Awake tracheal intubation: a narrative review

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Contributions: (I) Conception and design: D Yeow; (II) Administrative support: None; (III) Provision of study materials or patients: None; (IV) Collection and assembly of data: N Gostelow; (V) Data Analysis and interpretation: N Gostelow; (VI) Manuscript writing: Both authors; (VII) Final approval of manuscript: Both authors.

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Background and Objective: Awake tracheal intubation (ATI) is considered the gold standard for managing the anticipated difficult airway. However, ATI occurs in only 0.2% of all anaesthetics and evidence shows this is declining further, eroding skill retention and putting patients at risk of harm. The Difficult Airway Society (DAS) recently published ATI guidelines but focused largely on two techniques: awake video laryngoscopy and awake flexible bronchoscopy. This narrative review aims to summarise all techniques described for ATI, discuss controversies in methods of optimizing intubating conditions as well as patient experience and clinician training.

Methods: A literature search was performed of PubMed/Medline, Cochrane Central Register of Controlled Trials, and Cochrane Database of Systematic Reviews. Inclusion criteria were any English language reviews, editorials, correspondences or trials related to ATI in adults. Exclusion criteria included paediatric studies, trials without published results, those relating to surgical procedures such as awake tracheostomies, techniques performed in anaesthetized patients and any procedure felt not to be in line with current guidelines such as blind awake intubation.

Key Content and Findings: There is no strong evidence to promote one technique over another. Flexible bronchoscopy, videolaryngoscopy, optical stylets and supraglottic guided ATI have their own advantages and disadvantages with similar success rates. Awake video-assisted flexible bronschoscopic intubation has been described but not yet extensively investigated. ATI with local anaesthesia only is well established but case series describe minimal local anaesthesia with remifentanil or dexmedetomidine sedation without significant adverse incidents. When using sedation these drugs are equally favoured but with differing side effect profiles of which the anaesthetist should be aware. Remifentanil is more likely to result in recall but this has no correlation with patient dissatisfaction. Patient experience can be improved with tailored information and maintaining interaction throughout. Achieving enough clinical exposure for training and retention is a challenge and expanding the indications for ATI may promote greater clinician confidence and patient safety.

Conclusions: ATI remains vital to any anaesthetic department. This review describes various techniques meaning every anaesthetic department could perform ATI using familiar equipment. Questions remain over the safest method with particular gaps around performance of reusable versus single use equipment, minimal sedation versus minimal local anaesthesia for intubation, and the use of awake video-assisted flexible-bronchoscopic intubation.

Keywords: Airway management; difficult airway; flexible bronchoscopy; videolaryngoscopy; patient experience

Received: 19 May 2023; Accepted: 05 September 2023; Published online: 20 September 2023.

doi: 10.21037/joma-23-17

View this article at: https://dx.doi.org/10.21037/joma-23-17

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Introduction

Awake tracheal intubation (ATI) refers to any technique involving the placement of an endotracheal tube (ETT) in a non-anaesthetised, spontaneously breathing patient capable of obeying commands. It is considered the gold standard of managing the predicted difficult airway (1). This difficulty could arise from concerns over any one of facemask ventilation, supraglottic placement, tracheal intubation or front of neck access (1). Specific indications vary across the literature, institutional and cultural practices and include, but not limited to head and neck pathology including previous surgery, tumours and radiation therapy (2), haemodynamic instability (3), cervical spine pathology (4,5), risk of gastric aspiration (6), and raised body mass index (BMI) (7-9).

The 4th National Audit Project (NAP4) reported higher rates of morbidity and mortality amongst patients with anticipated difficult airways who should have undergone ATI, recommending this skill is mandatory to all anaesthetic departments (10). Despite this, rates of ATI remain low at around 0.2% of all anaesthetics (1) and recent evidence shows that this further declines by 50% between 2014 and 2020, having corrected for changes in activity during the coronavirus disease 2019 (COVID-19) pandemic (11). In 2019, the Difficult Airway Society (DAS) produced guidelines for adult ATI aiming to improve accessibility, uptake and patient safety (1). These guidelines concentrate primarily on two key methods: flexible bronchoscopy or videolaryngoscopy (2). However, other techniques exist and have been used successfully.

The aim of this narrative review is to describe a broader range of techniques and equipment available for ATI, any benefits of one over another, methods for optimizing intubating conditions, practicalities of training and skill retention and patient experience. The aim is not to replace pre-existing guidelines or meta-analyses (1,12,13) but to summarise the literature and any controversies within it, informing safe clinical decision making and improving patient consent and experience. We present this article in accordance with the Narrative Review reporting checklist (available at https://joma.amegroups.com/article/view/10.21037joma-23-17/rc).

Methods

A literature search was performed in April 2023 of PubMed/Medline, Cochrane Central Register of Controlled Trials, and Cochrane Database of Systematic Reviews. Search terms included 'awake tracheal intubation', 'awake fibreoptic intubation', 'awake bronchoscopic intubation', 'awake laryngoscopy' and 'awake videolaryngoscopy'. Inclusion criteria were any English language reviews, editorials, correspondences or trials related to ATI in adults. Exclusion criteria included paediatric studies, trials without published results, those relating to surgical procedures such as awake tracheostomies, techniques performed in anaesthetized patients and any procedure felt not to be in line with current guidelines such as blind awake intubation. There was no specified timeframe for inclusion. See *Table 1* for full search strategy summary.

This search initially produced 767 potential papers for review. One author (Gostelow N) examined initial search results by title/abstract resulting in 159 papers for assessment in full. These papers were examined for relevance, interest and innovation resulting in 127 papers informing the final review, see *Figure 1*.

Awake fibreoptic intubation (AFOI) or flexible bronchoscopic intubation

The first report of ATI was in 1967 where a patient was intubated using a surgical choledochoscope (14). AFOI increased as fibreoptic technology improved and became more readily available. Many trials still refer to AFOI as the 'gold standard' for managing the anticipated difficult airway although this narrative has changed reflecting the growing number of techniques to intubate a non-anaesthetised individual. DAS guidelines refer to ATI, not AFOI, as the gold standard (1) moving the emphasis from the method of intubation to its performance on a cooperative, spontaneously ventilating patient. Despite this, many trials still compare novel methods to the traditional AFOI cementing its place as an accepted standard of care.

