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ECDC, European Centre for Disease Prevention and Control; PBM, patient blood management; RBC, red blood cell; WHO, World Health Organization.

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HQ-FCM-2100014 February 2021

Guidelines

Multidisciplinary guidelines for the management of tracheostomy and laryngectomy airway emergencies

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Summary

Adult tracheostomy and laryngectomy airway emergencies are uncommon, but do lead to significant morbidity and mortality. The National Tracheostomy Safety Project incorporates key stakeholder groups with multi-disciplinary expertise in airway management. , the Intensive Care Society, the Royal College of Anaesthetists, ENT UK, the British Association of Oral and Maxillofacial Surgeons, the College of Emergency Medicine, the Resuscitation Council (UK) the Royal College of Nursing, the Royal College of Speech and Language Therapists, the Association of Chartered Physiotherapists in Respiratory Care and the National Patient Safety Agency. Resources and emergency algorithms were developed by consensus, taking into account existing guidelines, evidence and experiences. The stakeholder groups reviewed draft emergency algorithms and feedback was also received from open peer review. The final algorithms describe a universal approach to managing such emergencies and are designed to be followed by first responders. The project aims to improve the management of tracheostomy and laryngectomy critical incidents.

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On behalf of the Difficult Airway Society, the Intensive Care Society, the Royal College of Anaesthetists, ENT UK, the British Association of Oral and Maxillofacial Surgeons, the College of Emergency Medicine, Resuscitation Council (UK) the Royal College of Nursing, the Royal College of Speech and Language Therapists, the Association of Chartered Physiotherapists in Respiratory Care and with input from the National Patient Safety Agency.
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Accepted: 1 May 2012

Tracheostomies can be temporary or permanent and performed using an open surgical technique, or percutaneously. Over 5700 surgical tracheostomies were performed in adults in England during 2009/10, along with an estimated 5000–8000 percutaneous tracheostomies in critical care [1]. Tracheostomies are performed for a variety of clinical indications including management of upper airway obstruction, airway protection, to facilitate weaning from mechanical ventilation, to allow long-term ventilation and to provide assistance in removing respiratory tract secretions [2]. Around 570 laryngectomies were performed in England during 2009/10 [1], the majority for carcinoma of the larynx, resulting in permanent alteration of the airway; the upper airway is not, and cannot be, connected to the trachea. Collectively, these patient groups can be referred to as 'neck breathers', but confusion can arise if carers do not understand the differences between the procedures and the resultant anatomy. Complications following tracheostomy can be immediate, short-term or long-term. Immediate complications include haemorrhage and loss of the airway, with short-term complications including blockage or complete or partial tracheostomy tube displacement. Long-term complications include tracheomalacia, tracheal stenosis or problems relating to the stoma itself [3–6]. A variety of artificial airway devices can be inserted into tracheostomy or laryngectomy stomas and these may become blocked or displaced, leading to significant patient harm. The likelihood and nature of such harm depends on the incident location (e.g. critical care unit, operating theatre, ward, community) [4, 7–13], which reflects the underlying condition of the patient and the nursing and medical infrastructure available for both routine and emergency care [14].

In the UK, the Difficult Airway Society (DAS) guidelines for the management of difficult intubation [15] have become widely established in UK anaesthetic practice and are applicable to related fields, such as critical care. Similar systematically developed recommendations have been produced in other countries [16–20]. National guidelines have not been available for the management of tracheostomy-related emergencies; however, some local solutions have been developed piecemeal, a situation that is similar to that of general airway emergencies before publication of the DAS algorithms. Before such guidance, emergencies were commonly managed by relying on individually acquired skills and experience or lessons learned from previous errors [21, 22]. The spotlight has recently fallen again on airway management in the UK following the widely publicised National Audit Project (NAP4) report examining major complications of airway management [7, 8].

Following a cluster of serious untoward incidents involving hospitalised 'neck breathers' in the North West of England, similar critical incidents reported to the UK National Patient Safety Agency (NPSA) were examined and recurrent themes were identified [9, 10], evident in similar publications [4, 5, 11, 12, 23–27]. It was clear that simple, clear and authoritative guidelines were urgently required, similar in structure to previous DAS algorithms and Resuscitation Council (UK) guidelines [28]. These tracheostomy and laryngectomy emergency guidelines were developed following wide consultation with key national bodies involved in tracheostomy care, incorporating feedback from their members and utilising case reports in the literature. The purpose of this article is to present the guidelines and their rationale.

Methods: guideline development

The authors were tasked at their local hospitals to take the lead in developing guidelines for the management of tracheostomy/laryngectomy emergencies. Initial algorithms were tested in simulated scenarios and clinical environments, and then further refined using multidisciplinary feedback over a period of three years. Following trials of the resources in this local setting, it was recognised that, if suitably adapted, this approach might fulfil the needs identified by several organisations referred to above. Hence, a proposal was submitted to the DAS Committee and this work was formally launched as a DAS-sponsored guideline development project at the DAS Annual Scientific Meeting in Cheltenham in November 2010.

As the project initiators and DAS recognised the wider implications of this work, a multi-disciplinary, multi-site Working Party was established consisting of representatives of key organisations with a stated interest in airway management, namely: DAS, the Intensive Care Society (ICS), ENT UK and the British Association of Oral and Maxillofacial Surgeons (BAOMS).

A literature review was conducted of available scientific publications up to 2011 using databases (Medline, Embase, PubMed) and search engines (Google Scholar) and officially recognised websites (DAS, Society of Airway Management, American Society of Anesthesiologists, European Society of Anaesthesiology). English language and English abstract publications were searched using keywords and filters, using relevant words and phrases, such as 'tracheostomy', 'surgical airway', 'surgical access', 'laryngectomy', etc. A large number of papers, abstracts, case reports, opinion-based articles and websites were retrieved, but no large randomised controlled trials were found. Furthermore, the publications themselves lacked a clear coherent structure and instead examined the topic from very specific viewpoints. Thus, expert opinion in the form of editorials, book chapters and comments were also taken into consideration to generate these guidelines, using the available publications only as reference points.

