Guidelines

Difficult Airway Society guidelines for awake tracheal intubation (ATI) in adults

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Summary

Awake tracheal intubation has a high success rate and a favourable safety profile but is underused in cases of anticipated difficult airway management. These guidelines are a comprehensive document to support decision-making, preparation and practical performance of awake tracheal intubation. We performed a systematic review of the literature seeking all of the available evidence for each element of awake tracheal intubation in order to make recommendations. In the absence of high-quality evidence, expert consensus and a Delphi study were used to formulate recommendations. We highlight key areas of awake tracheal intubation in which specific recommendations were made, which included: indications; procedural setup; checklists; oxygenation; airway topicalisation; sedation; verification of tracheal tube position; complications; management of unsuccessful awake tracheal intubation; post-tracheal intubation management; consent; and training. We recognise that there are a range of techniques and regimens that may be effective and one such example technique is included. Breaking down the key practical elements of awake tracheal intubation into sedation, topicalisation, oxygenation and performance might help practitioners to plan, perform and address complications. These guidelines aim to support clinical practice and help lower the threshold for performing awake tracheal intubation when indicated.

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Recommendations

1 Awake tracheal intubation must be considered in the presence of predictors of difficult airway management.
2 A cognitive aid such as a checklist is recommended before and during performance of awake tracheal intubation.
3 Supplemental oxygen should always be administered during awake tracheal intubation.
4 Effective topicalisation must be established and tested. The maximum dose of lidocaine should not exceed 9 $mg.kg^{-1}$ lean body weight.
5 Cautious use of minimal sedation can be beneficial. This should ideally be administered by an independent practitioner. Sedation should not be used as a substitute for inadequate airway topicalisation.
6 The number of attempts should be limited to three, with one further attempt by a more experienced operator (3 + 1).
7 Anaesthesia should only be induced after a two-point check (visual confirmation and capnography) has confirmed correct tracheal tube position.
8 All departments should support anaesthetists to attain competency and maintain skills in awake tracheal intubation.

Why were these guidelines developed?

Awake tracheal intubation (ATI) has a high success rate and a low-risk profile and has been cited as the gold standard in airway management for a predicted difficult airway. However, ATI is reported to be used in as few as 0.2% of all tracheal intubations in the UK [1]. There are barriers preventing broad uptake and use of awake techniques for securing the airway. We aimed to produce generalisable guidelines to improve patient safety by making ATI more accessible to all clinicians, trainers and institutions. Rather than inform expert practice, these guidelines aim to support the use of ATI by more clinicians, with a particular focus on those that do not regularly perform ATI. There remains heterogeneity in clinical practice, underscoring the need for a more consistent approach using the available evidence, which these guidelines aim to deliver.

What other guidelines exist?

Although there are many guidelines on unanticipated difficult airway management [2–13], there are few that specifically focus on the anticipated difficult airway. The ASA, Canadian Airway Focus Group, French Society for Anesthesia and Intensive Care and German Society for Anesthesiology and Intensive Care describe clinical decision making in the anticipated difficult airway [6, 7, 10, 12].

How do these guidelines differ from existing guidelines?

At the time of writing, there were no nationally or internationally agreed guidelines on the practical performance of ATI.

Disclaimer

These guidelines are not intended to represent a minimum standard of practice, nor are they to be regarded as a substitute for good clinical judgement. They present key principles and suggested strategies for preparation, performance, consent and training to inform clinical practice. This document is intended to guide appropriately trained operators.

Introduction

A strategy for difficult airway management is necessary when facemask ventilation, supraglottic airway device (SAD) placement or ventilation, tracheal intubation or insertion of a front-of-neck airway (FONA) is predicted to be challenging. The incidence of difficult facemask ventilation is 0.66–2.5% [14–17], difficult SAD placement or ventilation 0.5–4.7% [18–22], difficult tracheal intubation 1.9–10% [14, 16, 23–25] and combined difficulty in both facemask and tracheal intubation 0.3–0.4% [16]. As a rescue technique after failed tracheal intubation, one study reported that SADs have a success rate as low as 65% in difficult airway management [26]. The reported incidence of requirement for emergency FONA and death due to airway management are 0.002–0.07% (1:50,000–1:1400) [1, 27, 28] and 0.0006–0.04% (1:180,000–1:2800), respectively [1, 28]. The risk and severity of adverse outcomes during difficult airway management is highlighted by the plethora of guidelines and cognitive aids for airway rescue [29].

Awake tracheal intubation involves placing a tracheal tube in an awake, spontaneously-breathing patient, most commonly with flexible bronchoscopy (ATI:FB) or videolaryngoscopy (ATI:VL, Table 1). This allows the airway to be secured before induction of general anaesthesia, avoiding the potential risks and consequences of difficult airway management in an anaesthetised patient [30].

Awake tracheal intubation has a favourable safety profile because both spontaneous ventilation and intrinsic airway tone are maintained until the trachea is intubated [31–35]. Awake tracheal intubation can be unsuccessful in 1–2% of cases, but this rarely leads to airway rescue strategies or death [33–35]. These guidelines aim to

Table 1 A summary of terms used in these guidelines.

Term	Definition
ATI	Awake tracheal intubation
ATI:FB	Awake tracheal intubation using flexible bronchoscopy
ATI:VL	Awake tracheal intubation using videolaryngoscopy
FONA	Front-of-neck airway
sTOP	Sedation, topicalisation, oxygenation, performance
Minimal sedation	Drug-induced state during which the patient responds normally to verbal commands, while the airway, spontaneous ventilation and cardiovascular function are unaffected
Airway topicalisation	Topical application of local anaesthetic to the airway
Performance	The practical conduct of awake tracheal intubation
Two-point check	1. Visualisation of the tracheal lumen with ATI:FB or tracheal tube through the cords with ATI:VL to confirm tracheal placement 2. Capnography to exclude oesophageal intubation
Unsuccessful attempt	Unplanned removal of flexible bronchoscope, videolaryngoscope or tracheal tube from the airway
Unsuccessful ATI	Successful tracheal intubation not achieved after 3 + 1 attempts[a]

[a]Three attempts by the primary operator and a fourth attempt by a more experienced operator.

increase the use of ATI by providing clear guidance for clinicians to support decision making, preparation and performance of ATI in the setting of a predicted difficult airway.

Methods

The development of these guidelines followed the appraisal of guidelines for research and evaluation (AGREE) reporting checklist [36]. To ensure these guidelines are supported by best evidence, a systematic review adhering to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) recommendations [37] was performed. We sought published data of relevance to ATI, including decision making, technical performance, complications, training and non-technical aspects. Details of the search, screening and study selection are shown in the supplementary material (Supporting Information, Appendix S1).

Data from included studies were synthesised and consensus from all 10 members of the guideline group was sought to formulate guideline recommendations using a three-round Delphi method [38, 39]. The first round entailed an initially proposed longlist of recommendations, which were each reviewed and rated for content and clarity. The recommendations in which six or more members of the guideline group approved were shortlisted. A second round of rating was then undertaken, in which the highest rated recommendations were selected. Finally, a third round involving recommendation-ratification in round-table discussions was undertaken. These recommendations were based on a number of factors, including: volume and consistency of supportive evidence; applicability and generalisability of the evidence to current practice; and clinical and practical implications of recommendations.

We determined the level of evidence and graded the strength of subsequent recommendations using a modified version of the system developed by the Centre for Evidence-based Medicine (Oxford, UK) (Table 2) [40]. Each recommendation was graded A to D according to the strength of the available evidence [41].

Over 3 years the guideline group met 21 times in person and 14 times remotely in order to develop, draft and finalise these guidelines. Draft versions were presented at the 2017 and 2018 Difficult Airway Society (DAS) annual scientific meetings. We sent an electronic survey to DAS members (n = 2150) to capture their opinions, preferences and clinical experiences in ATI, of whom 632 (29%) responded. This survey highlighted the need for guidelines for ATI and the role of a standardised technique for training and clinical practice. We also performed a survey of 43 international experts, seeking details on commonly used strategies for oxygenation, topicalisation, sedation and performance of ATI. Patient and public involvement was also used to explore the views and experiences of patients who had undergone ATI. This was achieved by conducting a fully anonymised multicentre structured survey of 100 patients, where we explored the self-reported experiences of the overall conduct of ATI. We consulted an anaesthetic assistant during the preparation of these guidelines and invited a senior anaesthetic nurse and two consultant head and neck surgeons to comment on the final draft. A draft

Table 2 Grading of recommendations based on the level of evidence available.

Grade	Level of evidence available
A	• Consistent systematic reviews of RCTs, single RCTs or all-or-none studies
B	• Consistent systematic reviews of low-quality RCTs or cohort studies, individual cohort study, or epidemiological outcome studies • Consistent systematic reviews of case–control studies, individual case–control studies • Extrapolations from systematic reviews of RCTs, single RCTs or all-or-none studies
C	• Case series, case reports • Extrapolations from systematic reviews of low-quality RCTs, cohort studies or case–control studies, individual cohort study, epidemiological outcome studies, individual case–control studies • Extrapolations from systematic reviews of case–control studies
D	• Expert opinion or ideas based on theory, bench studies or first principles alone • Troublingly inconsistent or inconclusive studies of any level

RCT, randomised controlled trial.

manuscript of these guidelines was then sent to 13 international experts with clinical or academic experience related to ATI to gather specific comments and feedback on recommendations and to assess applicability and feasibility. The guideline group considered the responses from expert reviewers to inform the final recommendations. The final draft of the guideline was then submitted to DAS executive committee for ratification.

Indications

Prediction of difficult airway management is unreliable [14, 23, 42], but there are common features that have been identified in patients requiring ATI. These include, but are not limited to: patients with head and neck pathology (including malignancy, previous surgery or radiotherapy); reduced mouth opening; limited neck extension; obstructive sleep apnoea; morbid obesity; and progressive airway compromise [32, 33, 35, 43, 44]. There is limited evidence for any individual, validated, predictive assessment tool developed specifically for ATI. Airway assessment including history, examination and appropriate investigations, is indicated for all patients [1, 2, 7, 45] (Grade D). Awake tracheal intubation must be considered in the presence of predictors of difficult airway management (Grade D). In an elective setting the patient should be appropriately fasted (Grade D). In the non-fasted patient, the potential for regurgitation or aspiration of gastric contents still exists even with ATI. There are few relative contra-indications to ATI (e.g. local anaesthetic allergy, airway bleeding, unco-operative patients) but the only absolute contra-indication is patient refusal.

Procedural setup

Awake tracheal intubation can be associated with the greatest operator-related physical, mental and psychological stress of all elective airway management interventions [46]. These stressors may be associated with suboptimal performance [47, 48], increasing the risk of complications including failure. Teamwork, good communication and appropriate preparation may mitigate these challenges [48–50] and the importance of well-trained, competent assistants should not be underestimated. Safety should not be compromised by time pressures presented by other staff members; therefore planning and communication with anaesthetic assistants, operating theatre nursing staff, surgeons and skilled anaesthetic colleagues is essential (Grade D).

Consideration and planning of the appropriate location is essential. Awake tracheal intubation should ideally be performed in the operating theatre environment (Grade D). This setting has ready access to skilled assistance, drugs, equipment and space. For high-risk patients, including those with significant airway obstruction, hypoxia, respiratory failure, challenging or failed ATI, the operating theatre may have advantages over an anaesthetic room [1, 51], such as greater space and immediate surgical assistance. When ATI is performed outside of the theatre environment (e.g. in the critical care unit or the emergency department), the same standards of care should apply (Grade D) [52].

Monitoring patients' physiological parameters during anaesthetic care mitigates risks and may alert operators to impending complications [53–57]. Frequently occurring avoidable complications in ATI that may be detected by monitoring are airway obstruction and hypoventilation secondary to over-sedation [33–35, 58]. Disturbances to cardiac rhythm and blood pressure following administration of pharmacological agents for topicalisation and sedation are possible [35, 59–61]. In accordance with Association of Anaesthetists' guidelines for patients receiving sedation

[62], it is recommended that ECG, non-invasive blood pressure, pulse oximetry and continuous end-tidal carbon dioxide monitoring are used throughout the process of ATI (Grade C). It is acknowledged that end-tidal carbon dioxide monitoring during ATI may be challenging in current practice.

Workspace ergonomics have an impact on performance and safety [51, 63], and should be considered before starting the procedure (Grade D; Fig. 1; Supporting Information, Appendix S2) [52]. This includes optimising the position of patient, operator and assistants, as well as location of equipment and monitors, which should be in the direct line of sight of the operator. There is no consensus on the ideal operator or patient position [64–67], but there are physiological and anatomical advantages to having patients sitting up [68–70].

Complications or unsuccessful ATI, although uncommon, should be prepared for [33–35], and immediate access to emergency drugs, staff and equipment is essential (Grade C). A plan for unsuccessful ATI, including possible postponement, FONA or high-risk general anaesthesia, should be discussed explicitly and agreed on by all team members before beginning the procedure (Grade D).