AFOI has a success rate of around 99% (13) and a complication rate ranging from 1–10% (13,15). AFOI can be achieved via the oral or nasal route. Nasal intubation may be necessitated by surgical access, limited mouth opening and potentially be easier to learn as the posterior nasopharynx can align the scope and glottis more favourably. However, nasal intubations are associated with more discomfort in an awake patient, even with topical anaesthesia (16) and are commonly associated with epistaxis (17,18). Therefore, the oral route should be considered first line unless contraindicated. Oral airways, such as William's (Williams Airway Intubator, Ltd., Calgary, Canada), Berman (Vital Signs, Totowa, NJ, USA), Ovassapian (Kendall-Sheridan, Argyle, NY, USA)

Table 1 Summary and example of search strategy

Items	Specification
Date of search	03/04/2023
Databases and other sources searched	PubMed/Medline, Cochrane Central Register of Controlled Trials, and Cochrane Database of Systematic Reviews
Search terms used	Awake tracheal intubation OR awake fibreoptic intubation OR awake flexible bronchoscopic intubation OR awake laryngoscopy OR awake videolaryngoscopy NOT paediatric NOT adolescent NOT neonatal
Timeframe	None specified
Inclusion and exclusion criteria	Inclusion: any English language reviews, editorials, correspondences or trials related to ATI in adults
	Exclusion: paediatric studies, trials without published results, those relating to surgical procedures such as awake tracheostomies, techniques performed in anaesthetized patients and any procedure felt not to be in line with current guidelines such as blind awake intubation
Selection process	One author reviewed titles and abstracts based on inclusion criteria. Remaining papers then included based on relevance and interest

ATI, awake tracheal intubation.

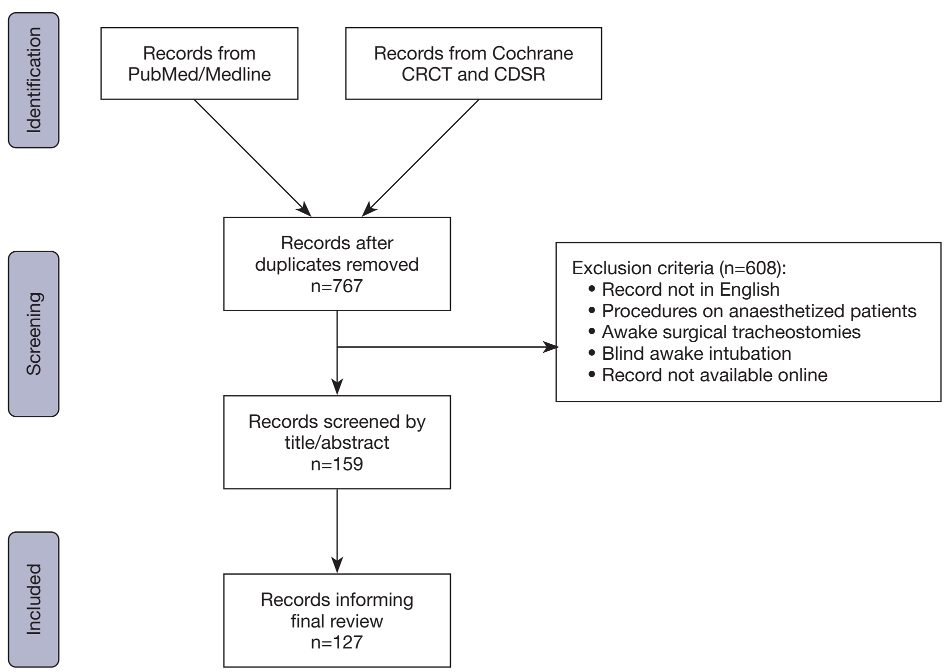

Figure 1 Summary of search strategy results, screening and exclusion criteria. CRCT, Central Register of Controlled Trials; CDSR, Cochrane Database of Systematic Reviews.

or modified oropharyngeal airways (19) can facilitate oral intubation by directing the scope posteriorly around the tongue and act as a bite block.

A traditional approach involves passing a flexible fibreoptic bronchoscope through the naso- or oropharyngeal airway, visualizing the glottis, advancing it through the glottis to just above the carina and railroading the ETT over the bronchoscope (14). The main advances our literature search identified were surrounding disposable flexible bronchoscopes, methods of oxygenation and fibre-capnic intubation.

Although many anaesthetists may still refer to awake 'fibre-optic intubation' flexible bronchoscopes may be either re-usable fibreoptic or disposable flexible videoscopes (20). Disposable scopes hold several possible advantages including no requirement for disinfection therefore more accessible in an emergency (20), no repair costs, no risk of cross-contamination, they are lightweight and easier to hold for prolonged intubation attempts (21). Initial comparisons with re-usable scopes showed poorer video quality and a longer time to intubation (20). However, disposable scopes are improving over time and there appears to be consensus that their convenience outweighs lower image quality. The Ambu aScope 2™ (Ambu, Ballerup, Denmark) was shown to be easier to use with equal performance and outcomes to a reusable scope for intubation in anaesthetised patients (21).This prompted the National Institute for Health and Clinical Excellence (NICE) to recommend their use for unanticipated difficult airways, where waiting for a reusable scope from sterile services may result in significant harm (22).The Ambu aScope2™ has now been superseded by the aScope4™ (Ambu) with an additional suction port and improved resolution (21). Other brands are available, such as the Glidescope BFlex™ (Verathon, Bothell, WA, USA) but we identified no studies comparing brands of disposable scope nor any other studies evaluating them for ATI, so potential benefits are mostly extrapolated from findings under anaesthesia. Cost analyses show disposable scopes are more expensive if greater than 22 scopes are used monthly (20). With AFOI occurring between 0.5–1.6% of anaesthetics (10,15), this is unlikely to be exceeded in the average anaesthetic department. The improved quality of disposable scopes alongside convenience and ease of setup has increased their uptake in our institution but their performance compared to reusable scopes is still an area requiring further research.