Draft guidelines were tested and refined locally before being re-submitted to the stakeholder organisations. Guidelines were published on the project's website (http://www.tracheostomy.org.uk), with links from the other organisations along with an invitation for member peer review, for a period of six months. During this period, the resources were accessed > 28 000 times and the emergency algorithms downloaded nearly 9000 times. A total of 452 emailed comments were received from a variety of critical care networks, individual NHS trusts, regional teams (medical, nursing and physiotherapy) and also international comments from individuals and similar groups in the United States, Canada, France, Spain, India and Turkey. In general, feedback was positive and supportive of the project aims, with many comments adapted to be included in the final version of the guidelines with the contributors' permission.

Comments regarding the applicability of the algorithms to children prompted contact with colleagues at Great Ormond Street Hospital and therefore the Working Party decided to focus these current guidelines purely on adults, commencing a separate project relating to paediatric patients.

The near-final version of the guidelines were then formally submitted by the Working Party to several organisations with a wider interest in patient safety, standards and professional regulation, which included: the Royal College of Anaesthetists (RCoA), the Royal College of Nursing (RCN), the Royal College of Speech and Language Therapists (RCSLT), the Association of Chartered Physiotherapists in Respiratory Care (ACPRC), the NPSA, the College of Emergency Medicine, the Resuscitation Council (UK), and patient associations.

Funding for the project has come from the ICS (£1000) and from running tracheostomy safety courses in the UK and abroad. Candidates are charged a small fee (typically £25–£125) and course sponsorship has been obtained from industry, used specifically to ensure that the courses remain accessible for multi-disciplinary candidates. The RCoA allowed use of its in-house programmers to develop and update our teaching resources and those for the related e-Learning for Healthcare modules. The website is designed, maintained and privately hosted by one of the authors (BAM) with the majority of resources developed collaboratively between all authors and members of the e-Learning for Healthcare team, with input from members of the Working Party. The smartphone applications have been developed by the authors, with associated costs met from course fees.

Results: the guidelines

Patients with tracheostomies or laryngectomies may be considered to have airways that are difficult to manage, either leading to the formation of the airway stoma itself or as a result. Because of this, several basic principles were agreed by the Working Party that would underpin guideline development.

First, it was clear from initial analyses that distinct bedside information and algorithms were required for patients with a potentially patent upper airway and those with a laryngectomy [29]. Bed-head signs (Figs 1a & 2a) were developed to allow essential information to be clearly displayed and immediately available to responders in an emergency, consistent with the views of the ICS, DAS and NPSA which have independently highlighted the importance of having information about the patient's airway immediately available at the bedside [7, 8, 26, 30, 31]. This allows the responder to know immediately whether or not the patient has any special considerations for managing the upper airway or the tracheostomy stoma [32]. Bedside information can also summarise key details of the nature and date of the tracheostomy, the method of forming the stoma and the function of any 'stay sutures' to inform the responder managing such an airway incident [32–37]. For example, if a 4-day old surgical tracheostomy tube became displaced, one could reasonably expect to be able to replace it (as the stoma tract is likely to remain initially patent), whereas replacement of a 4-day old percutaneous tracheostomy would be likely to prove much more difficult (as the dilated stoma tract tissues recoil) [33, 38–41] and this would therefore affect management of any attempts at replacement in certain circumstances [42, 43].

(a)

(b)