It is important to select an appropriate route for tracheal intubation, visualisation device and tracheal tube. The route for tracheal intubation should take into account patient anatomy, surgical access and tracheal extubation plan (Grade D). For example, in patients with limited mouth opening, the nasal approach may be the only option, while in patients having nasal surgery, the oral approach may be the preferred route. There is no evidence or consensus

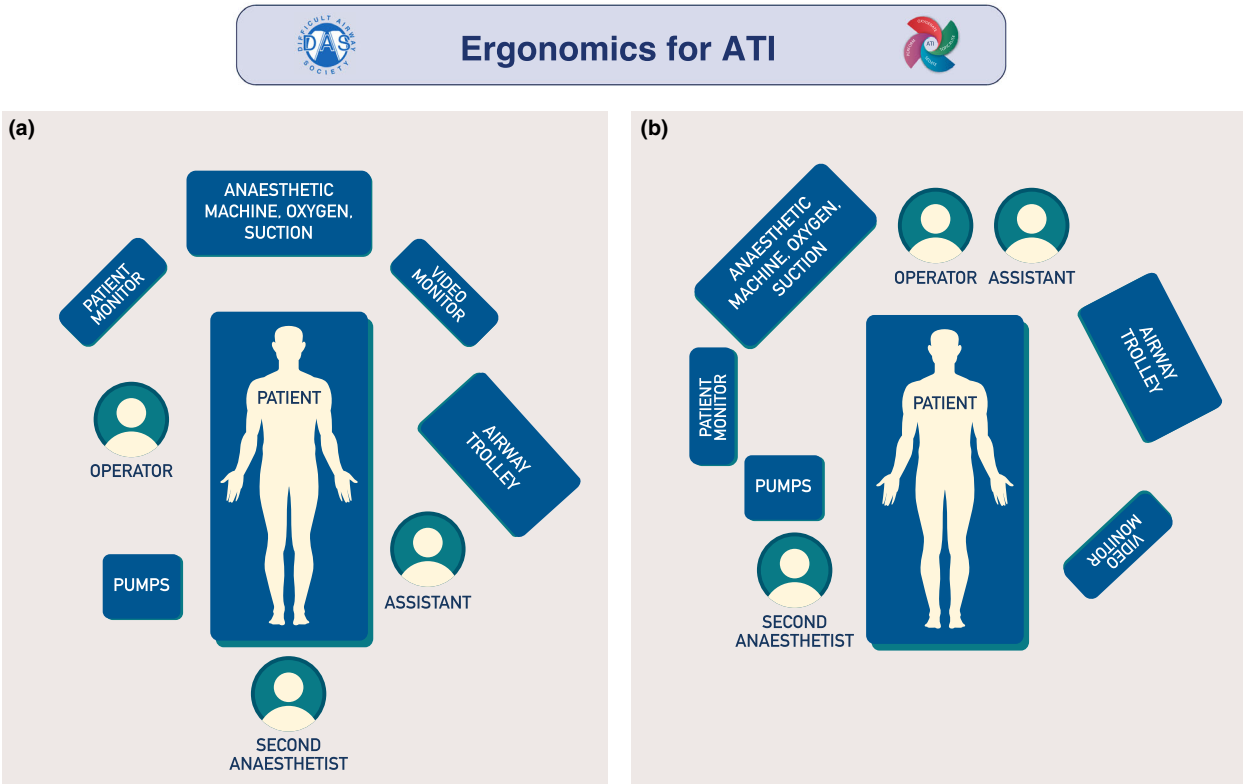

Figure 1 Examples of ergonomics for awake tracheal intubation (ATI). The primary operator should have a direct line of sight of the patient, video monitor and patient monitor, as well as immediate access to infusion pumps, anaesthetic machine, suction and oxygen delivery device. If a second anaesthetist is present, they should be positioned with a direct line of sight of the patient and have immediate access to infusion pumps, as well as be able to access all other equipment. The anaesthetic assistant's primary position should be with immediate access to the airway trolley, and in proximity to the operator. (a) Awake tracheal intubation performed with the operator positioned facing the patient who is in a sitting up position. (b) Awake tracheal intubation performed with the operator positioned behind the supine/semi-recumbent patient. This figure forms part of the Difficult Airway Society guidelines for ATI in adults and should be used in conjunction with the text. ©Difficult Airway Society 2019.

among experts demonstrating superiority of one route if both are feasible [33–35, 64, 71].

Awake tracheal intubation using videolaryngoscopy has a comparable success rate and safety profile to ATI:FB (98.3% each) [31]. Choosing between techniques is based on patient factors, operator skills and availability of equipment (Grade A). For example, in patients with limited mouth opening, a large tongue or fixed flexion deformity of the neck, ATI:FB may be more appropriate. Conversely, patients with airway bleeding may be more suitable for an ATI:VL technique. If the chosen ATI technique is unsuccessful, practitioners should consider using an alternative (e.g. ATI:FB if ATI:VL is unsuccessful or vice versa; Grade D). A combined approach to ATI using both VL and FB has been described [72–74] and could be considered in complex clinical scenarios (Grade D). In a well-topicalised patient, insertion of an SAD as a conduit for ATI:FB has also been described [75, 76], and may provide the benefit of maintaining airway patency. Single-use flexible bronchoscopes are associated with a similar safety profile to re-usable ones [77]. Operators should defer to local availability and personal experience in determining which flexible bronchoscope to use (Grade B). There is currently no evidence or consensus to support the safety or efficacy of any individual videolaryngoscope. For ATI:VL practitioners should use videolaryngoscopes with which they are most familiar (Grade B).

Careful selection of tracheal tube is integral to the success of any ATI technique. This should factor in size (internal and external diameter), shape, length, tip design and material. For ATI:FB, reinforced, Parker Flex-Tip™ (Bridgewater, CN, USA) and intubating laryngeal mask airway tubes (LMA® Fastrach™ ETT, Teleflex, Beaconsfield, UK) have been shown to be superior to standard polyvinylchloride (PVC) tracheal tubes in terms of ease of tracheal intubation, railroading (advancing the tracheal tube over the flexible bronchoscope) and decreasing laryngeal impingement [78–86]. Therefore, the use of a standard PVC tracheal tube is not recommended (Grade A). Using the smallest appropriate external diameter tracheal tube is advisable, as this may reduce the incidence of impingement [87] (Grade B). Positioning the bevel of the tracheal tube posteriorly is recommended [80, 82, 86] (Grade A). For ATI:VL, tracheal tube selection is similar to that in an asleep patient and is influenced by the VL selected.

Checklists

In the peri-operative setting the use of cognitive aids, such as checklists, improves inter-professional communication, teamwork and patient outcomes [88–91]. In anaesthetic practice, cognitive aids enhance performance in simulated emergency scenarios [92, 93], and their use been recommended in elective airway management [1]. Given the potential benefits, we recommend a cognitive aid such as a checklist before and during performance of ATI (Grade D; Supporting Information, Appendix S2). The key components of ATI are sedation, topicalisation, oxygenation and performance (sTOP; Fig. 2). The 's' is in lower case to emphasise the optional nature of sedation.

Oxygenation

The reported incidence of desaturation ($S_pO_2 \leq 90\%$) with low-flow (< 30 l.min^{-1}) oxygen techniques during ATI ranges between 12% and 16% [58, 94, 95]. When warmed and humidified high-flow nasal oxygen is used, the reported incidence of desaturation is 0–1.5% [33, 96]; this was the most common oxygenation strategy used by experts responding to our survey. Although there are no randomised controlled trials comparing air vs. oxygen during ATI, data from bronchoscopy studies demonstrate that there is a significant difference in the incidence and severity of desaturation [97, 98]. In patients receiving sedation in a variety of settings, administration of oxygen has been shown to reduce the incidence of desaturation when compared with air [97, 99–102]. United Kingdom, European and North American recommendations for sedation all suggest the use of supplemental oxygen [103–105]. Whilst airway topicalisation alone may rarely be associated with desaturation and airway obstruction [59, 106], there is no significant difference in the incidence of desaturation between ATI:FB and ATI:VL techniques, and therefore the recommendations apply to both approaches [31]. The administration of supplemental oxygen during ATI is recommended (Grade B). This should be started on patient arrival for the procedure and continued throughout (Grade D). If available, high-flow nasal oxygen should be the technique of choice (Grade C).

Airway topicalisation

The success of ATI depends on effective topical application of local anaesthetic to the airway. Vasoconstriction of the nasal passage reduces the incidence of epistaxis [107, 108]. The use of topical nasal vasoconstrictors before nasotracheal intubation is recommended (Grade A).

Lidocaine has theoretical safety benefits over other local anaesthetic agents due to a favourable cardiovascular and systemic toxicity risk profile [109]; this is the most commonly used local anaesthetic agent for ATI. Following airway topicalisation, clinical evidence of toxicity or levels

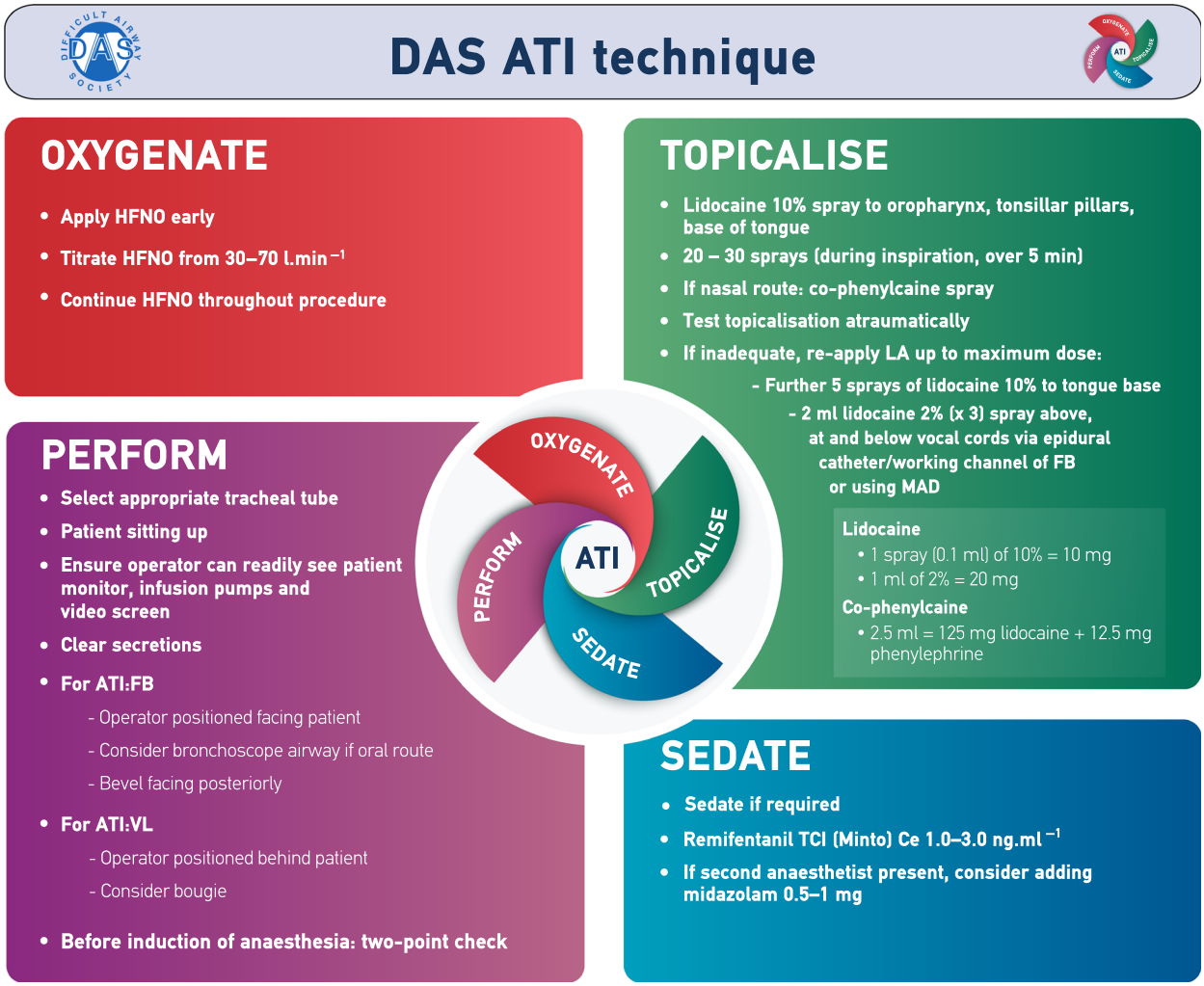

Figure 2 The Difficult Airway Society awake tracheal intubation (ATI) technique. This figure forms part of the Difficult Airway Society guidelines for ATI in adults and should be used in conjunction with the text. HFNO, high-flow nasal oxygen; LA, local anaesthetic; FB, flexible bronchoscopy; MAD, mucosal atomising device; TCI, target-controlled infusion; Ce, effect-site concentration; VL, videolaryngoscopy. ©Difficult Airway Society 2019.

exceeding toxic plasma concentrations have been shown with lidocaine doses of 6.0–9.3 mg.kg^{-1} lean body weight [110–114]. The dose of topical lidocaine should not exceed 9 mg.kg^{-1} lean body weight (Grade C) [115]. The recommendation of 9 mg.kg^{-1} rather than 9.3 mg.kg^{-1} is a pragmatic decision to allow ease of calculation. Practitioners should recognise that this is not a target but a maximum dose, and in practice this is rarely required. The total dose of all local anaesthetics administered, regardless of route (e.g. regional anaesthesia or surgical infiltration), must also be considered (Grade D). Some studies have shown that lower concentrations of lidocaine are as effective as higher concentrations [112, 116–118], but higher concentrations may be associated with more rapid onset of airway anaesthesia. As with all local techniques, a high index of suspicion of the rare possibility of local anaesthetic toxicity with appropriate training, procedures and emergency drug provision (including lipid emulsion) should be in place [119–122] (Grade D). The use of cocaine for topicalisation and vasoconstriction can be associated with toxic cardiovascular complications [123–126], while its analgesic efficacy during nasotracheal tube insertion is no better than co-phenylcaine (2.5 ml lidocaine 5%/phenylephrine 0.5%) [127]. Cocaine in this setting is therefore not advised, and phenylephrine in combination with lidocaine is more appropriate (Grade A).

