Airway Management Guidelines: An Overview

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Difficult airway can be predicted and seldom remembered, but failed airway can be experienced and never forgotten.

Abbreviations

AEC	Airway Exchange Catheter
AIDAA	All India Difficult Airway Association
APA	Association of Pediatric Anesthetists
ASA	American Society of Anesthesiologist
ATI	Awake tracheal intubation
BURP	Backward, upward, rightward pressure
CAFG	Canadian Airway Focus group
CICO	Can't intubate, can't oxygenate
CPAP	Continuous positive airway pressure
CVF	Complete ventilation failure
DAA	Difficult airway algorithm
DAS	Difficult Airway Society
ECG	Electrocardiogram
ECMO	Extracorporeal membrane oxygenation
ED	Emergency department
eFONA	Emergency front of neck access
$eTCO_2$	End tidal carbon dioxide
ETT	Endotracheal tube
FeO_2	Fraction of oxygen in the expired gas
FICM	Faculty of Intensive Care Medicine
FRC	Functional residual capacity
HFNC	High flow nasal cannula
HFNO	High flow nasal oxygen
HME	Heat and moisture exchanger
i.v.	Intravenous
ICS	Intensive Care Society
ICU	Intensive care unit
LMA	Laryngeal mask airway
NAP4/5	Fourth/Fifth National Audit Project
NIBP	Noninvasive blood pressure
NIV	Noninvasive ventilation
OAA	Obstetrics Anesthetist's Association
OR	Operating room
PACE	Probe, alert, challenge, emergency
PAPR	Powered air purifying respirators
PEEP	Positive end expiratory pressure
PPE	Personal protective kit
PUMA	Project for universal management of airways
RCoA	Royal College of Anesthetists
RSI	Rapid sequence induction

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SAD	Supraglottic airway device
SpO_2	Oxygen saturation
THRIVE	Transnasal Humidified Rapid Insufflation Ventilatory Exchange
WAMM	World Airway Management Meeting
WHO	World Health Organization

1 Introduction

Guidelines were developed to overcome the deficiencies in clinical care due to regional, institutional, and individual variations and inconsistencies due to differences in educational, socioeconomic, and cultural factors across the globe [1]. First difficult airway algorithm was published by American Society of Anesthesiologists (ASA) in 1993 and subsequently updated in 2003 and 2013 [2]. The 4th National Audit Project (NAP4) led to the development of several guidelines by Difficult Airway Society (DAS) following the identification of different factors contributing to adverse outcome following airway management [3]. Several other professional organizations also published airway management guidelines, independently or in association with other related professional bodies.

All India Difficult Airway Association (AIDAA) published the first Indian national guidelines for unanticipated difficult airway scenarios in adults [4], in obstetrics [5], pediatrics [6], critically ill patients [7], and extubation guidelines [8]. Most recently, the AIDAA guidelines for managing airway in COVID-19 patients were also published [9].

Project for Universal Management of Airways (PUMA) aims to reflect the consensus of existing published airway guidelines that can be applied to all episodes of airway care, without any geographical limitations, clinical discipline, and context. It was approved in the World Airway Management Meeting (WAMM) of 2019 [10].

2 Vortex Approach (VA)

Described as a "high acuity implementation tool," objective of the vortex approach is to reduce "cognitive overload" by helping in decision-making during an airway crisis [11]. Resulting transition from the primary failed airway technique to the emergency life-saving technique is more effective in preventing hypoxia and death. An inverted funnel with color-coded zones as shown in Fig. 17.1 makes the learning more effective. The color and shape of the funnel helps the clinician to develop, execute, and change the plans real time, based on the improvement and deterioration in oxygenation [12]. The sloping surface of the funnel

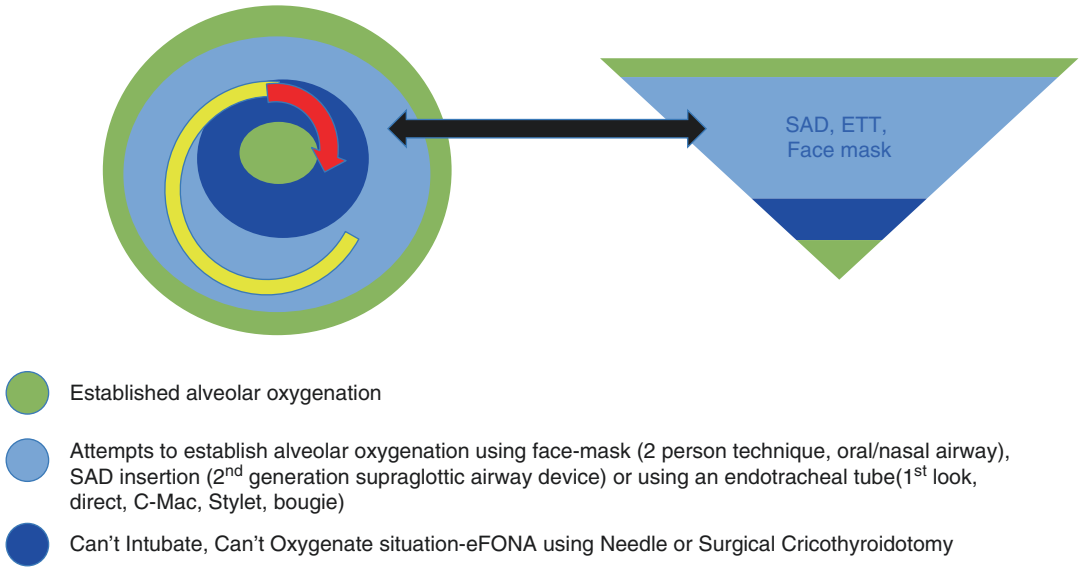

Fig. 17.1 Essence of vortex approach to the management of airway

denotes an unstable situation and emphasizes on proceeding forward to establish oxygenation. The top most green zone represents the safe zone where alveolar ventilation is achieved by three attempts of noninvasive techniques, either an endotracheal tube (ETT), second generation supra glottic airway device (SAD) or face mask as represented by a light blue color in the next zone. Fourth attempt with each device by an expert is permitted. The darker blue color represents "cannot intubate-cannot oxygenate" (CICO) situation causing hypoxia and cyanosis, which warrants emergency front of neck access (eFONA) to establish alveolar ventilation and is depicted in the central green zone of the funnel [12].

3 Transition in Airway Management

Concept of transition involves a parallel process of consecutive unsuccessful attempts of securing the upper airway along with preparation for eFONA [13]. This system significantly minimizes the time interval during the transition, reducing hypoxia as shown in Fig. 17.2. This is opposed to the tradi-

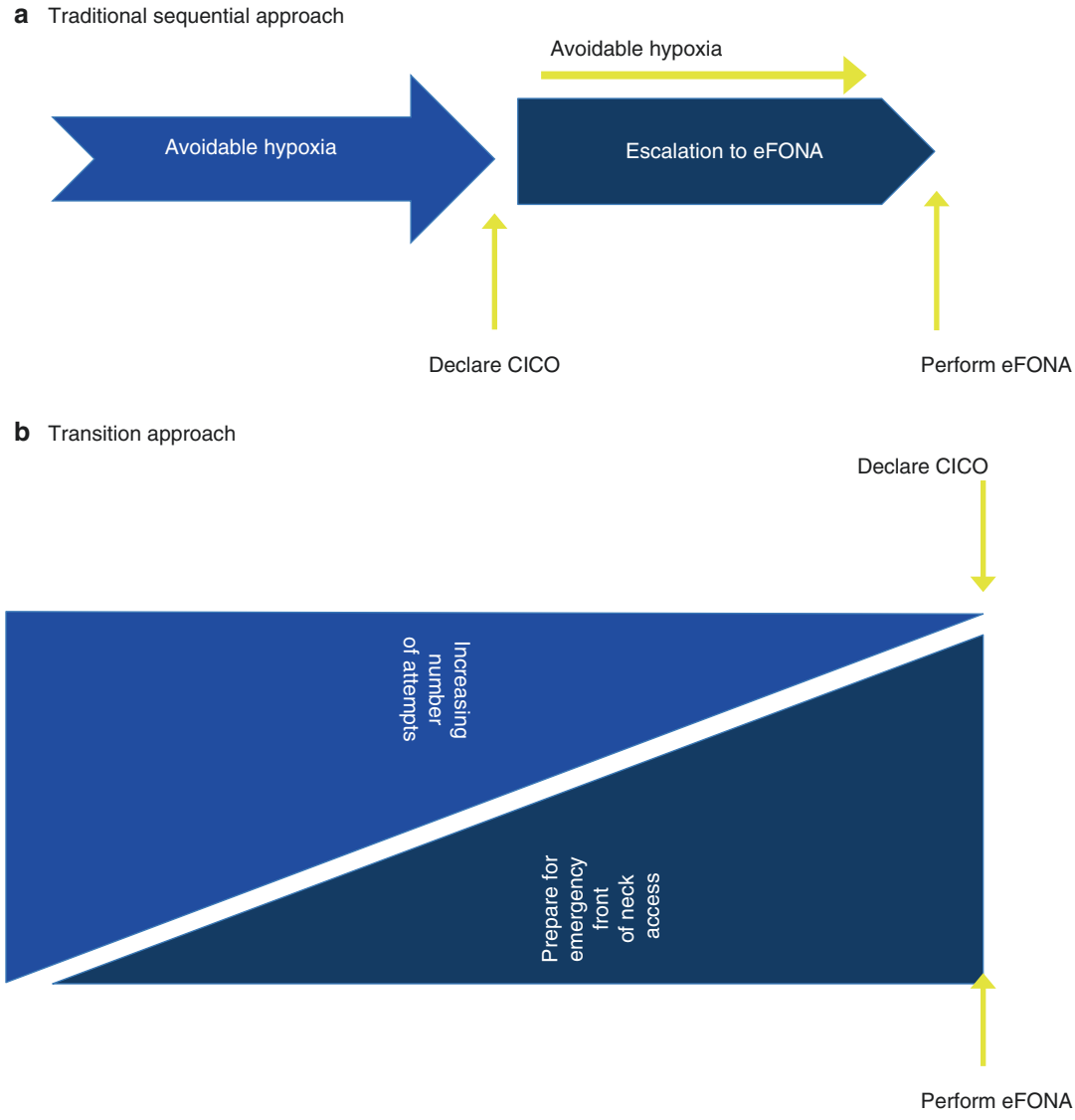

Fig. 17.2 Schematic representation of concept of transition in airway management [13]

tional system of declaring CICO and then preparing for invasive techniques. The steps included in transition are prevention of unnecessary FONA, Priming which involves both technical and psychological preparation for performing eFONA, Permission, i.e., willingness of the team to accept role of eFONA and Performance of the eFONA.

4 Various Guidelines

The important guidelines for airway management in various clinical scenarios and patient characteristics were formulated by the concerned organizations and are summarized in Table 17.1.