DAS strongly recommends the use of supplemental oxygen during ATI, specifically high flow nasal oxygen (HFNO) (1). But various techniques into providing supplemental oxygen have been described ranging from nasal cannulae, facemask oxygen (15), insufflating oxygen via the bronchoscope suction channel (23) and endoscopic masks with nasal or oral openings (24). Even before DAS' recommendations, El-Boghdadly *et al*. performed a prospective study across 3 years showing their use of HFNO increased from 49% to 100% despite no significant difference in desaturation in comparison to other methods (15). During their study period, another trial published no episodes of desaturation when using HFNO, even with apnoea, nor elevated end tidal carbon dioxide ($ETCO_2$) levels (25). The authors' postulated that benefits may extend beyond higher flow rates and apnoeic oxygenation to include aiding delivery of local anaesthetic, preventing airway collapse and, humidifying mucosal surfaces to reduce bleeding (25). These factors, rather than purely oxygenation, probably explain its increased popularity in both expert consensus (1) and studies such as that by El-Boghdadly *et al*. (15).

AFOI has been adapted by the addition of capnograph guided placement of the ETT, known as awake fibrecapnic intubation (26-28). This was used in patients with extreme anatomical abnormality and laryngeal distortion. A suction catheter placed through the working channel of the bronchoscope connected to the CO_2 sampling line identifies a capnograph when the catheter is in the trachea. This does however, seem to add further complexity to the procedure. Of 40 patients across two case series, there was one failure, two catheter blockages, one unable to record $ETCO_2$ despite being in the trachea and one (recognized) oesophageal intubation (27,28). Although this may provide another technique in the head and neck anaesthetist's armoury in cases of extreme difficulty, it does not appear to be widely adopted and we identified no further studies describing its use or comparing it to other techniques.

Despite proven safety records AFOI is, by its very nature, considered a high-risk procedure requiring careful planning and conduct (1). Reasons for failure include airway hyper-reactivity due to inadequate local anaesthesia, oversedation, mucosal bleeding and partial airway obstruction (29). Severe adverse events include laryngospasm (30,31), subcutaneous emphysema (32) and gastric rupture following oxygen insufflation and increased abdominal pressure from coughing (23). AFOI's main shortcoming is that the ETT is blindly railroaded and can impinge on laryngeal structures, most commonly the right arytenoid (33). This can result in hoarseness, dysphonia, haematoma and other laryngeal trauma (34).

Fear of these consequences, alongside lack of confidence and time pressures in the clinical environment can lead to its avoidance (29). One study found ATI added just eight minutes to the total anaesthesia time with no difference in route (35). A corresponding survey showed both anaesthetists and surgeons over-estimated this time with 60% of surgical attending physicians estimating it added more than 20 minutes to the case (35). Simple measures can increase first pass success rate: orientating the bevel of the ETT posteriorly rather than the left improves first pass intubation rate (33) probably due to less impingement on

Table 2 Randomised studies comparing VL to fibreoptic/FB intubations, patient groups, mouth opening and primary outcomes

Author	Year	VL	Patient group	Mouth opening	Route	Primary endpoint	Result	Other findings
Cohn *et al.* (49)	1995	Bullard (Olympus America, PA, USA)	Cervical spine surgery	Not reported	Oral	Time to glottic visualisation and intubation	Time to glottic visualisation (VL: 9.5 s, FB: 29.2 s); time to intubation (VL: 46.1 s, FB: 99.3 s), P<0.05	–
Rosenstock *et al.* (50)	2012	McGrath (Aircraft Medical, Edinburgh, UK)	Anticipated difficult airway	>15 mm	Oral	Time to intubation	No significant difference, P>0.05	No difference in success rate
Abdellatif *et al*. (51)	2014	Glidescope (Verathon Medical, Bothell, WA, USA)	Bariatric surgery	>15 mm	Oral	Time to intubation	VL: 73.6 s, FB: 84 s	80.6% VL intubated on first attempt, 75% FB
Kramer *et al*. (52)	2015	C-MAC D blade (Karl-Storz, Tuttlingen, Germany)	Anticipated difficult airway	>13 mm	Nasal	Time to intubation	VL: 34 s, FB: 94 s, P<0.05	No difference in success rate
Mendonca *et al*. (53)	2016	Pentax AWS (Pentax, Tokyo, Japan)	Anticipated difficult airway, most undergoing cervical spine surgery without laryngeal pathology	>25 mm	Oral	Time for whole procedure	VL: 651 s, FB: 900 s, P<0.05	Time to intubation also significantly shorter for VL
Mahran *et al*. (54)	2016	Glidescope	Oropharyngeal cancer surgery	Restricted mouth opening excluded	Nasal	Time to intubation	VL: 70.8 s, FB: 90.3 s, P<0.05	–
Moore *et al*. (55)	2017	Glidescope	Bariatric surgery	Not reported	Oral	Time to intubation	VL: 60.9 s, faster than FB, P<0.05	–
Dutta *et al*. (5)	2020	McGrath	Unstable cervical spine	>2.5 cm	Oral	Cervical spine movement at C1/2 and C3	VL significantly greater movement at C1/2	No difference in time to intubation

VL, videolaryngoscopy; FB, flexible bronchoscopy.

the right arytenoid. Similarly a narrower ETT can improve passage across the vocal cords as it more closely matches the width of the scope reducing risk of laryngeal trauma (34).

A meta-analysis by Cabrini *et al.* (13) of AFOI protocols showed no evidence to recommend one technique or route. El-Boghdadly *et al.*'s cohort study had a higher failure rate than Cabrini *et al.* (1% *vs.* 0.7%) and relatively high complication rate of 11% (15). These higher complication rates were by operators who had performed fewer procedures (15) highlighting the importance of experience in performing AFOI but also of practice and skill retention.

Awake videolaryngoscopy (AVL)

Reasons for avoiding AFOI, described above, are used to argue the expansion of AVL (29). The learning curve for AFOI is steep. The number of procedures required for competence is unknown but estimated between 10 (36) and 25 (37) compared to six with a videolaryngoscope (37). With videolaryngoscopy becoming increasingly available, most anaesthetists are more familiar and confident in its use (29). In addition, AVL can offer a bigger screen, improved spatial awareness, a larger field of view, no red-out phenomenon when touching the mucosa, direct visualisation and suctioning of secretions and, most importantly, visualization of passage of the tube through the glottis (37), a particular advantage in those with periglottic pathology. This also facilitates changing the type or size of the ETT without restarting the procedure (38).

