

SPECIAL ARTICLE

Guidelines for the management of tracheal intubation in critically ill adults

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Abstract

These guidelines describe a comprehensive strategy to optimize oxygenation, airway management, and tracheal intubation in critically ill patients, in all hospital locations. They are a direct response to the 4th National Audit Project of the Royal College of Anaesthetists and Difficult Airway Society, which highlighted deficient management of these extremely vulnerable patients leading to major complications and avoidable deaths. They are founded on robust evidence where available, supplemented by expert consensus opinion where it is not. These guidelines recognize that improved outcomes of emergency airway management require closer attention to human factors, rather than simply introduction of new devices or improved technical proficiency. They stress the role of the airway team, a shared mental model, planning, and communication throughout airway management. The primacy of oxygenation including pre- and peroxygenation is emphasized. A modified rapid sequence approach is recommended. Optimal management is presented in an algorithm that combines Plans B and C, incorporating elements of the Vortex approach. To avoid delays and task fixation, the importance of limiting procedural attempts, promptly recognizing failure, and transitioning to the next algorithm step are emphasized. The guidelines recommend early use of a videolaryngoscope, with a screen visible to all, and second generation supraglottic airways for airway rescue. Recommendations for emergency front of neck airway are for a scalpel–bougie–tube technique while acknowledging the value of other techniques performed by trained experts. As

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most critical care airway catastrophes occur after intubation, from dislodged or blocked tubes, essential methods to avoid these complications are also emphasized.

Key words: 'Can't Intubate Can't Oxygenate'; difficult airway; emergency medicine; intensive care; tracheal intubation

Airway management in anaesthesia has been transformed since the publication of national guidelines for management of the unanticipated difficult intubation,^{1–9} with the UK guidance updated in 2015.⁹ However, the 4th National Audit Project of the Royal College of Anaesthetists and Difficult Airway Society (NAP4) highlighted a significantly higher rate of adverse outcomes and important deficiencies of airway management in intensive care units (ICUs) and emergency departments (EDs), compared with anaesthetic practice.^{10,11}

The challenges of different patient populations (adult, paediatric, obstetric, emergency, prehospital, and extubation) have been addressed by specific guidelines.^{2,5,12–14} However, even though critically ill patients may present in any area of the hospital (ED, ICU, ward areas) posing unique challenges (Table 1), and having the highest risk of complications, there is little specific guidance for managing these patients, with only one published national guideline.¹⁵

In the critically ill, patient factors may preclude standard airway assessment. Urgency and reduced physiological reserve contribute dramatically to increased risks of profound peri-intubation hypoxaemia, hypotension, arrhythmia, cardiac arrest, and death.^{16,17} Delays during tracheal intubation and multiple attempts at laryngoscopy are associated with increased complications, again including cardiac arrest and death.^{11,18} Failure of 'first pass success' occurs in up to 30% of ICU intubations, significantly higher than in the operating room (OR).^{18–21} Severe hypoxaemia ($S_pO_2 < 80\%$) during ICU intubation is reported in up to 25% of patients.²² Further, approximately 4% of ICU patients are admitted for airway observation, intubation, or extubation of a primary airway problem and, overall, around 6% of ICU patients have a predicted difficult airway.²³ Critical illness and its management can make anatomically 'normal' airways 'physiologically difficult'. Fluid resuscitation, capillary leak syndromes, prone ventilation, and prolonged intubation all contribute to airway oedema and distortion. Awake intubation is often inappropriate and awakening the patient following failed airway management is usually impractical. Additional significant challenges include the environment, experience of the operator or attending staff, and other human factors (Table 1). When major airway events occur in ICU, the incidence of death and brain damage is roughly 60-fold higher than during operative anaesthesia.¹¹

Despite the high-risk nature of intubation in ICU, most airway incidents occur after the airway has been secured due to airway displacement or blockage; in one series, 82% occurred after intubation with 25% contributing to the patient's death.²⁴ Tracheostomy is used to manage 10–19% of level 3 ICU admissions and carries particularly high risks.^{11,24–26}

In the UK, the Difficult Airway Society (DAS), Intensive Care Society (ICS), Faculty of Intensive Care Medicine (FICM), and Royal College of Anaesthetists (RCOA) recognized the need for specific guidance to provide a structured approach to management of the airway in the critically ill adult. Airway management may be made difficult by anatomical or physiological factors and these notably affect patients in ICU, ED, and on the wards. This guideline applies to all these critically ill patients

irrespective of hospital location. In common with airway guidelines in other settings, it prioritizes oxygenation whilst endeavouring to limit the number of airway interventions, in order to prevent complications.⁹ To address the specific challenges in the critically ill, this guideline discusses preparation of the multidisciplinary team and environment, modified airway assessment, preoxygenation and oxygen delivery during intubation (described as 'peroxygenation'), haemodynamic management, the role of rapid sequence induction, optimal laryngoscopy including videolaryngoscopy, a unification of Plans B and C, choice of emergency front of neck airway (FONA), and several special circumstances. This guideline does not address indications for intubation.

Methods

The DAS commissioned a working group in 2014 with representation from DAS, ICS, FICM and RCoA. An initial literature search was conducted from January 2000 to September 2014 using Medline, PubMed, Embase, Ovid, and Google Scholar. English language articles and abstract publications were identified using keywords and filters. Search terms are listed in Supplementary material 1. Searches were repeated periodically until May 2017, retrieving a total of 33 020 abstracts, reduced to 1652 full-text articles following screening by the working group. Additional articles were retrieved by cross-referencing and hand searching. Controlled studies are not possible in unanticipated airway difficulty,^{10,11} especially in the critically ill. The quality of evidence varied considerably (GRADE²⁷ level 2+ to 5) and in its absence, consensus was sought.

Where deviation from the DAS 2015 guidance was unnecessary, notably practical Front Of Neck Airway (FONA) techniques for the 'can't intubate can't oxygenate' (CICO) situation via the cricothyroid membrane, this is reproduced in this guideline. Where additional external expertise or arbitration was considered useful, (videolaryngoscopy, burns, and cardiovascular collapse during intubation) this was sought and consensus achieved. Opinions of the critical care community and DAS membership were sought throughout the process with presentations at various national professional meetings between 2015 and 2017. A forum for comments and questions was hosted on the DAS website. As with previous DAS guidelines, a draft was circulated to relevant professional organizations, inviting UK and international experts to comment. The working group reviewed all correspondence before finalizing the guidelines.

Disclaimer

It is not intended that these guidelines should constitute a minimum standard of practice, nor are they to be regarded as a substitute for good clinical judgment. They represent an organizational and individual framework for preparation, training, and to inform clinical practice. This document is intended to guide appropriately trained operators.

Table 1 Challenges and solutions during tracheal intubation in the critically ill.

		Challenge	Potential solution in this guideline
Non-OR setting: ICU—ED—Ward	Guidance	<ul style="list-style-type: none"> Existing anaesthesia guidance not always applicable. Limited evidence base. 	Recognizes critical illness as a special circumstance. Comprehensive literature review and broad clinical consensus.
	Areas outside OR especially ED	<ul style="list-style-type: none"> Environmental, staff, monitoring, and equipment factors are often compounded, leading to increased risks of failure and patient harm. 	Common approach for all areas managing the critically ill. Encouraging joint training, purchasing and incident review.
	ICU environment	<ul style="list-style-type: none"> ICU bed space not designed for airway management. Bed space crowded with monitors and other equipment: limit access to patient, especially at head end. Lighting often suboptimal. 	Common airway management trolleys brought to bedside. Optimal positioning recommended.
	Equipment	<ul style="list-style-type: none"> Airway equipment different from OR. Access to advanced equipment may be limited and delayed in an emergency. 	Recommendation for availability of standardized airway trolley, VL, FOS and capnography. Purchasing with all users in mind.
	Monitoring	<ul style="list-style-type: none"> Monitoring usually positioned for end of bed viewing in ED and ICU. Capnography not always available. ET oxygen not always available. 	Team brief identifies individual responsible for monitoring. Minimum monitoring recommendation.
	Training	<ul style="list-style-type: none"> Limited low-risk cases for training. Infrequent exposure to airway management especially advanced and rescue techniques. 	Training programs including bedside simulation using local equipment. Local training to ensure relevance of skills. Central human factors approach
	Human factors Team working	<ul style="list-style-type: none"> Multiprofessional environment. Inconsistent team membership. Equipment may be unfamiliar. 	Structured algorithm Team briefs, checklist, handover, and signage. Leader and empowered follower roles explained. Joint training. Equipment limited to first choice and one alternative only.
	Transfers	<ul style="list-style-type: none"> High-risk period. Remote working. Often delegated to junior staff. Unfamiliar equipment and environment. May be time limited. 	Highlight importance of senior involvement, planning, risk assessment, team training, and standardized equipment.
	Airway assessment	<ul style="list-style-type: none"> Medical devices (collars, masks) and altered conscious level and lack of patient cooperation impede assessment. 	Evidence-based assessment tool. Prompt to assess risk and identify cricothyroid membrane linked to assessment.
	Patient factors	Aspiration risk	<ul style="list-style-type: none"> Patients often not fasted. Pathology and drugs cause gastric stasis. Oxygenation with CPAP, NIV, HFNO may risk gastric distention. NGT often <i>in situ</i>.
Difficult airways		<ul style="list-style-type: none"> Increased incidence of oedema, trauma, immobilized neck, prior intubation, tracheostomy. Acute ED presentation. Urgency increases difficulty. 6% ICU patients are admitted for difficult airway observation, extubation, or both Anatomically normal airways become physiologically difficult due to rapid deterioration, decreased reserve, and urgency. 	Recognition and preparedness for difficult intubation. MACOCHA score used. Care plan for intubated patients Optimal oxygenation techniques Limit on attempts at instrumentation. Use of cognitive aid and early use of VL. Neuromuscular blockade routinely. Plan for failure. Triggered transition to FONA.
Preoxygenation		<ul style="list-style-type: none"> Pulmonary shunt interferes with effective pre- and peroxygenation. Lack of cooperation common (delirium or reduced conscious level). 	CPAP, NIV or nasal oxygenation. Head-up position emphasized. Recruitment manoeuvre. DSI described.
Special circumstances		<ul style="list-style-type: none"> Cervical spine trauma Burns 	Management recommendations.
Respiratory physiology		<ul style="list-style-type: none"> Pulmonary shunt causes rapid desaturation and impedes reoxygenation. Limited time for airway management before life-threatening hypoxia. Need for TT for effective oxygenation. Bronchospasm causes breath-stacking. 	Optimal pre- and peroxygenation techniques including PEEP described. Logical, prompt progression through airway techniques emphasized. Strategies for intubation and TT change described.