Table 17.1 Various organizations and their important guidelines

Organization	Guidelines	Year
Difficult airway society (DAS)	Basic algorithm for extubation	2012
	Extubation guidelines-low risk algorithm	2012
	Extubation guidelines-at risk algorithm	2012
	Guidelines for management of difficult mask ventilation during routine induction of anesthesia in a child aged 1–8 years	2012
	Guidelines for management of unanticipated difficult tracheal intubation—during routine induction of anesthesia in a child aged 1–8 years	2012
	Guidelines for management of cannot intubate, cannot ventilate (CICV) in a paralyzed anesthetized child aged 1–8 years	2012
	Difficult intubation guidelines-overview	2015
	Management of unanticipated difficult tracheal intubation in adults	2015
	Failed intubation, failed oxygenation in the paralyzed, anesthetized patient	2015
	Master algorithm for obstetric general anesthesia and failed tracheal intubation	2015
	Safe obstetric general anesthesia algorithm	2015
	Obstetric failed tracheal intubation algorithm	2015
	Obstetric can't intubate, can't oxygenate algorithm	2015
	Guidelines for tracheal intubation of critically ill patients	2017
	Awake tracheal intubation guidelines	2019
	Consensus guidelines for managing the airway in patients with COVID-19	2020
All India Difficult Airway Association (AIDAA)	AIDAA Guidelines for the Management of Unanticipated Difficult Tracheal Intubation in Adults	2016
	AIDAA Guidelines for the Management of Unanticipated Difficult Tracheal Intubation in Obstetrics	2016
	AIDAA Guidelines for the Management of Unanticipated Difficult Tracheal Intubation in Pediatrics	2016
	AIDAA Guidelines for Tracheal Intubation in the Intensive Care Unit	2016
	AIDAA Guidelines for the Management of Anticipated Difficult Extubation	2016
	AIDAA consensus guidelines for airway management in the operating room during the COVID-19 pandemic	2020
Canadian Airway Focus Group (CAFG)	Anticipated difficult tracheal intubation	2013
	Difficult tracheal intubation encountered in an unconscious patient	2013
American Society of Anesthesiologists (ASA)	Practice Guidelines for Management of the Difficult Airway	2003
	Practice Guidelines for Management of the Difficult Airway-Updated Report	2013

4.1 Unanticipated Difficult Airway (UADA) in Adults

Primary objective is to maintain oxygenation in failed intubation and secondary objective is to decide next course of action. Both technical and non-technical skills are important. DAS (2004, 2015) [14], AIDAA (2016) [4], and CAFG [15] guidelines are available for management of UADA.

4.1.1 DAS Guidelines for Adult Unanticipated Difficult Airway

Recognition and declaration of difficult airway, emphasis on decision-making capabilities during an airway emergency and limiting the number of attempts while maintaining oxygenation through the procedure are given priority in this algorithm. Important components are algorithms for (a) overview of DAS difficult intubation guidelines, (b) unanticipated difficult intubation in adult patient, and (c) failed intubation and failed oxygenation in a paralyzed adult patient.

Algorithm 1: Overview

This algorithm consists of steps of transition and directions for management of failed first attempt laryngoscopy and intubation as shown in Fig. 17.3. Sequence is divided into Plan A, B, C, and D as shown in Fig. 17.3. Plan A is the straightforward facemask ventilation and intubation. If intubation fails declare failed intubation and proceed to Plan B, where the priority is to maintain oxygenation by inserting an SAD. If oxygenation is adequate with SAD, the clinician should "Stop and Think" to initiate the next set of options. If SAD ventilation fails, Plan C follows with the final attempt of facemask ventilation after adequate neuromuscular blockade to prevent hypoxia and if successful, waking up the

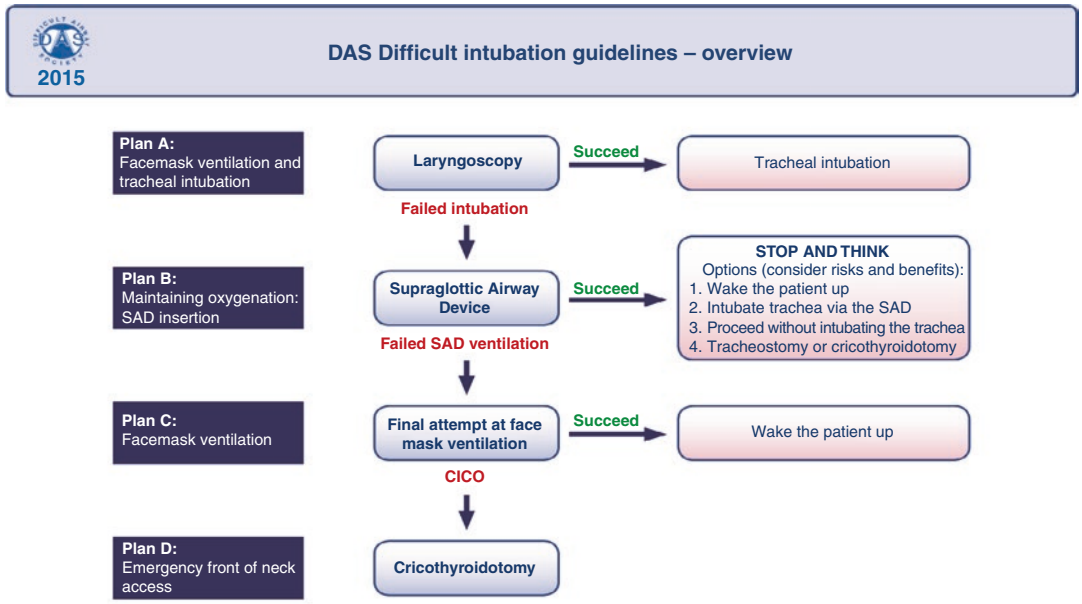

Fig. 17.3 Overview of difficult intubation guidelines from DAS. (Reproduced with permission from Difficult Airway Society, UK)

patient is the best option. If failed, Plan D is the emergency surgical airway to prevent hypoxia. The components of each plan are optimized for individual clinical situations in the subsequent specific algorithms.

Algorithm 2: Management of Unanticipated Difficult Intubation in Adults After Induction of Anesthesia

It describes the plan A, B, C, D of overview algorithm with descriptions of the factors which affect the success at each stage as shown in Fig. 17.4.

Plan A is about optimal mask ventilation and intubation. Call for help with the first indication of difficult airway. Key features include maintenance of oxygenation in the form of preoxygenation and apneic oxygenation techniques, head up and ramping position, use of neuromuscular blockers, videolaryngoscope, bougie, limiting the number of attempts to three and fourth by an experienced colleague, external laryngeal manipulation (ELM), and removal of cricoid pressure if required. It is not the number of attempts, but the clinical situation, which is the primary factor. The choice between direct and videolaryngoscope depends on the skill of the operator and availability of the device. When this stage is considered as successful use capnography, fiberscope, videolaryngoscope or ultrasound to confirm tracheal intubation. If failed, declare failed ventilation and proceed to Plan B.

Plan B is about maintaining oxygenation and ventilation with maximum three attempts of SAD insertion, preferably two with the second-generation device and another with the alternative, attempt also includes change in size. Second generation SAD is ideal to prevent gastric insufflation. If SAD is adequate to maintain oxygenation, four options can be considered beginning with waking up the patient (reversal with sugammadex) if surgery is not urgent, intubation through the SAD using fiberoptic bronchoscope (FOB), continua-

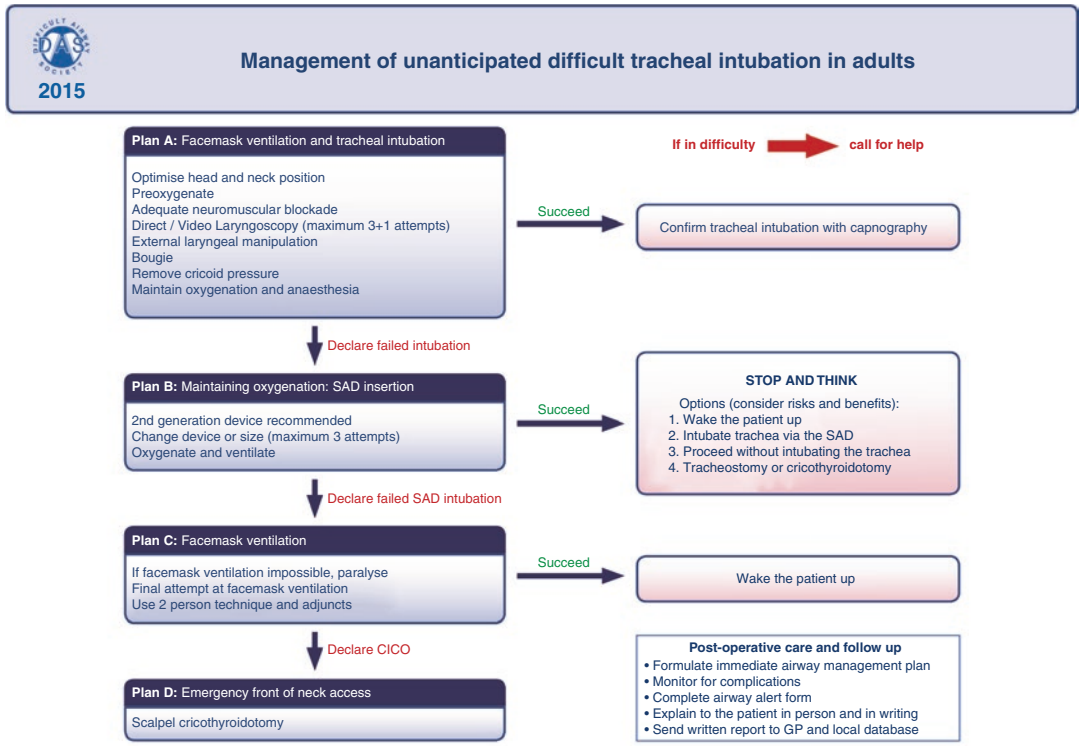

Fig. 17.4 DAS guidelines for management of unanticipated difficult tracheal intubation in adults. (Reproduced with permission from Difficult Airway Society, UK)

tion of the surgery with the SAD and a semi-elective or urgent surgical airway. If unsuccessful, declare failure of SAD ventilation, which increases the level of danger and Plan C, is initiated.

Plan C involves efforts to oxygenate by optimizing facemask ventilation with two-person ventilation, with aids such as airway if required and with a dose of muscle relaxant. Objective is to maintain oxygenation while considering the options of waking up (if mask ventilation is successful or after reversal with sugammadex) or surgical airway. Failed mask ventilation at this stage is considered as "cannot intubate cannot oxygenate" and is life threatening which warrants proceeding to Plan D.

Plan D is establishing immediate emergency front of neck access to the airway. Scalpel cricothyroidotomy and placement of a wide-bore cuffed tube for low-pressure ventilation with standard breathing system is the preferred technique.

Algorithm 3: Failed Intubation, Failed Oxygenation in the Paralyzed, Anesthetized Patient

This is about management of CICO with eFONA as shown in Fig. 17.5, the recommended technique being the scalpel cricothyroidotomy with description of equipment and technique in easy and difficult anatomy. Emphasis is also on main-