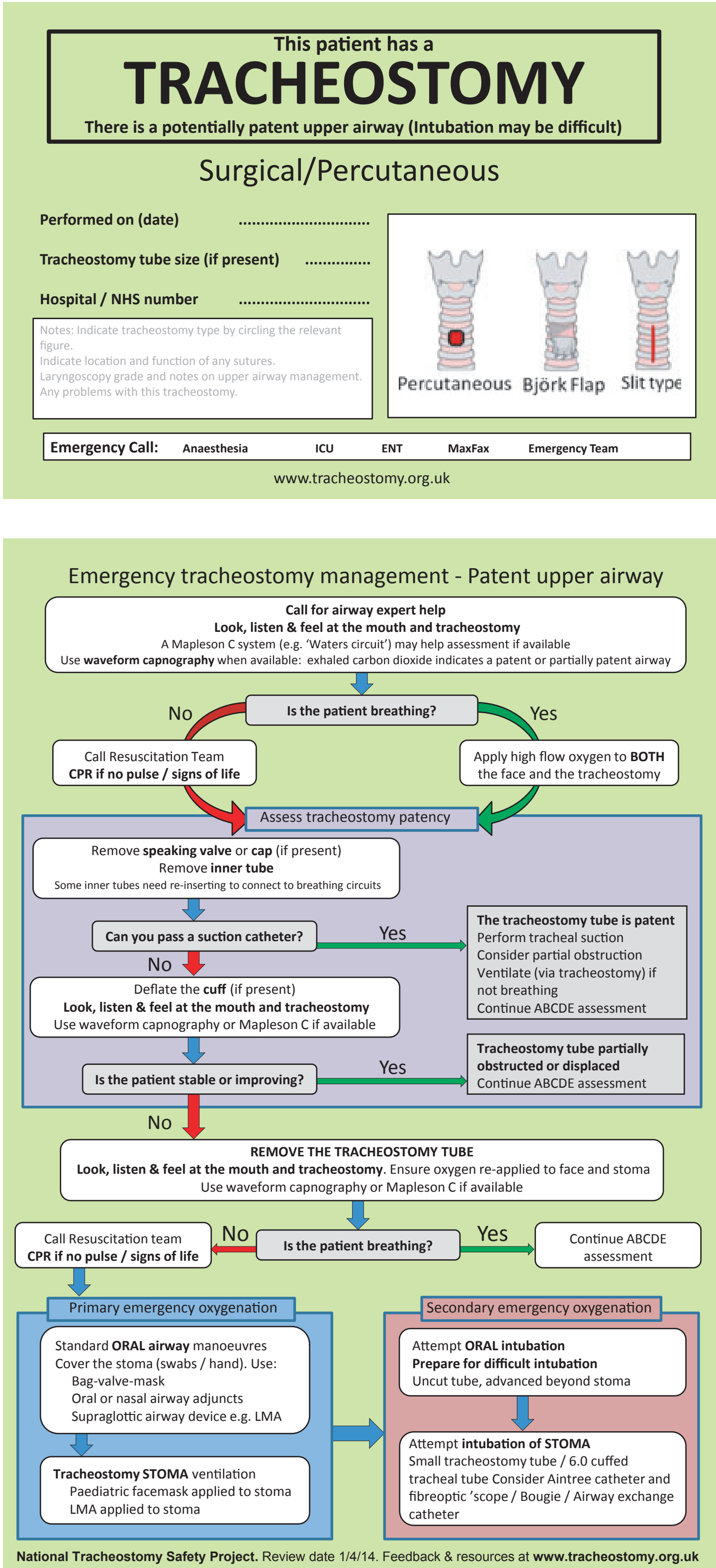
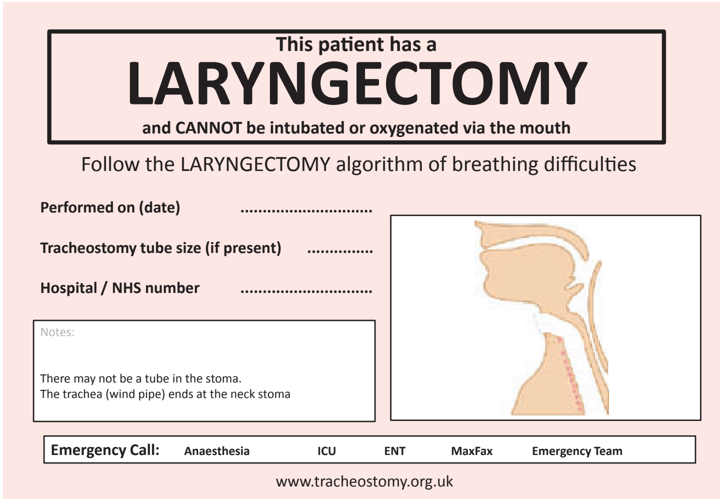


Figure 1 (a) Patent airway 'green' bed-head sign. This sign should be present at all times on the bed-head of patients with a tracheostomy and corresponds to the green algorithm in the event of an airway emergency. (b) Patent airway 'green' algorithm. Also available with the online version of the article as a downloadable PDF.

(a)



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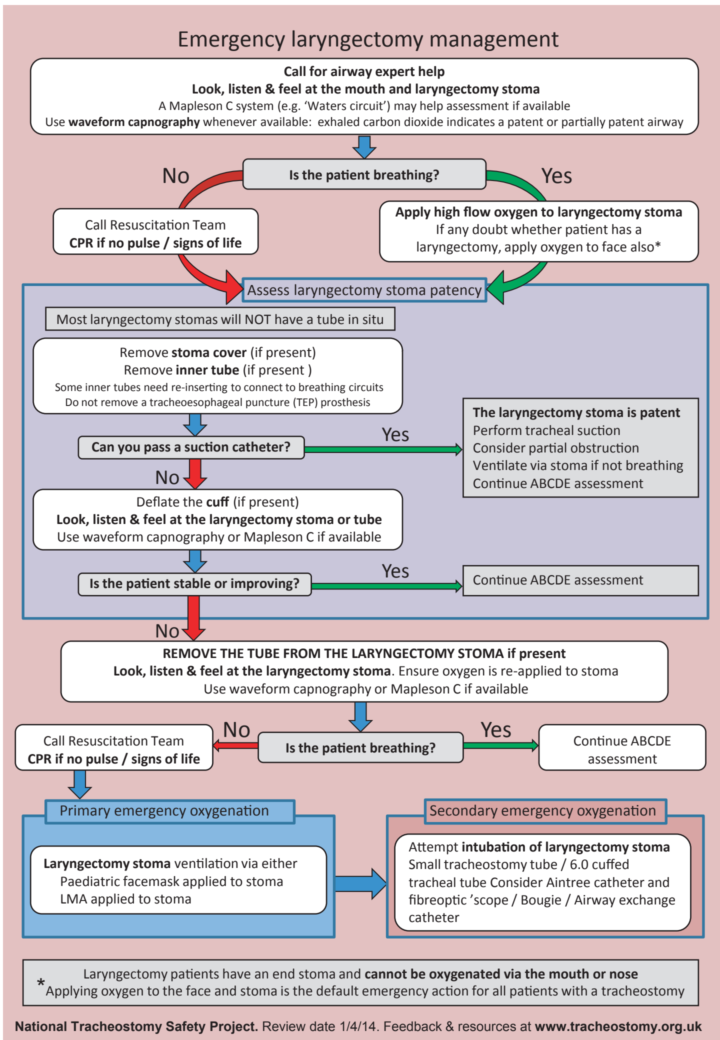

Figure 2 (a) Laryngectomy 'red' bed-head sign. This sign should be present at all times on the bed-head of patients who have had a laryngectomy and corresponds to the red algorithm in the event of an airway emergency. (b) Laryngectomy 'red' algorithm. Also available with the online version of the article as a downloadable PDF.