Depending on the delivery device used, there is variable local anaesthetic absorption [128] but this should not affect the maximal dose calculation. There is insufficient evidence to recommend any individual topicalisation

technique (e.g. mucosal atomisation, spray-as-you-go, transtracheal injection, nebulisation) [129]. However, blocks of the glossopharyngeal and superior laryngeal nerves have been associated with higher plasma concentrations of local anaesthetic [130], local anaesthetic systemic toxicity [131] and lower patient comfort [132]. Invasive techniques should therefore be reserved for those with expertise in their performance (Grade B). Nebulised lidocaine can be used but absorption is variable [133]; consequently higher doses have been used to compensate for this [59]. Regardless of technique used, the adequacy of topicalisation should be tested in an atraumatic manner before airway instrumentation [134] (Grade D), for example, with a soft suction catheter or Yankauer sucker.

The use of an antisialogogue is not mandatory in the performance of ATI and may be associated with undesirable clinical consequences (Grade D; Table 3) [135]. There is limited evidence to support their use in ATI, but in anaesthetised patients the clarity of a visual field through a flexible bronchoscope may be improved [136]. If used, intramuscular antisialogogues should be injected 40–60 min before performing ATI, for peak mucosal drying effect, but there are few data on the intravenous (i.v.) route in this setting.

Sedation

Awake tracheal intubation may be safely and effectively performed without sedation [33, 59, 60]. However, its use during ATI can reduce patient anxiety and discomfort and increase procedural tolerance [137]. Minimal sedation is defined as "*a drug-induced state during which the patient responds normally to verbal commands, whilst the airway, spontaneous ventilation and cardiovascular function are unaffected*" [138]. Sedative drugs can produce a number of effects which may be considered desirable (e.g. amnesia) or detrimental (e.g. over-sedation). The risk of over-sedation and its sequelae, including respiratory depression, airway loss, hypoxia, aspiration and cardiovascular instability, make the presence of an independent anaesthetist delivering, monitoring and titrating sedation desirable [1] (Grade D). In certain patient populations, the risk of over-sedation is particularly hazardous, thus an independent practitioner delivering sedation is strongly recommended (Grade D; Table 4). If required, we recommend the cautious use of minimal sedation (Grade D).

Remifentanil and dexmedetomidine are associated with high levels of patient satisfaction and low risk of over-sedation and airway obstruction when used for ATI [137]. A single-agent strategy is safest for the non-expert, and if used, remifentanil or dexmedetomidine are appropriate (Grade A). As a sole sedative agent, propofol is associated with a greater risk of over-sedation, coughing and airway obstruction than remifentanil [139–141] and is therefore not advisable in this setting (Grade A) [137]. If co-administration of sedative agents is to be performed, remifentanil and midazolam are both reversible and therefore appropriate, recognising the increased risk of over-sedation (Grade D). Sedation should not be used as a substitute for inadequate airway topicalisation (Grade D) [129]. A suggested sedation regimen is presented in Fig. 2.

Two-point check of tracheal tube placement

Awake tracheal intubation can result in incorrect tracheal tube placement, including pharyngeal, oesophageal or bronchial intubation. Oesophageal intubation occurs in 2.3% of procedures with ATI:FB and 4.9% with ATI:VL [58]. Capnography has 100% sensitivity and specificity in identifying correct tracheal tube positioning in patients who lungs are ventilated [142, 143]. However, in a patient who is spontaneously breathing, a capnographic trace may also be seen with supraglottic or bronchial placement of the tracheal tube. A two-point check is therefore required to confirm the position of the tracheal tube:

1. visualisation of the tracheal lumen with ATI:FB or the tracheal tube through the vocal cords with ATI:VL to confirm tracheal placement; and
2. capnography to exclude oesophageal intubation (Grade C)

Anaesthesia should be induced only when the two-point check has confirmed correct tracheal tube placement (Grade D). Once the flexible bronchoscope is in the trachea, the carina should be identified before advancing the tracheal tube to minimise the risk of misplacement (Grade D). The distance from the tracheal tube tip to the carina should be confirmed as appropriate before removing the bronchoscope (Grade D). On removal of the flexible bronchoscope or videolaryngoscope, care must be taken to maintain the correct position of the tracheal tube. The tip of the bronchoscope should be in the neutral position and the tracheal tube held firmly in position (Grade D). The tracheal tube cuff can be gently inflated before, during or after induction of anaesthesia. The decision around timing of cuff inflation should be guided by the relative risks of aspiration, patient movement, coughing and tracheal tube displacement (Grade D). If there is suspicion of a cuff tear, gentle inflation of the cuff to check integrity before induction of anaesthesia is recommended (Grade D).

Table 3 Characteristics of drugs used commonly during ATI.

Class	Drug	Onset	Duration of action	Terminal elimination half-life	Dosing	Notes
Antisialogogue	Glycopyrronium bromide	20 min (i.m.)	30–60 min	40–80 min	0.2–0.4 mg	Administer 30–60 min pre-procedure
		3–5 min (i.v.)	30–60 min	40–80 min	0.1–0.2 mg	May produce significant tachycardia
	Atropine	20 min (i.m.)	30–60 min	2 h	0.3–0.6 mg	Administer 30–60 min pre-procedure – less commonly used than glycopyrronium bromide due to tachycardia
		2–3 min (i.v.)	30–60 min	2 h	0.2–0.3 mg	May produce significant tachycardia
	Hyoscine hydrobromide	30 min (i.m.) 5–10 min (i.v.)	4 h	5 h	0.2–0.6 mg	Administer 30–60 min pre-procedure Longer lasting systemic effects than glycopyrronium bromide and atropine May produce tachycardia, dizziness and sedation
Topical anaesthesia	Co-phenylcaine spray	2–5 min	30 min	1.5–2 h	Lidocaine 125 mg Phenylephrine 12.5 mg	1 bottle = 2.5 ml of lidocaine 50 $mg.ml^{-1}$ and phenylephrine 5 $mg.ml^{-1}$
	Lidocaine 1–10%	5 min	30–60 min	1.5–2 h	Total dose not > 9 $mg.kg^{-1}$ LBW	1 ml of 1% = 10 mg 1 spray of 10% = 10 mg
	Cocaine 10%	1–3 min	30–60 min	1 h	< 1.5 $mg.kg^{-1}$	LD50 1.2 g, but significant toxic effects have been reported at doses as low as 20 mg in adults Particular care in older patients and/or those with cardiac disease
Sedatives	Propofol	30 s	5–10 min	1.5–3 h	TCI (effect-site) 0.5–1 $\mu g.ml^{-1}$	Caution with doses in excess of 1.5 $\mu g.ml^{-1}$: risk of over-sedation and hypoventilation, particularly with concomitant opioid use Avoid bolus dosing
	Midazolam	3–5 min	1–2 h	1.5–3 h	Bolus 0.5–1 mg	Titrate to effect Peak effect at 5–10 min so care with multiple doses
	Dexmedetomidine	1–2 min	5–10 min	2 h	Bolus 0.5–1 $\mu g.kg^{-1}$ over 5 min followed by infusion (0.3–0.6 $\mu g.kg^{-1}.h^{-1}$)	Caution with bolus dosing as associated with hypertension and bradycardia
Analgesia	Remifentanil	1 min	3–5 min	1–20 min	TCI (effect-site) 1–3 $ng.ml^{-1}$	Caution with respiratory depression. Avoid bolus dosing.
	Fentanyl	2–5 min	30–60 min	6–10 min	Bolus 0.5–1 $\mu g.kg^{-1}$, subsequent doses of 0.5 $\mu g.kg^{-1}$ as required	
	Alfentanil	2–3 min	15 min	90–120 min	Bolus 5 $\mu g.kg^{-1}$, subsequent doses of 1–3 $\mu g.kg^{-1}$ as required	

ATI, awake tracheal intubation; i.m., intramuscular; i.v., intravenous; TCI, target-controlled infusion; LD50, median lethal dose; LBW, lean body weight.

Table 4 Special circumstances that may affect standard performance of ATI with suggested management options.

Special circumstance	Considerations	Modification	Potential management options
Critically ill	Limited physiological reserve and greater adverse consequences associated with sedation	Sedation	Avoid or minimise sedation
	Higher risk of local anaesthetic systemic toxicity Increased secretions	Topicalisation	Cautious use of local anaesthetic Suction airway before instrumentation
	Increased oxygen demand and reduced oxygen reserves	Oxygenation	Supplemental oxygen essential
	Unstable for transfer to operating theatre	Performance	Do not transfer patient out of critical care settings Maintain same standards of equipment and monitoring Time-critical performance of ATI Early consideration for high-risk general anaesthesia
Obstetrics	Fetal sedation with benzodiazepines, long-acting opioids or propofol	Sedation	Sedation with dexmedetomidine or remifentanil Warn neonatologists
	Higher risk of local anaesthetic systemic toxicity; concomitant use of local anaesthetics via epidural analgesia	Topicalisation	Cautious dosing of local anaesthetic; consider using pre-pregnancy body weight for dosing
	Increased oxygen demand and reduced oxygen reserves	Oxygenation	Supplemental oxygen essential
	Increased upper airway oedema and perfusion thus increasing risk of nasal haemorrhage FONA more difficult	Performance	Oral approach to ATI Identify and mark cricothyroid membrane early Airway ultrasound to identify cricothyroid membrane
Obesity	Critical adverse consequences of over-sedation	Sedation	Avoid or minimise sedation
	Risk of local anaesthetic overdose	Topicalisation	Local anaesthetic dosing on lean body weight
	Increased oxygen demand and reduced oxygen reserves	Oxygenation	Supplemental oxygen essential
	Diaphragmatic splinting and reduced functional residual capacity	Performance	Sitting position or reverse Trendelenburg Operator facing patient
	FONA more difficult		Identify and mark cricothyroid membrane early Airway ultrasound to identify cricothyroid membrane
Trauma	Critical adverse consequences of over-sedation	Sedation	Avoid or minimise sedation
	Difficult administration due to airway soiling	Topicalisation	Clear soiled airway before topicalisation
	Increased oxygen demand and reduced oxygen reserves	Oxygenation	Supplemental oxygen essential
	Unstable for transfer to operating theatre	Performance	Do not transfer patient out of critical care settings Maintain same standards of equipment and monitoring
	Airway soiling from haemorrhage, secretions, vomitus and tissue oedema		ATI: VL Tracheal intubation via SAD
	Suspected base of skull or facial fracture		Avoid HFNO Oral approach to ATI
Trismus	Critical adverse consequences of over-sedation	Sedation	Avoid or minimise sedation
	Limited pharyngeal access	Topicalisation	Nebulised lidocaine Spray-as-you-go Transtracheal lidocaine injection Insertion of mucosal atomiser and patient gargling
	Potentially increased oxygen demand	Oxygenation	Supplemental oxygen essential
	Limited mouth opening	Performance	Nasal approach to ATI: FB

(continued)

Table 4 (*continued*)

Special circumstance	Considerations	Modification	Potential management options
Stridor	Critical adverse consequences of over-sedation	Sedation	Avoid or minimise sedation
	Risk of laryngospasm	Topicalisation	Consider nebulised and/or lower concentrations of lidocaine
	Airway obstruction	Oxygenation	HFNO highly recommended
	Narrowed airway	Performance	Recognise that airway narrowing may preclude oral or nasal tracheal intubation Prime for emergency FONA Use smaller tracheal tube Most experienced practitioner to perform May require combined technique

ATI, awake tracheal intubation; VL, videolaryngoscopy; SAD, supraglottic airway device; HFNO, high-flow nasal oxygen; FB, flexible bronchoscopy; FONA, front-of-neck airway.