Continued

Table 1 Continued

	Challenge	Potential solution in this guideline
	<ul style="list-style-type: none"> Narrow-bore cricothyroidotomy may not be adequate for oxygenation. ED: little time for diagnosis and assessment. 	Rapid, sequential progression to scalpel-bougie-tube FONA.
CVS physiology	<ul style="list-style-type: none"> Unstable, collapse imminent before intubation. Standard induction drugs problematic. Instability leads to time pressure. 	Preinduction optimization. Ketamine recommended. Proactive use inotropes or pressors.
Urgency	<ul style="list-style-type: none"> May be no time to assemble expert team in ICU or ED or even perform adequate assessment, pre-oxygenation or stabilization. 	Checklist to improve reliability of care: standardized trolley; communication stressed; technique standardized; team roles identified.
Awake intubation often inappropriate	<ul style="list-style-type: none"> Hypoxia, agitation or reduced conscious level often precludes awake intubation. 	RSI with double set-up emphasized. DSI recommended.
No wake up if fail	<ul style="list-style-type: none"> Critical illness usually precludes wake-up as rescue: reduced conscious level +/- hypoxia already. 	Proactive decision before induction.
Positioning	<ul style="list-style-type: none"> Optimal positioning may not be feasible. ICU management requires frequent turns, movement for procedures, manipulation near airway and prone positioning. 	Identification of high-risk periods. Turns in high-risk patients require dedicated airway personnel. Intubated patient red flags to identify displaced airway device.
Sedation and agitation	<ul style="list-style-type: none"> Sedation holds risk airway displacement Agitation precludes adequate preparation. 	Identification of high risk periods. Caution over sedation holds in difficult airway. DSI described.
Airway maintenance	<ul style="list-style-type: none"> Prolonged intubation, increased secretions, and procedures all risk blockage and displacement. Multiple professional teams manage and maintain the airway. 	Intubated patient care plan highlighted. Intubated patient red flags. Team training including simulation.
Tracheostomy and laryngectomy	<ul style="list-style-type: none"> Higher incidence of tracheostomy with increased risk of blockage/displacement. Junior staff unfamiliar with and cognitively challenged by tracheostomy management. 	Recognition of tracheostomy insertion skills. Red flags also appropriate. Signposting to tracheostomy resources.
Increasing incidence of obesity	<ul style="list-style-type: none"> Obese tolerate airway management poorly. Short safe apnoeic time. Positioning, oxygenation, FMV, FONA difficult. 	MACOCHA highlights increased risk. Strategies for airway management described. Option of awake intubation emphasized.
Staff Resource	<ul style="list-style-type: none"> Nursing, medical and AHP often lack anaesthetic airway experience. Senior staff not continually present. May lack out of hours airway cover. Routine airway care and maintenance performed by nurses. Capnography not universal. Equipment not OR standard. 	Communication and handover emphasized. Multiprofessional training. Checklist identifies defined roles. Role of arriving expert defined. Waveform capnography mandated. Equipment choice limited.
Training	<ul style="list-style-type: none"> Focused airway training in ED and ICU infrequent. Doctors may not have anaesthesia and airway skills. Nursing airway and crisis management training rare. Critically ill not recognized as specific airway-risk. 	Focus on risk assessment, prevention of hypoxia and early request for advanced airway skills. Airway red flags. Specific guideline presented. Team training emphasized.
Immediate Surgical availability	<ul style="list-style-type: none"> Rare. May be distant from hospital 	Pre-emptive identification of at risk patients. Early intubation: not out of hours if possible. FONA experience recognized.

AFOI, awake fiberoptic intubation; AHP, allied healthcare professionals; CF, cricoid force; CPAP, continual positive airway pressure; CVS, cardiovascular system; DSI, delayed sequence induction; ED, emergency department; ET, end-tidal; FMV, facemask ventilation; FONA, front of neck airway; FOS, fiberoptic scope; HFNO; high-flow nasal oxygen; ICU, intensive care unit; NGT, nasogastric tube; NIV, non-invasive ventilation; OR, operating room (theatre); RSI, rapid sequence induction; TT, tracheal tube; VL, videolaryngoscope.

Human factors

Human factors include environmental influences, team behaviours, and individual performance. Human factors are the most prevalent cause of medical error and were prominent in NAP4 ICU reports.¹¹ Human factors deficits such as lack of patient preparation, equipment checks, or protocol deviation occur in up to half of ICU critical incidents.^{28,29} During ICU airway management, factors relating to the patient, clinical team work, environment, and the need for immediate decision-making contribute to potential difficulty.³⁰ Latent threats related to communication, training, equipment, systems, and processes are also common, contributing to poor decision-making and loss of situation awareness.⁹ A NAP4 follow-up study identified human factors elements in all NAP4 cases, with a median 4.5 contributory human factors per case. Loss of situation awareness (poor anticipation and suboptimal decision making) was the most common.²⁸

Environmental influences

The ICU is not designed primarily for airway management. Monitors and equipment limit access to the patient. Airway equipment should be chosen carefully. Complex equipment or devices with multiple variations can cause cognitive overload and impair decision-making.³¹ Options should be restricted,³¹ providing a primary device and, where necessary, a maximum of one alternative. Local choices should reflect proven efficacy but also consider the training and skillset of junior staff.¹⁰ Wherever practical, airway equipment should be standardized across the organization.³² A standardized airway trolley should be brought to the bedside for the procedure.

High reliability organizations accept the inevitability of latent (environmental) and human errors, but opportunities exist within healthcare systems to influence these. Cognitive aids (checklists and algorithms) improve performance in stressful situations^{33,34} and should be prominent wherever airway interventions are performed. Robust incident reporting and investigation should be embraced as an opportunity to improve care. Open, no-blame discussions, including after near-misses, involving all grades of staff, should form a routine part of morbidity and mortality meetings.³⁵

Team

The composition and roles of the intubation team are described in [Figure 1](#).

Team behaviour and individual performance

High-risk interventions require good teamwork including leadership and 'followership'. The leader is responsible for introducing team members and their roles, and identifying and clearly communicating key points in the process. For example, explicitly verbalizing 'failed intubation' creates a shared mental model.³⁶

The team leader remaining 'hands free' lessens the risk of task fixation and maintains situation awareness. Careful task allocation avoids individual cognitive overload and clarifies what is expected in both routine and challenging situations. Deciding, prior to induction of anaesthesia, who will make the second or third intubation attempt or perform FONA if it becomes necessary, could reduce delay in transitioning. We recommend prebriefs and checklists to help decision-making, evaluate options, limit interventions, and prompt calls for

help. They enable cognitive unloading, improve reliability, and enable staff members to voice concerns.³⁰

When help is summoned, communicate using structured handover techniques such as SBAR (situation, background, assessment, recommendation).^{36,37} Hierarchies can promote task fixation and impair communication.³⁸ The leader should unambiguously state that all staff may 'speak up' and identify potential problems. Well-briefed team members adopt 'active followership': empowered to actively anticipate the next steps, organise equipment, personnel, other resources, and themselves.³⁹

Training should include use of locally available equipment, checklists ([Fig. 2](#)), algorithms ([Figs 3 and 4](#)), and teamwork. It should be provided at staff orientation, with regular refreshers for permanent staff.^{30,40} Team leaders should be trained for this role. The importance of training with local equipment before use cannot be overemphasised.^{41,42} Airway simulation performed in the ICU, involving all grades of staff, improves skill retention and may also identify latent errors and poor processes.⁴³

Handovers should routinely share information about the airway, highlighting airway difficulties and ensuring individualized management plans are in place.^{11,23}

Managing cognitive overload and the Vortex approach

Cognitive overload is a particular problem during airway crises, which impairs decision-making and performance.³⁴

The 'Vortex approach' to airway crisis management employs a simple graphic designed to be easily recalled and referred to by stressed clinicians during the process of difficult airway management (<http://vortexapproach.org/Supplementary Fig. 1>). It emphasizes the importance of avoiding repeated attempts with the same technique when difficulties arise.⁴⁴ The Vortex approach permits a maximum of three attempts each of oxygenation via a supraglottic airway (SGA), facemask ventilation, or tracheal intubation, with the option of a fourth attempt with each device by an expert. Failure of all attempts or clinical deterioration mandates transition to FONA. The Vortex approach has considerable intuitive appeal albeit with a limited evidence base, and elements of it are incorporated into these guidelines.

The call for help and the role of the airway expert

The airway should be managed by an appropriately trained operator. This does not have to be the most senior team member, as this individual may adopt the team leader role. The trigger for summoning additional airway expertise and how to do so should be outlined at the team brief. We recommend the call for help is made at the earliest opportunity, and explicitly after one failed intubation attempt.

Expertise may be procedure-specific rather than reflecting seniority (e.g. head and neck surgeon). The expert should receive a focused handover on arrival to understand potential next steps and priorities, and should avoid 'analysis paralysis' (an over-detailed exploration of possible options which delays definitive action).³¹ The SNAPPI (Stop, Notify, Appraise, Plan, Prioritise, Invite comments) communication tool may be useful.⁴⁵ The expert may adopt the team leader role, or undertake expert interventions.

If junior but more airway-experienced personnel arrive they should communicate their status using Crew Resource Management-style 'assertiveness with respect'.^{38,40,46–49} Expert interventions may include.

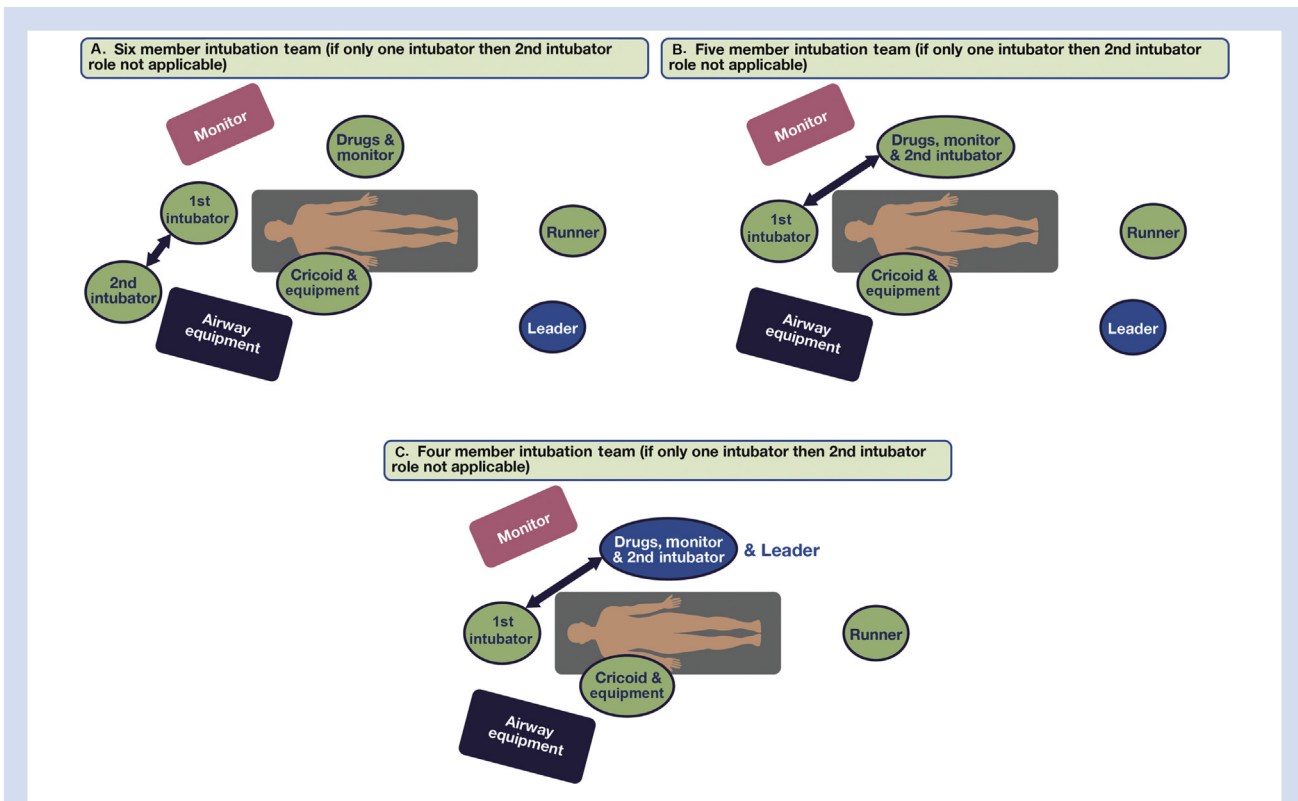


Fig 1. The composition and roles of the intubation team. During an intubation procedure, the discrete functional roles can be described as: (1) first intubator; (2) drug administrator (drugs); (3) observer of patient's clinical state and monitors (monitor); (4) cricoid force applier (cricoid); (5) airway equipment assistant (equipment); (6) runner to fetch additional equipment or call for help; (7) second intubator; (8) team leader—coordinator (leader); and (9) manual in-line stabiliser (MILS). A single team member may perform more than one role. The detailed division of labour will depend on how many staff can be assembled. This may vary from a minimum of four staff up to six staff members. The figure describes the division of labour for teams consisting of (A) six, (B) five, and (C) four members. For each size of team, the roles change after the first failed intubation attempt, when the second intubator becomes active. If the team consists only a single intubator, the second intubator role is not included and the roles remain unchanged between intubation attempts until airway-expert help arrives, if at all. The Team Leader coordinates the team with the senior intubator. (MILS is a trauma-specific role, which must be added to any intubation team's complement).