Second, it was recognised that separate algorithms were needed for patients with a potentially patent upper airway and those with a laryngectomy [29]. However, it was also apparent that there would be a commonality, with the management of laryngectomy patients following the same steps as for tracheostomy patients, but without the upper airway elements. The advised series of actions in both algorithms should describe the simple, immediate assessment and management of blocked or displaced tubes and then progress towards more complex scenarios and advanced options should the patient not respond to simpler interventions.

The overall style of the algorithms was to be based on the highly successful flow charts produced by DAS to build on the success of previous guidance [19, 44], highlighting how effective emergency management requires careful advanced planning and a multi-disciplinary team approach [7, 8]. Two further principles were adopted from previous DAS work, supported by our critical incident reviews: oxygenation of the patient takes priority (not necessarily securing the airway immediately and definitively, unless required for oxygenation); and the best assistance should be sought early [15]. Ideally, this assistance would include other members of the multi-disciplinary team who are trained and competent to deal with tracheostomy emergencies [27, 45, 46], working in adequately equipped clinical environments [25, 31, 47–49].

There was debate as to how many algorithms were required to cover all clinical situations. The Working Party reviewed examples of detailed local algorithms focussing on specific elements of tracheostomy management (e.g. the blocked tube, the bleeding stoma, the patient receiving controlled ventilation). However, in contrast to these problem-specific approaches, the Working Party decided to develop a generic algorithm that would cover the vast majority of common and easily reversible clinical situations that arise whilst accepting that a number of special circumstances do exist (e.g. the critically ill patient in the intensive care unit or the patient who has undergone a complex tracheal reconstruction). It was felt that even in these complicated scenarios, adherence to certain key airway management principles would be beneficial, whilst also allowing training to be standardised [21, 50–52].

The Working Party recognised that competencies and training are likely to be divided between those of the primary and secondary responder. The primary responder (typically a nurse, junior doctor or allied health professional) needs to be guided to detect airway problems, to assess tracheostomy and airway patency and to provide basic emergency oxygenation. The secondary responder (typically an anaesthetist, intensivist, head and neck surgeon or specialist practitioner) will have skills in conventional airway management and will also be guided to use skills in managing the tracheostomy or stoma [53]. These skills could include difficult oral/nasal intubation techniques, the ability to use a fibreoptic 'scope to assess or replace tracheostomy tubes and the ability to perform and manage an emergency surgical airway or tracheostomy. It became clear that the algorithms required division into sections to reflect the differing skills of the responders.

Finally, the Working Party recognised that with all such guidance, the maximum benefits will be achieved through education. The algorithms themselves would provide only the reference point or focus for the wider educational process. Local adoption and local training will address many of the special circumstances encountered in individual clinical areas [54], and therefore web-based demonstrations and discussion of the algorithms along with other resources including workshops would be needed in the longterm.

The following section includes detailed discussion and explanation of the algorithms, which are shown in Figs 1a and 2a. The algorithms are applicable for any urgent or emergency situation that develops in a patient with a tracheostomy or laryngectomy. Adverse clinical signs may be reported or observed and may (or may not) be related to airway compromise. As with all unwell patients, the assessment of the airway occurs first.

Patent upper airway: the 'green algorithm'

This algorithm (Fig. 1b) is paired with the green bed-head sign (Fig. 1a) and assumes a *potentially patent* upper airway, meaning that it is anatomically possible for the upper airway to connect to the trachea and thus theoretically allow ventilation by this route. This is in contrast to a laryngectomy. As the original reason for the tracheostomy may have been an upper airway that is difficult or impossible to manage, the paired green bed-head sign emphasises that the airway may be difficult and documents the original grade of laryngoscopy and any airway devices or techniques used successfully [55]. However, the majority of patients will have an upper airway that could be used in addition to the tracheostomy [3].

Help and equipment

The first step is to call for help. Who is called will depend on the patient, the responder and the location. The bed-head sign will display local details specific to this patient of whom to call and how to avoid delays. Clinical areas caring for patients with tracheostomies should be staffed and equipped to do so. This includes the provision of routine and emergency airway equipment. Most equipment should be at the bedside, usually in a dedicated emergency box [36, 56]. Additional equipment should also be summoned (Table 1). A fibreoptic 'scope should be available at all sites (including wards) where patients with a tracheostomy are cared for, and used either to enable inspection of the tube position, to assist in the replacement of the tube or to enable management of the upper airway [42, 57]. Specialist areas such as critical care will need a difficult intubation trolley, waveform capnography and a fibreoptic 'scope immediately available, as recommended in NAP4 [43].

Table 1 Recommended bedside and emergency airway equipment for patients who have had a tracheostomy or laryngectomy.

Bedside equipment
- Humidification equipment
- Suction with selection of appropriate suction catheters
- Spare tracheostomy tubes
  - One the same size
  - One tube one size smaller
- Clean pot for spare inner cannula
- Sterile water for cleaning the suction tube
- Scissors (and stitch cutter if tracheostomy tube is sutured)
- Water soluble lubricating jelly
- Sterile dressing pack
- Tracheostomy dressings
- Tracheostomy tapes
- Personal protective equipment (gloves, aprons, eye protection)
- Sterile gloves for performing deep suction
- Nurse call bell: the patient may be unable to call for help verbally
- Communication aids: the patient may not be able to verbalise
- Bedside equipment checklist

Emergency equipment
- Basic airway equipment – oxygen masks, self inflating bags, oral and nasal airways
- Advanced airway equipment – laryngeal mask airways and laryngoscopes with appropriate tubes (arrest trolley or similar)
- Capnography[1]
- A fibreoptic 'scope[2]
- Tracheal dilators[3]
- Bougies

[1,2] Waveform capnography and a fibreoptic 'scope (suitable for immediate use) should be available for all patients with a tracheostomy. In critical care and specialist areas, these should be *immediately* available. For other ward areas, availability should be within minutes (e.g. on a cardiac arrest trolley). All staff caring for tracheostomy patients and those who respond to emergencies should know how to access and operate these devices around the clock.