Difficult Airway Society ATI technique

An example of a practical approach to the sTOP ATI technique is shown in Fig. 2. This technique has been specifically considered for simplicity and generalisability. We recognise that there are a range of different techniques and regimens which also address the key sTOP components that will be equally effective.

Special circumstances

Specific patient pathophysiology may dictate modifications to the performance of ATI that must be considered and planned for. As with all other aspects of ATI, these modifications can be categorised based on sTOP. Examples of suggested changes to technique are presented in Table 4.

Managing complications

The reported overall complication rate in patients undergoing ATI either flexible bronchoscopic or videolaryngoscopic, is up to 18% [33–35, 58, 144–146]. Complications during ATI occur due to inadequate sTOP. In the event of a complication, its aetiology should be determined and appropriately managed (Grade D; Fig. 3).

We define an unsuccessful attempt at ATI as the unplanned removal of flexible bronchoscope, videolaryngoscope or tracheal tube from the airway. Patients in whom ATI is indicated are at greater risk of the adverse consequences of multiple attempts, such as airway trauma, airway obstruction, bleeding and unsuccessful ATI [1]. It is therefore advisable to minimise the number of attempts at ATI (Grade D). Operators should consider if they require more experienced support before commencing ATI (Grade D). Operators should ensure sTOP is optimised before the first attempt (Grade D). If unsuccessful with the first attempt, operators should re-assess, correct any inadequate sTOP components, and call for help before proceeding with a second attempt (Grade D). If unsuccessful with the second attempt, a third may be considered only if conditions can be further optimised (Grade D). A fourth and final attempt (3 + 1) should only be undertaken by a more experienced operator, which may include a surgeon (Grade D). Each attempt subsequent to the first should involve a change in the elements of performance to improve the likelihood of success (Grade D). The use of an alternative device (e.g. FB to VL or vice versa) should be counted in the total number of attempts. Each failed attempt may adversely affect patient and operator confidence. Seeking expert help at the earliest opportunity is recommended (Grade D). If unsuccessful after 3 + 1 attempts, the unsuccessful ATI algorithm should be followed (Grade D; Fig. 4).

Management of unsuccessful ATI

The unsuccessful ATI algorithm is a guide for the rare occasions where successful tracheal intubation has not been achieved in 3 + 1 attempts. Immediate actions should include a call for help, ensuring 100% oxygen is applied and stopping (if necessary, reversing) any sedative drugs (Grade D). Operators should 'stop and think' to determine subsequent airway management, while also 'priming' for emergency FONA [2, 52] (Grade D). The default action in the event of unsuccessful ATI should be to postpone the procedure (Grade D). Operators should only proceed with immediate airway management if essential (e.g. if airway patency, ventilation or neurology is compromised; urgent or immediate surgery is required; or clinical deterioration is expected) (Grade D).

If airway management is deemed essential, the preferred option for securing the airway after unsuccessful ATI:VL or ATI:FB should be ATI using FONA (ATI:FONA),

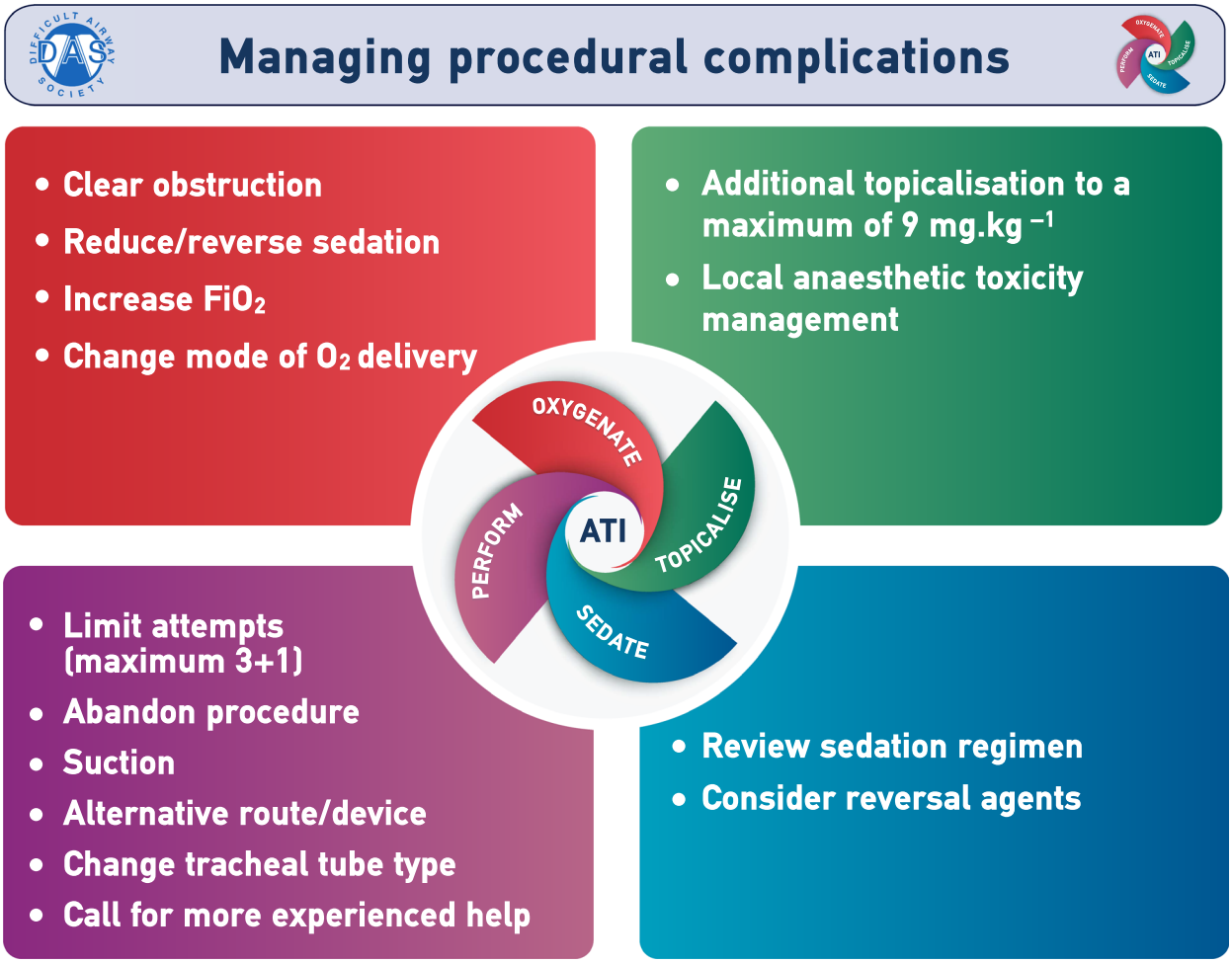

Figure 3 Managing procedural complications during awake tracheal intubation (ATI). This provides a framework for managing complications, but is not meant to be a comprehensive guide. This figure forms part of the Difficult Airway Society guidelines for ATI in adults and should be used in conjunction with the text. F_IO_2, fractional inspired concentration of oxygen; O_2, oxygen ©Difficult Airway Society 2019.

which includes cricothyroidotomy or tracheostomy (Grade D). The most appropriately skilled clinician available should perform this (Grade C). The considerations for the appropriateness of ATI:FONA include: patient factors; skill; and equipment availability. If inappropriate or unsuccessful, a high-risk general anaesthetic is the only remaining option. In this scenario, the operator should formulate an achievable A to D airway management strategy informed by the unsuccessful attempts at ATI and based on the 2015 DAS guidelines [2], recognising that they are primarily for the unanticipated difficult tracheal intubation (Grade D). This strategy should include an i.v. induction of anaesthesia with full neuromuscular blockade [2, 52] (Grade D). Videolaryngoscopes may improve tracheal intubation success rates in cases of difficult tracheal intubation [147]; therefore, the first attempt at tracheal intubation in this scenario should be with a videolaryngoscope (Grade A). All attempts with any device should be performed by the most appropriately skilled clinician present (Grade C).

Post-tracheal intubation management

Patients who have had ATI due to predicted difficult airway management are at high risk of complications at tracheal extubation [1, 148], and require an appropriate tracheal extubation strategy. Planning, preparation, performing and post-tracheal extubation care should follow DAS guidelines [148] (Grade D).

Before tracheal extubation, laryngoscopy, either with a direct laryngoscope or videolaryngoscope, may provide useful information for risk stratification of tracheal extubation and any subsequent airway management. The view at laryngoscopy may be altered by the presence of a

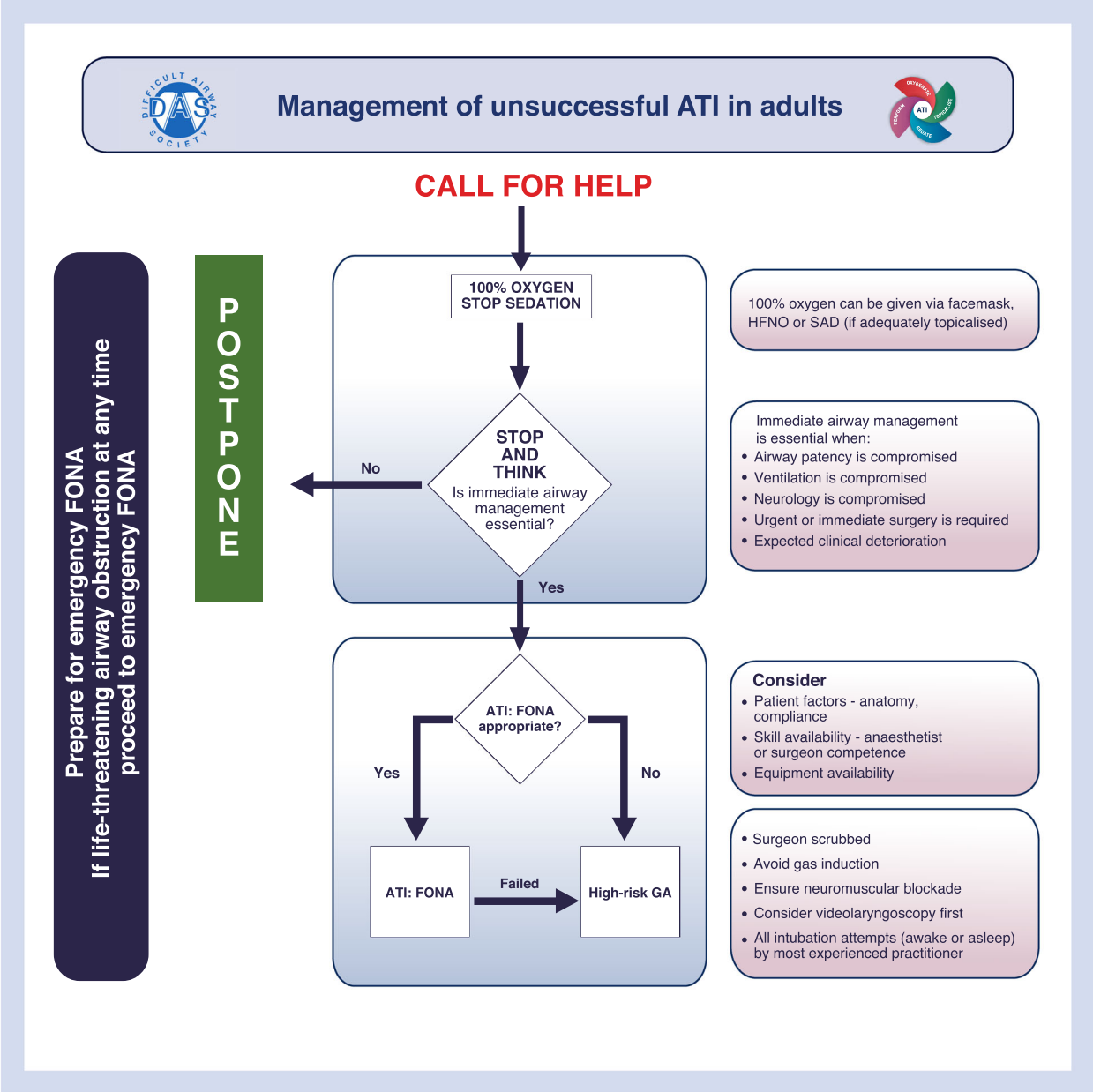

Figure 4 The Difficult Airway Society management of unsuccessful awake tracheal intubation (ATI) in adults. This algorithm forms part of the Difficult Airway Society guidelines for ATI in adults and should be used in conjunction with the text. HFNO, high-flow nasal oxygen; SAD, supraglottic airway device; FONA, front-of-neck airway; GA, general anaesthesia. ©Difficult Airway Society 2019.

tracheal tube [148]. Therefore, verification of laryngoscopy grade may rule out, but not rule in, easy subsequent asleep tracheal intubation.