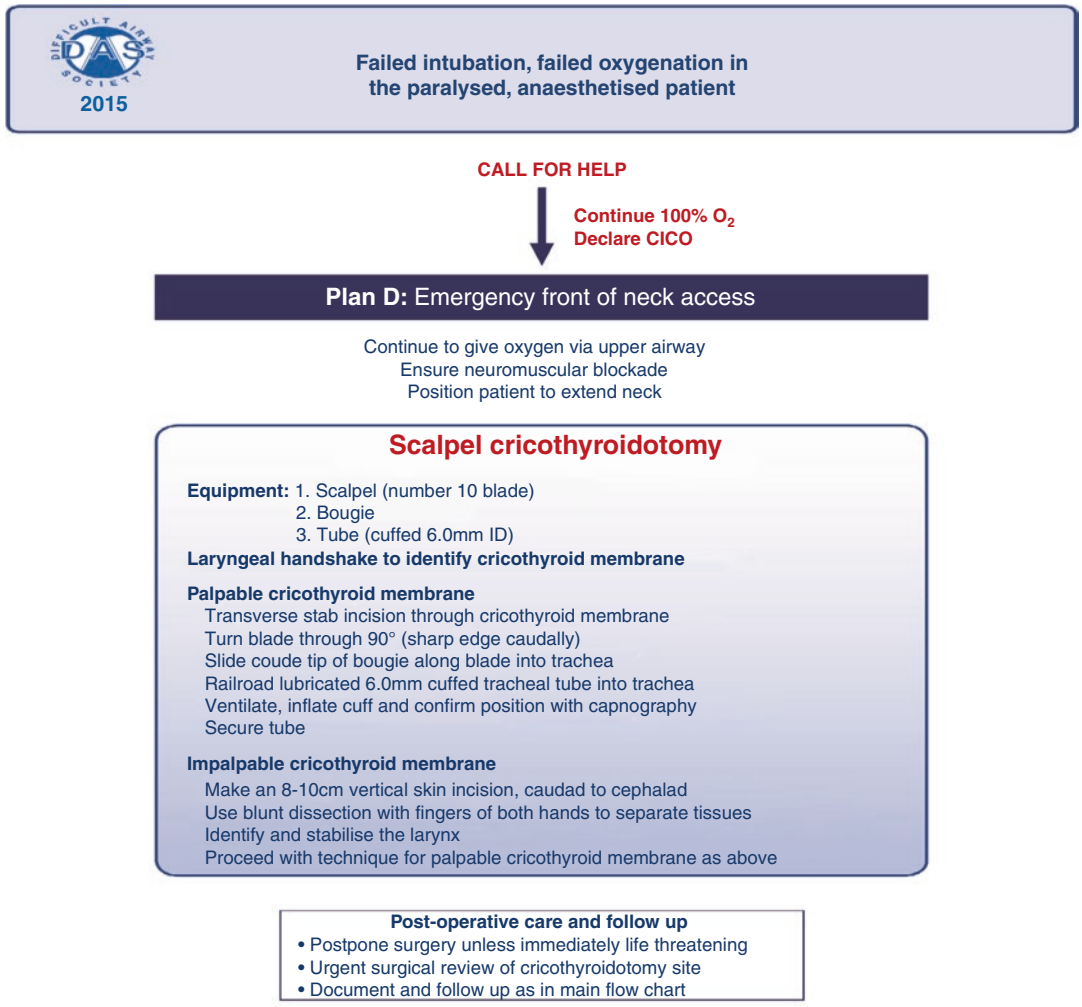

Fig. 17.5 DAS guidelines for failed intubation and failed oxygenation in paralyzed, anesthetized patients. (Reproduced with permission from Difficult Airway Society, UK)

taining oxygenation during preparation and performing eFONA, with oxygen administration through upper airway with mask or SAD, optimizing position and muscle paralysis if appropriate.

Algorithm ends with postoperative and follow-up care, the components of which are decision on whether securing airway is imminent, formulating the immediate airway management plan, monitoring for complications, information to patient, documentation and completion of airway alert form, and necessary legal formalities including reporting of the incident.

Important features of DAS algorithm for unanticipated difficult intubation scenarios are as follows:

1. Role of human factors such as judgment, communication, teamwork, and cognitive impairment are responsible for success of airway management. Also included is the communication tool, PACE, which stands for probe, alert, challenge, and emergency.
2. Preoperative assessment of the patient is the corner stone of explanation/discussion with patient, team preparation, aspiration risk assessment and prophylaxis and team preparation.
3. Positioning appropriate to patient profile like head up in obese patients will prevent early hypoxia.
4. Preoxygenation and preparation for apneic oxygenation such as Nasal Oxygen during attempts of Securing the Tube (NODESAT) and Transnasal Humidified Rapid–Insufflation Ventilatory Exchange (THRIVE) will delay onset of hypoxia.
5. Role of muscle paralysis and prevention of awareness.
6. Description of each step included in algorithm such as external manipulation, direct and video laryngoscope, airway aid, and release of cricoid pressure.
7. Details of supraglottic airway device related recommendations, recommendations for intubation through SAD and hazards of continuing with SAD without intubation.
8. Confirmation of endotracheal intubation with capnography and other signs.
9. Standardization of surgical airway technique for ease of training and execution.
10. Recommendation for simulation-based training.

4.1.2 AIDAA Guidelines for Adult Unanticipated Difficult Airway

The algorithm consists of four steps, 1–4 with progressively increasing difficulty as shown in Fig. 17.6. All through the procedure of securing the airway, nasal oxygen is continued using oxygen flow at 15 L/min, depth of anesthesia is maintained, and mask ventilation attempts are continued.

Highlights of AIDAA guidelines for unanticipated difficult airway in adults are as follows:

1. Inclusion of continuous positive airway pressure (CPAP) and pressure support ventilation (PSV) along with THRIVE for pre and per oxygenation to prolong the safe apnea period.
2. Direct or videolaryngoscope can be used depending on the availability or skill of the operator.
3. Intubation through SAD is recommended only with fiberoptic endoscope guided or with Aintree Intubation Catheter.

4. Choice of surgical airway is left to discretion of the clinician.
5. Early conversion of cricothyroidotomy to surgical airway is recommended.
6. Post-procedure, complete airway examination and monitoring for late airway complications are recommended.
7. Recommendation for the contents of difficult airway cart and guidelines for its maintenance.
8. Standard difficult airway alert form will be helpful for future references.

Step wise approach of AIDAA guidelines are as follows [4].

Step 1: After initial failed attempt of intubation with direct or videolaryngoscope, two more attempts are permitted provided oxygen saturation (SpO_2) remains more than 95%. In between every attempt, consider change in plan, person, position, device, adjuncts, and technique. If successful, confirm intubation-using capnogram. If unsuccessful, declare failed intubation, maintain depth of anesthesia, and proceed to Step 2. Call for help at the first sign of difficulty in securing the airway.

Step 2: Insertion of second generation SAD for maintaining oxygenation with a maximum of

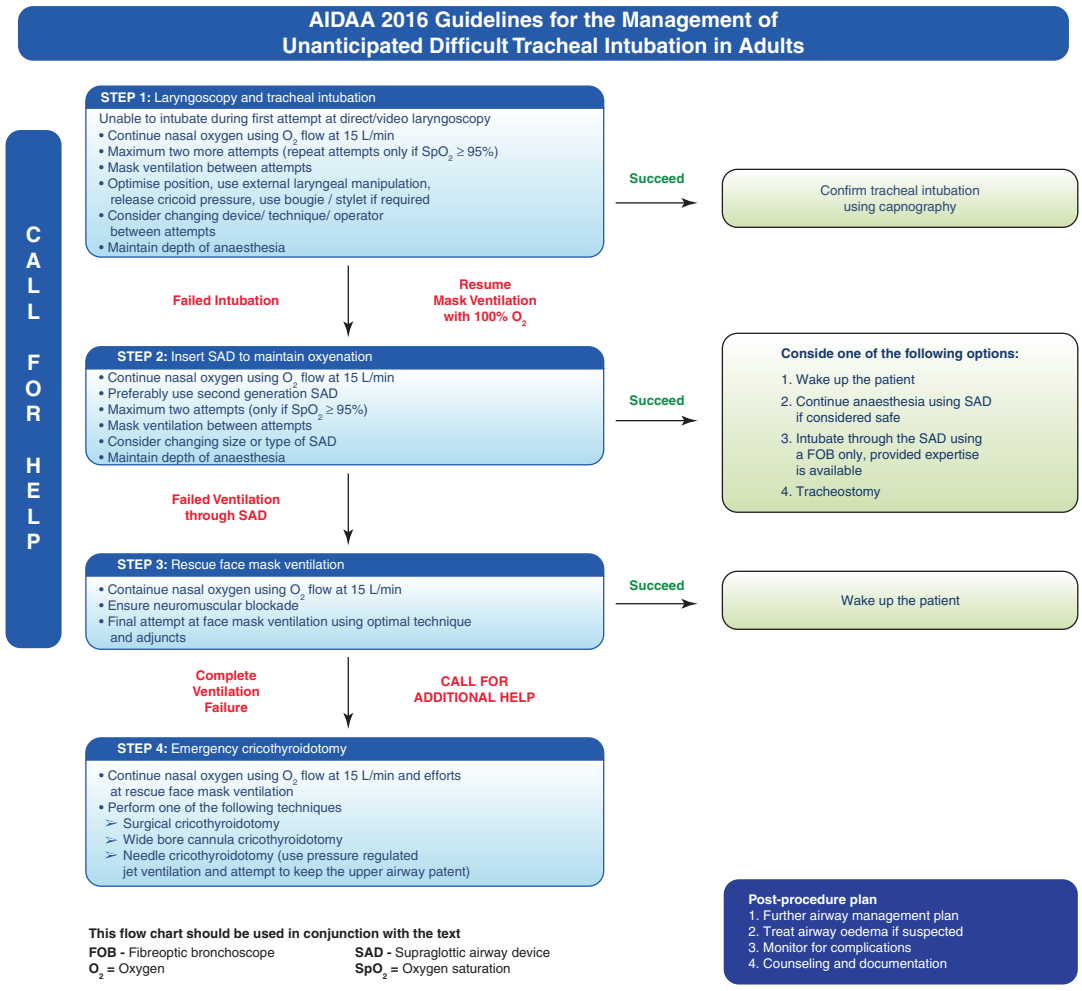

Fig. 17.6 AIDAA guidelines for Adult Unanticipated Difficult Airway. (Reproduced with permission from AIDAA, India)

two attempts if $SpO_2 > 95\%$. Change in size and type of SAD for the second attempt is recommended. If successful, the following options should be considered; waking up the patient, proceed with surgery using SAD, fiberoptic-guided intubation through SAD, and initiation of surgical airway. If unsuccessful, declare failed ventilation through SAD and proceed to Step 3.

Step 3: Rescue technique of facemask ventilation with 100% oxygen with adequate muscle relaxation should be attempted. If successful, waking up can be considered after reversal of relaxants. If unsuccessful, complete ventilation failure (CVF) is declared, where intubation, ventilation using facemask, and SAD have all failed (CICO situation) despite maintaining oxygenation. This is the last crucial relatively safe window period during which if the surgical access is established hypoxia related complications can be prevented. Call for additional help and proceed to Step 4.

Step 4: Emergency cricothyroidotomy, either needle, wide bore or surgical cricothyroidotomy can be performed based on familiarity and availability of equipment.

4.1.3 Canadian Airway Focus Group Guidelines for Unanticipated Difficult Airway

CAFG guideline for unanticipated difficult airway was published in 2013 [15]. Salient features of this guideline are, (1) if oxygenation is maintained with SAD or mask ventilation after first attempt of unsuccessful conventional intubation, then second attempt is with a different device or operator, which if unsuccessful must proceed to exit strategy and (2) if oxygenation has failed after first attempt, proceed to emergency FONA.

4.2 Guidelines for Anticipated Difficult Airway Management in Adults

Preprocedural preparation for the planned procedure in terms of device, technique, personal, and drugs is very essential for the successful airway management where difficulty is anticipated. A thorough history, physical examination, and evaluation form the cornerstone for framing the structured action plan for airway management.

4.2.1 ASA Guidelines for Difficult Airway Management in Adults

ASA guidelines adopted in 2012 for the management of difficult airway has been revised and published in January 2022 [16]. An international task force of anesthesiologists representing several anesthesiology, airway, and other medical organizations, developed these guidelines. It focuses on management of difficult airway pertaining to difficult mask ventilation, tracheal intubation, or supraglottic airway placement during procedures requiring general anesthesia, deep sedation, moderate sedation or regional anesthesia or elective airway management without a procedure.

Important highlights of ASA algorithm are as follows:

1. Considerations for awake airway management are prioritized as a part of difficult airway management strategy.
2. Equipment required for standard and advanced airway management has to be updated.
3. Noninvasive and invasive approaches should be considered for difficult airway management.
4. Confirmation of tracheal intubation is by using capnography.
5. Emphasis is on the duration and number of attempts required to provide oxygen using different devices and techniques during difficult airway management.
6. Robust recommendations for the extubation of difficult airway are provided.
7. New algorithms and info graphics for adult and pediatric difficult airway management are provided.