[3] There is conflicting opinion on whether tracheal dilators are useful in an emergency. This should be agreed locally; influences include patients' characteristics, types of tracheostomy performed and clinicians' preference.

Assessment of breathing

Following the principles of basic life support, the first clinical steps attempt to open the airway and look for evidence of breathing [28]. Tracheostomy patients will usually have two airways (the native upper airway and the tracheostomy) and clinical assessment takes place by looking, listening and feeling at the face *and* tracheostomy tube or stoma for 10 s, following basic upper airway opening manoeuvres. A Mapleson C anaesthetic breathing system (commonly referred to as a 'Waters circuit') can be used attached to a facemask placed over the face or tracheostomy stoma, or directly to the tracheostomy tube. The collapsible bag can offer visual confirmation to the presence of respiration if the bag is seen to move. This circuit also enables ventilation, but must be used only by those who are competent to do so, as harm may occur if the expiratory valve is left closed [58]. Waveform capnography is invaluable when managing airways and should be used at the beginning of the assessment [7, 8, 59, 60]. If the patient is breathing, high-flow oxygen should be applied to the face *and* tracheostomy. This will require two oxygen supplies, which may necessitate the use of the oxygen cylinder on the resuscitation trolley. Pulse oximetry can add valuable information as to the success of interventions and to the urgency of subsequent interventions.

If the patient is not breathing (apnoea or occasional gasps) or there are no signs of life, then a pulse check must occur and cardiopulmonary resuscitation commenced as per published guidelines [28]. Note that in the course of such resuscitation, the steps outlined in the remainder of this algorithm should be employed, as a primary tracheostomy problem (e.g. tracheostomy tube blockage) may have led to the cardiorespiratory arrest.

Assessment of tracheostomy patency

With all resuscitation attempts and approaches to the critically ill, an assessment of airway patency is the first step of the familiar 'ABCDE' approach. Here, we have two airways to consider. Simple, easily reversible problems have caused significant morbidity and mortality in tracheostomy patients, including the presence of obstructing (decannulation) caps or obturators attached to the tracheostomy tubes [61–63]. Speaking valves can be used incorrectly (with an inflated, cuffed tube) and these, along with small humidifying devices (e.g. Swedish noses), can become blocked with secretions [64] (Fig. 3). Any such device attached to a tracheostomy tube must be removed in an emergency.

Inner tubes are increasingly used with tracheostomies and can significantly reduce the risk of tube occlusion with secretions, provided they are cared for and used appropriately [31, 65]. If a tracheostomy tube becomes blocked, simply removing the inner tube may resolve the obstruction. Inner tubes vary significantly in their design from single-use disposable tubes with or without fenestrations through to tubes that require a dedicated inner cannula to allow connection to standard 15-mm resuscitation and breathing circuits [66–69]. These inner tubes may need replacing after cleaning, as only then will connection to breathing circuits be possible. Unfamiliarity with equipment may lead to morbidity and mortality. Although there will always be a small number of patients who require bespoke devices, standardisation of the range of tracheal tubes within an organisation could be expected to reduce these errors [70].

Passing a suction catheter via the tracheostomy will establish whether or not the airway is patent along its length and also allow therapeutic suction to be performed [71, 72]. The suction catheter needs to pass easily beyond the tracheostomy tube tip and into the trachea, and the depth of insertion will depend on the length of the tube in situ [73–75]. Gum-elastic bougies or similar introducers should be avoided as these stiffer devices are more likely to create a false passage if the tracheal tube tip is partially displaced [76–78] (Fig. 4). Soft suction catheters will not advance sufficiently into the pre-tracheal tissues [79–82].

The algorithm makes proper distinction between using hand ventilation (by attaching an anaesthetic breathing system to the tracheostomy tube) for resuscitation and its use for diagnosing airway patency. The

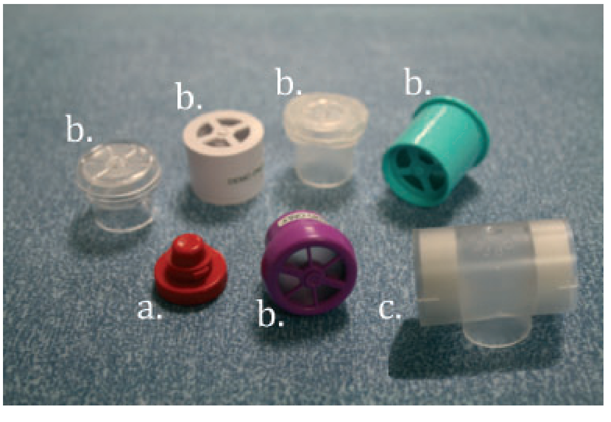

Figure 3 Devices that may be attached to a tracheostomy tube. (a) Decannulation cap. (b) Speaking valves. (c) 'Swedish nose' humidifier.