Topical lidocaine has a dose-dependent duration of analgesic action of up to 40 min although this may vary with concentration and method of administration [149, 150]. However, the time to return of laryngeal reflexes can be longer [151]. Given that the terminal elimination half-life of lidocaine is up to 2 h, patients should remain nil by mouth for at least 2 h following airway topicalisation for ATI (Grade D).

Documentation of ATI in clinical records is necessary to inform and guide future patient management [1, 152]. This should include: documentation of oxygenation; topicalisation; sedation strategy; device and tracheal tube used; approach (e.g. right nasal, left nasal, oral); number of

attempts; and any complications or notes (Grade D; Supporting Information, Appendix S3).

Consent

Clinicians should adhere to the Association of Anaesthetists' guidelines on consent for anaesthesia [153] (Grade D). Informed consent must be taken, with patients being given information (ideally including a patient information leaflet [154]) in a timely manner (Grade D). The risks of ATI and its alternative (induction of general anaesthesia before securing the airway) should be discussed (Table 5) (Grade D). Appropriate explanation is vital and a good rapport can increase the confidence and co-operation of the patient in the procedure and is strongly encouraged (Grade D). The consent process should be documented (Grade D).

Training

Successful performance of ATI has been shown to be independent of seniority, but related to experience [33]. There are many strategies used for training in the technical aspects of ATI, including the use of manikins, simulators, cadavers and patients [59, 155–161]. All anaesthetists should seek every opportunity to attain and maintain skills in ATI and all departments should support this [1] (Grade C). Awake tracheal intubation is a skill in the compulsory higher training curriculum of the Royal College of Anaesthetists [162], but opportunities for training are known to be limited [163–167]. These guidelines provide a common stem for sedation, topicalisation, oxygenation and performance to encourage training in ATI. Experience using a range of tools should be sought, complementing active clinical practice to develop non-technical aspects of ATI (Grade B). We recognise this may be difficult to achieve [163–167], but local hospital airway leads are ideally placed to facilitate training and provision of ATI skills and equipment. Team training in ATI should include anaesthetic assistants, operating department practitioners and theatre staff. Awake tracheal intubation may be performed solely for the purposes of training provided appropriate consent is taken (Grade D).

Future directions

These guidelines highlight the paucity of high-quality evidence in ATI, as demonstrated by the need for expert opinion for the majority of recommendations. This presents an opportunity for further research to be undertaken to improve both clinical and patient-centred outcomes [168]. In particular, the ideal topicalisation and sedation strategies are yet to be elucidated, with a limited evidence base for individual drugs, administration methods (e.g. infusion vs. bolus, combinations of sedatives, mucosal atomiser vs. nebulisation) and their related outcomes [129]. There remains uncertainty regarding many aspects of procedural performance such as ideal patient and operator positioning, the role of checklists and cognitive aids and immediate management of complications. Moreover, training in ATI has thus far focussed on technical aspects, primarily with FB, but training with alternative devices and non-technical skills have had little attention in the published literature and warrant further investigation. Novel technology for ATI must also be developed, such as improved capnography and monitoring, safer sedation delivery devices and better image visualisation and guidance technology. Finally, the impact these guidelines have on clinical practice should be examined to allow further iterations to be improved upon. This will require updates of these guidelines using similar methodology when a more robust evidence base becomes available.

Table 5 Incidence of complications when asleep or awake tracheal intubation is performed. The rates reported for asleep tracheal intubation include data for all patients, and patients who are predicted to have difficult airway management. The rates reported for awake tracheal intubation are only for patients who are predicted to be at risk of difficult airway management.

	Asleep tracheal intubation		
	All patients	**Predicted difficult tracheal intubation**	**Awake tracheal intubation**
Difficult facemask ventilation	2.2–2.5%	18.6–22%	Not applicable
Impossible facemask ventilation	0.15%	Not currently available	Not applicable
Difficult tracheal intubation	1.9–10%	25%	Not applicable
Failed tracheal intubation	0.15%	0.36%[a]	1–2%
CICO	0.04%	0.75%[a]	0–0.06%
Front-of-neck airway	0.002–0.07%	0.12%[a]	0–0.38%
Death	0.0006–0.04%	Not currently available	Not currently available

CICO, cannot intubate, cannot oxygenate.
[a]Unpublished data from the Danish Anaesthesia Database.

Discussion

The primary aims of these guidelines are to provide practitioners with a comprehensive document on ATI. These guidelines should support clinical practice and lower the performance threshold thereby increasing the use of ATI when indicated. The quality of evidence supporting many recommendations is limited, with interventions and outcomes being highly heterogeneous. This is likely influenced by the fact that ATI can be successfully performed in a wide range of settings and patients with varying techniques [129]. For example, the use of SADs as a conduit to ATI or optical stylets in awake patients have not been well-described but warrant future investigation as their role becomes more defined. Similarly, the lack of previously published specific guidelines means that research in ATI is disparate and inconsistent [169]. However, we have sought and appraised the available evidence in ATI, and in its absence we have incorporated the practical and theoretical experience of international experts. We have involved patients, DAS members and international experts in order to further understand current practice and the need for these guidelines. Formal resource implication analysis has not been conducted; however, the tools to practically perform ATI are available widely, and thus we expect the resource impact to be modest.

These guidelines prioritise patient safety and provide recommendations for best clinical practice. It is hoped that they will lead to a paradigm shift in clinical practice and improve the care of patients with predicted difficult airway management in the UK and beyond.

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References

1. Cook TM, Woodall NM, Frerk CM. 4th National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. *British Journal of Anaesthesia* 2011; **106**: 617–31.
2. Frerk C, Mitchell VSS, McNarry AFF, et al. Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. *British Journal of Anaesthesia* 2015; **115**: 827–48.

3. Mushambi MC, Kinsella SM, Popat M, et al. Obstetric Anaesthetists' Association and Difficult Airway Society guidelines for the management of difficult and failed tracheal intubation in obstetrics. *Anaesthesia* 2015; **70**: 1286–306.
4. Petrini F, Accorsi A, Adrario E, et al. Recommendations for airway control and difficult airway management. *Minerva Anestesiologica* 2005; **71**: 617–57.
5. Australian and New Zealand College of Anaesthetists. Guidelines for the management of evolving airway obstruction: transition to the can't intubate can't oxygenate airway emergency. Australian and New Zealand College of Anaesthetists (ANZCA) 2016.; 2016.
6. Law JA, Broemling N, Cooper RM, et al. The difficult airway with recommendations for management – Part 1 – Intubation encountered in an unconscious/induced patient. *Canadian Journal of Anesthesia* 2013; **60**: 1089–118.
7. Apfelbaum JL, Hagberg CA, Caplan RA, et al. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. *Anesthesiology* 2013; **118**: 251–70.
8. Myatra SN, Shah A, Kundra P, et al. All India Difficult Airway Association 2016 guidelines for the management of unanticipated difficult tracheal intubation in adults. *Indian Journal of Anaesthesia* 2016; **60**: 885–98.
9. Ramkumar V, Dinesh E, Shetty SR, et al. All India difficult airway association 2016 guidelines for the management of unanticipated difficult tracheal intubation in obstetrics. *Indian Journal of Anaesthesia* 2016; **60**: 899–905.
10. Langeron O, Bourgain J-LL, Francon D, et al. Difficult intubation and extubation in adult anaesthesia. *Anaesthesia Critical Care and Pain Medicine* 2018; **37**: 639–51.
11. Rehn M, Hyldmo PK, Magnusson V, et al. Scandinavian SSAI clinical practice guideline on pre-hospital airway management. *Acta Anaesthesiologica Scandinavica* 2016; **60**: 852–64.
12. Piepho T, Cavus E, Noppens R, et al. S1-Leitlinie Atemwegsmanagement: Leitlinie der Deutschen Gesellschaft für Anästhesiologie und Intensivmedizin (DGAI). *Anaesthesist* 2015; **64**: 27–40.
13. Anon JSA. airway management guideline 2014: to improve the safety of induction of anesthesia. *Journal of Anaesthesia* 2014; **28**: 482–93.
14. Nørskov AK, Rosenstock CV, Wetterslev J, Astrup G, Afshari A, Lundstrøm LH. Diagnostic accuracy of anaesthesiologists' prediction of difficult airway management in daily clinical practice: a cohort study of 188 064 patients registered in the Danish Anaesthesia Database. *Anaesthesia* 2015; **70**: 272–81.
15. Nørskov AK, Wetterslev J, Rosenstock CV, et al. Prediction of difficult mask ventilation using a systematic assessment of risk factors vs. existing practice – a cluster randomised clinical trial in 94,006 patients. *Anaesthesia* 2017; **72**: 296–308.
16. Kheterpal S, Healy D, Aziz MF, et al. Incidence, predictors, and outcome of difficult mask ventilation combined with difficult laryngoscopy: a report from the multicenter perioperative outcomes group. *Anesthesiology* 2013; **119**: 1360–9.
17. Kheterpal S, Martin L, Shanks AM, Tremper KK. Prediction and outcomes of impossible mask ventilation: a review of 50,000 anesthetics. *Anesthesiology* 2009; **110**: 891–7.
18. Verghese C, Brimacombe JR. Survey of laryngeal mask airway usage in 11,910 patients: safety and efficacy for conventional and non-conventional usage. *Anesthesia and Analgesia* 1996; **82**: 129–33.
19. Saito T, Liu W, Chew STH, Ti LK. Incidence of and risk factors for difficult ventilation via a supraglottic airway device in a population of 14,480 patients from South-East Asia. *Anaesthesia* 2015; **70**: 1079–83.
20. Francksen H, Renner J, Hanss R, Scholz J, Doerges V, Bein B. A comparison of the i-gel with the LMA-Unique in non-paralysed anaesthetised adult patients. *Anaesthesia* 2009; **64**: 1118–24.
21. Rose DK, Cohen MM. The airway: problems and predictions in 18,500 patients. *Canadian Journal of Anesthesia* 1994; **41**: 372–83.
22. Cook TM, Trümpelmann P, Beringer R, Stedeford J. A randomised comparison of the Portex Softseal™ laryngeal mask airway with the LMA-Unique™ during anaesthesia. *Anaesthesia* 2005; **60**: 1218–25.
23. Shiga T, Wajima Z, Inoue T, Sakamoto A. Predicting difficult intubation in apparently normal patients: a meta-analysis of bedside screening test performance. *Anesthesiology* 2005; **103**: 429–37.
24. Lundstrøm LH, Møller AM, Rosenstock C, Astrup G, Gätke MR, Wetterslev J. A documented previous difficult tracheal intubation as a prognostic test for a subsequent difficult tracheal intubation in adults. *Anaesthesia* 2009; **64**: 1081–8.
25. Detsky ME, Jivraj N, Adhikari NK, et al. Will this patient be difficult to intubate? the rational clinical examination systematic review. *Journal of the American Medical Association* 2019; **321**: 493–503.
26. Thomsen JLD, Nørskov AK, Rosenstock CV. Supraglottic airway devices in difficult airway management: a retrospective cohort study of 658,104 general anaesthetics registered in the Danish Anaesthesia Database. *Anaesthesia* 2019; **74**: 151–7.
27. Rosenstock CV, Nørskov AK, Wetterslev J, Lundstrøm LH. Danish Anaesthesia Database. Emergency surgical airway management in Denmark: a cohort study of 452,461 patients registered in the Danish Anaesthesia Database. *British Journal of Anaesthesia* 2016; **117**(Suppl): i75–82.
28. Huitink JM, Lie PP, Heideman I, et al. A prospective, cohort evaluation of major and minor airway management complications during routine anaesthetic care at an academic medical centre. *Anaesthesia* 2017; **72**: 42–8.
29. Edelman DA, Perkins EJ, Brewster DJ. Difficult airway management algorithms: a directed review. *Anaesthesia* 2019; **74**: 1175–85.
30. Cook TM. Strategies for the prevention of airway complications – a narrative review. *Anaesthesia* 2018; **73**: 93–111.
31. Alhomary M, Ramadan E, Curran E, Walsh SR. Videolaryngoscopy vs. fibreoptic bronchoscopy for awake tracheal intubation: a systematic review and meta-analysis. *Anaesthesia* 2018; **73**: 1151–61.
32. Ajay S, Singhania A, Akkara AG, Shah A, Adalja M. A study of flexible fiberoptic bronchoscopy aided tracheal intubation for patients undergoing elective surgery under general anesthesia. *Indian Journal of Otolaryngology and Head and Neck Surgery* 2013; **65**: 116–19.
33. El-Boghdadly K, Onwochei DN, Cuddihy J, et al. A prospective cohort study of awake fibreoptic intubation practice at a tertiary centre. *Anaesthesia* 2017; **72**: 694–703.
34. Law JA, Morris IR, Brousseau PA, de la Ronde S, Milne AD. The incidence, success rate, and complications of awake tracheal intubation in 1,554 patients over 12 years: an historical cohort study. *Canadian Journal of Anesthesia* 2015; **62**: 736–44.
35. Joseph TT, Gal JS, DeMaria SJ, Lin H-M, Levine AI, Hyman JB. A retrospective study of success, failure, and time needed to perform awake intubation. *Anesthesiology* 2016; **125**: 105–14.
36. Brouwers MC, Kerkvliet K, Spithoff K, Consortium ANS. The AGREE Reporting Checklist: a tool to improve reporting of clinical practice guidelines. *British Medical Journal* 2016; **352**: i1152.
37. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, John PA. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare

interventions: explanation and elaboration. *British Medical Journal* 2009; **339**: b2700.
38. Boulkedid R, Abdoul H, Loustau M, Sibony O, Alberti C. Using and reporting the Delphi method for selecting healthcare quality indicators: a systematic review. Wright JM, ed. *PLoS ONE* 2011; **6**: e20476.
39. Diamond IR, Grant RC, Feldman BM, et al. Defining consensus: a systematic review recommends methodologic criteria for reporting of Delphi studies. *Journal of Clinical Epidemiology* 2014; **67**: 401–9.
40. Pandit JJ, Popat MT, Cook TM, et al. The Difficult Airway Society "ADEPT" Guidance on selecting airway devices: the basis of a strategy for equipment evaluation. *Anaesthesia* 2011; **66**: 726–37.
41. Du Rand IA, Blaikley J, Booton R, et al. Summary of the British Thoracic Society guideline for diagnostic flexible bronchoscopy in adults. *Thorax* 2013; **68**: 786–7.
42. Roth D, Pace NL, Lee A, et al. Airway physical examination tests for detection of difficult airway management in apparently normal adult patients. *Cochrane Database of Systematic Reviews* 2018; **2018**: CD008874.
43. Benumof JL. Obstructive sleep apnea in the adult obese patient: implications for airway management. *Anesthesiology Clinics of North America* 2002; **20**: 789–811.
44. Petrini F, Di Giacinto I, Cataldo R, et al. Perioperative and periprocedural airway management and respiratory safety for the obese patient: 2016 SIAARTI Consensus. *Minerva Anestesiologica* 2016; **82**: 1314–35.
45. Law JA, Broemling N, Cooper RM, et al. The difficult airway with recommendations for management – Part 2 – Difficult airway. *Canadian Journal of Anesthesia* 2013; **60**: 1119–38.
46. Weinger MB, Vredenburgh AG, Schumann CM, et al. Quantitative description of the workload associated with airway management procedures. *Journal of Clinical Anaesthesia* 2000; **12**: 273–82.
47. Reason J. Human error: models and management. *British Medical Journal* 2000; **320**: 768–70.
48. Rall M, Dieckmann P. Safety culture and crisis resource management in airway management: general principles to enhance patient safety in critical airway situations. *Best Practice and Research: Clinical Anesthesiology* 2005; **19**: 539–57.
49. Smith AF, Mishra K. Interaction between anaesthetists, their patients, and the anaesthesia team. *British Journal of Anaesthesia* 2010; **105**: 60–8.
50. Flin R, Fioratou E, Frerk C, Trotter C, Cook TM. Human factors in the development of complications of airway management: preliminary evaluation of an interview tool. *Anaesthesia* 2013; **68**: 817–25.
51. Davis M, Hignett S, Hillier S, Hames N, Hodder S. Safer anaesthetic rooms: human factors/ergonomics analysis of work practices. *Journal of Perioperative Practice* 2016; **26**: 274–80.
52. Higgs A, McGrath BA, Goddard C, et al. Guidelines for the management of tracheal intubation in critically ill adults. *British Journal of Anaesthesia* 2018; **120**: 323–52.
53. Eichhorn JH, Cooper JB, Cullen DJ, Maier WR, Philip JH, Seeman RG. Standards for patient monitoring during anesthesia at Harvard Medical School. *Journal of American Medical Association* 1986; **256**: 1017–20.
54. Webb RK, Currie M, Morgan CA, et al. The Australian incident monitoring study: an analysis of 2000 incident reports. *Anaesthesia and Intensive Care* 1993; **21**: 520–8.
55. Williamson JA, Webb RK, Sellen A, Runciman WB, Van der Walt JH. The Australian incident monitoring study. Human failure: an analysis of 2000 incident reports. *Anaesthesia and Intensive Care* 1993; **21**: 678–83.
56. Keenan RL, Boyan CP. Decreasing frequency of anesthetic cardiac arrests. *Journal of Clinical Anaesthesia* 1991; **3**: 354–7.
57. McKay WPS, Noble WH. Critical incidents detected by pulse oximetry during anaesthesia. *Canadian Journal of Anesthesia* 1988; **35**: 265–9.
58. Rosenstock CV, Thogersen B, Afshari A, Christensen AL, Eriksen C, Gatke MR. Awake fiberoptic or awake video laryngoscopic tracheal intubation in patients with anticipated difficult airway management: a randomized clinical trial. *Anesthesiology* 2012; **116**: 1210–16.
59. Woodall NM, Harwood RJ, Barker GL, et al. Complications of awake fibreoptic intubation without sedation in 200 healthy anaesthetists attending a training course. *British Journal of Anaesthesia* 2008; **100**: 850–5.
60. Patil V, Barker GL, Harwood RJ, Woodall NM. Training course in local anaesthesia of the airway and fibreoptic intubation using course delegates as subjects. *British Journal of Anaesthesia* 2002; **89**: 586–93.
61. Sun Y, Liu J-X, Jiang H, Zhu Y-S, Xu H, Huang Y. Cardiovascular responses and airway complications following awake nasal intubation with blind intubation device and fibreoptic bronchoscope: a randomized controlled study. *European Journal of Anesthesiology* 2010; **27**: 461–7.
62. Checketts MR, Alladi R, Ferguson K, et al. Recommendations for standards of monitoring during anaesthesia and recovery 2015: association of Anaesthetists. *Anaesthesia* 2016; **71**: 85–93.
63. Carayon P, Xie A, Kianfar S. Human factors and ergonomics as a patient safety practice. *British Medical Journal Quality and Safety* 2014; **23**: 196–205.
64. Ovassapian A, Tuncbilek M, Weitzel EK, Joshi CW. Airway management in adult patients with deep neck infections: a case series and review of the literature. *Anesthesia and Analgesia* 2005; **100**: 585–9.
65. Meghjee SPL, Marshall M, Redfern EJ, McGivern DV. Influence of patient posture on oxygen saturation during fibre-optic bronchoscopy. *Respiratory Medicine* 2001; **95**: 5–8.
66. van Zwam JP, Kapteijns EFG, Lahey S, Smit HJM. Flexible bronchoscopy in supine or sitting position. *Journal of Bronchology and Interventional Pulmonology* 2010; **17**: 29–32.
67. Ling IT, Piccolo F, Mulrennan SA, Phillips MJ. Posture influences patient cough rate, sedative requirement and comfort during bronchoscopy: an observational cohort study. *Cough* 2011; **7**.
68. Altermatt FR, Muñoz HR, Delfino AE, Cortínez LI. Pre-oxygenation in the obese patient: effects of position on tolerance to apnoea. *British Journal of Anaesthesia* 2005; **95**: 706–9.
69. Isono S, Ishikawa T, Nishino T, Tanaka A, Tagaito Y. Sitting posture decreases collapsibility of the passive pharynx in anesthetized paralyzed patients with obstructive sleep apnea. *Anesthesiology* 2010; **113**: 812–18.
70. Ikeda H, Ayuse T, Oi K. The effects of head and body positioning on upper airway collapsibility in normal subjects who received midazolam sedation. *Journal of Clinical Anesthesia* 2006; **18**: 185–93.
71. Heidegger T, Gerig HJ, Ulrich B, Schnider TW. Structure and process quality illustrated by fibreoptic intubation: analysis of 1612 cases. *Anaesthesia* 2003; **58**: 734–9.
72. Gómez-Ríos MÁ, Nieto SL. Combined use of an Airtraq® optical laryngoscope, Airtraq video camera, Airtraq wireless monitor, and a fibreoptic bronchoscope after failed tracheal intubation. *Canadian Journal of Anesthesia* 2011; **58**: 411–12.
73. Chung MY, Park B, Seo J, Kim CJ. Successful airway management with combined use of McGrath MAC video laryngoscope and fiberoptic bronchoscope in a severe obese patient with huge goiter -a case report. *Korean Journal of Anesthesiology* 2018; **71**: 232–6.

74. Liew GHC, Wong TGL, Lu A, Kothandan H. Combined use of the glidescope and flexible fibrescope as a rescue technique in a difficult airway. *Proceedings of Singapore Healthcare* 2015; **24**: 117–20.
75. Shiraishi T. Awake insertion of the air-Q™ intubating laryngeal airway device that facilitates safer tracheal intubation in morbidly obese patients. *British Journal of Anaesthesia* 2013; **111**: 1024–5.
76. Lim WY, Wong P. Awake supraglottic airway guided flexible bronchoscopic intubation in patients with anticipated difficult airways: a case series and narrative review. *Korean Journal of Anesthesiology* 2019.
77. Kristensen MS, Fredensborg BB. The disposable Ambu aScope vs. a conventional flexible videoscope for awake intubation – a randomised study. *Acta Anaesthesiologica Scandinavica* 2013; **57**: 888–95.
78. Brull SJ, Wiklund R, Ferris C, Connelly NR, Ehrenwerth J, Silverman DG. Facilitation of fiberoptic orotracheal intubation with a flexible tracheal tube. *Anesthesia and Analgesia* 1994; **78**: 746–8.
79. Hakala P, Randell T, Valli H. Comparison between tracheal tubes for orotracheal fibreoptic intubation. *British Journal of Anaesthesia* 1999; **82**: 135–6.
80. Jafari A, Gharaei B, Reza Kamranmanesh M, et al. Wire reinforced endotracheal tube compared with Parker Flex-Tip tube for oral fiberoptic intubation: a randomized clinical trial. *Minerva Anestesiologica* 2014; **80**: 324–9.
81. Lucas DN, Yentis SM. A comparison of the intubating laryngeal mask tracheal tube with a standard tracheal tube for fibreoptic intubation. *Anaesthesia* 2000; **55**: 358–61.
82. Sharma D, Bithal PK, Rath GP, Pandia MP. Effect of orientation of a standard polyvinyl chloride tracheal tube on success rates during awake flexible fibreoptic intubation. *Anaesthesia* 2006; **61**: 845–8.
83. Kristensen MS. The Parker Flex-Tip tube versus a standard tube for fiberoptic orotracheal intubation: a randomized double-blind study. *Anesthesiology* 2003; **98**: 354–8.
84. Rai MR, Scott SH, Marfin AG, Popat MT, Pandit JJ. A comparison of a flexometallic tracheal tube with the intubating laryngeal mask tracheal tube for nasotracheal fibreoptic intubation using the two-scope technique. *Anaesthesia* 2009; **64**: 1303–6.
85. Barker KF, Bolton P, Cole S, Coe PA. Ease of laryngeal passage during fibreoptic intubation: a comparison of three endotracheal tubes. *Acta Anaesthesiologica Scandinavica* 2001; **45**: 624–6.
86. Lomax SL, Johnston KD, Marfin AG, Yentis SM, Kathawaroo S, Popat MT. Nasotracheal fibreoptic intubation: a randomised controlled trial comparing the GlideRite® (Parker-Flex® Tip) nasal tracheal tube with a standard pre-rotated nasal RAE™ tracheal tube. *Anaesthesia* 2011; **66**: 180–4.
87. Koga K, Asai T, Latto IP, Vaughan RS. Effect of the size of a tracheal tube and the efficacy of the use of the laryngeal mask for fibrescope-aided tracheal intubation. *Anaesthesia* 1997; **52**: 512.
88. Arriaga AF, Bader AM, Wong JM, et al. Simulation-based trial of surgical-crisis checklists. *New England Journal of Medicine* 2013; **368**: 246–53.
89. Ziewacz JE, Arriaga AF, Bader AM, et al. Crisis checklists for the operating room: development and pilot testing. *Journal of the American College of Surgeons* 2011; **213**: 212.e10–217.e10.
90. Russ S, Rout S, Sevdalis N, Moorthy K, Darzi A, Vincent C. Do safety checklists improve teamwork and communication in the operating room? A systematic review *Annals of Surgery* 2013; **258**: 856–71.
91. Haynes AB, Weiser TG, Berry WR, et al. A surgical safety checklist to reduce morbidity and mortality in a global population. *New England Journal of Medicine* 2009; **360**: 491–9.
92. Harvey R, Foulds L, Housden T, et al. The impact of didactic read-aloud action cards on the performance of cannula cricothyroidotomy in a simulated 'can't intubate can't oxygenate' scenario. *Anaesthesia* 2017; **72**: 343–9.
93. Marshall SD, Mehra R. The effects of a displayed cognitive aid on non-technical skills in a simulated "can't intubate, can't oxygenate" crisis. *Anaesthesia* 2014; **69**: 669–77.
94. Sidhu VS, Whitehead EM, Ainsworth QP, Smith M, Calderl. A technique of awake fibreoptic intubation. Experience in patients with cervical spine disease. *Anaesthesia* 1993; **48**: 910–13.
95. Fuchs G, Schwarz G, Baumgartner A, Kaltenböck F, Voit-Augustin H, Planinz W. Fiberoptic intubation in 327 neurosurgical patients with lesions of the cervical spine. *Journal of Neurosurgical Anesthesiology* 1999; **11**: 11–16.
96. Badiger S, John M, Fearnley RA, Ahmad I, Asai T. Optimizing oxygenation and intubation conditions during awake fibre-optic intubation using a high-flow nasal oxygen-delivery system. *British Journal of Anaesthesia* 2015; **115**: 629–32.
97. Rozario L, Sloper D, Sheridan MJ. Supplemental oxygen during moderate sedation and the occurrence of clinically significant desaturation during endoscopic procedures. *Gastroenterology Nursing* 2008; **31**: 281–5.
98. Milman N, Faurschou P, Grode G, Jørgensen A. Pulse oximetry during fibreoptic bronchoscopy in local anaesthesia: frequency of hypoxaemia and effect of oxygen supplementation. *Respiration* 1994; **61**: 342–7.
99. Reed MWR, O'leary DP, Duncan JL, Majeed AW, Wright B, Reilly CS. Effects of sedation and supplemental oxygen during upper alimentary tract endoscopy. *Scandinavian Journal of Gastroenterology* 1993; **28**: 319–22.
100. Reshef R, Shiller M, Kinberg R, et al. A prospective study evaluating the usefulness of continuous supplemental oxygen in various endoscopic procedures. *Israel Journal of Medical Sciences* 1996; **32**: 736–40.
101. Deitch K, Chudnofsky CR, Dominici P, Latta D, Salamanca Y. The utility of high-flow oxygen during emergency department procedural sedation and analgesia with propofol: a randomized, controlled trial. *Annals of Emergency Medicine* 2011; **58**: 360–4.
102. Deitch K, Chudnofsky CR, Dominici P. The utility of supplemental oxygen during emergency department procedural sedation and analgesia with midazolam and fentanyl: a randomized. Controlled Trial. *Annals of Emergency Medicine* 2007; **49**: 1–8.
103. Hinkelbein J, Lamperti M, Akeson J, et al. European Society of Anaesthesiology and European Board of Anaesthesiology guidelines for procedural sedation and analgesia in adults. *European Journal of Anesthesiology* 2018; **35**: 6–24.
104. Surgeons M. Practice guidelines for moderate procedural sedation and analgesia 2018: a Report by the American Society of Anesthesiologists Task Force on Moderate Procedural Sedation and Analgesia, the American Association of Oral and Maxillofacial Surgeons, American. *Anesthesiology* 2018; **128**: 437–79.
105. Newton M, Blightman K. Guidance on the provision of sedation services 2016. In: *Royal College of Anaesthetists. Guidelines for the Provision of Anaesthesia Services*. London: Royal College of Anaesthetists, 2016: Chapter 19.
106. Ho AMH, Chung DC, To EWH, Karmakar MK. Total airway obstruction during local anesthesia in a non-sedated patient with a compromised airway. *Canadian Journal of Anesthesia* 2004; **51**: 838–41.
107. Song J. A comparison of the effects of epinephrine and xylometazoline in decreasing nasal bleeding during nasotracheal intubation. *Journal of Dental Anesthesia and Pain Medicine* 2017; **17**: 281.