Videolaryngoscopes require less traction and force to align the pharyngeal and laryngeal structures than their direct counterparts. They can be divided into channeled and unchanneled. A channeled scope, such as Airtraq™ (Prodol Meditect S.A.,Vizcaya, Spain), Kingvision™ (Ambu), and channeled Pentax Airwayscopes™ (Pentax, Tokyo, Japan) have an exaggerated curvature of the blade and guiding channel on the right acting as a conduit for the ETT (39). Some argue that channeled videolaryngoscopes are better designed for ATI requiring almost no traction to provide a glottic view, negate the use of a stylet, which can itself cause trauma, and allow direct application of local anaesthetic via a suction catheter through the ETT (40). Case reports describe their successful use in those with fixed cervical spines (7,41), odontogenic abscesses, airway tumours, previous difficult intubations, previous head and neck surgery (42-44) and in obstetrics (3). However, we found no randomised studies comparing them to other videolaryngoscopes to support that they are better suited to ATI. Their limitations include inability to pass the scope in limited mouth opening, to facilitate nasal intubation, to change the ETT during the procedure and difficulty in passing a double lumen tube.

There are as many, if not more, reports of unchanneled scopes in ATI. Unlike channeled versions, they facilitate nasal intubation (44) and also the passage of double lumen ETTs (45). They have been used in scenarios which may have traditionally mandated a flexible bronchoscopic approach such as pharyngeal and laryngeal malignancies, supra and infraglottic swelling (46) and epiglottitis (47). AVL may offer advantages here by avoiding a 'cork in bottle' phenomenon precipitated by a bronchoscope in a narrow airway (46). These case reports had a 100% success rate although one study looking at Glidescope™ (Verathon) use in obese patients found a first pass success rate of only 56% and commented that AVL may induce more gagging than AFOI (48).

There is increasing experimental evidence comparing unchanneled videolaryngoscopes to AFOI. These papers are summarized in *Table 2*. Some studied specific groups such as morbid obesity, cervical spine instability or head and neck malignancies whilst others included any predictors of or known difficult airway. Alhomary *et al*. (38) performed a meta-analysis and systematic review comparing these studies with the exception of Dutta *et al*. (5) who published their work more recently. They showed intubating time was significantly shorter for AVL, no significant difference in failure or first pass success rates nor in patient satisfaction or complications (38). The studies are heterogenous and mostly in small populations so the overall quality of evidence is low. In addition, a primary outcome of time to intubation is only a surrogate marker for ease and not necessarily an indication for patient safety or comfort (38). Restricted mouth opening often necessitates AFOI. *Table 2* includes the minimum mouth opening permitted in each study. Three studies used AVL with mouth opening of <15 mm and one of these used 13 mm as their lower limit. This may be lower than traditional teaching and opens AVL to a cohort of patients otherwise not offered this. Dutta *et al*. (5) found AFOI produced less cervical spine movement in those at risk of neurological injury on intubation (5). Time to intubation was not a primary outcomes and therefore their results would not affect Alhomary's conclusion; however, AFOI may still be a safer and necessary choice in those with unstable cervical spines.

Findings such as this counter arguments that successful AVL now makes AFOI obsolete. Device selection depends not just on the operator but patient as well, and in the presence of extremely limited mouth opening or neck movement, the need for AFOI will still exist. AVL may however be better suited to centres with lower caseloads due to its similarity with the asleep technique, resulting in continued skill retention and potentially more opportunities for training (23).

Awake video-assisted flexible bronchoscopic intubation (VAFI)

This technique, which has been reported for difficult intubations in anaesthetized patients, describes a combination of both AVL and AFOI. The flexible bronchoscope passes either nasally or orally whilst the videolaryngoscope creates more space in the airway and visualises part or all of the glottis (56,57). Awake VAFI may overcome limitations of both AVL and AFOI by providing a wider glottic view, visualizing passage of the ETT and reducing the time taken to perform bronchoscopic intubation, whilst also requiring less force from the videolaryngoscope as the bronchoscope travels around the epiglottis without the structures being aligned. Additionally, their combination should require no further preparation or sedation as both techniques can be tolerated. Our literature search found only case reports or case series (56,57) of this approach and another case report of a similar method using an optical stylet rather than a flexible bronchoscope (58). Combining the benefits of both techniques may make awake

VAFI deserving of further investigation and comparative studies between this and both AFOI and AVL alone.

Optical stylets

Optical stylets combine fibreoptic and videotechnology with an intubating stylet (59). They can allow indirect visualization of the glottis via an eyepiece or attachment to a separate monitor (60). Some have additional channels allowing suctioning, application of local anaesthetic and oxygen insufflation (59).

Our literature search identified 10 articles examining optical stylets for ATI. The commonest was the Bonfills Fibrescope™ (Karl Storz, Tuttlingen, Germany) in five studies (60-64). The Bonfills Fibrescope™ is a rigid indirect laryngoscope, 40 cm long with a fixed anterior curvature of 40 degrees and a 5 mm outer diameter (60). The scope was originally designed for retro-molar insertion although can also be inserted in the midline with the patient protruding their tongue or an operator holding the tongue forwards (60). Their use has been reported when AFOI has failed (63) and it is suggested they may be cheaper, more portable and durable than a flexible bronchoscope (59). One study compared the Bonfills™ to the Glidescope™ videolaryngoscope for ATI (64). They found no difference in time to intubation or success rates and patients in the Bonfills™ group had higher satisfaction rates.

Other designs such as the C-MAC video stylet™ (Karl Storz), Sensascope™ (Acutronic Medical Systems AG, Hirzel, Switzerland), Shikani Optical Stylet™ (Clarus Medical, Minneapolis, MN, USA) and Clarus video system or Trachway™ (Biotronic Instruments Enerprise Ltd., Taiwan, China) have flexible or malleable tips. Studies show success rates of 97% (65) and 92% for nasal intubations (66) and a similar time scale to AVL (65). They are suitable for restricted mouth opening and have been used in difficult laryngeal anatomy and cervical spine instability (67,68).

Although they may facilitate intubation quicker than AFOI, they do have limitations. Unlike AVL, optical stylets are unfamiliar to many anaesthetists resulting in a new learning curve, the difficulty of which is not reliably demonstrated. One study showed a non-expert operator achieve high success rates within 30 intubations (61) whereas another revealed difficulty in up to one third of patients (62). This was most commonly from blood, condensation and secretions obscuring the view (62,66). Rigid versions are not suitable for nasal intubation and the anaesthetist should be aware that some versions, such as the Bonfills™ do not have additional working channels for oxygen insufflation or suction.