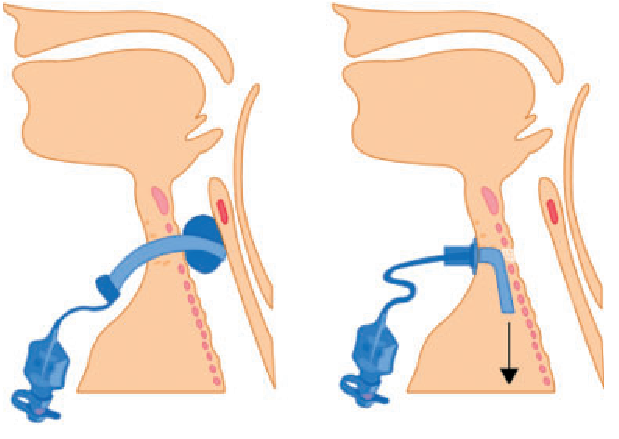

Figure 4 Left-hand figure shows a partially displaced tracheostomy tube with the cuff obstructing the trachea. The right-hand figure shows complete displacement into the soft tissues of the anterior neck (a 'false passage').

former is acceptable and the latter is not. There have been several incidents, including deaths, where vigorous attempts at ventilation via a displaced tracheostomy tube have caused significant surgical emphysema, making access to the neck increasingly difficult [7, 83–86]. This situation is made worse if a fenestrated tube becomes partially displaced [87, 88]. Therefore, it is recommended only to use gentle hand ventilation if required, and only after the tracheostomy has been confirmed to be patent using a suction catheter.

If the suction catheter passes easily into the trachea, then the tracheostomy tube can be regarded as patent and the 'ABCDE' assessment can continue as per standard guidelines. If the patient is apnoeic, effective ventilation via the tracheostomy will require an inflated cuff (with un-fenestrated inner tube if necessary) to seal the trachea and allow positive pressure to be delivered to the lungs.

If the suction catheter will not pass, the tube is blocked or displaced [83]. Deflating the distal cuff, if present, may allow airflow past a partially displaced tracheostomy tube to the upper airways [89–91] (Fig. 4). In the special circumstance of early post-procedural haemorrhage (complicating up to 5% of tracheostomies) leaving the cuff inflated may cause a tamponade effect, reducing bleeding [92]. Reassessment of both the tracheostomy and the upper airways will determine if the airways are now patent. If cuff deflation improves the clinical condition then the responder can continue the 'ABCDE' assessment and await experienced assistance. Here, although the tracheostomy tube may still be (partially) occluded or displaced, there is sufficient air entry to ensure some clinical stability.

Removal of the tracheostomy tube

If a suction catheter cannot be passed and deflating the cuff fails to improve the clinical condition, the tracheostomy tube may be completely blocked or displaced, and the patient cannot breathe around the tube adequately [93]. Continued attempts at 'rescue' ventilation will not be effective as the airway is obstructed and the tracheostomy tube should be removed. Although there may be concerns about the consequences of removing a tracheostomy tube at this stage (especially from a patient with a difficult or obstructed upper airway, or one whose tracheostomy is known to be difficult) [94, 95], when faced with a deteriorating patient with an obstructed airway, a non-functioning tracheostomy offers no benefit, with considerable potential for harm [36, 89, 96–98]. Following tracheostomy tube removal, reassessment at both airways (mouth and trachea) is required, ensuring oxygen is reapplied to face and stoma [36, 98, 99]. These actions may resolve the airway problem and if the patient is breathing and improving, ABCDE assessment continues. Definitive management of the airway (re-insertion of a tracheostomy or oral tube) is not necessarily required immediately if the patient is not hypoxic. Insertion of an airway device may require expertise and equipment, and harm has resulted from inappropriate attempts to manipulate the stoma blindly when not required [66, 76].

The special circumstance of a known difficult or obstructed upper airway, or previously difficult-to-insert tracheostomy, may necessitate a fibreoptic inspection of the tube whilst it remains in situ, in preference to its prompt removal. This is only relevant where appropriate equipment and expertise is immediately available and the patient is clinically stable [34, 66, 94, 95]. This should not delay the removal of a blocked or displaced tube when faced with a deteriorating patient.

Emergency oxygenation

If the patient fails to improve after removing the tracheostomy tube, primary emergency oxygenation may be achieved by the oro-nasal route, the tracheostomy stoma or by both routes. Most first responders will correctly attempt to manage the airway as they would in any apnoeic patient, but must remember to occlude the tracheal stoma to maximise the possibility of effective ventilation [100, 101]. Ventilation can also be achieved via the stoma using a small, paediatric facemask or a laryngeal mask airway (LMA) applied to the skin [102–105]. To achieve this, occlusion of the upper airway by closing the nose and mouth may be required if there is a large leak [101]. The goal remains oxygenation, and formal insertion of an airway device may not be required – a situation analogous to prioritising oxygenation and not intubation at every cardiac arrest [28].

If effective oxygenation or ventilation cannot be achieved, secondary emergency oxygenation manoeuvres are required. These are advanced techniques and the choice will depend on the patient, the responders and the equipment available [33, 53, 66, 106, 107]. These are likely to be dire clinical situations and separate airway teams may be appropriate – one working at the head/face and one working on the neck. Oral intubation may be possible and, if so, a long (i.e. uncut) tube can be used and advanced beyond the stoma to bypass the hole in the anterior tracheal wall (Fig. 5).

It may be more appropriate to attempt intubation of the tracheostomy stoma at this point, for example in an established tracheostomy or if the upper airway is known to be difficult [108]. Simple re-insertion of a smaller tracheostomy tube or tracheal tube may establish a patent airway, although a 'deeper' stoma may require more advanced techniques [109, 110]. Where possible, a fibreoptic 'scope should be used to facilitate placement of an airway catheter (e.g. Aintree catheter) or bougie, or to allow an tracheal or tracheostomy tube to be 'rail-roaded' into the trachea and help to ensure correct placement [34, 42, 66]. In an emergency situation without availability of a fibreoptic 'scope, blind or digitally assisted placement of a bougie may be helpful, but risks malposition [111, 112].

The use of waveform capnography in establishing effective ventilation via a patent airway has been reinforced by recent guidelines and capnography should be available for hospitalised patients in a resuscitation attempt regardless of location [60, 113, 114].