108. O'Hanlon J, Harper KW. Epistaxis and nasotracheal intubation–prevention with vasoconstrictor spray. *Irish Journal of Medical Science* 1994; **163**: 58–60.
109. El-Boghdadly K, Pawa A, Chin KJ. Local anesthetic systemic toxicity: current perspectives. *Local and Regional Anesthesia* 2018; **11**: 35–44.
110. Milman N, Laub M, Munch EP, Angelo HR. Serum concentrations of lignocaine and its metabolite monoethylglycinexylidide during fibre-optic bronchoscopy in local anaesthesia. *Respiratory Medicine* 1998; **92**: 40–3.
111. Hasmoni MH, Rani MFA, Harun R, Manap RA, Tajudin NAA, Anshar FM. Randomized-controlled trial to study the equivalence of 1% versus 2% lignocaine in cough suppression and satisfaction during bronchoscopy. *Journal of Bronchology* 2008; **15**: 78–82.
112. Mainland PA, Kong AS, Chung DC, Chan CH, Lai CK. Absorption of lidocaine during aspiration anesthesia of the airway. *Journal of Clinical Anaesthesia* 2001; **13**: 440–6.
113. Efthimiou J, Higenbottam T, Holt D, Cochrane GM. Plasma concentrations of lignocaine during fibreoptic bronchoscopy. *Thorax* 1982; **37**: 68–71.
114. Williams KA, Barker GL, Harwood RJ, Woodall NM. Combined nebulization and spray-as-you-go topical local anaesthesia of the airway. *British Journal of Anaesthesia* 2005; **95**: 549–53.
115. Ingrande J, Lemmens HJM. Dose adjustment of anaesthetics in the morbidly obese. *British Journal of Anaesthesia* 2010; **105**: i16–23.
116. Woodruff C, Wieczorek PM, Schricker T, Vinet B, Backman SB. Atomised lidocaine for airway topical anaesthesia in the morbidly obese: 1% compared with 2%. *Anaesthesia* 2010; **65**: 12–17.
117. Xue FS, Liu HP, He N, et al. Spray-as-you-go airway topical anesthesia in patients with a difficult airway: a randomized, double-blind comparison of 2% and 4% lidocaine. *Anesthesia and Analgesia* 2009; **108**: 536–43.
118. Wieczorek PM, Schricker T, Vinet B, et al. Airway topicalisation in morbidly obese patients using atomised lidocaine: 2% compared with 4%. *Anaesthesia* 2007; **62**: 984–8.
119. Haldar R, Gyanesh P, Samanta S. Lignocaine toxicity from topical anaesthesia of airway during awake fibreoptic intubation. *Journal of Neuro Anesthesiology and Critical Care* 2014; **1**: 146–7.
120. Giordano D, Panini A, Pernice C, Raso MG, Barbieri V. Neurologic toxicity of lidocaine during awake intubation in a patient with tongue base abscess. Case report. *American Journal of Otolaryngology – Head and Neck Medicine and Surgery* 2014; **35**: 62–5.
121. El-Boghdadly K, Chin KJ. Local anesthetic systemic toxicity: continuing professional development. *Canadian Journal of Anesthesia* 2016; **63**: 330–49.
122. Association of Anaesthetists. Safety Guideline: management of severe local anaesthetic toxicity, 2010. https://anaesthetists.org/Home/Resources-publications/Guidelines/Management-of-severe-local-anaesthetic-toxicity (accessed 17/10/2019).
123. Osula S, Stockton P, Abdelaziz MM, Walshaw MJ. Intratracheal cocaine induced myocardial infarction: an unusual complication of fibreoptic bronchoscopy. *Thorax* 2003; **58**: 733–4.
124. Chiu YC, Brecht K, Dasgupta DS, Mhoon E. Myocardial infarction with topical cocaine anesthesia for nasal surgery. archives of otolaryngology-head and neck. *Surgery* 1986.
125. Higgins TS, Hwang PH, Kingdom TT, Orlandi RR, Stammberger H, Han JK. Systematic review of topical vasoconstrictors in endoscopic sinus surgery. *Laryngoscope* 2011; **121**: 422–32.
126. Lenders GD, Jorens PG, De Meyer T, Vandendriessche T, Verbrugghe W, Vrints CJ. Coronary spasm after the topical use of cocaine in nasal surgery. *American Journal of Case Reports* 2013; **14**: 76–9.
127. Cara DM, Norris AM, Neale LJ. Pain during awake nasal intubation after topical cocaine or phenylephrine/lidocaine spray. *Anaesthesia* 2003; **58**: 777–80.
128. Takaenoki Y, Masui K, Oda Y, Kazama T. The pharmacokinetics of atomized lidocaine administered via the trachea: a randomized trial. *Anesthesia and Analgesia* 2016; **123**: 74–81.
129. Cabrini L, Baiardo Redaelli M, Ball L, et al. Awake fiberoptic intubation protocols in the operating room for anticipated difficult airway: a systematic review and meta-analysis of randomized controlled trials. *Anesthesia and Analgesia* 2019; **128**: 971–80.
130. Reasoner DK, Warner DS, Todd MM, Hunt SW, Kirchner J. A comparison of anesthetic techniques for awake intubation in neurosurgical patients. *Journal of Neurosurgical Anesthesiology* 1995; **7**: 94–9.
131. Wiles JR, Kelly J, Mostafa SM. Hypotension and bradycardia following superior laryngeal nerve block. *British Journal of Anaesthesia* 1989; **63**: 125–7.
132. Sitzman BT, Rich GF, Rockwell JJ, Leisure GS, Durieux ME, DiFazio CA. Local anesthetic administration for awake direct laryngoscopy. Are glossopharyngeal nerve blocks superior? *Anesthesiology* 1997; **86**: 34–40.
133. O'Callaghan C, Barry PW. The science of nebulised drug delivery. *Thorax* 1997; **52**: S31–44.
134. Kundra P, Kutralam S, Ravishankar M, Scand AA, Care C, Education PM. Local anaesthesia for awake fibreoptic nasotracheal intubation. *Acta Anaesthesiologica Scandinavica* 2000; **44**: 511–16.
135. Ali-Melkkila T, Kaila T, Kanto J. Glycopyrrolate; pharmacokinetics and some pharmacodynamics findings. *Acta Anaesthesiologica Scandinavica* 1989; **33**: 513–17.
136. Brookman CA, Teh HP, Morrison LM. Anticholinergics improve fibreoptic intubating conditions during general anaesthesia. *Canadian Journal of Anaesthesia* 1997; **44**: 165–7.
137. Johnston KD, Rai MR. Conscious sedation for awake fibreoptic intubation: a review of the literature. *Canadian Journal of Anesthesia* 2013; **60**: 584–99.
138. Academy of Medical Royal Colleges. Safe sedation practice for healthcare procedures, 2013. https://www.rcoa.ac.uk/system/files/PUB-SafeSedPrac2013.pdf (accessed 17/10/2019).
139. Rai MR, Parry TM, Dombrovskis A, Warner OJ. Remifentanil target-controlled infusion vs propofol target-controlled infusion for conscious sedation for awake fibreoptic intubation: a double-blinded randomized controlled trial. *British Journal of Anaesthesia* 2008; **100**: 125–30.
140. Lallo A, Billard V, Bourgain JL. A comparison of propofol and remifentanil target-controlled infusions to facilitate fiberoptic nasotracheal intubation. *Anesthesia and Analgesia* 2009; **108**: 852–7.
141. Zhang X, He W, Wu X, Zhou X, Huang W, Feng X. TCI remifentanil vs. TCI propofol for awake fiber-optic intubation with limited topical anesthesia. *International Journal of Clinical Pharmacology and Therapeutics* 2012; **50**: 10–16.
142. Silvestri S, Ladde JG, Brown JF, et al. Endotracheal tube placement confirmation: 100% sensitivity and specificity with sustained four-phase capnographic waveforms in a cadaveric experimental model. *Resuscitation* 2017; **115**: 192–8.
143. Grmec Š. Comparison of three different methods to confirm tracheal tube placement in emergency intubation. *Intensive Care Medicine* 2002; **28**: 701–4.
144. Merry AF, Mitchell SJ. Complications of anaesthesia. *Anaesthesia* 2018; **73**: 7–11.
145. Wahba SS, Tammam TF, Saeed AM. Comparative study of awake endotracheal intubation with Glidescope video