- One further attempt at tracheal intubation
- One further attempt at SGA insertion
- One further attempt at facemask ventilation
- FONA
- Directing other team members

Assessment

Airway assessment should include risks of difficult intubation, of difficulty with rescue techniques and of aspiration. While assessments to identify difficult intubation have a low positive predictive value and specificity,^{50,51} recognition of patients at particular risk of difficult airway management aids planning and is recommended, even in the most urgent situations.^{52,53} Cases reported to NAP4 from ICU and ED frequently included failure to assess the airway. More importantly, identification of the high-risk patient was not followed by an appropriate airway strategy.¹¹ The only validated airway assessment tool in the critically ill is the MACOCHA score.^{54–56} There are seven components in three domains (Table 2).

Full airway assessment in the most critically ill is often impractical but even in hypoxic patients removing a facemask

for a few seconds can enable a basic airway assessment. Nasal oxygenation can be used to facilitate assessment and subsequently for pre- and peroxxygenation. A MACOCHA score ≥ 3 predicts difficult intubation in the critically ill. The degree of cardiorespiratory disturbance should be noted as haemodynamic optimization prior to induction improves outcome.⁵⁷

Assessment is particularly difficult in obtunded or uncooperative patients but patient records, body habitus, submental airway dimensions, and handover details are useful; Mallampati class is valid in supine patients with voluntary mouth opening.^{54,58}

The 'laryngeal handshake' (Supplementary Fig. 2) technique is recommended to identify the cricothyroid membrane.⁹ Ultrasonography is more accurate than palpation, identifying cricothyroid membrane size, depth, deviation, overlying blood vessels, or thyroid tissue, and may be useful if time permits.^{59–61} Patient positioning for FONA will be likely to move any skin markings relative to the cricothyroid membrane and identification and simply marking only the trachea or midline may be more appropriate.^{60,62} When laryngeal pathology is suspected (e.g. supraglottitis or laryngeal tumour), nasendoscopy is uniquely useful in planning management.⁶³

Intubation Checklist : critically ill adults – to be done with whole team present.

Prepare the patient

- Reliable IV / IO access
- Optimise position
 - Sit-up?
 - Mattress hard
- Airway assessment
 - Identify cricothyroid membrane
 - Awake intubation option?
- Optimal preoxygenation
 - 3 mins or $ETO_2 > 85\%$
 - Consider CPAP / NIV
 - Nasal O_2
- Optimise patient state
 - Fluid / pressor/ inotrope
 - Aspirate NG tube
 - Delayed sequence induction
- Allergies?
 - ↑ Potassium risk?
 - avoid suxamethonium

Prepare the equipment

- Apply monitors
 - SpO_2 / waveform $ETCO_2$ / ECG / BP
- Check equipment
 - Tracheal tubes x 2
 - cuffs checked
 - Direct laryngoscopes x 2
 - Videolaryngoscope
 - Bougie / stylet
 - Working suction
 - Supraglottic airways
 - Guedel / nasal airways
 - Flexible scope / Aintree
 - FONA set
- Check drugs
 - Consider ketamine
 - Relaxant
 - Pressor / inotrope
 - Maintenance sedation

Prepare the team

- Allocate roles
 - One person may have more than one role.
 - Team Leader
 - 1st Intubator
 - 2nd Intubator
 - Cricoid force
 - Intubator's assistant
 - Drugs
 - Monitoring patient
 - Runner
 - MILS (if indicated)
 - Who will perform FONA?
- Who do we call for help?
- Who is noting the time?

Prepare for difficulty

- Can we wake the patient if intubation fails?
- Verbalise "Airway Plan is:"
 - Plan A:
 - Drugs & laryngoscopy
 - Plan B/C:
 - Supraglottic airway
 - Face-mask
 - Fibreoptic intubation via supraglottic airway
 - Plan D:
 - FONA
 - Scalpel-bougie-tube
- Does anyone have questions or concerns?

Fig 2. Intubation checklist. Modified from checklist described in NAP4.¹¹ IV: intravenous. IO: intra-osseous. ETO_2 : end-tidal oxygen. CPAP: continuous positive airway pressure. NIV: non-invasive ventilation. NG: naso-gastric.

Plan A: preparation, oxygenation, induction, mask ventilation, and intubation

Team assembly and preintubation brief

A preintubation checklist should be undertaken (Fig. 2).¹¹ The team leader should ensure that clear roles have been assigned, the strategy (for Plans A, B/C, and D) is shared and invite comments, including whether further expertise is needed. Prepare equipment and drugs and prominently display the algorithm (Fig. 3). Agree whether awakening the patient is planned in the event of failure to intubate. Preoxygenation techniques can occur concurrently.

Positioning for initial airway management

When tolerated, sit or tilt the patient's head up 25–30°^{64–66} and position the head and neck: the lower cervical spine is flexed and the upper cervical spine extended—'flexion, or so-called sniffing position'.^{67–69} Tilting the whole bed head-up is useful for patients with suspected cervical spine injury.^{69,70} Ramping (external auditory meatus level with sternal notch) is useful in obese patients and the head should be extended on the neck such that the face is horizontal.^{65,68,71,72} Optimal positioning improves upper airway patency and access, increases functional residual capacity, and may reduce aspiration risk.^{69,73} Ensure the bed mattress is as firm as possible to optimize cricoid force (cricoid pressure), head extension and access to the cricothyroid membrane.

Monitoring

Standard monitoring should include oximetry, waveform capnography, blood pressure, heart rate, ECG, and, where available, end-tidal oxygen concentration.⁷⁴

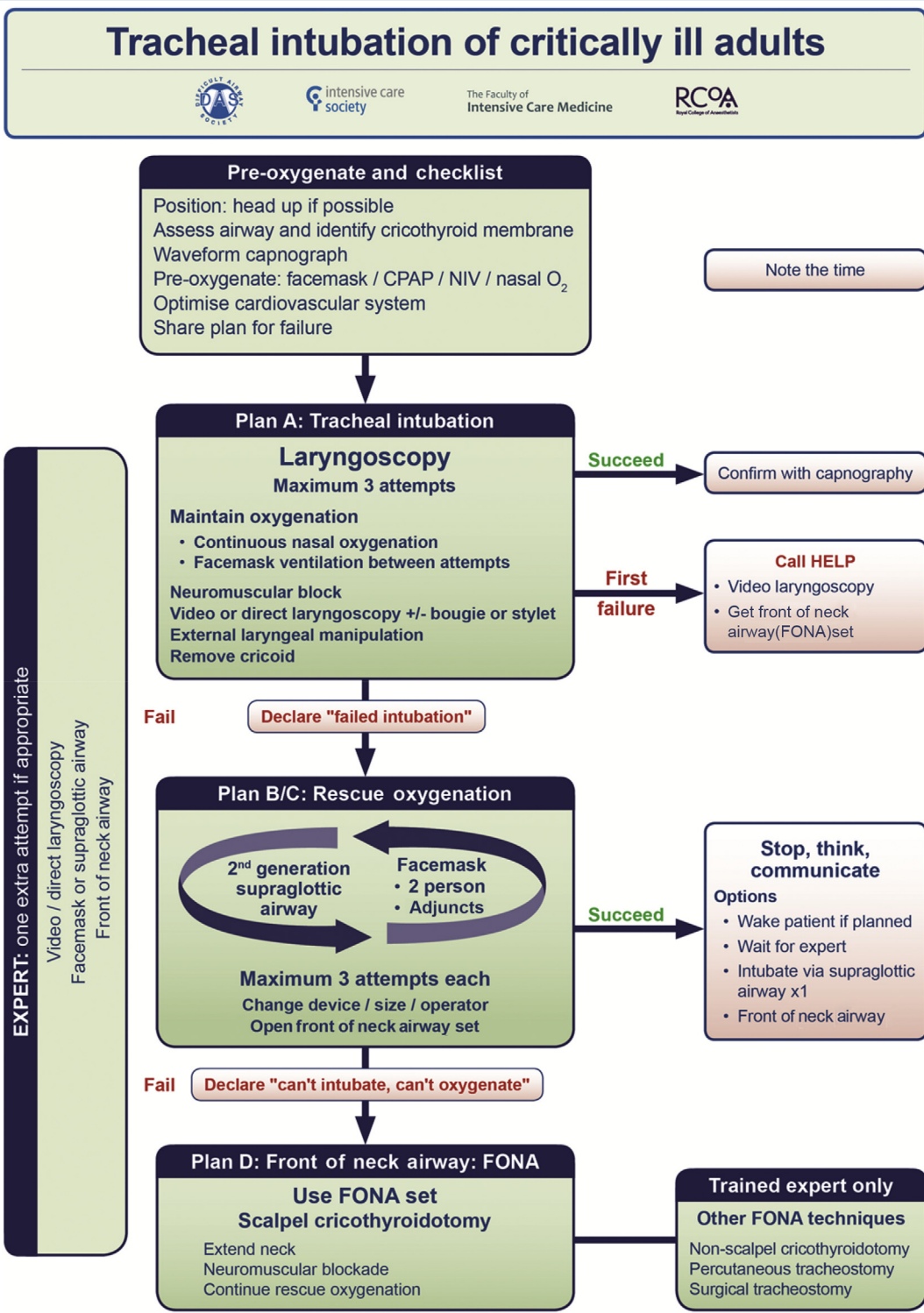
Preoxygenation and peroxygenation

Preoxygenation

Critically ill patients are uniquely liable and vulnerable to hypoxaemia, but 'standard' methods of preoxygenation are only partially effective.⁷⁵ In the absence of respiratory failure, preoxygenate using a tight-fitting facemask, with 10–15 litres min^{-1} 100% oxygen for 3 min.^{76–78} We do not recommend preoxygenation with a 'Hudson-type' facemask, with or without a reservoir. Use of a circuit with an adjustable valve enables continuous positive airway pressure (CPAP) to be applied but its precise level cannot be controlled.⁷⁹ Significant leak is indicated by absence or attenuation of a capnograph trace,⁷⁶ minimized using a two-handed technique and an appropriately sized facemask.⁸⁰ Adequate preoxygenation is preferably measured using end-tidal oxygen concentration (>85%).^{81,82}

In hypoxaemic patients, CPAP and non-invasive ventilation (NIV) may be beneficial.^{83–88} Improved oxygenation has been demonstrated using NIV with CPAP (5–10 cm H_2O) and supported breaths (tidal volume of 7–10 ml kg^{-1}).⁸⁹ CPAP reduces absorption atelectasis associated with breathing 100% oxygen.⁹⁰ Gastric distension may occur when airway pressure exceeds 20 cm H_2O .^{91,92} In patients with an incompletely healed tracheostomy stoma, this must be occluded to benefit from CPAP.

Nasal oxygen can be used during both pre- and peroxygenation. Standard nasal cannulae enable a good mask seal and can be applied during preoxygenation.⁹³ High-flow nasal oxygenation (HFNO) at flows between 30–70 litres min^{-1} is an alternative, although contraindications include severe facial trauma or suspected skull base fractures.⁹⁴ HFNO prolongs safe apnoea time in anaesthetic settings and has been studied for preoxygenation in the critically ill.⁹⁵ Recently, the combination



This flowchart forms part of the DAS, ICS, FICM, RCoA guideline for tracheal intubation in critically ill adults and should be used in conjunction with the text.

Fig 3. Algorithm for tracheal intubation of critically ill adults.