Laryngectomy: the 'red algorithm'

This algorithm is paired with the red bed-head sign and indicates that the patient does not have an upper airway in continuity with the lungs. The principles of the algorithm are the same, without the conventional upper airway management steps. Patients with laryngectomies usually do not have a tracheostomy tube in situ, but may have other devices inserted into their airways to allow speech via the oesophagus (tracheo-oesophageal puncture 'TEP' valves). These devices should not be removed [115] (Fig. 6). The exclusion of the upper airway means laryngectomy patients will not obstruct their airway when laying flat on their back and aspiration of gastric contents is not a concern. In the context of cardiopulmonary resuscitation, chest compressions will generate more significant tidal volumes owing to a reduction in dead space [116]. Oxygen insufflation without ventilation may be reasonably efficacious if ventilation is difficult.

There are around ten times as many surgical tracheostomies as laryngectomies performed in England [1]. When percutaneously formed tracheostomies are also taken into consideration, the likelihood that an airway stoma encountered in an emergency situation is a laryngectomy is between one in 20 and one in 30. A patient with a tracheostomy is more likely to come to harm by not having oxygen applied to the face if confusion surrounds the nature of the stoma. The default emergency action is to apply oxygen to the face

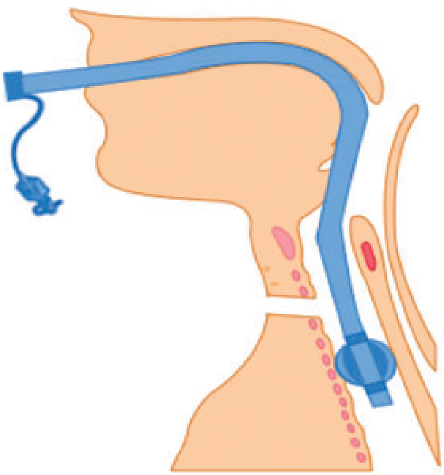

Figure 5 An uncut tube is advanced beyond the stoma to allow effective ventilation. Care must be taken to avoid an endobronchial intubation.

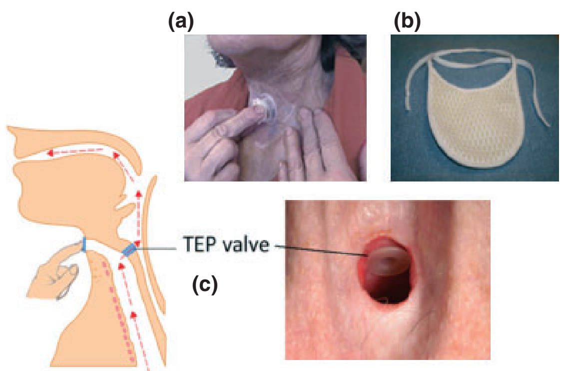

Figure 6 Devices relevant to laryngectomy. (Published with the consent of the patients where applicable). (a) Stoma 'button'. (b) Buchannon bib. (c) Tracheo-oesophageal puncture (TEP) valve schematic with valve visible through stoma.

and the stoma for all neck breathers when there is any doubt as to the nature of a stoma. Any oxygen applied to the upper airway can be removed in the case of a laryngectomy, once this has been confirmed to be the case. Ventilation via laryngectomy stomas can be achieved using paediatric facemasks or LMAs applied to the anterior neck [103].

Discussion

It is not possible to conduct controlled studies in the emergency airway situation and as such, these guidelines represent expert opinion and experience, supported by the best available evidence where possible [117, 118].

There are numerous local and regional guidelines available [119–126, Warrington and Halton Hospitals NHS Foundation, Personal communication, 2010; Countess of Chester tracheostomy policy, Personal communication, 2010]. Their focus ranges from information for patients or their relatives who have tracheostomies or laryngectomies through to routine nursing care. Others offer more comprehensive teaching on all aspects of care and include algorithms for emergency management. Although some guidelines cite published articles in support of some of their recommendations, as far as can be ascertained, no other guideline has evaluated this evidence using representatives of key national bodies, followed by peer review by members of those bodies. As a result, specific differences with other guidelines are evident. In our algorithms:

1 Waveform capnography has a prominent role at an early stage in emergency management.
2 Oxygenation of the patient is prioritised.
3 Trials of ventilation via a potentially displaced tracheostomy tube to assess patency are avoided.
4 Suction is only attempted after removing a potentially blocked inner tube.
5 Oxygen is applied to both potential airways.
6 Simple methods to oxygenate and ventilate via the stoma are described.
7 A blocked or displaced tracheostomy tube is removed as soon as this is established, not as a 'last resort'.

In addition, previous guidance for tracheostomy emergencies has generally not been published as an algorithm, making it difficult to follow in emergency situations. Where algorithms have been used, they are often complex and not easily followed when tested in simulated emergencies. No algorithms were colour coded and none are presented paired with bed-head signs. No emergency guidance was applicable to all situations (critical care, controlled ventilation, surgical vs percutaneous tracheostomy, community patients) and many offered no 'Plan B' if the initial measures failed to resolve the situation.

The full impact of any guidelines requires their dissemination and adoption through teaching, and incorporation into relevant local and national programmes [21, 44, 52, 127]. Today's wards and critical care units are staffed with doctors with less experience and reduced exposure to difficult airways. This is due to numerous factors including a reduction in the number of difficult airways that present late, shorter working hours, better airway equipment, increased use of supraglottic airways and a reduction in training opportunities [54, 59, 128–134]. It is essential that frontline medical, nursing and allied health staff are competent to manage and assist with tracheostomy and other related airway emergencies if they work in a relevant clinical area [31, 38, 53, 135–140].

Staff with limited exposure to these patients may find it difficult to maintain adequate skills [10, 11, 24, 141]. Organisational changes within trusts to place tracheostomy and laryngectomy patients on to designated wards will concentrate skills, experience and equipment and provide relevant and consistent medical support, with improvements in patient care described [27, 48, 49, 142–146].

