, often underpowered for secondary outcomes, as well as differing levels of training in ultrasound airway anatomy recognition.[15]

Ultrasound guidance can provide valuable information in pre-procedural airway assessment and planning, guide real-time needle placement and assist in screening for complications. Ultrasound has been shown to be useful in delineating pre- and paratracheal airway anatomy, especially in cases where distortion or obesity obscured normal palpation, with improved speed and success of cannula placement and reduced number of attempts required.[15–17,23] Measuring the pretracheal soft-tissue distance can also help determine appropriate tracheostomy length (regular vs. extended).[16,17,22] Additionally, intra-procedural ultrasound may assist in identifying the correct level of puncture between the appropriate tracheal rings, guide midline placement of the needle and assist physicians to avoid vulnerable structures, particularly the thyroid isthmus and aberrant vessels, helping minimise the likelihood of immediate vascular complications. Following the procedure, the ultrasound can help confirm the position and is a faster and more sensitive screening test for pneumothorax than chest radiography.[6,16,17,23]

As air conducts ultrasound poorly, it limits visualisation of structures behind the air–membrane interface, such as the posterior tracheal wall. Ultrasound alone cannot exclude the possibility of injury, but assessing the distance to trachea and real-time visualisation of the needle path can give a guide as to a safe depth of needle advancement. The combination of ultrasound alongside bronchoscopy can improve efficacy and safety.[13,14,16]

Ultrasound is a non-invasive, repeatable and increasingly available tool that has shown promise in both simulated scenarios and clinical application. The small amount of emerging literature suggests that ultrasound-guided PT is safe and offers a potential benefit over the traditional landmark-guided technique, with specific relevance for certain patient groups, such as those with increased BMI and obscured surface landmarks. A learning curve is to be expected before the technique can be adopted in routine use.[13,16]

In this case, ultrasound revealed the optimal location for tracheostomy, substantially lateral to the conventional tracheostomy site. The ENT surgeons were concerned about placing a tracheostomy in an infected neck but were reassured by the superficial location of the trachea and the absence of pus loculations in the vicinity of the planned stoma. The use of dilatation rather than sharp dissection to form the stoma has also been associated with reduced infectious complications.[24]

Conclusion

Management of the threatened airway can be a complex and perilous endeavour. Very often, at the end of the anticipated difficult airway algorithm, one finds oneself with the option of an awake tracheostomy but the ASA algorithm also recommends a tracheostomy as an initial intervention with a severely compromised airway.

The role of emergency percutaneous tracheostomy is not yet well established, but cases such as this illustrate the viability of awake percutaneous tracheostomy as a further option available to the anaesthetist. In certain circumstances it may prove to be a safer, more efficient method than the open route, as it may have been in the above case where distortion of landmarks and normal anatomy had occurred. Greater consideration should be given to its use in the future, and greater efficiency with the technique perhaps recognised as a goal for future training.

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