laryngoscope versus flexible fiber optic bronchoscope in patients with traumatic cervical spine injury. *Egyptian Journal of Anaesthesia* 2012; **28**: 257–60.
146. Kramer A, Müller D, Pförtner R, Mohr C, Groeben H. Fibreoptic vs. videolaryngoscopic (C-MAC® D-BLADE) nasal awake intubation under local anaesthesia. *Anaesthesia* 2015; **70**: 400–6.
147. Lewis SR, Butler AR, Parker J, Cook TM, Smith AF. Videolaryngoscopy versus direct laryngoscopy for adult patients requiring tracheal intubation. *Cochrane Database of Systematic Reviews* 2016; **2016**: CD011136.
148. Popat M, Mitchell V, Dravid R, Patel A, Swampillai C, Higgs A. Difficult Airway Society Guidelines for the management of tracheal extubation. *Anaesthesia* 2012; **67**: 318–40.
149. Kirkpatrick MB, Sanders RV, Bass JB. Physiologic effects and serum lidocaine concentrations after inhalation of lidocaine from a compressed gas-powered jet nebulizer. *American Review of Respiratory Disease* 1987; **136**: 447–9.
150. Schønemann NK, van der Burght M, Arendt-Nielsen L, Bjerring P. Onset and duration of hypoalgesia of lidocaine spray applied to oral mucosa – a dose response study. *Acta Anaesthesiologica Scandinavica* 1992; **36**: 733–5.
151. Roberts MH, Gildersleve CD. Lignocaine topicalization of the pediatric airway. *Pediatric Anesthesia* 2016; **26**: 337–44.
152. General Medical Council. Good medical practice Domain 1: Knowledge skills and performance Manchester, UK. 2019.
153. Yentis SM, Hartle AJ, Barker IR, et al. Association of Anaesthetists: consent for anaesthesia 2017. *Anaesthesia* 2017; **72**: 93–105.
154. Difficult Airway Society. DAS ATI Patient Information Leaflet. https://das.uk.com/files/awake_leaflet.pdf (accessed 21/02/2019).
155. Martin KM, Larsen PD, Segal R, Marsland CP. Effective nonanatomical endoscopy training produces clinical airway endoscopy proficiency. *Anesthesia and Analgesia* 2004; **99**: 938–44.
156. Baker PA, Weller JM, Baker MJ, et al. Evaluating the ORSIM ® simulator for assessment of anaesthetists' skills in flexible bronchoscopy: aspects of validity and reliability. *British Journal of Anaesthesia* 2016; **117**: i87–91.
157. Casso G, Schoettker P, Savoldelli GL, Azzola A, Cassina T. Development and initial evaluation of a novel, ultraportable, virtual reality bronchoscopy simulator. *Anesthesia and Analgesia* 2018; **1**.
158. Jiang B, Ju H, Zhao Y, Yao L, Feng Y. Comparison of the efficacy and efficiency of the use of virtual reality simulation with high-fidelity mannequins for simulation-based training of fiberoptic bronchoscope manipulation. *Simulation in Healthcare: Journal of the Society for Simulation in Healthcare* 2018; **13**: 83–7.
159. Marsland C, Larsen P, Segal R, et al. Proficient manipulation of fibreoptic bronchoscope to carina by novices on first clinical attempt after specialized bench practice. *British Journal of Anaesthesia* 2010; **104**: 375–81.
160. Cole AFD, Mallon JS, Rolbin SH, Ananthanarayan C. Fiberoptic intubation using anesthetized, paralyzed, apneic patients results of a resident training program. *Anesthesiology* 1996; **84**: 1101–6.
161. De Oliveira GS, Glassenberg R, Chang R, Fitzgerald P, McCarthy RJ. Virtual airway simulation to improve dexterity among novices performing fibreoptic intubation. *Anaesthesia* 2013; **68**: 1053–8.
162. The Royal College of Anaesthetists. CCT in Anaesthetics – Advanced Level Training (Annex E) Edition 2, 2017. https://www.rcoa.ac.uk/system/files/TRG-CCT-ANNEXE.pdf (accessed 29/03/2019).
163. McNarry AF, Dovell T, Dancey FML, et al. Perception of training needs and opportunities in advanced airway skills: a survey of British and Irish trainees. *European Journal of Anesthesiology* 2007; **24**: 498–504.
164. Ezri T, Szmuk P, Warters RD, Katz J, Hagberg CA. Difficult airway management practice patterns among anesthesiologists practicing in the United States: have we made any progress? *Journal of Clinical Anaesthesia* 2003; **15**: 418–22.
165. Wiles MD, McCahon RA, Armstrong JAM. An audit of fibreoptic intubation training opportunities in a UK teaching hospital. *Journal of Anesthesiology* 2014; **2014**: 1–4.
166. Dawson AJ, Marsland C, Baker P, Anderson BJ. Fibreoptic intubation skills among anaesthetists in New Zealand. *Anaesthesia and Intensive Care* 2005; **33**: 777–83.
167. Goldmann K, Braun U. Airway management practices at German university and university-affiliated teaching hospitals – Equipment, techniques and training: results of a nationwide survey. *Acta Anaesthesiologica Scandinavica* 2006; **50**: 298–305.
168. Ahmad I, Onwochei DN, Muldoon S, Keane O, El-Boghdadly K. Airway management research: a systematic review. *Anaesthesia* 2019; **74**: 225–36.
169. Ahmad I, El-Boghdadly K. From evidence based on practice to evidence-based practice: time for a difficult airway management research strategy. *Anaesthesia* 2019; **74**: 135–9.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Appendix S1. Summary of the systematic review methodology.

Appendix S2. The Difficult Airway Society checklist for awake tracheal intubation (ATI) in adults. SAD, supraglottic airway device.

Appendix S3. The Difficult Airway Society documentation sticker for awake tracheal intubation (ATI) in adults. FB, flexible bronchoscopy; VL, videolaryngoscopy; L, left; R, right.

Difficult Airway Society guidelines for awake tracheal intubation in adults

The Difficult Airway Society guidelines for awake tracheal intubation (ATI) in adults are an excellent, well-presented, researched and practical guide with useful infographics [1]. There will always be some criticism of any guideline, of course, and I do not wish to be pedantic but I am really surprised at their suggestions for sedation (shown in their Fig. 2). Although judicious use of sedation is important to alleviate anxiety and improve patient comfort and compliance, I am concerned with the recommendation to use remifentanil for this purpose. Remifentanil is an extremely potent opioid and certainly not a sedative. It is a poor hypnotic in clinically-relevant concentrations with minimal effect on cognitive function [2, 3]. Although it has been used as an analgesic adjunct in procedural sedation, it is very dangerous to recommend it in a patient with a difficult airway. Respiratory depression, nausea/vomiting and muscle rigidity can easily occur and this is even more likely if combined with sedative drugs. I appreciate that some clinicians will have extensive experience with remifentanil and can probably titrate it fairly safely, but these are general guidelines and I feel that it should not be so readily suggested. As the authors have alluded to meticulously and correctly elsewhere, the key to management is successful 'topicalisation' with local anaesthetic. If this is done correctly (and it is not difficult, nor do you need as much as 9 $mg.kg^{-1}$ lidocaine), there is absolutely no need for adjunct potent respiratory depressant analgesia. If sedation is deemed helpful then either dexmedetomidine (which has no respiratory depression and an antisialogogue effect assisting local anaesthetic application) or, very judiciously titrated, low-dose propofol target-controlled infusion (0.8–1.5 $\mu g.ml^{-1}$ using the Marsh or Eleveld model) is all that is required. Why complicate things by suggesting a potent respiratory depressant in a general guideline? Although the counter argument that it can be reversed with naloxone has some merit, this can take around 4 min in a healthy patient and can itself induce a number of adverse effects [4].

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References

1. Ahmad I, El-Boghdadly K, Bhagrath R, et al. Difficult Airway Society guidelines for awake tracheal intubation (ATI) in adults. *Anaesthesia* 2020; **75**: 509–28.
2. Iselin-Chaves IA, Flaishon R, Sebel PS, et al. The effect of the interaction of propofol and alfentanil on recall, loss of consciousness, and the Bispectral Index. *Anesthesia and Analgesia* 1998; **87**: 949–55.
3. Shiokawa H, Yamaura K, Karashima Y, Hoka S, Megumu Y. Evaluation of analgesic and hypnotic effects of remifentanil by in vivo patch-clamp recordings: 14AP8-7. *European Journal of Anaesthesiology* 2013; **30**: 225.
4. Tylleskar I, Skulberg AK, Skarra S, Nilsen T, Dale O. Pharmacodynamics and arteriovenous difference of intravenous naloxone in healthy volunteers exposed to remifentanil. *European Journal of Clinical Pharmacology* 2018; **74**: 1547–53.

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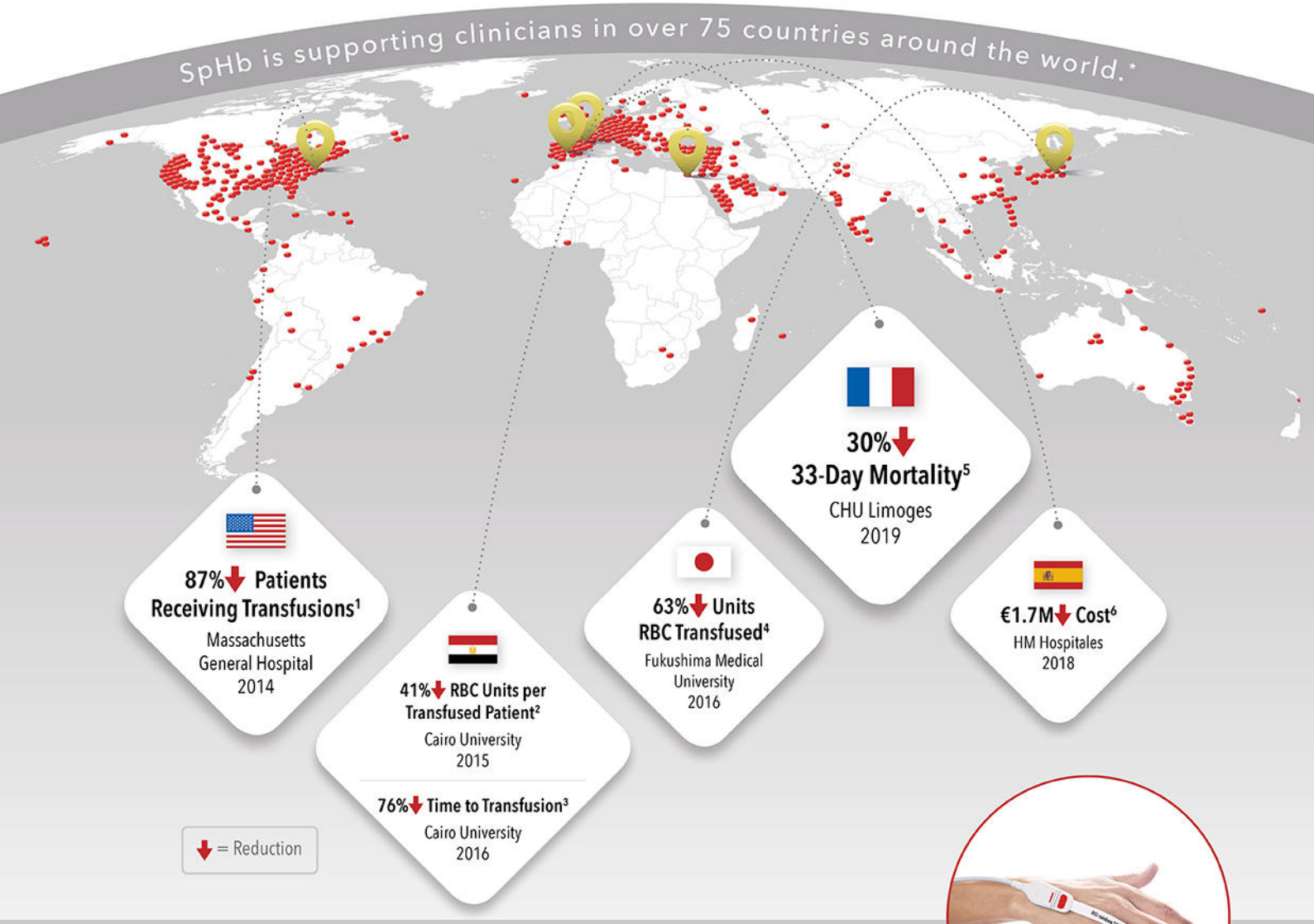

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Clinical decisions regarding red blood cell transfusions should be based on the clinician's judgment considering among other factors: patient condition, continuous SpHb monitoring, and laboratory diagnostic tests using blood samples. SpHb monitoring is not intended to replace laboratory blood testing. Blood samples should be analysed by laboratory instruments prior to clinical decision making.

[1] Ehrenfeld et al. *J Blood Disorders Transf.* 2014. 5:9. [2] Awada WN et al. *J Clin Monit Comput.* DOI 10.1007/s10877-015-9660-4. Study Protocol: In each group, if researchers noted SpHb trended downward below 10 g/dL, a red blood cell transfusion was started and continued until SpHb trended upward above 10 g/dL. The transfusion threshold of 10 g/dL was predetermined by the study protocol and may not be appropriate for all patients. Blood sampling was the same for the control and test group. Arterial blood was drawn from a 20 gauge radial artery cannula into 2 mL EDTA collection tubes, mixed and sent for analysis by a Coulter GEN·S Hematology Analyzer. [3] Kamal A, et al. *Open J of Anesth.* 2016 Mar; 6, 13-19. [4] Imaizumi et al. *Proceedings from the 16th World Congress of Anaesthesiologists* Hong Kong. Abstract #PR607. [5] Cros et al. *J Clin Monit Comput.* Aug 2019: 1-9. Study utilised a goal-directed fluid therapy protocol with PVi® in conjunction with a blood transfusion protocol based on SpHb. [6] Ribed-Sánchez B, et al. *Sensors* (Basel). 2018 Apr 27;18(5). pii: E1367. Estimated national savings derived from hospital savings extrapolated nationwide. * Data on file.

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