Essential equipment should be immediately available at the patient's bedside, including spare inner tubes and tracheostomy tubes, appropriate suction and basic airway management devices [147, 148]. The full list of recommended bedside equipment in various clinical situations can be found at http://www.tracheostomy.org.uk (summarised in Table 1). Waveform capnography must be available, supported by training to ensure appropriate connection to a breathing circuit and correct interpretation [7–9, 59, 149–152]. Capnography modules are becoming available on resuscitation trolleys and defibrillators and this must be encouraged and supported [28, 60, 113]. The NAP4 study recently reported that 50% of airway-related deaths in critical care were associated with tracheostomy displacement and that use of capnography could have prevented more than 80% of such deaths [8]. The universal availability, use and interpretation of capnography in critical care units and emergency departments can be expected to reduce morbidity and mortality of both neck-breathing patients and those requiring more conventional airway management. It is now recommended that all patients whose lungs are ventilated via a tracheostomy have continuous waveform capnography monitoring [7, 8, 60, 113, 114] and this should enable prompt diagnosis of tube blockage or displacement. In patients who are not ventilator-dependant, there may still be an argument for use of capnography [60], but more active hospitalised patients may find that capnography restricts their movement or adds weight to the tube, which may even contribute to displacement. The benefits of waveform capnography in assessing the patency of an airway are clear. At the very least, it should be in use for patients whose lungs are ventilated via tracheostomy or laryngectomy and immediately available for those who are not attached to a ventilator.

Further developments

Following trials of the resources in the community, some members of the Working Party recognised the need for a simplified algorithm, without the advanced airway manoeuvres applicable for a hospital situation [11, 153, 154]. These would be suitable for non-hospital or isolated sites or non-medically qualified carers. This guidance, along with specific paediatric and community resources, is currently being developed.

Conclusion

By highlighting some of the problems associated with tracheostomy management, these algorithms, supported by accessible resources, aim to improve the safety and emergency management of neck-breathing patients. As with other DAS and Resuscitation Council (UK) guidance, these guidelines will undergo regular review and update further to improve standards through reflection, audit and research where possible. This includes lessons learned from moving and handling precarious airway devices in the operating theatre environment, addressing shortcomings in tracheostomy tube design, selection and fixation [155], adequately equipping appropriate clinical areas and ensuring that all staff have access to appropriate education before being exposed to patients with tracheostomies and laryngectomies.

Acknowledgements

We are indebted to the following organisations and individuals for comments and advice on early versions of the manuscript and algorithms and for their input into the wider resources and remit of the project:

Difficult Airway Society: Dr Ellen O'Sullivan (President), Dr Atul Kapilla (Secretary), Prof Jaideep Pandit (Scientific Officer)

Royal College of Anaesthetists: Dr Peter Nightingale (President), Dr Tim Cook (NAP advisor to the RCoA)

Intensive Care Society: Dr Simon Baudouin (Standards Committee chair), Dr Andrew Bodenham (ICS Tracheostomy Standards Author), Dr Andrew Bentley (Council member)

ENT UK: Mr Andrew McCombe (Honorary Secretary), Mr Vinidh Paleri, Mr Paul Pracy and Mr Richard Wight (Head & Neck Committee)

BAOMS: Prof Simon Rogers (Chair, Clinical Effectiveness Committee)

RCSLT: Mrs Sarah Wallace & Mrs Susan McGowan (Expert Advisors)

CSP: Mrs Cathy Sandsund (ACPRC Research Officer), Mr David McWilliams (ACPRC Critical Care Champion)

RCN: Sr Rachel Binks (Chair, Critical Care Steering Committee)

CEM: Prof Jonathan Benger (Chair, Clinical Effectiveness Committee and Emergency Airway Lead)

NPSA: Mrs Joan Russell (Head of Patient Safety, Anaesthesia and Surgery); Mrs Fran Watts (Patient Safety Lead, Surgery)

Resuscitation Council (UK): Dr Carl Gwinnutt, Dr Jerry Nolan, Dr Jasmeet Soar (on behalf of the Executive Committee)

With thanks to all Working Party members, especially:

Sr Sam Westwell, Nurse Consultant in Critical Care, Salford Royal Hospitals FT; Dr Anna Perks, Consultant Anaesthetist, Salford Royal Hospitals FT; Dr Jane Eddleston, Consultant Intensivist, Central Manchester FT; Dr Bernard Foex, Consultant Intensivist, Central Manchester FT; Dr Irfan Chaudry, Consultant Intensivist, Royal Preston Hospital; Dr Ben Slater, Consultant Anaestheist, NHS Fife; Dr Cath Roberts, Consultant in

Emergency & Intensive Care Medicine, Royal Preston Hospital; Sr Elaine Grainger, Critical Care Outreach, UHSM; and CN Tim Baker, AICU Practice Educator, UHSM

Competing interests

The National Tracheostomy Safety Project has received funding from the ICS and assistance from the RCoA (allowed use of in-house programmers) specifically to contribute towards the e-Learning for Healthcare modules that were developed as part of this project.

The project has also received sponsorship from the following companies: Smiths-Medical (Portex); Cook; Kapitex; Ambu a-scope; Olympus; Astellas Pharma; and Pfizer. This sponsorship has specifically been used to reduce the cost of medical, nursing and allied health staff attending our tracheostomy safety courses and has not influenced the production or development of these resources. No individual or organisation has benefitted financially from this project.

Disclaimer

These guidelines should not constitute a minimum standard of practice nor should they be regarded as a substitute for good clinical judgement.

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Supporting information

Additional supporting information may be found with the online version of this article:

Figure S1 Tracheostomy bed-head and algorithm.

Figure S2 Laryngectomy bed-head and algorithm.

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