ASA recommendations for:

(a) Evaluating the airway-the ASA recommendations for evaluating the difficult airway ensure the person responsible for airway management performs the airway risk assessment. This includes assessment for risk of aspiration, physical evaluation and using ultrasound, endoscopy, virtual laryngoscopy/bronchoscopy or three-dimensional printing.
(b) Preparation for difficult airway management include availability of airway management equipment in the room, a portable storage unit for management of difficult airway is immediately available and skilled individual to assist airway management is present when required. Proper positioning of the patient with supplemental oxygen throughout the process of airway management including extubation and ASA standard basic anesthesia monitoring is essential.
(c) Recommendations for anticipated difficult airway management depends on the surgery, anticipated condition of the patient, patient co-operation/consent, age of the patient, and the skills of the anesthesiologist. Identify the strategy for awake intubation, adequately ventilated but difficult to intubate intubations, difficulty in both ventilation and intubation, and difficulty with securing invasive airway. Attempt awake intubation when there is a risk of aspiration, difficult ventilation, patient is incapable of tolerating short periods of apnea and securing emergency invasive airway is difficult. Induction of general anesthesia may be required in pediatric/uncooperative difficult airway patients. Before attempting difficult airway intubation, prioritize invasive and non-invasive approaches, identifying the important airway devices that can be sequentially used for securing the airway. Invasive approaches should be dealt with expertise and an option for alternate invasive approach. If all options fail, extra corporal membrane oxygenation (ECMO) has to be initiated at the earliest.
(d) Recommendations for unanticipated and emergency difficult airway management include call for help, optimize oxygenation, use of algorithm or cognitive aid, maintenance of spontaneous breathing, options of non-invasive and invasive approach.
(e) Recommendations for extubation of the difficult airway include assessment of the patient's readiness for extubation and strategizing a plan for subsequent airway management if required and use of airway exchange catheter and/or SAD as a guide for extubation. Evaluate the risk benefit ratio of awake or extubation before the return of consciousness, use of supplemental oxygen, and consider any clinical factors that could adversely impact ventilation following extubation.
(f) Recommendations for follow-up care include the use of steroids or racemic epinephrine in the post-extubation period, information to the patient or attenders regarding the difficulty in securing the airway and documentation of the same.

4.2.2 DAS Guidelines for Awake Tracheal Intubation

DAS guidelines for awake tracheal intubation were published in 2019 as a comprehensive document to support decision-making, preparation and decrease the threshold for awake tracheal intubation (ATI) [17]. Awake tracheal intubation is the process of placing a tracheal tube in an awake, spontaneously breathing patient often with a flexible fiberoptic bronchoscope or videolaryngoscope. Elaborate preparation of the patient, operating room and the team, communication with the team are the key factors to reduce the complications. Counseling about the technique of airway anesthesia and endotracheal intubation along with prior administration of mild anxiolytic or sedative will relieve patient anxiety. Consent for the procedure is vital. Oxygenation in the form of high flow nasal oxygen is beneficial. Airway topicalization is the important step in ATI. Various techniques like mucosal atomization, spray as you go (SAYGO), transtracheal injection, nebulization, and individual nerve blocks with lidocaine up to a maximum dose of 9 mg/kg is recommended [18] Nasal vasoconstrictors prior to nasal intubation has to be

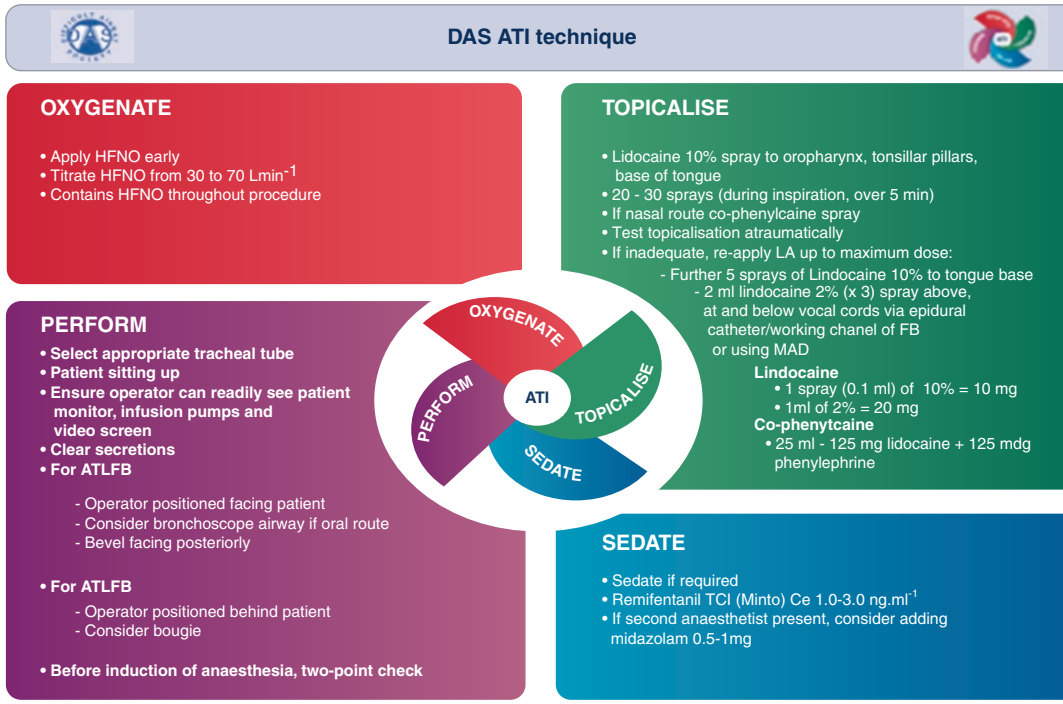

Fig. 17.7 Components of DAS Awake tracheal intubation. (Reproduced with permission from Difficult Airway Society, UK)

applied. Antisialogogues is not an essential component but has the advantage of providing better vision. Safer drugs for sedation are the combination of midazolam and remifentanil (both are reversible) or dexmedetomidine [19].

Components of ATI (sTOP, Fig. 17.7) Sedation (s), Topicalization, Oxygenation, and Performance. Sedation is optional, based on clinical judgment. All the components should be optimized before the first attempts, total number of attempts three, and one more only by experienced anesthesiologist. SGAD can be utilized as a conduit for intubation.

Plan for extubation in these patients is based on the assessment of the airway at the end of procedure. Preparation and performing extubation as per the DAS guidelines and clinical judgment [20] will reduce the complications.

Complications and management due to each of the components of ATI are as follows:

Oxygenation: clear secretions, reduce/reverse sedation, increase inspired oxygen concentration (FiO_2), change mode of oxygen delivery system.

Topicalization: maximum dose of lidocaine used should be restricted to 9 mL/kg and preparedness for local anesthesia systemic toxicity (LAST) management is very essential.

Sedation: if there are signs of oversedation, consider specific antagonist like naloxone.

Performance: limit the number of attempts to 3 + 1, call for help immediately when there are signs of difficult airway, consider change of route, size, and type of airway gadget in between attempts

Management of unsuccessful ATI is depicted in Fig. 17.8.

Unsuccessful attempt of ATI is defined as unplanned removal of flexible bronchoscope,

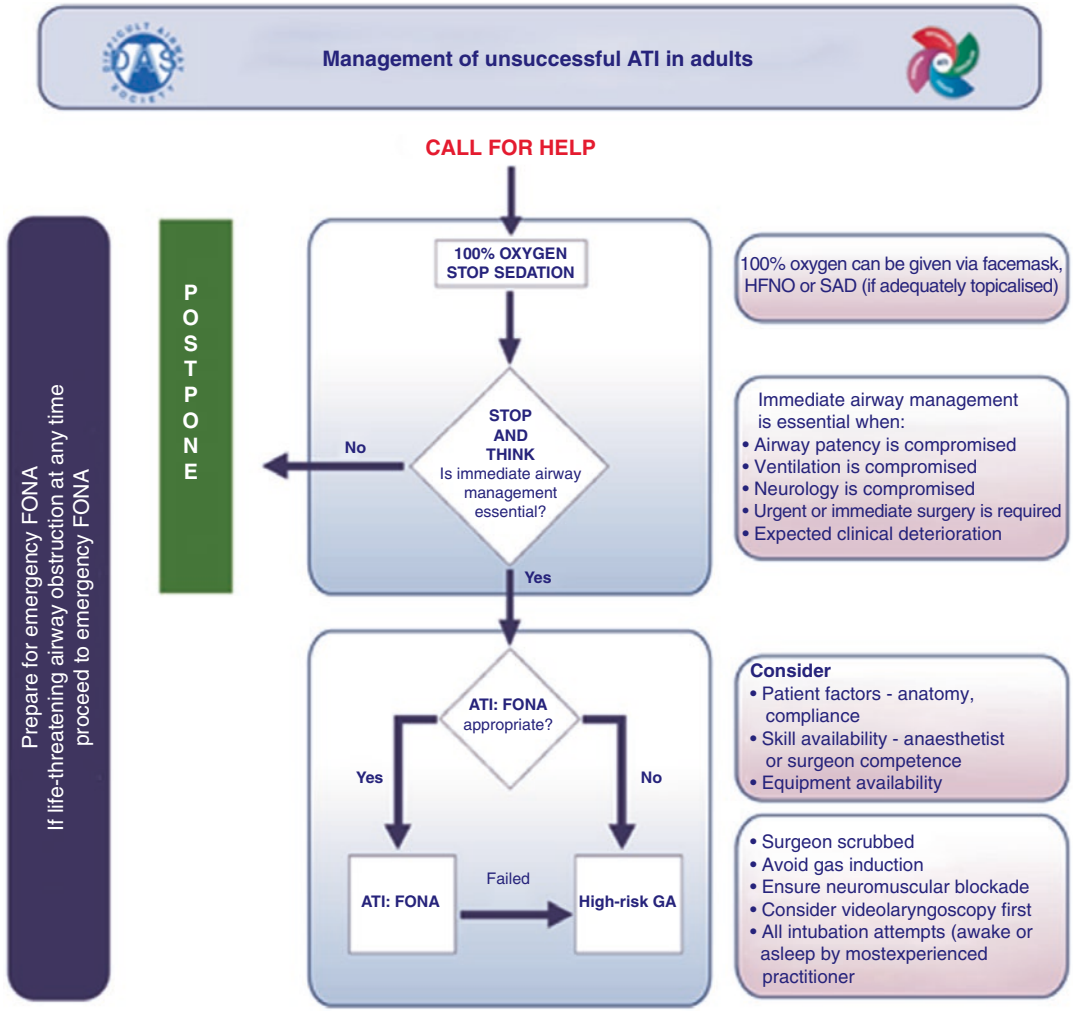

Fig. 17.8 DAS algorithm for management of unsuccessful ATI in adults. (Reproduced with permission from Difficult Airway Society, UK)

videolaryngoscope or tracheal tube from the airway [17] and also if tracheal intubation is not achieved in three plus one attempt. Failed ATI is managed by eFONA during which oxygenation should be actively maintained by facemask, high flow nasal oxygen (HFNO) or SAD (after topicalization). Indications for immediate airway management are clinical deterioration of airway patency, ventilation, or neurological status or when indication for surgery is urgent or immediate. If general anesthesia (GA) has to be administered for FONA, after failure of ATI, ensure adequate neuromuscular blockade, first attempt being with videolaryngoscope. Documentation of the ATI approach and complications is necessary to guide future management. Training in the technical aspects of ATI is essential for managing the airway efficiently [21, 22].

Key features of DAS awake tracheal intubation are as follows:

1. A checklist is essential before and during ATI.
2. Supplemental oxygen has to be continued through the procedure.

3. Sedation not to be used as a substitute for inadequate airway topicalization.
4. Number of attempts limited to three and fourth attempt by an experienced operator.
5. Anesthesia to be induced only after confirming correct tracheal tube position.