Can't Intubate, Can't Oxygenate (CICO) in critically ill adults



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Intensive Care Medicine



CALL FOR HELP

Declare "Can't Intubate, Can't Oxygenate"

Plan D: Front Of Neck Airway: FONA

Extend neck
Ensure neuromuscular blockade
Continue rescue oxygenation
Exclude oxygen failure and blocked circuit

Scalpel cricothyroidotomy

Equipment: 1. Scalpel (wide blade e.g. number 10 or 20)
2. Bougie (≤ 14 French gauge)
3. Tube (cuffed 5.0-6.0mm ID)

Laryngeal handshake to identify cricothyroid membrane

Palpable cricothyroid membrane

Transverse stab incision through cricothyroid membrane
Turn blade through 90° (sharp edge towards the feet)
Slide Coudé tip of bougie along blade into trachea
Railroad lubricated cuffed tube into trachea
Inflate cuff, ventilate and confirm position with capnography
Secure tube

Impalpable cricothyroid membrane

Make a large midline vertical incision
Blunt dissection with fingers to separate tissues
Identify and stabilise the larynx
Proceed with technique for palpable cricothyroid membrane as above

Trained expert only

Other FONA techniques

Non-scalpel cricothyroidotomy
Percutaneous tracheostomy
Surgical tracheostomy

Post-FONA care and follow up

- Tracheal suction
- Recruitment manoeuvre (if haemodynamically stable)
- Chest X-ray
- Monitor for complications
- Surgical review of FONA site
- Agree airway plan with senior clinicians
- Document and complete airway alert

This flowchart forms part of the DAS, ICS, FICM, RCoA Guideline for tracheal intubation in critically ill adults and should be used in conjunction with the text.

Fig 4. Can't Intubate, Can't Oxygenate algorithm.

Table 2 MACOCHA score. MACOCHA: Mallampati score III or IV, Apnoea syndrome (obstructive), Cervical spine limitation, Opening mouth <3 cm, Coma, Hypoxaemia, Anaesthetist non-trained. Scores: from 0 (easy) to 12 (very difficult). Reprinted with permission of the American Thoracic Society. Copyright © 2017 American Thoracic Society. De Jong et al.⁵⁴

Factors	Points
Factors related to patient	
Mallampati class III or IV	5
Obstructive sleep Apnoea syndrome	2
Reduced mobility of Cervical spine	1
Limited mouth Opening <3 cm	1
Factors related to pathology	
Coma	1
Severe Hypoxaemia (SpO ₂ <80%)	1
Factor related to operator	
Non-Anaesthetist	1
Total	12

of HFNO and NIV was reported to reduce desaturation in a pilot study.⁹⁵ Current evidence shows no harm but no outcome benefits from use of HFNO and, whilst attractive, limitations of available studies make the evidence inconclusive.^{96–104} The potential benefit of improved oxygenation after induction of anaesthesia must be balanced against the HFNO circuit interfering with the facemask seal and ventilation, reducing CPAP efficacy before and after induction.¹⁰⁵

Pre-induction oxygenation can be difficult in agitated patients; *delayed sequence induction* in which small doses of a sedative such as ketamine are administered to enable effective preoxygenation before induction may be a practical solution.⁹³

Patients already receiving NIV, CPAP, or HFNO should undergo tracheal intubation promptly when it becomes apparent that these modalities are failing; delay is likely to lead to profound hypoxaemia during intubation.

We recommend preoxygenation via a tight-fitting facemask and circuit capable of delivering CPAP (e.g. Waters circuit). We recommend nasal oxygen is applied throughout airway management. If standard nasal cannulae are used these should be applied during preoxygenation with a flow of 5 litres min⁻¹ while awake, increased to 15 litres min⁻¹ when the patient loses consciousness. We recommend using 5–10 cm H₂O CPAP if oxygenation is impaired. HFNO may be logical if already in use or may be chosen instead of standard nasal cannulae, or existing NIV instead of CPAP, caveats notwithstanding.^{9,89,95}

Oxygenation during intubation: peroxygenation

With the onset of apnoea and neuromuscular blockade, alveolar de-recruitment occurs and, if untreated, will lead to hypoxaemia. Oxygen delivery via standard nasal or buccal cannulae at 15 litres min⁻¹ produces high hypopharyngeal concentrations of oxygen during apnoea^{93,106} and is still partially effective at intrapulmonary shunt levels of up to 35%.¹⁰⁷ We recommend nasal oxygen at 15 litres min⁻¹, or HFNO, during intubation attempts.^{70,95,102,106,108,109}

Facemask ventilation with CPAP may improve oxygenation, extend the safe apnoea time, and indicate the ease of facemask ventilation.⁹ Cricoid force should be reduced or removed if facemask ventilation proves difficult.⁹ A ‘two-person’ technique (in which the mask is held using two hands and a second operator compresses the bag), oral airway adjuncts, or both

may improve facemask ventilation. High respiratory rates and volumes are rarely necessary and may cause hypotension or ‘breath-stacking’ in cases of expiratory airflow limitation.¹¹⁰ Inexpert cricoid force may obstruct the laryngeal inlet (or upper airway) and render nasal oxygen ineffective. Concomitant use of HFNO during facemask ventilation with a tight-fitting facemask can result in high airway pressures and care is required. If facemask ventilation between intubation attempts is unsuccessful, rescue oxygenation using a second-generation SGA may be required; this is Plan B/C (see below).

We recommend facemask ventilation with CPAP before attempting intubation, and between intubation attempts where hypoxia occurs or is likely to occur (e.g. respiratory failure, obesity).¹⁰³ We also recommend facemask ventilation with CPAP before attempting intubation if hypercarbia is problematic (metabolic acidosis, raised intracranial pressure, pulmonary hypertension).¹¹¹

Induction of anaesthesia

Many critically ill patients are at risk of aspirating gastric contents and a ‘modified’ rapid sequence induction (RSI) approach is emphasized in this guideline.^{112–114} We recommend preoxygenation, optimal positioning, intravenous induction and a rapid-onset neuromuscular blocking agent (NMBA), precautions against pulmonary aspiration, peroxygenation, facemask ventilation with CPAP, laryngoscopic techniques aimed at maximizing first-pass success, and confirmation of successful tracheal intubation by waveform capnography.

The risk of pulmonary aspiration may be reduced by discontinuing enteral feeding, removing the gastric contents by suction, and, whilst still debated, by cricoid force application by a trained assistant.^{115–117} A videolaryngoscope screen visible to the team enables real-time cricoid force optimization. Correct application of cricoid force is a skill requiring training and practice, and we recommend a standard method of applying cricoid force using 1 kg (10 N) awake increasing to 3 kg (30 N) after loss of consciousness.^{116–118} An existing gastric tube does not compromise the protection offered by cricoid force and should be left in place. Gastric insufflation during mask ventilation is reduced by application of cricoid force.¹¹⁵ Cricoid force should be reduced or removed if there is difficulty with laryngoscopy, passage of the tracheal tube, facemask ventilation or active vomiting.^{115,119} Successful SGA insertion requires removal of cricoid force.

Induction drug choices

The choice of induction drug is dictated by haemodynamic considerations; ketamine is increasingly favoured in most circumstances.⁵⁷ Coinduction with rapidly-acting opioids enables lower doses of hypnotics to be used, promoting cardiovascular stability and minimizing intracranial pressure changes. We recommend the use of a NMBA, as this reduces intubation complications in the critically ill.¹²⁰ NMBAs improve intubating conditions, facemask ventilation, SGA insertion, abolish upper airway muscle tone including laryngospasm, optimize chest wall compliance, reduce the number of intubation attempts, and reduce complications. Avoiding NMBAs is associated with increased difficulty.^{121–124} Succinylcholine has numerous side-effects including life-threatening hyperkalaemia and its short duration of action can hamper intubation if difficulty prolongs the attempt. Rocuronium may be a more rational choice in the critically ill,

providing similar intubating conditions to succinylcholine.^{113,122,124} Rocuronium can be antagonized using a pre-calculated dose of sugammadex, but this does not guarantee resolution of an obstructed airway.^{125–128}

Time

As induction commences, note the time (allocate a team member). During airway crises, significant time may pass unnoticed, which may mean progress through the algorithm does not assume the urgency required.¹²⁹

Laryngoscopy

Difficult laryngoscopy occurs frequently in critically ill patients.^{18–20} Difficult laryngeal view is associated with multiple intubation attempts and failure; it is associated with severe hypoxia, hypotension, oesophageal intubation and cardiac arrest.^{17,18,130} The goal is to achieve timely, atraumatic tracheal intubation using the minimum number of attempts. Repeated attempts to pass a tracheal tube are associated with trauma, airway deterioration, and progression to a CICO situation.

The patient should be:

- positioned optimally;
- preoxygenated;
- anaesthetized;
- neuromuscularly relaxed.

The operator should:

- have a primary plan and a plan for failure;
- be trained and proficient in all the techniques they intend to use;
- be supported by a trained, briefed team.

A blade entering the oral cavity constitutes one attempt at laryngoscopy. If one laryngoscopy attempt fails, ensure the FONA set is immediately to hand ('get FONA set', Fig. 3) and senior help is summoned. The number of attempts is limited to three. Following a failed intubation attempt, we recommend manoeuvres to improve the laryngoscopic view or ease of intubation in a correctly positioned and adequately paralysed patient. Manoeuvres include: different device or blade, partial withdrawal of the blade to facilitate a wider field of view, different operator, suction and reduction or release of cricoid force. Optimal external laryngeal manipulation or backwards upwards rightward pressure may improve the view, and are aided by videolaryngoscopy with a screen visible to all. Use of a bougie or stylet is recommended when the laryngeal opening is poorly seen (Grade 2b or 3a views) or when using a hyperangulated videolaryngoscope.¹³¹ Blind efforts to pass a tracheal tube in Grade 3b and 4 views are potentially traumatic and should be avoided.¹³¹

If all relevant factors have already been addressed and an optimal intubation attempt fails, making no further attempts may be indicated (i.e. all three permitted attempts are not mandated). Failure after a maximum of three attempts should prompt the declaration, "This is a failed intubation." Move to Plan B/C. A fourth attempt may be considered by a suitable expert.

Videolaryngoscopy in the critically ill

Published data on videolaryngoscopy in critically ill patients are generally of poor quality, with limited evidence from ICU

and ED populations^{120,132–141} and results from these two locations might not necessarily be transferrable. Evidence from anaesthesia practice is relevant and generally of higher quality, but there are again issues of transferability. A recent systematic review of videolaryngoscopy, in all settings, reported improved laryngeal view with videolaryngoscopy, improved ease of use, reduced airway trauma and reduced failures, both in an unselected population and in predicted difficult intubation.¹⁴² Evidence highlights the importance of training in success with videolaryngoscopy,^{142,143} an important omission in many studies in the critically ill. The systematic review also identified that not all videolaryngoscopes perform equally.¹⁴² There is uncertainty over the impact of videolaryngoscopy on intubation speed,¹⁴² but it is likely that hyperangulated (as opposed to MacIntosh-shaped) blades prolong easy intubations. Synthesizing the available evidence, and given the importance of avoiding multiple attempts and reducing failed intubations in the critically ill, we make the following recommendations for videolaryngoscopy.

A videolaryngoscope should be available and considered as an option for all intubations of critically ill patients. Those involved in critical care intubation should be appropriately trained in use of the videolaryngoscope(s) they may be called upon to use. If difficult laryngoscopy is predicted in a critically ill patient (MACOCHA score ≥ 3)⁵⁴ videolaryngoscopy should be actively considered from the outset. If during direct laryngoscopy there is a poor view of the larynx, subsequent attempts at laryngoscopy should be performed with a videolaryngoscope.