Supraglottic guided ATI

ATI may be achieved by first placing a supraglottic airway device (SAD) in an awake patient and utilising this to locate the glottis. All SADs identified in our literature search were those specifically designed to facilitate intubation such as the Auragain™ (Ambu), Air-Q intubating Laryngeal Mask Airway (LMA)™ (Mercury Medical, Clearwater, FL, USA) or LMA Fastrach™ (Intravent, Reading, UK). Their anatomically curved tubing is designed to deliver an ETT to the glottis without use of a laryngoscope (69). This can be a blind procedure even in the awake patient (70) but this review will concentrate on flexible bronchoscopic intubations through SADs as this correlates with international consensus recommending a two-point check after intubation with both visualization of trachea and $ETCO_2$ (1).

Reports of awake supraglottic airway guided flexible bronchoscopic intubation (SAGFBI) show they are well tolerated in adequately anaesthetized airways (71-73). If AVL can permit an 'awake look' prior to induction, awake SAGFBI can provide awake confirmation that a SAD has an adequate seal and $ETCO_2$ (72). In addition, as the tip of the SAD sits in the oesophageal sphincter not the vallecula, it may produce less gagging (71). The technique has been used in patients with fixed neck deformities (74), Halo traction (70), obesity (9), obstetrics (75) and laryngeal pathology (76). One small randomized study found higher first pass intubation success via a SAD in comparison to AFOI and time to intubation was also shorter (92 *vs.* 246 s) (77). In addition, the placement of a SAD negates the need for an oral guide for AFOI and may be easier for novices (74). Limitations are predominantly that SADs cannot be placed in patients with limited mouth opening, although one case series did use the AuragainTM down to an inter-incisor distance of 16 mm (71). It may also be harder to perform a spray-as-you-go technique as the larynx cannot be topicalised with local anaesthetic until the SAD is in situ. Caution should be used in those with pharyngeal or laryngeal pathology prone to bleeding on contact and they cannot guide a nasal ETT.

We identified two situations where awake SAGFBI may offer benefits over other devices. It is the only technique to have supported continuous non-invasive bilevel positive airway pressure (BIPAP) by connecting an Air-q™ iLMA to the anaesthetic circuit whilst the bronchoscope and ETT were railroaded through the glottis (78). The cuff can also shield the glottis from blood originating from the upper airway where other techniques have failed due to blood obstructing the camera (79,80).

Desai *et al*. performed a meta-analysis of randomized control trials comparing different devices to achieve ATI including flexible bronchoscopes, videolaryngoscope and optical stylets. They did not include SADs. Their review showed first past success rates were comparable across the three techniques with optical stylets resulting in the shortest intubation time and flexible bronchoscopes the longest (12). Of particular importance no studies compare the use of any technique in a non-elective setting where procedural performance may be hampered by additional stressors. In conclusion there is no strong evidence to recommend one technique over another but the anaesthetist should be aware of the advantages and pitfalls of each. These are summarized in *Table 3*.

Optimising conditions for awake intubation

DAS recommends the ideal conditions for performing ATI are with two anaesthetists (one operator and one for sedation and monitoring), a trained assistant, a well oxygenated, cooperative patient able to obey commands and an adequately anaesthetized airway which has been atraumatically tested before proceeding (1). There is however debate in the literature over the balance of local anaesthesia, which may adversely stimulate an 'at risk airway', and sedation, which brings with it risks of cardiovascular and respiratory depression.

Performing ATI with local anaesthesia alone is well established (6,17,18). There are two main ways to anaesthetize the airway: injections of local anaesthesia to block afferent nerves or topical application (81) including atomization, nebulization and the 'spray as you go' technique (1). See *Figure 2* for a summary of these different methods.

There is no convincing evidence that one technique confers benefit over another; nebulisation and spray as you go perform similarly in meta-analyses. Regional techniques may be faster and slightly superior but are more invasive and require additional expertise (13). Higher volume techniques, e.g., nebulisation, atomisation and spray-as-you-go, are more likely to result in plasma levels above the toxic dose of 5 mcg/mL with 4% lidocaine (84). In comparison, 2% lidocaine produces equally acceptable intubating conditions to 4% (102) and is superior to 1% (85).

Regional anaesthesia blocks to the glossopharyngeal, superior, or recurrent laryngeal nerve often result in shorter intubating times, better patient comfort scores and less gagging (82,92-95,98). These techniques require lower doses but result in greater absorption and higher plasma concentrations than topical counterparts (81). This may be partly due to accidental intravascular injection but also topical administration has lower absorption due to loss of local anaesthetic by nebulisation and atomization, or swallowing (85). Improvements in ultrasound technology have added additional safety measures and accuracy in performing regional anaesthesia. Bilateral superior laryngeal nerve blocks performed under ultrasound guidance can facilitate ATI even in those with unidentifiable anatomical landmarks (96,97). Equally ultrasound can assist in performing a transtracheal block and provide reassurance by reliably identifying the cricothyroid membrane in advance should a Cannot-Intubate-Cannot-Oxygenate situation arise (102).

The UK's DAS guidance places significant emphasis on adequate local anaesthesia rather than sedation (1) and this concurs with the Canadian Airway Focus Group guidelines which state that systemic sedation 'should not be used to compensate for inadequate topicalization' (p1413) (103). There are however case reports describing airway loss associated with application of local anaesthetics. Two cases describe upper airway obstruction attributed to a combination of laryngospasm and reduced upper airway tone precipitating airway collapse (30,104) both resulting in emergency front of neck access. Transtracheal blocks have also been implicated in the development of subcutaneous emphysema (32,105) and high doses run the risk of local anaesthetic toxicity, symptoms of which have been documented in healthy volunteers (18).