4.3 Airway Guidelines in Obstetrics

The anatomical and physiological changes during pregnancy can significantly contribute to converting a normal airway into a difficult airway. Failed intubation, hypoxia, risk of aspiration, and awareness are the most important complications. Regional anesthesia is considered as the safest option for obstetric anesthesia at present, but conversion to general anesthesia may be a necessity at any time [23]. However, maternal safety is the priority and the guidelines for securing the airway in obstetrics aim at prevention of maternal fatalities.

Preparation and Airway Management

Appropriate aspiration prophylaxis is provided, which includes fasting and medications to minimize the increased aspiration risk due to delayed gastric emptying [5, 24]. Intravenous route is preferred if patient is in active labor [25]. Lateral tilt in non-obese patients and supine ramped up position (suprasternal notch in line with external auditory meatus) with 20–30° head up tilt in pregnant patients is ideal [26]. Preemptive neck ultrasound to identify the cricothyroid membrane (CTM) and marking of the same is suggested in difficult airway management [27]. Preoxygenation is mandatory to increased oxygen reserve to meet the increased demands. The goal is to achieve an end tidal oxygen concentration > 90% [28]. Tight fitting mask with >10 L/min of oxygen flow, nasal insufflation of oxygen at 5 L/min or use of THRIVE can be advantageous [29].

Propofol is the induction agent of choice to prevent the risk of awareness [30]. Rocuronium 1.2 mg/kg is preferred relaxant. Gentle facemask ventilation (inflation pressure < 20 cmH_2O) is indicated during rapid sequence induction to reduce desaturation and assess the ease of ventilation [31]. Videolaryngoscopes may be of great benefit in the obstetric population. The experience of the operator and the type of videolaryngoscope is of prime importance [32].

Training

Simulation based training is recommended for training residents in advanced techniques and devices for managing both routine and critical obstetric airway situations. Use of checklists and cognitive aids can improve standardization; teamwork and overall performance in times of crisis, which can significantly alter the course of airway management.

4.3.1 DAS Guidelines for Obstetrics

First obstetric failed intubation guideline was published by Tunstall in 1976 [33]. The Obstetric Anesthetist's Association (OAA)/DAS obstetric anesthesia difficult airway group was formed in 2012 with representatives from both organizations and the guidelines were formulated in 2015 [34]. Certain important considerations in the DAS guidelines help in the easier and safer management of airway.

Key features of OAA/DAS guidelines are:

1. Communication of the methods adapted to secure the airway should be shared with the teammates as elective case may be converted to emergency.
2. Oral route is preferred for elective awake FOB guided intubation to prevent epistaxis.
3. Preoxygenation and apneic oxygenation, rapid sequence induction, use of propofol, and suxamethonium or

rocuronium are the key steps for success.
4. Videolaryngoscopes should be used as first line laryngoscopes during RSI [23].
5. Maximum of two intubation attempts, third attempt by an experienced colleague is preferred.

The master algorithm of obstetric airway management as shown in Fig. 17.9 comprises of three specific algorithms that include obstetric general anesthesia, failed tracheal intubation, and "Can't Intubate, Can't Oxygenate" situation which are separately explained in Figs. 17.10, 17.11, and 17.12, respectively.

Algorithm 1/Safe Obstetric General Anesthesia Algorithm

Poor view of the larynx in the first attempt should lead to immediate measures to improve the view in the next by making changes in position and laryngoscopic blades, readjusting or release of cricoid pressure. Procedure should be abandoned with Cormack–Lehane grade 3b or 4. Blind insertion of airway aids or devices is not recommended. Use of bougie and change in the tube size is commended. Correct placement of ETT should be confirmed by capnogram, auscultation, and fiberoptic or ultrasound confirmation.

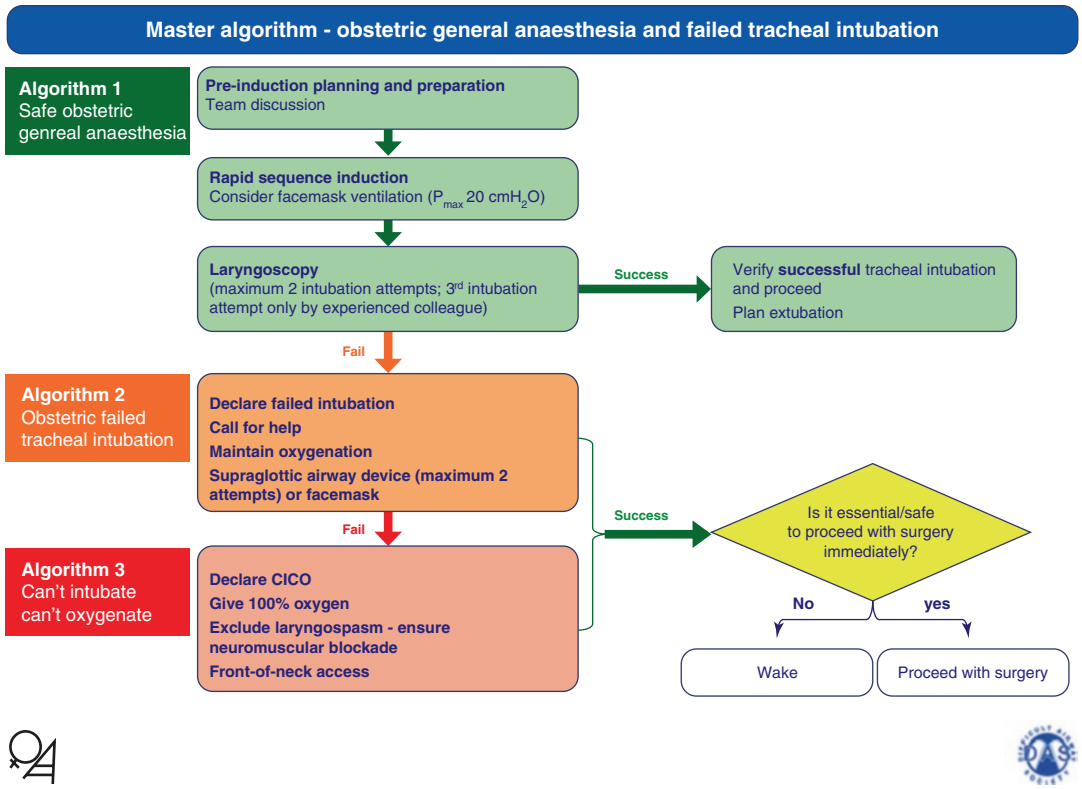

Fig. 17.9 DAS master algorithm of obstetric general anesthesia and failed tracheal intubation. (Reproduced with permission from Difficult Airway Society, UK). (© Obstetric Anaesthetists' Association/Difficult Airway Society (2015))

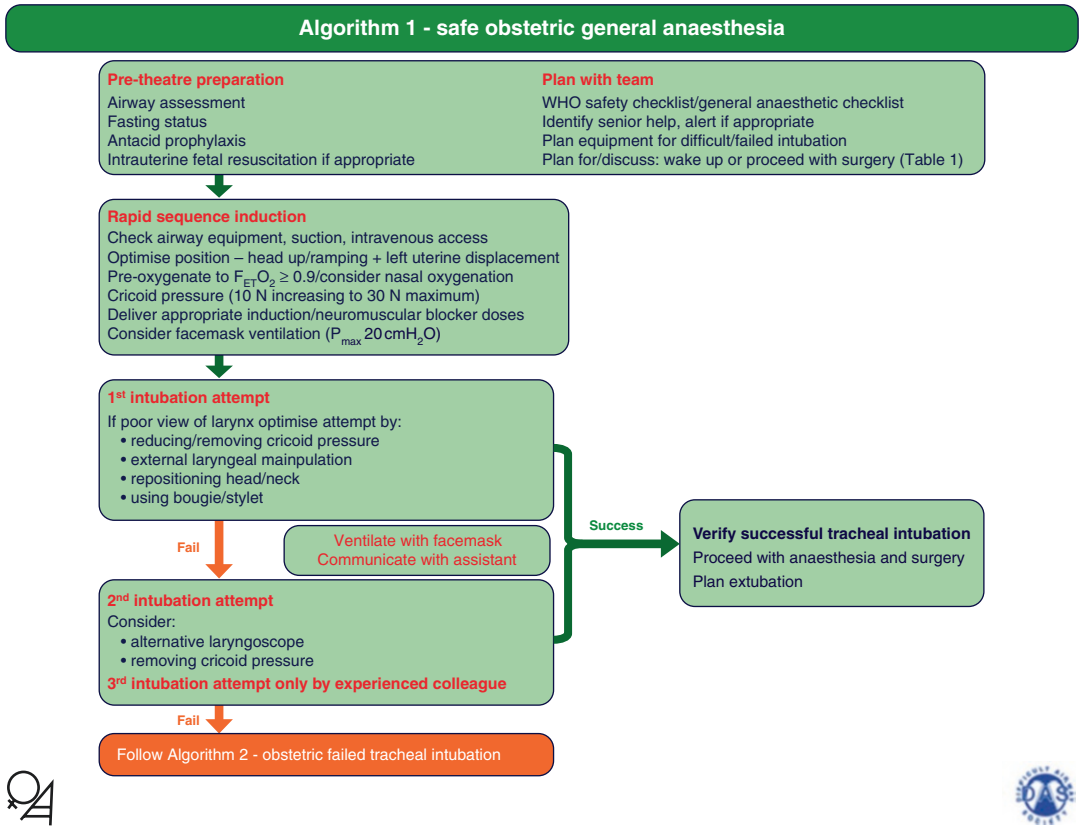

Fig. 17.10 DAS Algorithm 1—safe obstetric general anesthesia algorithm. (Reproduced with permission from Difficult Airway Society, UK). (© Obstetric Anaesthetists' Association/Difficult Airway Society (2015))

Algorithm 2/Obstetric Failed Tracheal Intubation Algorithm

Key recommendations are communication to the team including neonatologist regarding failed intubation and face mask ventilation (with oral airway if needed) or second generation SGAD for oxygenation and ventilation. Maximum 2 attempts are permitted for SGAD insertion and change of the type or size should be considered for the second attempt. Gastric aspiration through the drain tube and better airway seal for positive pressure ventilation are the major advantages of second-generation SAD [35]. Cuff pressure should never exceed 60 cmH_2O [36].