Individuals and departments may decide to use videolaryngoscopy as first choice for all intubations in the critically ill. Departmental device selection is multifactorial but we recommend a device with a screen, visible to all members during intubation, to improve assistance, cricoid force optimization, training, supervision, and teamwork.¹⁴⁴ These recommendations apply both to ICUs and EDs but may be difficult in remote parts of hospitals. Where videolaryngoscopy is used as first choice, it is logical to use a device that enables use both as a direct laryngoscope and as a videolaryngoscope (i.e. Macintosh-type blade). Where videolaryngoscopy is used as a rescue device (whether direct laryngoscopy or videolaryngoscopy was used initially) it is likely that a hyperangulated device (used with a stylet or bougie) will perform best.¹⁴⁵ Blood, secretions, and vomitus in the airway can hamper videolaryngoscopy in the critically ill patient.

Further high-quality research in this area is required and these recommendations may assist in defining the standards necessary for such studies.

Confirmation of intubation

It is mandatory to use waveform capnography to confirm intubation.^{146,147} Absence of a recognizable waveform trace indicates failed intubation unless proven otherwise.¹¹ During cardiac arrest, effective cardiopulmonary resuscitation leads to an attenuated, but recognizable capnograph trace.¹¹ Rarely, an absent capnograph waveform may be caused by tube obstruction (e.g. severe pulmonary oedema, severe bronchospasm, or blood), secretions, or water in the capnograph circuit—but tube misplacement should always be initially assumed and actively excluded. Bronchoscopy via the tracheal tube can also confirm tracheal placement. Auscultation and observation of chest wall movement are unreliable signs, particularly in the critically ill.^{148,149}

Post-intubation recruitment manoeuvres

Anaesthesia and intubation attempts worsen pulmonary mechanics and gas exchange in the critically ill.^{150,151} Provided haemodynamic stability is maintained, recruitment manoeuvres are potentially beneficial in hypoxic patients following intubation. An inspiratory pressure 30–40 cm H₂O for 25–30 s can increase lung volume and oxygenation and decrease atelectasis without adverse effects.^{152,153}

Plan B/C: rescue oxygenation using SGA or facemask after failed intubation

Failed intubation occurs in 10–30% in critically ill patients and should be anticipated.^{17–21} Failed intubation is likely to result in severe hypoxaemia (SpO₂ <80%)^{22,154–156} and while restoring oxygenation remains the priority, this may be difficult.^{70,157,158} Reoxygenation is attempted using a second-generation SGA or facemask.¹⁵⁹ Successful reoxygenation offers the opportunity to 'stop and think'.

Previous guidelines have defined Plan B as airway rescue using an SGA and Plan C as a final attempt to achieve oxygenation with facemask ventilation.⁹ However, whilst this B-to-C sequence is useful conceptually, it is an artificial distinction in clinical practice. Following failed intubation attempts, experienced operators enter a phase of airway rescue, attempting SGA placement interspersed with attempted facemask ventilation. This is recognised by the 'Vortex approach', which we commend.⁴⁴ Briefly, the Vortex approach defines a 'green zone' as a place of effective oxygenation and relative safety and the Vortex as the converse. While in the Vortex, attempts at intubation, SGA placement, and facemask ventilation form an alternating continuum, culminating in success (movement into the green zone) or in cumulative failure (spiralling further into the Vortex), necessitating transition to FONA. In practice, in the critically ill, the attempts at intubation will usually occur before attempts at SGA insertion and rescue facemask ventilation. One optimal attempt, or a maximum of three attempts each with SGA or facemask are recommended in Plan B/C before declaring failure.

An expert may arrive during rescue oxygenation attempts. The Vortex approach permits one further expert attempt at intubation, one further expert attempt at SGA oxygenation and one further attempt at facemask ventilation if appropriate. It may be clear to the expert that rapid transition to FONA is necessary.

The principles of the Vortex approach are adapted in the algorithm. Successful ventilation is evidenced by an appropriate capnograph trace and stable or improving oxygenation. Recourse to rescue SGA oxygenation mandates that the team prepare for FONA (Fig. 3).

Rescue oxygenation using an SGA

During airway rescue, SGA insertion is initially preferable to attempted facemask ventilation because SGAs may frequently enable oxygenation, provide some protection from aspiration and facilitate 'fiberoptic' (referring to all types of airway endoscopes) intubation using the device as a conduit.^{154,155} There are reports of successful SGA rescue in ICU patients with difficult intubation, high airway pressures, and high aspiration risk.¹⁶⁰

Second-generation SGAs should be immediately available in all locations where intubation of critically ill patients is

attempted. A second-generation SGA is one with design features specifically intended to reduce the risk of aspiration such as higher oropharyngeal seal pressures and oesophageal drain tubes [e.g. i-gel™, ProSeal™ Laryngeal Mask Airway (PLMA)].¹⁵⁹ Training with specific devices improves success and should be undertaken with the same emphasis as tracheal intubation.^{161,162} It is important to continue peroxygenation efforts with nasal oxygen, facemask ventilation, or both between SGA insertion attempts.

Optimizing SGA insertion

Cricoid force occludes the hypopharynx and prevents correct SGA placement.^{163–165} We recommend cricoid force is removed before SGA insertion.¹¹⁵ Success is most likely with the patient correctly positioned, using an optimal insertion technique, performed by an individual trained in the technique.^{9,166–168} After intubation fails, a maximum of three SGA insertion attempts should be made with changes to SGA size, type, insertion technique or operator as necessary.^{167,169–174}

Critically ill patients may have a gastric tube in situ. These do not require removal to facilitate SGA insertion.^{175,176} Second-generation SGAs can vent regurgitated material via the drain tube, offering a degree of airway protection and facilitating insertion of a gastric tube.

Choice of SGA

The attributes of an ideal SGA for ICU airway rescue are: reliable first-time placement (including by non-airway experts), high oropharyngeal seal pressure, ability to ventilate (with PEEP, Positive End Expiratory Pressure), separation of gastrointestinal and respiratory tracts, and compatibility with fiberoptic intubation techniques.¹⁷⁷ Oropharyngeal seal pressures of first-generation SGAs are unlikely to provide adequate ventilation of poorly compliant lungs and are more likely to lead to gastric inflation. Some second-generation SGAs have most of the desirable properties and although devices vary in performance,¹⁷⁷ only second-generation SGAs are recommended in this guideline.¹⁷⁸

Second-generation SGAs are more likely to enable reoxygenation, ventilation, and maintenance of PEEP. The PLMA (Teleflex Medical Europe Ltd, Athlone, Ireland) has the most effective seal pressure of currently available devices, followed by the LMA® Supreme™ (SLMA; Teleflex) and i-gel™ (Intersurgical, Wokingham, UK). Where a PLMA is used, insertion over a bougie may improve placement success.^{179,180} The narrow airway channel of the SLMA precludes its easy use as a conduit for fiberoptic intubation.¹⁸¹

'Stop, think, communicate' after successful rescue oxygenation with an SGA

Successful ventilation is evidenced by an appropriate capnograph trace and stable or improving oxygenation. Whilst critical illness may impair reoxygenation with even correctly placed devices, success provides an opportunity to stop, think and communicate. Call for help, if not already summoned. The optimal course of action depends on the clinical situation and the team's skill-set. The priority remains oxygenation, while minimizing the risk of losing the airway, aspiration, and airway trauma.

Options are:

- wake the patient;

- wait for an expert to arrive;
- a single attempt at fiberoptic intubation via the SGA;
- proceed to FONA.

Wake the patient

This is rarely applicable in critically ill patients, especially with neurological, cardiovascular or respiratory failure. Whether this is appropriate should have been decided before induction. Such patients rarely awaken adequately. Failed intubation attempts cause airway trauma and respiratory deterioration and may compromise attempts to awaken the patient.

Neurological impairment, residual drug effects,^{182,183} (iatrogenic) airway trauma, oedema, or pre-existing upper airway pathology may all contribute to airway obstruction during attempted emergence.^{9,128,184} If wake up is attempted, neuromuscular blockade must be fully reversed and adequate neuromuscular function confirmed. Sugammadex reverses rocuronium (and vecuronium), but is not universally available and its significant preparation time impairs its utility.^{125–128} Simply reversing the effects of opioids, benzodiazepines, or NMBAs does not reverse mechanical or physiological causes of airway obstruction, does not reliably prevent, and may precipitate CICO.^{126,128,184}

Wait for an expert to arrive

If oxygenation can be safely maintained via an SGA and a more skilled operator is able to attend promptly, it may be reasonable to await their (prompt) attendance to determine which of the above options (or one further expert attempt at laryngoscopy) is most suitable. During this time, the patient and their airway should be monitored meticulously to detect evidence of deterioration. Awaiting an expert should not delay actions necessary to establish or maintain oxygenation.

Intubation via the SGA

Whilst blind insertion of a tracheal tube via an SGA is unreliable and is not recommended, a correctly placed SGA may facilitate fiberoptic-guided intubation.^{171,185–187} The ICS, DAS, National Tracheostomy Safety Project, NAP4, and National Institute for Health and Care Excellence recommend immediate availability of fiberoptic endoscopes in ICU.^{9,10,188–190}

Fiberoptic-guided intubation via an SGA may be achieved with a small tracheal tube preloaded over the endoscope, with both introduced via the SGA.^{191–198} This technique is suitable for some but not all SGAs and significantly limits the size of tracheal tube that can be inserted (typically 6.0 mm inner diameter). Alternatively, an Aintree Intubation Catheter™ (AIC; Cook Medical, Bloomington, IN, USA) may be fiberoptically inserted via the SGA before railroading a larger (≥ 7.0 mm) tracheal tube over this conduit. Bullet-tipped (e.g. intubating LMA tracheal tube, Teleflex) tracheal tubes are ideal.^{181,195,199–205} This technique works well via the i-gel and PLMA,²⁰⁶ but the narrow, rigid, curved airway channel of the SLMA is poorly suited.^{9,181,202}

Oxygenation and ventilation should be maintained throughout fiberoptic-guided intubation. To avoid the risk of barotrauma, oxygenation via the SGA is safer than via the AIC.^{207,208} Limiting the number of airway interventions is a core principle of safe airway management; we recommend a single attempt at fiberoptic-guided intubation through an SGA.⁹ Training is essential.

Proceed to FONA

Do not wait for life-threatening hypoxaemia before transitioning to FONA.²⁰⁹ After failed intubation, critically ill patients are more likely to require a definitive airway than in the OR. Following successful SGA insertion and ventilation, it is often appropriate to proceed directly to FONA. Indications include marginal oxygenation, aspiration, difficult ventilation, or when fiberoptically guided intubation via the SGA is not possible. Oxygenation via an SGA has been reported as a successful bridge to FONA in cases of failed ICU airway management.^{210–215}

Facemask ventilation

Oxygenation using facemask ventilation is an alternative to SGA use when intubation has failed and is vital between attempts at airway instrumentation.²¹⁶ CPAP during facemask ventilation is advantageous in the critically ill.²¹⁷ Techniques to optimize success include: optimal head, mandible, and body position to improve upper airway patency, oral or nasal airway adjuncts, and a 'two-person' technique.²¹⁸ Neuromuscular blockade improves facemask ventilation, especially in the context of laryngeal spasm, chest wall rigidity or obesity.^{219,220}

Difficult ventilation via SGA and facemask are more common after failed intubation,^{154,221} increasing the likelihood of progression to CICO. Recourse to rescue facemask ventilation mandates that the team prepare for FONA ('open FONA set', Fig. 3).

Successful facemask ventilation

Successful facemask ventilation is evidenced by waveform capnography and stable or improving oxygenation. If facemask ventilation is achieved, the same options as for successful SGA insertion should be considered (wake patient, wait for expert, FONA). Clinical deterioration and worsening oxygenation should prompt immediate transition to FONA if an SGA has also failed. After failed intubation is declared, a maximum of three facemask ventilation attempts are permitted, with changes to size, type, adjuncts, position, and operator as required. If facemask ventilation is difficult, SGA has failed and waking the patient is not immediately planned, adequate neuromuscular blockade should be ensured while proceeding to FONA.