As a result some centres promoting a sedation only or minimal local anaesthesia technique described most extensively with remifentanil (106). Since the aforementioned international guidelines were published, one institution has described their 10 years of practice using remifentanil target controlled infusion (TCI). Its antitussive effects limits coughing and also reduces risk of laryngospasm. Lower local anaesthesia doses reduces the risk of local anaesthetic toxicity (107). They had no adverse incidences due to over-sedation and comparable patient comfort to other studies (107). However, it should be noted that the authors were describing ATI using flexible bronchoscopy. This may not be applicable to AVL which usually requires some anaesthesia of the vallecula. Dexmedetomidine has also been successfully used without local anaesthetic in a patient with local anaesthetic allergy (108) although once again this

Table 3 Comparison of advantages and disadvantages of commonly used techniques for ATI

ATI technique/device	Advantages	Disadvantages
Flexible bronchoscope	• Suitable for oral or nasal route	• Steep learning curve and decreased safety profile in inexperienced or out of practice operators
	• Able to manoeuvre around abnormal pathology	• Potential for 'cork in bottle' phenomenon through a narrowed airway
	• Disposable scopes may be more readily available and do not require disinfecting	• Unable to visualize railroading of ETT
	• Additional channels facilitate 'spray as you go' local anaesthesia	• Unable to change ETT easily
	• Additional channels can allow insufflation of oxygen or suctioning	• Excessive blood or secretions may block obscure camera
	• Can be used in restricted or no mouth opening	• Most time-consuming technique
	• Results in least movement in unstable cervical spines	• Disinfection of reusable scopes may mean they are not available when required
Videolaryngoscope	• Suitable for oral or nasal route	• Those requiring stylets have an increased risk of trauma
	• Larger field of view may allow easier identification of abnormal anatomy	• Excessive traction or force may not be tolerated in an awake patient
	• May be easier to suction and clear blood or secretions from airway	• Unable to perform in restricted mouth opening
	• Can visualize railroading of ETT	
	• Can easily change ETT	
	• More regularly practiced and easier to learn	
	• Can facilitate an 'awake look' prior to induction of anaesthesia	
Optical stylet	• Suitable for restricted mouth opening	• High failure rate with blood or secretions in airway
	• Flexible tips may improve maneuverability	• Steep learning curve and unfamiliar technique in inexperienced or out of practice operators
	• Some have additional channels for local anaesthesia, suction and oxygen insufflation	• Variability between scopes—many do not have additional channels for oxygen, suction or local anaesthesia
	• Least time-consuming technique	• Rigid scopes not suitable for nasal intubation
	• Less rigid scopes can facilitate nasal intubation	• Requires traction of the tongue or use of a mackintosh laryngoscope
	• Scopes with separate cameras allows assistants to also visualize procedure	
Supraglottic airway guided	• Potentially easiest technique for novices to learn	• Lower quality evidence not widely assessed with RCTs or meta-analyses
	• Allows awake assessment of SAD seal and function	• Unable to perform in restricted mouth opening
	• Requires minimal cervical spine movement	• Unable to facilitate 'spray as you go technique' as SAD needs to be in situ to visualize and spray supraglottic region
	• Can facilitate ventilatory support in respiratory failure	• Unable to visualize railroading of ETT
	• Can seal glottis from upper airway bleeding improving bronchoscopic view	• Could still experience 'cork in bottle phenomenon' when inserting bronchoscope into glottis.
	• Quicker than fibreoptic intubation	• Removal of the SAD after intubation adds potential of accidental extubation

ATI, awake tracheal intubation; ETT, endotracheal tube; RCTs, randomized controlled trials; SAD, supraglottic airway device.