Algorithm 3: Can't Intubate, Can't Oxygenate and Front of Neck Access

If oxygenation is not improved with face mask or SGAD, laryngospasm and poor chest compliance should be ruled out and rocuronium can be administered. Continuing desaturation should lead to declaring "can't intubate, can't oxygenate" and arrangements have to be made immediately for front of neck access. Scalpel cricothyroidotomy over needle technique is recommended due to the speed and reliability. At this stage, maternal cardiac arrest is imminent and cardiac life support measures should be initiated. Perimortem cesarean section within 5 min

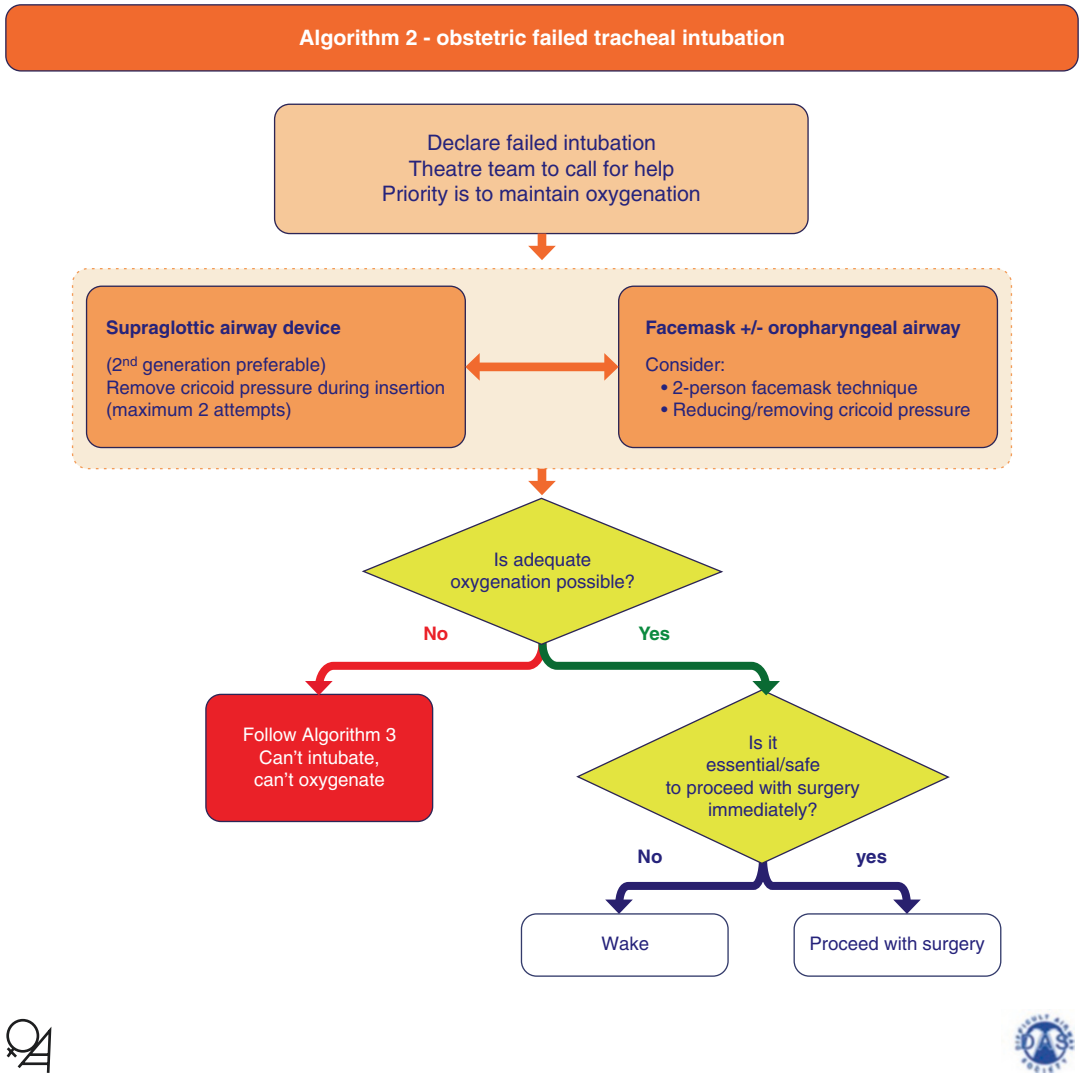

Fig. 17.11 DAS Algorithm 2—obstetric failed tracheal intubation. (Reproduced with permission from Difficult Airway Society, UK). (© Obstetric Anaesthetists' Association/Difficult Airway Society (2015))

of cardiac arrest is the last available option if there is an undelivered fetus >20 weeks of gestation [37].

To wake up or proceed with surgery is a decision based on the clinical judgment and consensus by the whole team, capability, and skill of the attending anesthesiologist and the situation at that point of time has to be considered as given in Table 17.2.

Figure 17.13 gives an outline of the management of the patient after a failed intubation attempt.

If surgery is imminent with a fully awake patient, awake intubation using a fiberoptic scope, videolaryngoscope [38], or direct laryngoscope after airway topicalization is the choice. Regional anesthesia with a back-up plan for high or failed block should be formulated. Tracheostomy is the only option for extreme

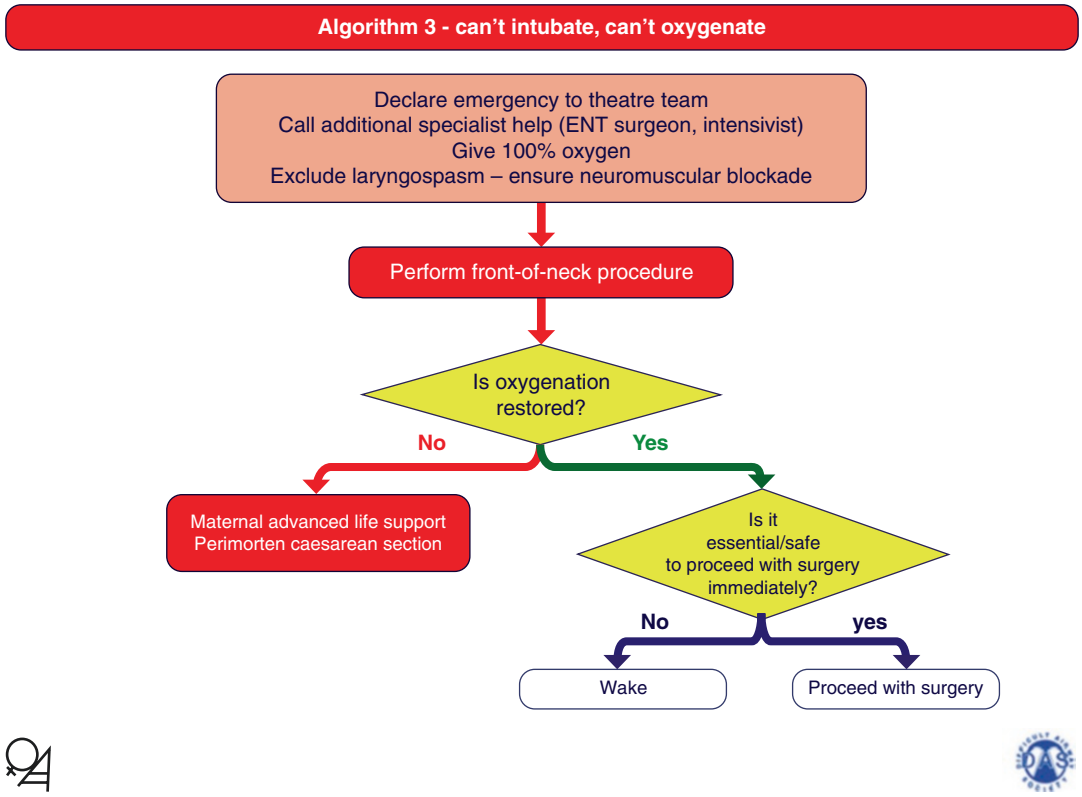

Fig. 17.12 DAS Algorithm 3—Can't Intubate, Can't oxygenate. (Reproduced with permission from Difficult Airway Society, UK). (© Obstetric Anaesthetists' Association/Difficult Airway Society (2015))

Table 17.2 Decision to awaken the patient or proceed with the surgery

	Wake	Proceed
Factors responsible prior to induction of anesthesia		
Maternal factors	No compromise	Hypovolemia requiring emergency surgery
		Critical cardiac or respiratory compromise
		Cardiac arrest
Fetal condition	No compromise	Sustained bradycardia
		Fetal hemorrhage
		Suspected uterine rupture
Anesthesiologist	Novice	Consultant/specialist
Obesity	Super morbid	Normal
Surgical factors	Complex surgery or anticipated major hemorrhage	No risk factors
Aspiration risk	Recent food intake	Fasting
		Aspiration prophylaxis
		Not in labor
Alternative regional or awake intubation	Not anticipated	Absolutely contraindicated or has failed
		Surgery has started
Factors responsible after failed Intubation		
Airway device/ventilation	Difficult face-mask ventilation and FONA	Second generation SAD
Airway hazards	Laryngeal edema and stridor	None evident

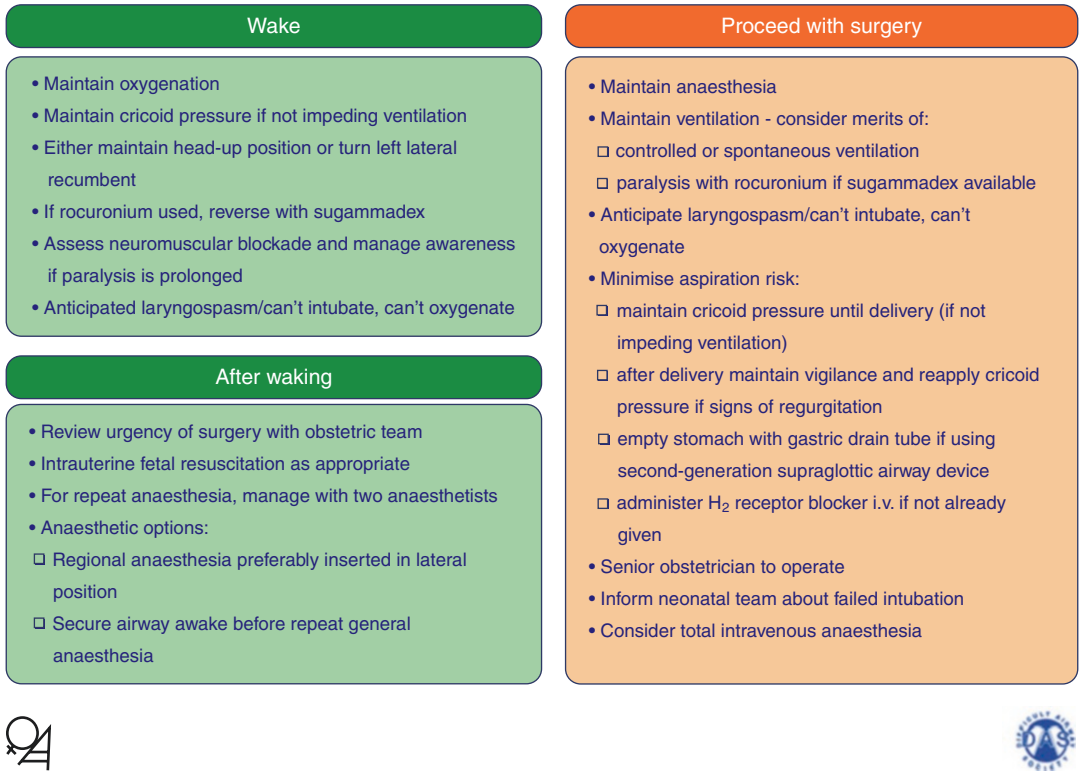

Fig. 17.13 DAS recommendations for patient management after failed intubation in obstetrics. (Reproduced with permission from Difficult Airway Society, UK). (© Obstetric Anaesthetists' Association/Difficult Airway Society (2015))

cases where securing the airway through other means is impossible. Communication and documentation of the difficulties in securing the airway, its complications, management, and the outcomes to prevent future complications is important along with follow-up and debriefing.

4.3.2 The AIDAA Obstetric Airway Guidelines

The AIDAA guidelines published in 2016 provide a comprehensive approach to obstetric anesthesia [5] as shown in Fig. 17.14.