Unsuccessful ventilation via SGA and facemask

Recognition of failed ventilation via an SGA or facemask may be difficult and there is a risk of task fixation. Clinical signs are unreliable, especially differentiation between pulmonary and gastric inflation. In the absence of cardiac arrest, the presence of an end tidal capnograph trace is the definitive monitor indicating success or failure of alveolar ventilation.

To ensure rapid transition to FONA, we recommend opening the FONA set following the first failed attempt at SGA ventilation or the first failed attempt at facemask ventilation. With progressive failures of SGA and facemask ventilation it should be feasible to transition to FONA within 60 s. Recognition of failed or failing ventilation or worsening oxygenation should prompt a declaration of failure from the team ('This is a can't intubate, can't oxygenate situation') and urgent transition to FONA (stating 'We need to perform an emergency front of neck airway').

The arrival of the expert during plan B/C

See the 'Human factors' section (heading 'The call for help and the role of the airway expert').

Plan D: emergency FONA

Transition to FONA

Emergency FONA is indicated following failed intubation, when rescue oxygenation via SGA and facemask ventilation have also failed. Unless this CICO situation is rapidly resolved profound hypoxaemia and cardiac arrest are inevitable. Hence, failure to ventilate the apnoeic critically ill patient should prompt transition to FONA.⁴⁴ There is no specific threshold oxygen saturation for transition, and establishing an emergency airway before profound hypoxaemia occurs is desirable.⁶

Delayed transition to FONA because of procedural reluctance is common in airway crises and is a greater cause of morbidity than complications of the procedure.^{10,40,209,222–224}

An explicit declaration of failure facilitates practical and psychological 'priming' for FONA.⁴⁴ Oxygenation attempts should be continued by nasal oxygen, SGA, or facemask during the transition and whilst performing FONA.^{1,6,9,10,210}

Ensure adequate neuromuscular blockade: this increases success of FONA (and other airway rescue techniques).^{9,10} If sugammadex has been administered earlier, a second NMBA other than rocuronium or vecuronium is indicated.

Important CICO considerations

Whilst transition to FONA should not be delayed, there are potentially remediable factors to consider during transition to CICO:

Equipment

- Oxygen failure
- Blocked breathing system (including heat and moisture exchanger filter)
- Blocked airway device
- Poor mask seal

Airway

- Excessive cricoid force
- Laryngeal spasm
- Foreign body
- Regurgitated material
- Blood
- Severe bronchospasm

Other

- Profound cardiovascular collapse/cardiac arrest

Priming for FONA

Transition to FONA has traditionally been poorly understood and unplanned. This contributes to the widely recognized problem of delayed progression to FONA, resulting in avoidable harm.^{10,11} 'Priming for FONA' refers to formalizing this transition using defined triggers prior to and at the declaration of CICO. The three steps are: (i) 'getting the FONA set' to the

bedside (or ensuring it is there) after one failed intubation attempt; (ii) 'opening the FONA set' after one failed attempt at facemask or SGA oxygenation; and (iii) immediately using the FONA set at CICO declaration. A staged, didactic approach facilitates psychological and operational preparation to act and priming thereby expedites FONA performance (see Fig. 3).^{44,45}

Performing FONA

The optimal FONA technique is via the cricothyroid membrane.²²⁵ Current evidence supports an open 'surgical' approach (scalpel cricothyroidotomy). This is a fast and reliable technique, has few steps, a high success rate, uses familiar standard equipment, is suitable for almost all patients, enables confirmation of success by waveform capnography, provides a definitive airway offering a degree of protection against aspiration, facilitates exhalation, and enables application of PEEP.^{10,222,226–228}

We recommend a scalpel-bougie-tube cricothyroidotomy technique (Fig. 4) in common with the DAS 2015 guidelines and readers are referred there and to the associated DAS e-learning cricothyroidotomy module (<http://das.uk.com>) for details.^{9,229} Key steps include maximum neck extension, a horizontal incision with a wide scalpel blade (size 10 or 20) for those with a palpable cricothyroid membrane, or an initial large vertical midline skin incision if the cricothyroid membrane is impalpable, and insertion of a bougie as a guide for a 5.0–6.0 mm tracheal tube.⁹ A 5.0 mm Melker™ (Cook Medical) cricothyroidotomy tube may be appropriate in this setting.²³⁰ Ensure the smaller tracheal tube size fits over the type of bougie used in your unit.

High pressure source transtracheal ventilation via a narrow bore cannula—colloquially termed 'transtracheal jet ventilation' (TTJV)—is increasingly recognized as a high-risk rescue technique with both device insertion and subsequent ventilation prone to failure and complications. Closed claims analysis in the USA demonstrate extremely poor outcomes with TTJV.²²³ NAP4 identified high rates of device and technique failure with TTJV.¹⁰ In a systematic review, emergency TTJV in CICO was associated with a high risk of failure (42%), barotrauma (32%), and complications (51%).²³¹ Subcutaneous emphysema hinders later open approaches.²³¹ TTJV is especially poorly suited to management of CICO in the critically ill because re-recruitment and reoxygenation of poorly compliant lungs requires PEEP and is difficult without a cuffed tube. The ventilatory requirements of the critically ill are also less likely to be met by TTJV. There is a lack of evidence to support or refute use of controlled oxygen insufflation (e.g. RapidO2™; Meditech Systems Ltd, Shaftsbury, UK) in this setting. Narrow-bore cannulae are non-definitive airways and require urgent conversion to more reliable devices.^{10,11,222} Whilst numerous Seldinger cricothyroidotomy techniques and devices are described, there is insufficient evidence to recommend this technique for FONA. Similarly, percutaneous and surgical tracheostomy has been described for airway rescue, but is likely to take longer than a scalpel cricothyroidotomy.^{225,232–234} Trained and experienced operators have successfully used alternative FONA techniques in the critically ill, but for the above reasons, we recommend scalpel cricothyroidotomy as the default technique for CICO situations (Fig. 4).

If a patient's tracheostomy has been very recently removed, it may be possible to re-cannulate the stoma, but this should not delay FONA.

Failed FONA

This is a desperate situation. Cardiac arrest is usual. If scalpel cricothyroidotomy via the cricothyroid membrane fails, FONA can be attempted lower in the trachea. An experienced operator may attempt a percutaneous or surgical tracheostomy or non-scalpel FONA.^{225,235,236} Arrival of an expert at this point may lead to single attempts at techniques described above (Fig. 3).

Management following FONA

Waveform capnography should be used to confirm tracheal placement. Clinical examination may identify inadvertent endobronchial placement, but is insensitive. Fiberoptic inspection or chest X-ray is required. Once stabilized, the airway will need conversion to tracheal tube or tracheostomy.^{11,237} Pharyngeal or oesophageal injury may have occurred, with potential for mediastinal infection and may require further investigation.²²³

Peri-intubation haemodynamic management

Even successful ICU intubation has a high risk of significant haemodynamic instability (up to 25%).^{17,22,57,238–240} Cardiac arrest has been reported in approximately 2% of ICU intubations, increasing with repeated intubation attempts. In one study, cardiac arrest occurred in one in eight emergency intubations outside the OR when four or more intubation attempts were required.¹³⁰ Causes include hypoxaemia, underlying critical illness, vasodilation from anaesthetic agents, hypovolaemia, and positive pressure ventilation reducing venous return. Risks can be reduced by addressing underlying causes, pre-emptive management of blood pressure, and judicious selection and use of drugs. Severe haemodynamic instability may be reduced by 50% using an 'intubation bundle'.⁵⁷

We recommend that a team member is tasked with monitoring and managing haemodynamic status. Timing of intubation in the potentially unstable patient is complex. Reliable intravenous or intraosseous access is vital to enable rapid volume replacement (before and during intubation) and reliable drug administration. Balancing the risks of delaying tracheal intubation against the potential benefits of a more stable induction following fluid resuscitation requires experience.

Effective preoxygenation with CPAP reduces hypoxic myocardial depression and left ventricular afterload.²⁴¹ In the absence of cardiac failure, rapid infusion of 500 ml crystalloid solution before or during intubation can mitigate hypotension.⁵⁷ A vasopressor or inotrope should be immediately available for bolus and infusion during induction and intubation. In shock states, a vasopressor should also be considered before induction.²³⁹ Ketamine (1–2 mg kg⁻¹) produces less cardiovascular instability than propofol or thiopentone.^{240,242,243} Etomidate-induced adrenal suppression remains a concern and this drug is not routinely used in critically ill patients.^{244,245} Positive pressure ventilation with large tidal volumes, high respiratory rates and high PEEP will worsen hypotension and must be avoided. Similarly, bronchospasm may result in breath-stacking. Post-intubation recruitment manoeuvres are contraindicated with peri-intubation haemodynamic instability.

Bradycardia during airway manipulation can be related to hypoxaemia or vagal reflexes and is commonly followed by

haemodynamic collapse. Epinephrine or atropine might be required but oxygenation is vital. If hypoxaemic cardiac arrest complicates failed airway management, perform chest-compressions in tandem with airway management. The combination of severe hypoxaemia and cardiac arrest is likely to become rapidly fatal.²⁴⁶ Airway interventions are made more difficult by chest compressions, so cardiac compressions may need to be paused very briefly.²⁴⁶ A flat capnograph trace during cardiac arrest is indicative of a misplaced or obstructed airway provided effective cardiopulmonary resuscitation is in progress.^{10,241}

Tube selection

A full discussion of tracheal tube selection is beyond the remit of this guideline. In general terms, the tracheal tube should be wide enough to enable suction catheter and adult bronchoscope insertion, provide low resistance to airflow²⁴⁷ whilst reducing the risk of blockage.^{248,249} Tubes with subglottic suction or specialised cuffs may reduce the incidence of micro-aspiration and ventilator-associated pneumonia.²⁵⁰ However, during difficult airway management, a smaller (e.g. 6.0 mm inner diameter) or non-specialized tracheal tube may facilitate easier intubation. Tube exchange to a larger size or more specific type can be performed when the airway crisis is resolved.²⁵¹

Care of the intubated ICU patient

In ICU, the most hazardous phase of airway care is after initial airway management.^{11,24} In the UK, over 80% of airway-related critical incidents occurred after the initial intubation and 30% were serious.^{11,24} Incidents commonly relate to complete or partial device displacement and less frequently occlusion with secretions or device failure. Training, teamwork, monitoring, communication, and provision of suitable, familiar equipment are the basis of prevention and management of these complications. All staff managing patients on ICU should be trained to recognize and manage airway displacement or blockage.

We recommend that the ICU consultant ensures that the team is aware of patients known to have difficult airways. Ward round safety briefings should include handover of patients at risk of airway problems with details of initial airway management and laryngoscopy grade.²⁵² We recommend handover include patient-specific strategies to prevent and manage airway risks including device displacement or blockage, a (re-)intubation and an extubation strategy.

Communication should include relevant clinicians, nurse in charge, bedside nurse, and physiotherapist: multiprofessional ward rounds are useful in this regard. Strategies should use immediately available equipment and appropriately skilled clinicians and documented plans should be visible at the bedside.¹¹

Lack of availability of appropriately skilled clinicians may require pre-emptive escalation of airway management in potentially difficult patients (e.g. daytime intubation, before experienced staff become non-resident).^{10,11}

Bedside care

Bedhead signage highlighting tracheostomy or laryngectomy stomas are established safety precautions¹⁸⁹; examples can be downloaded from www.tracheostomy.org.uk. Similarly,

signage identifying airway difficulty may reduce adverse incidents.