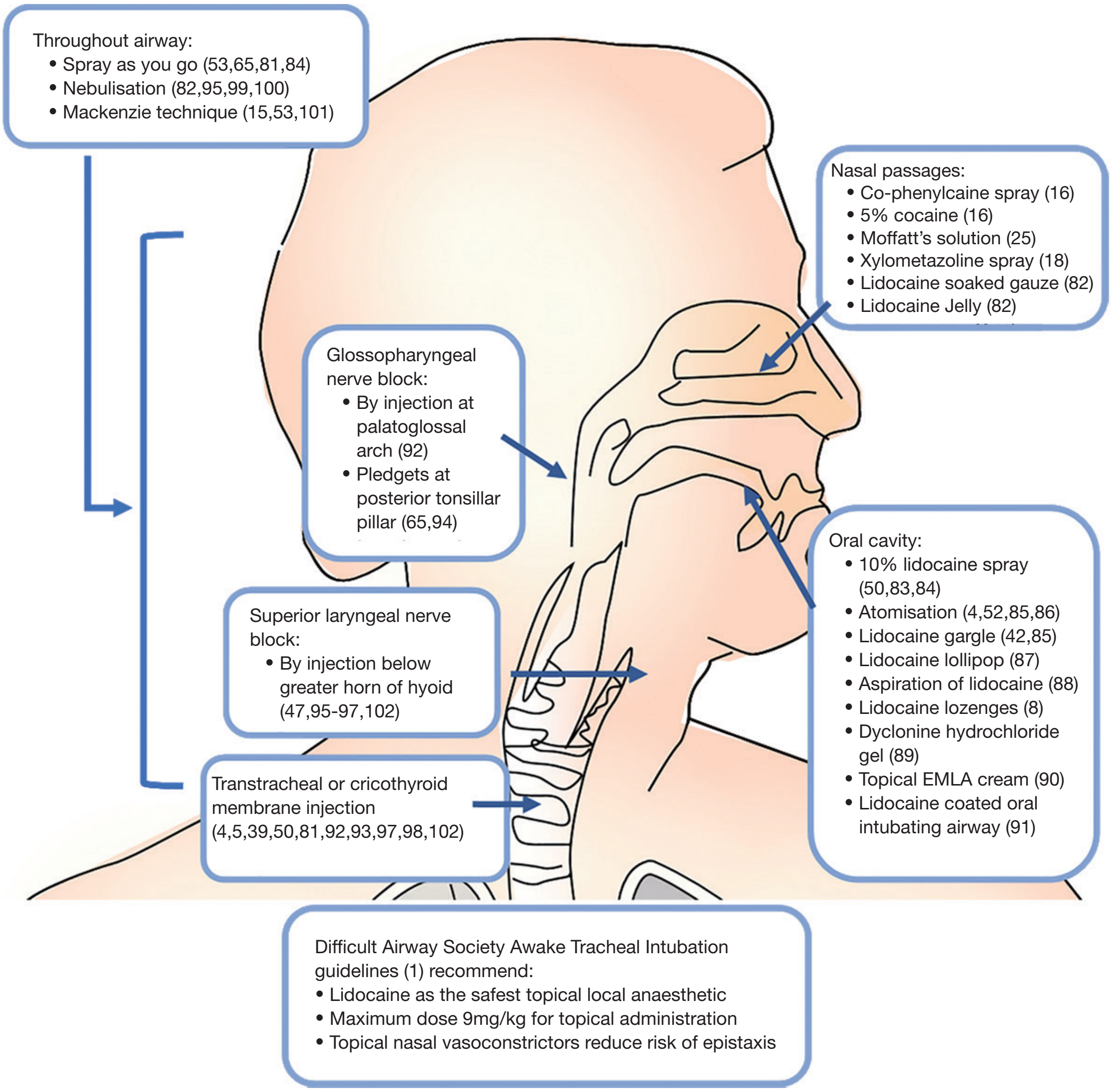

Figure 2 Methods described to apply local anaesthesia to the upper airways for the purpose of ATI (1,4,5,8,15,16,18,25,39,42,47,50,52,53)(65,81-102). Image created using a diagram published under Creative Commons CC0 1.0 Universal Public Domain Dedication. EMLA, eutectic mixture of local anaesthetics; ATI, awake tracheal intubation.

was performed with flexible bronchoscopy. There are no randomized studies comparing minimal local anaesthesia with full topicalization in terms of time to intubation, ease of performance and patient satisfaction and we found no studies using minimal local anaesthesia for AVL, optical stylets or SAD guided techniques.

Perhaps debate may be settled if the ideal sedative agent for ATI existed? This would be titratable, short acting with minimal residual effects and no active metabolites, anxiolytic, analgesic, antitussive and reduce airway reflexes without causing respiratory or cardiovascular depression. Such a drug is yet to be described.

Propofol and midazolam were frequently used Rai *et al.* compared propofol and remifentanil TCI (109). The remifentanil group had easier, quicker endoscopies and shorter intubation times. Propofol has been added to remifentanil for the purpose of amnesia (110), however Rai *et al.* found that higher recall in the remifentanl group did not affect patient satisfaction (109). It is effective as a sole sedative agent alongside local anaesthesia at effect site concentrations between 2 to 3.5 ng/mL (111,112) although studies describing minimal local anaesthesia techniques use higher concentrations of up to 5 ng/mL (107).

Dexmedetomidine is an alpha-2 agonist which produces sedative affects resembling natural sleep with preserved muscle tone, ventilation and the ability to obey simple instructions (113). It has been extensively described in ATI (108,114-116), and favourably compared to other sedatives including sufentanil (117,118), fentanyl (119), midazolam, propofol (120) and remifentanil (121,122). In comparison to remifentanil, dexmedetomidine requires a loading dose of 1 mcg/kg to be given over 10 minutes before starting a maintenance dose of 0.5–0.7 mcg/kg/h (121,122). This is slower than initiating a remifentanil TCI and could add to the perception that ATI is time consuming. In one case series the time to intubation was 25–37 minutes (115). Dexmedetomidine has been reported to achieve better endoscopy conditions, with less respiratory depression and desaturation but less anti-tussive than remifentanil (121). In one study the sedation scores with dexmedetomidine were higher those than with remifentanil (122) suggesting they were not being used to the same endpoint. This was also seen in comparison with other opiates (117) perhaps implying more sedation is required to achieve improved intubating conditions. Dexmedetomidine is also more likely to cause bradycardia than opiate sedation (117,120).

Although remifentanil is widely recommended (1), dexmedetomidine is the single most evaluated drug (13) and can reduce discomfort without increasing risks of airway obstruction, hypoxia or cardiovascular instability (120). It is already safely used in critical care so may have benefits over opiates in critically unwell patients where respiratory depression should be avoided (123). Remifentanil has recall rates of between 55% and 65% (106,112,121,122) whereas dexmedetomidine is lower between 30% and 34% (121,122). However, choosing dexmedetomidine for lower recall may not be clinically beneficial as there is no established link between recall of ATI and patient dissatisfaction (121).

Patient experience

Almost all aforementioned studies have looked at patient satisfaction or comfort in some capacity and found ATI to be acceptable in the majority. However, these are secondary outcomes and hence underpowered. Training programmes using course delegates as volunteers found they all reported AFOI with local anaesthesia only as acceptable with 54% reporting no pain and 46% reporting slight pain (17). However, these delegates were better informed than the average patient and extremely motivated as they valued the educational impact.

Our search identified two studies which looked at patient experience as a primary outcome. One questionnaire found 16.7% of patients feared the awake intubation prior to the procedure and 15% reported discomfort at the time. However, there were no long-term psychological sequelae (124). Knudsen *et al*. performed a qualitative study interviewing patients who had undergone ATI (125). They also found fear around the intubation, particularly the potential for coughing or gagging, and some described it as very painful. Most found it acceptable but being unable to talk during the procedure makes patients feel more vulnerable. This is improved by the anaesthetist maintaining eye contact in front of them, interaction and explanations throughout the procedure. Patients had differing views on the amount of information they wished to receive with some finding detailed explanations intimidating. Tailoring information to individuals and written information was helpful, as well as drawing comparisons with other common procedures such as gastroscopies (125). Knudsen *et al*.'s study is useful for any anaesthetist consenting for and performing ATI and can give confidence to clinicians who otherwise avoid it due to potential patient trauma.

Training and skill retention

Training in ATI is challenging due to a lack of suitable patients, particularly in centres without head and neck surgery, clinical time pressures and ethical considerations (17). In addition, mannikins are not realistic, have no secretions and require no communication skills (17). Most training schemes describe a gradual learning programme with progression described as follows (17,126,127):

(I) Theory based lectures;
(II) Observing procedures performed by others;
(III) Practising on mannikins or bronchoscopy models;
(IV) Performing nasendoscopy in a sedated patient or performing AFOI in a sedated patient with a normal airway;
(V) Performing AFOI in an awake patient or an awake volunteer.

These structured programmes show high success rates even amongst novices (126,127).

Advances in simulation technology has provided high fidelity task trainers such as the ORSIM^{TM} (Airway Simulation Limited, Auckland, New Zealand). This virtual reality simulator advances a replica bronchoscope through a desktop sensor whilst software provides a virtual airway through which the user navigates (128). In comparison to low fidelity trainers, ORSIM™ allows basic competence to be reached faster on the task trainer itself but this does not correlate to speed or quality of real-life intubations (128). Task trainers also do not require the railroading of an ETT and are useful only for AFOI not any other awake method. As other ATI techniques do not differ greatly between awake and asleep patients, training could focus on ensuring adequate airway topicalization and/or safe sedation.