Key points of the AIDAA obstetric airway guidelines include:

1. Detailed preanesthetic airway evaluation including the cricothyroid membrane in the third trimester of pregnancy and at the onset of labor.
2. Nasal oxygen at 15 L/min during all the steps of securing the airway.
3. Thiopentone sodium 3–5 mg/kg, propofol 2 mg/kg or etomidate 0.2–0.3 mg/kg for induction with suxamethonium 1.5 mg/kg or rocuronium 1.2 mg/kg for muscle relaxation is beneficial.
4. Gentle mask ventilation during classical rapid sequence induction (RSI) also termed as modified RSI using small tidal volume breaths (adjustable pressure valve limiting valve closed to <20 cmH_2O).
5. Cricoid pressure can be released in a graded manner when the tidal volume

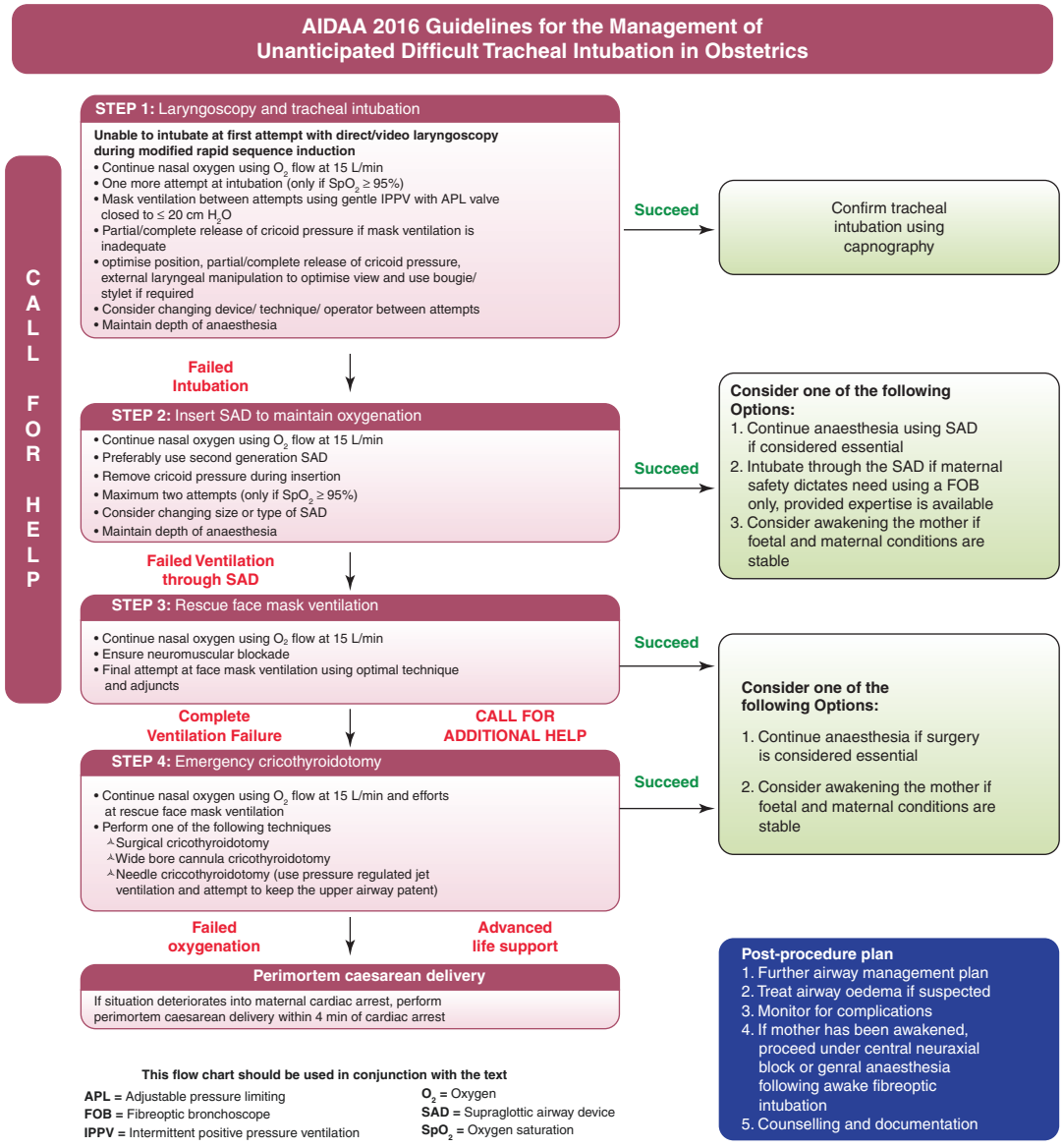

Fig. 17.14 AIDAA obstetric airway guidelines. (Reproduced with permission from AIDAA, India)

generated is inadequate, vision of the laryngeal inlet is distorted or inability to negotiate the laryngoscope, SAD or endotracheal tube to its optimal position [6].

6. Limiting the number of intubation attempts to two before proceeding to the next step.
7. SpO_2 of equal to or more than 95% is a cut off for escalating airway interventions.
8. Airway alert card, which includes the airway difficulty encountered, and the subsequent management and outcome should be handed over to the patient and relatives.

Step 1: This step emphasizes on recognition of difficult airway problem, "Call for help" and attempt to reoxygenate with bag-mask ventilation, the pressure limiting valve set at ≤20 cmH_2O and "two-hand, two-person" technique. Oral and nasopharyngeal airways can be used and cricoid pressure can be gradually released to provide better ventilation. Good ventilation enables the clinician to attempt laryngoscopy for the second time by correcting the position of the head and neck and use of different sizes, blades, and bougies [39]. A videolaryngoscope is better used for the second attempt as it also helps in rectifying the cricoid pressure applied externally by the assistant through direct visualization in the monitor. Confirm intubation-using capnography. Failure of two attempts of intubation results in "failed intubation" and should proceed to Step 2.

Step 2: Two attempts of second-generation SGAD placement are allowed by decreasing the pressure on cricoid cartilage if required. If successful and surgery is urgent, it can be proceeded with SGAD. Intubation through SGAD under fiberoptic guidance is attempted following delivery of the fetus if there is maternal hemorrhage, imminent seizures, and high risk for aspiration. If unsuccessful, then "failed ventilation through supraglottic airway device" is declared and proceed to Step 3. If there is no emergency, awaken the mother and plan for regional anesthesia technique or awake fiberoptic intubation.

Step 3. Facemask ventilation is tried after a dose of muscle relaxant along with other airway adjuncts like nasopharyngeal/oropharyngeal airway, which if fails is termed "complete ventilation failure" subsequently proceed to Step 4.

Step 4. FONA is the only option with the aid of expert assistance either in the form of surgical cricothyroidotomy, wide-bore cannula cricothyroidotomy, or needle cricothyroidotomy. Failure to secure the airway by FONA can potentially lead to cardiac arrest.

Perimortem cesarean section attempted within 4 min of maternal cardiac arrest may enhance the chances of fetal survival provided maternal chest compressions and left lateral tilt is continued by multiple teams and the fetus is >20 weeks of gestational age [40].

If Step 3 and 4 are successful, consider continuing the surgery with the SAD in situ or wake up the patient if it is not an emergency.

Post-procedure plan includes plan regarding further airway management, treat airway edema if present, monitor for complications. Consider regional anesthesia or awake fiberoptic intubation if surgery is emergency and counseling and documentation.

4.4 Airway Guidelines for the Management of Pediatric Difficult Airway

Due to the various anatomical and physiological properties in children, hypoxia and hemodynamic deterioration occurs at a faster rate when compared to adults [41]. The reported incidence of unexpected difficult airway is very low [42]. Laryngospasm is an important functional cause of adverse airway event hence the rationale for advocating the use of muscle relaxant in algorithms is "cannot (mask) ventilate-paralyze!" [43]. Early recognition of known risk factors and proper preparation can prevent and reduce the complications during airway management in children [42]. The options during pediatric airway management are facemask, SAD or tracheal tube for airway device and spontaneous or positive pressure ventilation. Availability of resources such as appropriate gadgets, personnel, and monitors is very essential.

4.4.1 Difficult Airway Society/ Association of Pediatric Anesthetist's (DAS/APA) Guidelines

The guidelines were specifically developed for specialists practicing pediatric airway management in the age group of 1–8 years as shown in Fig. 17.15. Extensive literature search, external reviews, and placing the guidelines on the Association of Pediatric Anesthetists (APA) [44] website for critical acclaims were the methods

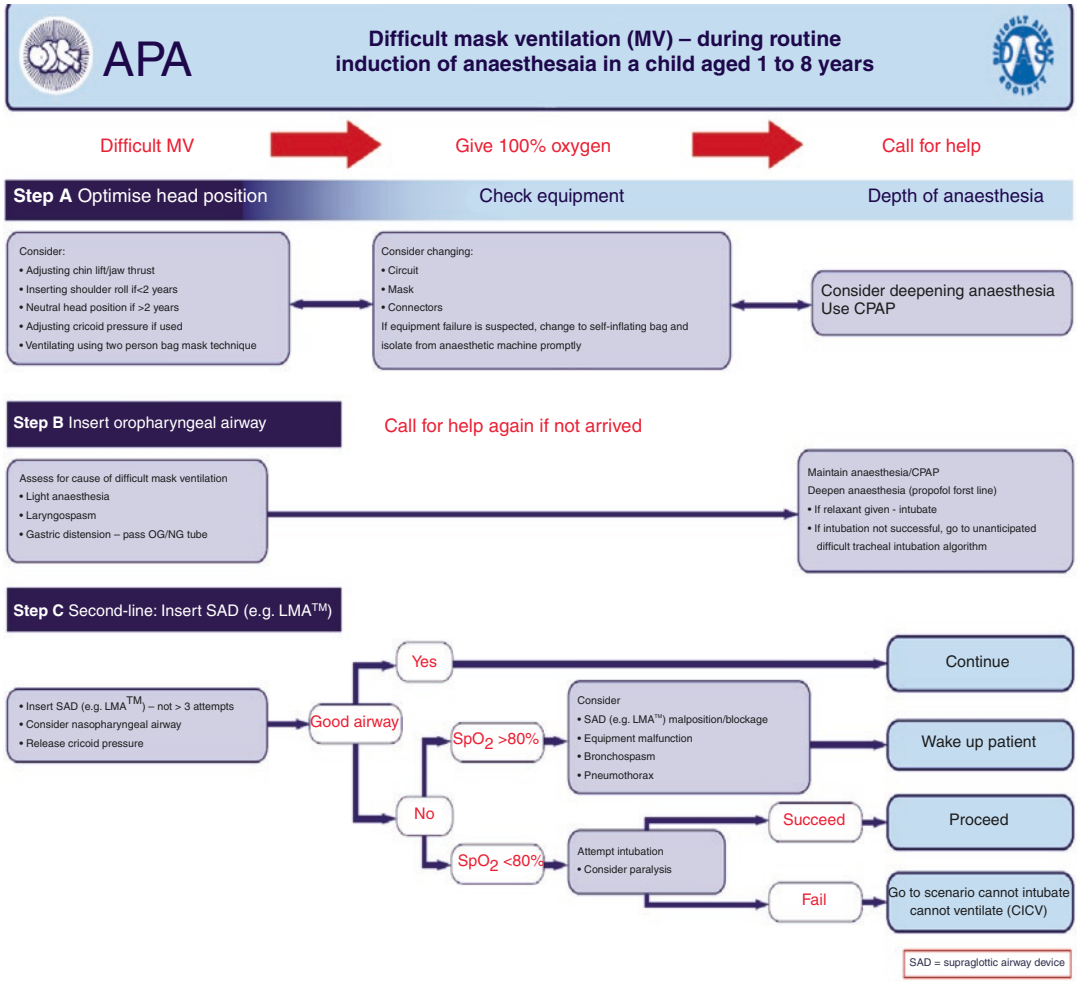

Fig. 17.15 DAS/APA pediatric difficult mask ventilation guidelines during routine induction of anesthesia in children between 1 and 8 years of age. (Reproduced with permission from Difficult Airway Society, UK)

for formulating this stepwise approach along with RCoA in 2012. Greater emphasis is laid on maintaining oxygenation throughout the procedure so as to avoid hypoxemia induced bradycardia and cardiac arrest.

Anticipated Difficult Airway in Pediatrics

The experience of the anesthesiologist in managing difficult pediatric airway, the availability of required gadgets, airway aids, and the benefit/risk ratio of the proposed surgery in anticipated difficult airways determine the outcome. The Anesthesia Practice in Children Observational trial (APRICOT trial) of Europe and Pediatric Difficult Airway Registry (PeDIR) of USA found an increased incidence of difficult airway in infants and increased respiratory events in children with more than three intubation attempts [45].