The depth of tracheal tube insertion should be documented on the bedside chart and checked each shift or if respiratory deterioration occurs. Tubes should be well secured, but the optimal method is unknown; experienced, vigilant staff are crucial.^{253,254} Cuff pressure should be maintained at 20–30 cm H₂O.^{255,256} Higher inspiratory pressures may require higher cuff pressures. Apparent cuff leak should be assumed to be partial extubation until proven otherwise.²⁵⁷

The use of appropriate monitoring is estimated to detect 95% of all critical incidents, and 67% before potential organ damage has occurred.²⁵⁸ Deterioration may not indicate an airway emergency, but the airway should be systematically evaluated in all unstable critically ill patients. Failure to use capnography in ventilated patients probably contributes to >70% of ICU airway-related deaths.¹¹ Increasing use of capnography on ICU was described in NAP4 as ‘the single change with the greatest potential to prevent deaths from airway complications outside operating theatres’.¹⁰ National standards recommend waveform capnography for all intubations performed on critically ill patients and for all patients dependent on an artificial airway.^{147,259,260} Changes in practice since NAP4 mean that this is now the expected standard in the UK.²⁶¹ While baseline understanding of capnography interpretation is poor amongst nursing staff and allied health professionals, it improves with simple training,^{10,262} and it is essential that staff receive regular training in capnography interpretation and crisis management.²⁶³

Humidification and regular tracheal suction reduce avoidable tube blockage. Management of an apparent partial tracheal tube obstruction is aided by prompt fiberoptic inspection.¹⁹⁰

Interventions such as changing patient position (turns), physiotherapy, transfers, and insertion of other devices near the airway (gastric tubes or oesophageal Doppler ultrasound/echocardiography probes) can cause airway displacement.^{11,24} Ventilation with the patient in the prone position worsens airway oedema and is both a risk for displacement and for difficult management when it occurs. During such procedures in high-risk patients, nominating an experienced team member solely to safeguard the airway may reduce complications.

Sedation holds (to enable assessment of neurological and cardiorespiratory status) are hazardous with high-risk airways and require risk assessment.^{264,265} ‘Mittens’ and other forms of physical restraint can minimize risk of self-extubation.²⁶⁶

Airway swelling may be reduced by maintaining 35° head-up positioning and avoidance of unnecessary positive fluid balances.²⁶⁷ Intravenous corticosteroids for at least 12 h in high-risk patients may reduce airway oedema, post extubation stridor, and reintubation rates.^{267,268} Antibiotics are indicated if upper airway infection is suspected.

Difficult laryngoscopy is associated with inadvertent endobronchial intubation and traumatic intubation can cause air leak or pneumothorax.²⁶⁹ Difficult facemask ventilation can distend the stomach necessitating decompression for optimal mechanical ventilation. Postintubation chest X-ray can confirm appropriate tracheal tube insertion depth (but does not confirm tracheal placement) and identify complications.^{270,271}

If the airway has been traumatized or operated upon, observe for bleeding, swelling, and surgical emphysema. Difficult airway management is associated with pharyngeal or oesophageal injury, which may lead to deep infection and life-threatening sepsis.²⁷²

Respiratory deterioration, especially ‘red flags’ (Table 3) should prompt immediate attention to the airway and breathing circuit, particularly after patient movement or procedures.

Difficult tracheal tube exchange

A tracheal tube may require urgent replacement if displaced, blocked, kinked, if the cuff has failed, or if a small tracheal tube has been inserted during difficult or fiberoptic airway management. The safest method of tracheal tube exchange ensures airway continuity is maintained throughout the procedure.^{273,274} Airway exchange catheters (AECs) are specifically designed for this purpose.^{251,275–277}

Exchange should be performed using laryngoscopy. Videolaryngoscopy is recommended as it is superior to direct laryngoscopy, leading to better glottic view, higher success rate, and fewer complications.²⁷⁴

Appropriately trained staff should perform tracheal tube exchange. Optimal positioning, equipment provision and preparation, emptying the stomach, preoxygenation, peroxxygenation, and full neuromuscular blockade increase safety. Tracheal tube exchange should always be approached as a high-risk intervention, with the same level of preparation as intubation. Some AECs are hollow and enable oxygen administration, but even low flow oxygen administration via an AEC risks barotrauma if the catheter tip is placed or migrates beyond the carina.^{207,208,278} We do not recommend oxygen administration via an AEC during tracheal tube exchange and, if an AEC is left in place after extubation, it is safer to administer oxygen by other means.²

Follow-up

When it is anticipated that future airway management will prove difficult, an airway alert should be completed and the information communicated to the patient, family, and their doctor.^{279,280} Coding this correctly (e.g. SNOMED CT 718447001: Systematized Nomenclature of Medicine–Clinical Terms in the UK) increases the likelihood that the information remains in electronic patient record.²⁸¹ Prolonged intubation or tracheostomy may cause subglottic or tracheal stenosis which should be considered at ICU follow up.

Tracheostomy in ICU patients

In the UK approximately two-thirds of new tracheostomies are performed percutaneously by intensivists in critically ill patients^{26,282} and typically 7–19% of all patients admitted to ICU will undergo tracheostomy.^{283–286} In NAP4, 50% of ICU incidents were complications of tracheostomies,^{11,24,25} most occurring after insertion due to displacement with fewer episodes of blockage or haemorrhage. Systematic analyses of adverse incidents demonstrate common themes: lack of staff training, lack of capnography and basic bedside equipment, inadequate environments and support mechanisms, compounded by poorly considered care pathways and responses.^{11,24,26,287}

Management of tracheostomy emergencies is described by the UK National Tracheostomy Safety Project (www.tracheostomy.org.uk), but there are specific considerations for typical ICU patients with a tracheostomy.¹⁸⁸ Most of these patients have a potentially patent upper airway, although management of this native airway is ‘difficult’ in approximately 30%, with complications often compounded by obesity.²⁶ In patients who are tracheostomy-dependent,

Table 3 Intubated patient: airway red flags.

1. Absence or change of capnograph waveform with ventilation
2. Absence or change of chest wall movement with ventilation
3. Increasing airway pressure
4. Reducing tidal volume
5. Inability to pass a suction catheter
6. Obvious air leak
7. Vocalization with a cuffed tube in place and inflated
8. Apparent deflation, or need for regular re-inflation, of the pilot balloon
9. Discrepancy between actual and recorded tube insertion depth
10. Surgical emphysema

Adapted from McGrath BA. National Tracheostomy Safety Project.¹⁸⁸

displacement or blockage may be rapidly fatal and the central role of waveform capnography in monitoring, recognition, and management of such events is critical.

Percutaneous tracheostomy stomas are unlikely to be mature enough for safe tube exchange until 7–10 days, meaning management of tube blockage/displacement in this period should focus on securing the native upper airway.¹⁸⁹ Improvements in the quality and safety of tracheostomy care have been demonstrated through comprehensive staff education, multidisciplinary oversight, multidisciplinary ward rounds, displaying relevant information on bedhead signs, and ensuring equipment and infrastructure are available to prevent, detect, and respond to emergencies.^{288–295}

We recommend that all ICU staff caring for patients receive training in prevention, detection, and management of tracheostomy emergencies.

Extubation

The topic of extubation has been extensively covered by separate DAS extubation guidelines,² which are readily applied to ICU practice, with a recent narrative review focussed on ICU management.²⁹⁶ Extubation occurs either as an unplanned complication of airway management or as a planned event. In either case, reintubation after prolonged ventilation can be anticipated to be more difficult because of airway oedema and the emergent nature of many re-intubations.

Unplanned extubation

This is common enough that all ICUs should anticipate unplanned extubation and plan for its occurrence.^{297,298} Early recognition is the key to preventing harm and continuous waveform capnography should enable early detection of both partial and complete airway displacement. For the patient without a difficult airway, an urgent intubation strategy using the current algorithm (Fig. 3) is appropriate. For patients who have a known difficult airway, evidence suggests that identification of such patients and appropriate planning is not done reliably.²³

Planned extubation

Up to 15% of patients extubated in ICU require reintubation within 48 h.²⁹⁹ Extubation should therefore be considered a ‘trial’, with the possibility of (difficult) reintubation actively

planned for.²⁹⁶ Elective extubation of known difficult airways should only be performed in ‘daytime’ hours. AECs are recommended: these are airway exchange bougies placed prior to extubation and retained *in situ* after extubation and that act as a conduit for reintubation.^{2,300} After extubation, the patient should be observed carefully, with reintubation anticipated, until they are stable. CPAP, NIV, or HFNO can reduce reintubation rates, especially in high-risk patients.^{301–304} Post-extubation stridor occurs in 12–37% of patients.^{268,305} Steroids have been advocated to prevent the need for reintubation in high-risk patients,^{306,307} but the evidence does not support their routine use.³⁰⁸

Location of extubation

Where intubation or other aspects of airway management have been difficult, extubation should be planned carefully. Depending on the specific patient, personnel, and institutional situation, it may be best to transfer the patient to the operating theatre, or to bring anaesthetic staff to the patient’s location to facilitate safe extubation. In either situation, it must be remembered that extubation failure in a patient with a difficult airway may occur late. The ICU team must be prepared for this possibility: in-theatre extubation does not address this potential complication. The specifics of extubation planning are outside the limits of this guidance and specific and relevant guidance is available.²

Special circumstances

Managing the known or anticipated difficult intubation in the critically ill patient

Identifying patients on ICU with a predicted or known difficult airway and creating a clear airway strategy is key to safety. Bedhead signs identifying airway difficulty and describing the intended airway plan may reduce adverse incidents (<http://das.uk.com>).

The combination of a difficult upper airway and impaired pulmonary gas exchange is an extremely challenging situation. The most experienced available operator must manage such cases. Moving patients with borderline respiratory function may precipitate complete respiratory failure: ideally the team should come to the patient in an adequately equipped critical care environment, in preference to transferring the patient to an operating theatre for airway management. In elective patients, awake fiberoptic intubation is regarded as the gold standard for securing the difficult airway, although seldom used in the critically ill in the UK.³⁰⁹ More recently videolaryngoscopy, including awake techniques, has become a viable option in experienced hands.^{309–311}

There are several practical limitations to awake intubation in the critically ill, including time-critical intubation, and limited patient cooperation. Blood, secretions and vomitus in the airway hamper both fiberoptic visualization and videolaryngoscopy. Awake techniques may precipitate complete airway obstruction from over-sedation, topical anaesthesia, laryngospasm, or bleeding^{300,312,313}; there is a risk of aspiration and if the nasal route is used this usually requires subsequent conversion to an oral tracheal tube.²⁴⁸ Critical respiratory failure may be precipitated during awake intubations, particularly in patients dependent on CPAP/PEEP.

We recommend that awake intubation should only be attempted by a suitably skilled and experienced clinician, with

careful (head-up) positioning,^{65,71} minimal sedation (if needed), adequate topical anaesthesia, active peroxygenation (e.g. HFNO³¹⁴), and a clear plan for failure.³⁰⁰

When a patient is known to have significant glottic narrowing, all options are difficult but the practicality of awake techniques and patient tolerance should be carefully balanced against the potential success of a technique performed after induction of anaesthesia. There may be a role for preprocedural elective cricothyroid or tracheal cannulation to administer oxygen and assist conversion to FONA if necessary.^{10,11}

Inadequate patient cooperation or urgency usually requires intubation after induction of anaesthesia.³⁰⁰ We do not recommend inhalational techniques for difficult airway management in the critically ill as this results in a slow, difficult induction complicated by upper airway obstruction, hypoxaemia, and hypercarbia.^{11,315} Intravenous induction using full neuromuscular blockade is optimal in most critically ill patients. When difficult intubation is anticipated, 'intravenous induction with 'double set-up' has been advocated: the midline is identified (the cricothyroid membrane moves with neck extension) and marked before induction of anaesthesia, after which intubation is attempted by one operator with a second operator primed to perform FONA if required.³⁰⁰

Obesity

There is robust evidence that obesity is an important risk factor for airway misadventure in the critically ill.^{261,316} Obese patients accounted for around 50% of cases in NAP4 and events led to death or brain damage more often than in non-obese patients.²⁶¹ In NAP4, a patient with a BMI >30 kg m⁻² was twice as likely as a slim patient to have a complication of airway management, and four times as likely with BMI >40 kg m⁻². Difficult intubation was reported twice as commonly in obese patients in ICU compared to obese patients in the OR and life-threatening complications were increased 22-fold compared to the non-obese.³¹⁶ Complications included difficult intubation (16%), severe hypoxaemia (39%), cardiovascular collapse (22%), cardiac arrest (11%), and death (4%).³¹⁶

Obesity is a risk factor for difficult facemask ventilation,³¹⁷ SGA placement,³¹⁸ tracheal intubation,³¹⁹ and FONA.^{320,321} However, irrespective of procedural difficulty, the main problem with obesity is the speed and severity of desaturation, especially with airway obstruction.³²² Obstructive sleep apnoea should be actively considered as it is often undiagnosed³²² and further increases the risk of intubation, extubation, and cardiovascular complications.^{316,323} If the cricothyroid membrane is impalpable, we recommend preinduction identification using ultrasound.³²⁰ We recommend thorough pre- and peroxygenation head up with CPAP/NIV or HFNO.^{72,86,324} The ramped position increases intubation success rates.³²⁵ If intubation fails, rapid refractory hypoxaemia is likely and we do not recommend multiple attempts at intubation, SGA rescue, or facemask ventilation, but recommend prompt transition to FONA. Where FONA is required a scalpel technique with a vertical incision is recommended (Fig. 4).⁹ This is one group in whom securing the airway awake with a fiberoptic or videolaryngoscopy technique should be actively considered.