A survey of anaesthetists in training in the UK and Ireland showed they believed competence could be achieved by performing 10 AFOIs and this should be as standard by completion of training (129). However, the median number performed across all training years was four and 93% had either already attended a course, or intended to do so, indicating the difficulty in achieving clinical experience. This study is now over 15 years old and it would be interesting to know if increases in videolaryngoscopy have reduced these numbers further or increased confidence in performing ATI.

Despite increases in co-morbidity, BMI and head and neck malignancies (130), the number of awake intubations is in decline and may not provide enough cases to gain or retain skills (11). Whilst simulators may help, anaesthetic trainees express concerns that it is unethical to perform ATI on patients without an indication (129). Given most patients tolerate ATI well there is a call to expand the indications to improve skill retention and therefore patient safety (29). These could include poor dentition, risk of hypotension, training purposes and BMI >35 kg/m^2 (29). Some studies have included obesity only as a risk factor for difficult airway (8,87,102). Whilst not our current practice this, alongside training purposes, could increase the scope of patients offered ATI and promote change in departmental culture, expertise and how safe intubation options are discussed and presented to patients.

Experience of ATI within our institution

Our centre is a regional oncological centre with both maxillo-facial and ear, nose and throat (ENT) surgical services providing emergency and elective care, including major head and neck cases. We perform at least 100 ATI annually when a difficult airway is anticipated. ATI is usually performed in cases where mouth opening is limited such as fractured mandible, dental abscess and Ludwig's angina. Or in cases with anticipated difficulty in effective face mask ventilation or intubation including but not limited to base of tongue or laryngeal tumours, previous radiotherapy or head and neck surgery.

We found the DAS ATI guidelines (1) provided an easy to follow checklist and practical approach of sedation, topicalisation, oxygenation and performance (STOP) to ATI which we have since adopted in our department. Sedation is commonly done utilizing TCI remifentanil, ideally managed by a second anaesthetist. With a second anaesthetist, the usage of an additional sedative agents such a midazolam or even propofol is safer and more manageable. Dexmedetomidine is currently not widely used in our centre, although we are aware of its increased use. Topicalisation is commonly achieved with either lidocaine 2% or 10%, usually administered via atomisation or the spray nozzle that comes with Xylocaine® 10 mg spray (Aspen, Dublin, Ireland). If the nasal route is used, co-phenylcaine (2.5 mL lidocaine 5%/phenylephrine 0.5%) spray is added. Nebulisation or transtracheal blocks are less commonly used. The adequacy of the topicalisation is then tested atraumatically before instrumenting the airway. HFNO is now commonly used for all ATI. We currently use the Ambu® aScope4 having moved on from the re-usable fibreoptic bronchoscope. We have both McGrath™ and GlideScope™ videolaryngscopes that we routinely use for asleep intubations as well as ATI. We agree that familiarity with these videolaryngoscopies is useful for ATI but the conduct and patient preparation for an awake technique still requires adequate training and practice.

With relatively high rates of ATI in our centre, we actively encourage our anaesthetic trainees to be involved in performing them under direct supervision. We also provide simulation and workshop teaching in ATI with the availability of ORSIM™. Importantly, apart from providing training in its performance, emphasis is also given in management of complications and unsuccessful ATI according to national guidelines (1).

Limitations

This narrative review was conducted with articles written in English only and initial results reviewed by one author. In addition, our search strategy only included procedures performed on awake patients. Whilst this ensured relevance to our initial aims some sections may be improved by inclusion of data on asleep individuals, such as quality of disposable videoscopes or training methods. Publication bias results in a high incidence of successful procedures, particularly amongst case reports and case series which are less likely to publish failed attempts.

Conclusions

Despite a potential decline in its use, ATI is still a mandatory skillset to any anaesthetic department (10) and should be taught with the same rigour as a rapid sequence induction (29). Advances in both asleep and awake airway management have been equally matched by an increasingly complex and comorbid population, making ATI as relevant as when it was first described. Heterogenous studies means there are still questions over the safest technique and protocol. In particular we have identified a lack of robust evidence surrounding reusable versus single use flexible bronchoscopes, despite increasing uptake of the latter. No studies confirm or refute that minimal anaesthesia and higher sedation is less safe or less tolerated than protocols recommended by international guidelines (1,103) and awake VAFI may combine the benefits of both AFOI and AVL and retain both these skills, but needs further exploration beyond case series. It should also be acknowledged that most experimental studies described are in the elective setting resulting in no clear evidence relating to the emergency anticipated difficult airway. Readers should appreciate that, even following international consensus, failure rates may be higher in this group and we would emphasize the importance of seeking out additional expertise if time allows and communicating the airway plan in the case of failure with the whole multidisciplinary team prior to starting.

The range of techniques we have described goes beyond other guidelines (1) or meta-analyses (12,13) and should mean every anaesthetic department could perform ATI using familiar equipment. Consideration of patient experience should inform perioperative consent and conduct of the procedure. Who these procedures are offered to should be balanced by the need for skill retention and training as well as patient safety and acceptance. In addition, awareness of international guidelines (1,103) and consideration of human factors should be used to empower clinicians to always make the safest choice when managing the difficult airway.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the Guest Editors (Chris Jones and Bhavesh Patel) for the series "Anaesthesia for Maxillofacial Surgery" published in *Journal of Oral and Maxillofacial Anesthesia*. The article has undergone external peer review.

Reporting Checklist: The authors have completed the Narrative Review reporting checklist. Available at https://joma.amegroups.com/article/view/10.21037/joma-23-17/rc

Peer Review File: Available at https://joma.amegroups.com/article/view/10.21037/joma-23-17/prf

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at https://joma.amegroups.com/article/view/10.21037/joma-23-17/coif). The series "Anaesthesia for Maxillofacial Surgery" was commissioned by the editorial office without any funding or sponsorship. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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doi: 10.21037/joma-23-17
Cite this article as: Gostelow N, Yeow D. Awake tracheal intubation: a narrative review. J Oral Maxillofac Anesth 2023;2:27.