Cervical spine injury

Between 2% and 5% of major trauma patients have a cervical spine injury, of which approximately 40% are unstable.^{326–330} However, the rate of secondary neurological injury

attributable to airway management is extremely low.³³¹ Many patients are uncooperative, hypoxaemic, and hypotensive. Specific goals include urgent airway protection, limiting neuroaxial mechanical damage whilst maintaining oxygenation and cord perfusion.

The risk of cervical movement is highest with facemask ventilation and securing the airway early with RSI is likely to be beneficial. RSI should be performed using manual-in-line stabilization with removal of at least the anterior part of the cervical collar to facilitate mouth opening, application of cricoid force and FONA.^{326,332–334} Laryngeal view is worsened by manual-in-line stabilization and we recommend use of a bougie during direct laryngoscopy.^{335,336} Videolaryngoscopy increases intubation success with minimal cervical movement and we recommend a low threshold for its use by appropriately skilled intubators.^{335,337–339} There is no compelling evidence that jaw thrust or laryngeal manipulations (backward upward rightward pressure, optimal external laryngeal manipulation, cricoid force) worsen neurological injury.³⁴⁰ Awake techniques are an option in stable, cooperative patients.³⁴¹ It is good practice to record neurological status prior to airway management.

Burns and thermal injury

The classic features of thermally-induced potential airway obstruction include hoarseness, dysphagia, drooling, wheeze, carbonaceous sputum, soot in the airway, singed facial or nasal hairs, or a history of confinement in a burning environment.³⁴² Clinical signs lack sensitivity and are unreliable predictors of the requirement for intubation.^{343,344} Normal nasendoscopic mucosal appearance is reassuring and nasendoscopy can be repeated at intervals or if there is clinical deterioration.^{342,343} Dyspnoea, desaturation, and stridor are indications for urgent intubation.³⁴² Carbon monoxide (which artificially increases peripheral oximetry readings) and cyanide poisoning may worsen tissue hypoxia and compound the emergency.

In the absence of indications for urgent intubation, the decision to intubate early (to prevent deterioration and increased difficulty) or manage conservatively (as ventilation may worsen outcome) may be complex and requires a senior decision-maker. We recommend obtaining specialist advice early from a burns centre.³⁴² Patients managed conservatively should be observed in a high-dependency area, nursed head-up and remain nil-by-mouth. There should be regular reassessment to detect deterioration early. Large volume fluid resuscitation will worsen airway swelling.³⁴⁵

Awake intubation is an option in this group, but requires cooperative, stable patients with minimal airway soot and swelling. Modified RSI is usually the most appropriate technique. Avoid succinylcholine from 24 h postinjury to avoid hyperkalaemia. Use an uncut tracheal tube to allow for subsequent facial swelling. Insert a gastric tube after securing the airway as this may become difficult later.

Discussion

The purpose of these guidelines is to provide guidance on airway management in the critically ill, irrespective of location in the hospital, that is clear, practical, logical and consistent with the current evidence base. We believe the guidelines are necessary and timely as patients with critical illness are a particularly high-risk group, with specific problems and needs.^{10,11,24} As such, the extent to which practice advice and

evidence can be extrapolated from the OR is limited. The specialty of intensive care medicine is evolving, and this evolution includes increasing involvement of both junior and senior clinicians without an anaesthetic background. All these factors reinforce the need for specialty-specific guidance.

Given the limited robust evidence available, it is inevitable that the guidelines are an expert consensus opinion (based on that evidence) and it is equally inevitable that there will be areas with which some will disagree. To minimize this and to ensure our goals are met, we have performed up to date literature searches, liaised with stakeholders and sought external expert advice in those areas that require particular subspecialty input.

The guidelines are consistent with current evidence, but there are considerable areas where the evidence is inadequate to make robust evidence-based recommendations. Three areas of particular concern are: (i) the role of HFNO in pre- and peroxygenation; (ii) the value of videolaryngoscopy in general, including the role of individual videolaryngoscopes in primary and rescue airway management; and (iii) the optimal FONA technique. These are all areas where high quality evidence is needed to guide practice. The current evidence base is weak, including studies that are too small, enrol inexperienced clinicians, exclude relevant patients, or have problems of control group bias. We urge the critical care community to consider this in prioritizing and funding future research, so that when these guidelines are revised, the evidence base will be more relevant and informative. Despite these current limitations, quality improvement initiatives can and should occur in every hospital, and by recording the details and complications of airway management in the critically ill, strategies, equipment and training needs can be evaluated and addressed.

The authors have reviewed many airway related deaths and have observed that a typical fatality often takes 45–60 min from first airway intervention until death occurs. During this time, it is typical for multiple individuals to make multiple attempts to secure the airway. Some procedures are repeated by one, or more than one, person. Many of these deaths also start with an 'awkward' airway (e.g. intubation is almost achieved at first attempt and ventilation/oxygenation is possible between attempts), but progresses to an impossible airway (CICO). In publishing these guidelines, we are keen to emphasize the 'timeliness' of airway management and the importance of progressing through the airway pathway at an appropriate speed, without undue repetition of failing techniques. Acute life support guidelines specify times that each intervention should take (e.g. 2 min cycles of cardiopulmonary resuscitation between pulse checks and epinephrine administration every 4 min).³⁴⁶ It seems likely this mandated timeline improves algorithm compliance. We considered adding a timeline to the main algorithm but ultimately found this impractical. Information about the timelines (and transition points) of both successful and failed difficult airway management in the critically ill would be of great benefit. Our opinion is that it should take significantly less than 15 min to progress from the beginning of the algorithm to the point at which FONA is performed.

In this guideline, we emphasize the primacy of oxygenation during airway management. We also stress embracing the best in terms of non-technical skills, modern equipment and technical expertise. These are all emphasized in other airway guidelines but are especially pertinent to the management of this vulnerable group of patients.

Endorsements

The following national organizations have reviewed and endorse these guidelines: Association of Anaesthetists of Great Britain and Ireland, Association of Peri-Operative Practice, British Association of Critical Care Nurses, College of Operating Department Practitioners, Difficult Airway Society, Faculty of Intensive Care Medicine, Intensive Care Society, National Tracheostomy Safety Project, Royal College of Anaesthetists and Royal College of Emergency Medicine.

Authors' contributions

The Working Party acted together over the course of about 20 face-to-face meetings in addition to many hundreds of electronic exchanges. The Chair and Convener was A.H. All authors contributed materially to all sections as the internal review process of initial drafts was extensive. A brief outline of initial drafting is described below. A.H. coordinated the initial literature search, but the more than 30 000 abstract summaries were scrutinised by equal proportions of the entire group. Subsequent hand searching was directed by initial section drafters. Initial drafts were often written by more than one author and the description below refers to these initial drafts; subsequent refinement was fully shared at face-to-face meetings and by electronic communications.

A.H.: Treasurer, Difficult Airway Society. Representing the Difficult Airway Society. Responsible for conception of the project, writing terms of reference and convening the working group. Coordinated literature search. Divided literature abstracts for detailed scrutiny between other members of group and reviewed literature. Repeated literature search three times and again directed hand-search of documents. Meeting agendas. Methods, human factors, assessment, Plan A, Plan D, haemodynamic optimization, care of intubated patient, anticipated difficult airway and burns sections. Initial full draft and revisions. Algorithms initial draft and revisions. [Figures 1–4](#). Overall design, drafting, and revisions. Final draft revision.

B.A.M.: Representing the National Tracheostomy Safety Project. Literature review, subsequent hand-searching and document scrutiny, reference management, introduction, human factors, [Table 1](#) design, Plan B/C, tracheostomy, care of intubated patient, tube choice sections, [Table 3](#). Initial and final drafts. [Figures 1–4](#). Overall design, drafting. Final draft revision.

C.G.: Representing the Difficult Airway Society. Literature review, subsequent hand-searching and document scrutiny, introduction, human factors, [Tables 1 and 3](#), algorithms, [Figures 2–4](#), Plan B/C, anticipated difficult airway, cervical spine sections. Review final draft. Overall design, drafting, and revisions.

J.R.: Ex-Officio President, Difficult Airway Society. Representing the Difficult Airway Society. Literature review, subsequent hand-searching and document scrutiny. Introduction, Plan A, obesity, care of intubated patient, tube choice sections. Algorithms, [Figures 2–4](#), [Table 3](#). Overall design, drafting, and revisions.

G.S.S.: President-elect, Intensive Care Society. Representing the Intensive Care Society & Faculty of Intensive Care Medicine Joint Standards Committee. Literature review, subsequent hand-searching and document scrutiny. Abstract, introduction, human factors, Plan A. Haemodynamic optimization, burns sections. Algorithms, [Figure 2](#). Overall design, drafting, and revisions.

R.G.: Representing the Difficult Airway Society doctors in training. Literature review, subsequent hand-searching and document scrutiny. Introduction. Assessment, Plan B/C, tracheostomy. Algorithms, [Figures 2–4](#), [Tables 1 and 3](#). Minutes and meeting planning. Overall design, drafting, and revisions. T.M.C.: Representing the Royal College of Anaesthetists. Literature review, subsequent hand-searching and document scrutiny. Plan A, Plan D, haemodynamic optimization, anticipated difficult airway, obesity, extubation and discussion sections. Algorithms, [Figures 1–4](#) and [Table 1](#), Final draft revision. Overall design, drafting, and revisions. Final draft revision.

Overall, this was very much a group effort in which the team worked extremely closely. All authors agree to be accountable for all aspects of the work and give approval for publication.

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Declaration of interest

A.H.: has received expenses for speaking at educational events for which he has declined payment, has received one payment for an advisory meeting (Cook Medical), and has received expenses to attend one event (Fisher Paykel); Specialist Advisor for the National Institute of Clinical Excellence.

B.A.M.: has received expenses from Smiths-Medical and Ambu for attending company educational and product evaluation events, for which he has declined personal payment.

C.G.: has been loaned equipment by Verathon Medical for training purposes and received free equipment (Karl Storz) for evaluation.

J.R.: None declared.

G.S.S.: None declared.

R.G.: None declared.

T.M.C.: associate editor of the *British Journal of Anaesthesia*. His department has received free or at cost airway equipment for evaluation or research. He has spoken at a company educational meeting (Storz GmbH) and at a sponsored educational meeting (Fisher Paykel) and attended an advisory meeting (Covidien) for which he has declined payment. He is not aware of any financial conflicts.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.bja.2017.10.021>.

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