If mask ventilation is not possible, chin lift-jaw thrust maneuver and use of airway aids like oral/nasopharyngeal airways and SGAD should be considered. Adequate depth of anesthesia should be ensured. Two-hand ventilation and continuous positive airway pressure may be required and, laryngospasm should be ruled out. Gastric distension should be relieved, suxamethonium may be considered depending on the clinical situation [46].

Recommendations for difficult laryngoscopy include repositioning of the head, change in laryngoscope blades, change of person, proper external laryngeal manipulation, neuromuscular blockade, use of videolaryngoscopes [47], SAD insertion, and oxygenation or two attempts of intubation using fiberoptic scope through SAD. Blind intubation through SAD is not recommended in children due to the risk of airway trauma. Difficulty in laryngoscopy and SAD insertion may call for nasal fiberoptic intubation if expertise is available. Pierre Robin syndrome warrants awake fiberoptic intubation in view of severe upper airway obstruction and increased risk of aspiration. Difficulty in laryngoscopy, SAD insertion, and nasal fiberoptic scopy signals for "can't intubate, can't oxygenate" situation and mandates surgical airway (preferably surgical tracheostomy in infants and small children, but surgical cricothyroidotomy in older children) using inhalational or intravenous anesthetic agents. Consider waking up the patient if surgery is not an emergency.

The newer approach to anticipated pediatric difficult airway is as follows:

1. In children <10 kg, who represent a major portion of difficult airway cases should have supplemental oxygen by nasal cannula, high flow nasal oxygen, THRIVE [48], modified nasal trumpet or SAD.
2. Direct laryngoscopy should be less than two attempts and early transition to advanced airway technique like videolaryngoscopy or fiberoptic scopy is recommended [49].
3. Videolaryngoscopes are found to be more useful in managing difficult airways [50].
4. Elective use of SAD in case of difficult ventilation or failed intubation, and fiberoptic intubation through the SAD is another option [50].
5. Oxygenation is the only goal and intubation is secondary.
6. If elective fiberoptic scopy is the only option for endotracheal intubation dexmedetomidine, ketamine, propofol, and inhalational agent like sevoflurane is useful for sedation.
7. Limit the number of tracheal intubation attempts to two.
8. Airway exchange catheters are a helpful tool prior to extubation.
9. A systematic review by Koers found no clear advantage between catheter-over-needle, scalpel, or other surgical techniques in the emergency pediatric airway, with all being associated with high complication rates [51].
10. Regular update and training with advanced gadgets and techniques is essential.

The Unanticipated Difficult Airway in Pediatrics

Difficult mask ventilation can be either due to equipment or patient factors. Patient factors are due to dynamic airway obstruction, which can be either supraglottic or infraglottic. Supraglottic obstructions are the easiest to treat, whereas laryngospasm can be relieved with continuous positive airway pressure (CPAP). Gastric decompression is the most effective and simpler means of maintaining oxygenation. Fiberoptic scope is ideal for placement of endotracheal tube through the SAD under vision. After failed direct laryngoscopy, common options include the use of videolaryngoscopy [52]. The subsequent management is shown in Fig. 17.16.

Number of direct laryngoscopy attempts should be limited to four and intubation attempts should be limited to three as multiple attempts will cause airway edema and worsen the crisis. Change of personnel, position, and equipment is recommended after unsuccessful first attempt of intubation along with external laryngeal manipu-

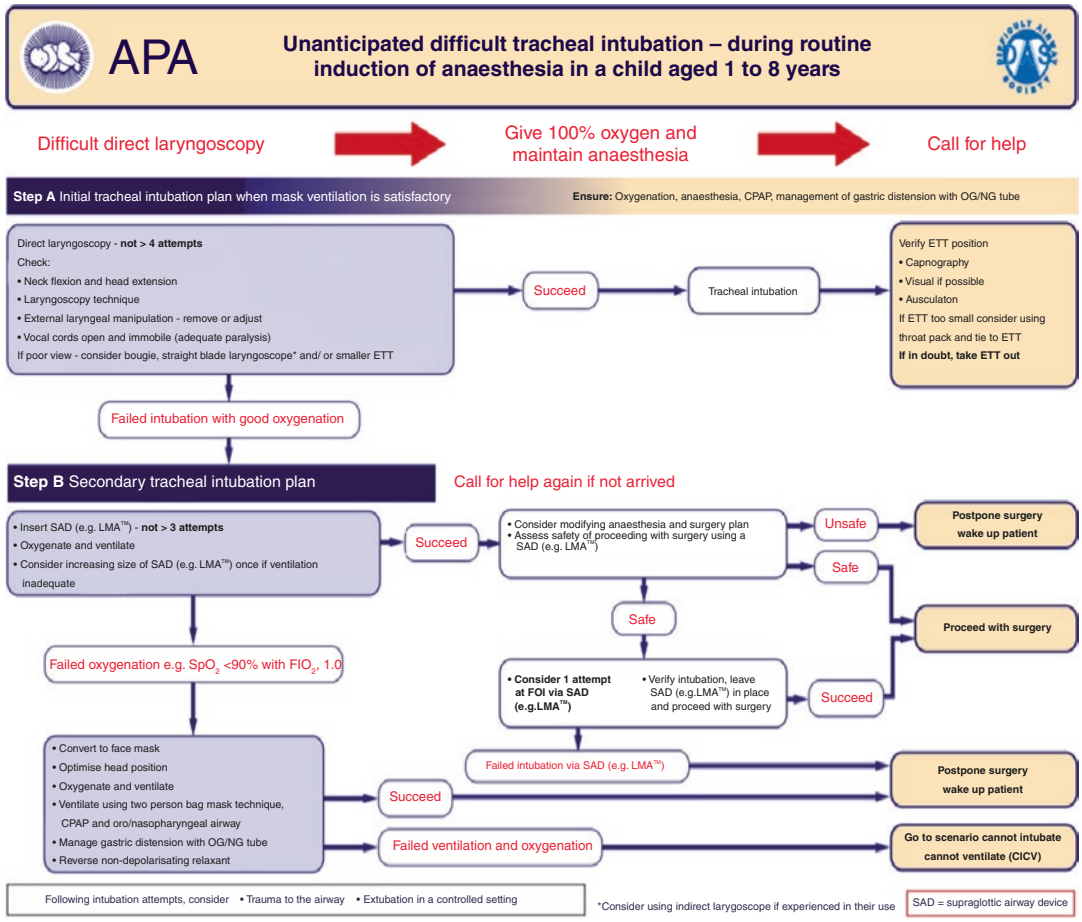

Fig. 17.16 DAS/APA unanticipated pediatric difficult intubation guidelines for a child aged 1–8 years. (Reproduced with permission from Difficult Airway Society, UK)

lation (ELM), muscle paralyses, use of advanced airway gadgets like videolaryngoscopes and intubation aids like bougies and stylets. Two attempts at insertion of SAD at the earliest to maintain oxygenation is vital at this stage. If unsuccessful, awakening the child with reversal of neuromuscular blockade is ideal for non-emergent surgeries.

Cannot intubate, cannot ventilate situation and subsequent management in pediatrics is shown in Fig. 17.17.

Surgical tracheostomy by experienced personnel is the only option to secure the airway and restore oxygenation in complete failure of oxygenation. Needle cricothyroidotomy, if tried initially has to be replaced by tracheostomy within 40 min. Cannula with a diameter > 4 mm should not be used in children <8 years of age [53].

4.4.2 AIDAA Pediatric Airway Guidelines for Children Between 1 and 12 Years (Fig. 17.18)

Key features of AIDAA pediatric guidelines are as follows:

1. Call for help with the first sign of difficult airway, continue nasal apneic oxygen throughout the procedure to maintain SpO_2 ≥95%.
2. Laryngoscopy: Not >2 attempts, third only by anesthesiologist experienced in pediatric airway management.

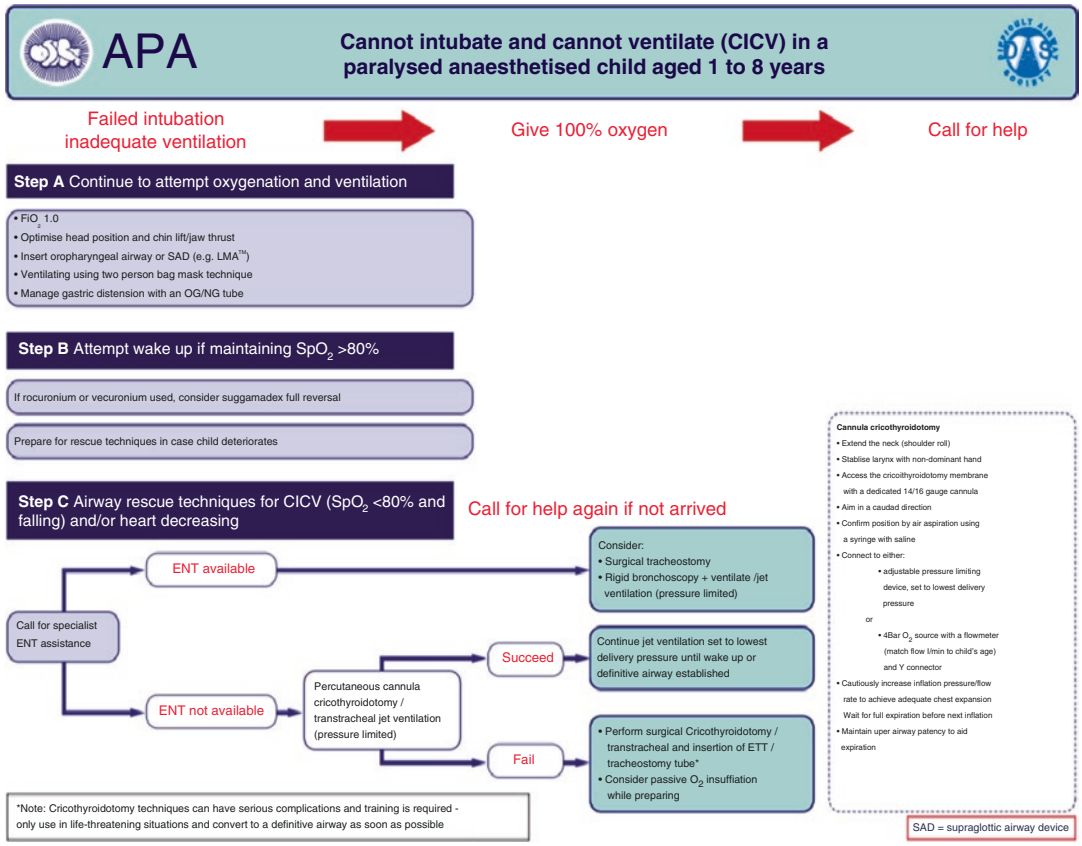

Fig. 17.17 DAS/APA guidelines for pediatric cannot intubate, cannot ventilate situation. (Reproduced with permission from Difficult Airway Society, UK)

Analyze the problem in between attempts. Second attempt should include change in position, technique, ELM, videolaryngoscope, and intubation attempts. Videolaryngoscope is recommended when there is failure of direct laryngoscopy in the first attempt.

3. If Cormack–Lehane grading is three or more abandon the procedure unless expert help is available. If intubation is unsuccessful in two attempts, insert a SAD for oxygenation and meanwhile plan the next alternative as to retain the SAD, to pass the endotracheal tube through SAD, wake up the child or proceed with FONA.
4. Change in type or size of SAD and personnel is recommended for the second attempt of SAD insertion [54]. If two attempts of SAD insertion fail, consider neuromuscular paralysis and mask ventilation with a oropharyngeal/nasopharyngeal airway in place.
5. Decompress the stomach and consider waking up the child with reversal of neuromuscular blockade if rocuronium was used.
6. If mask ventilation is difficult, then reconsider adequate depth of anesthesia and neuromuscular blockade. Neutral position of head and shoulder roll for children <6 months is ideal

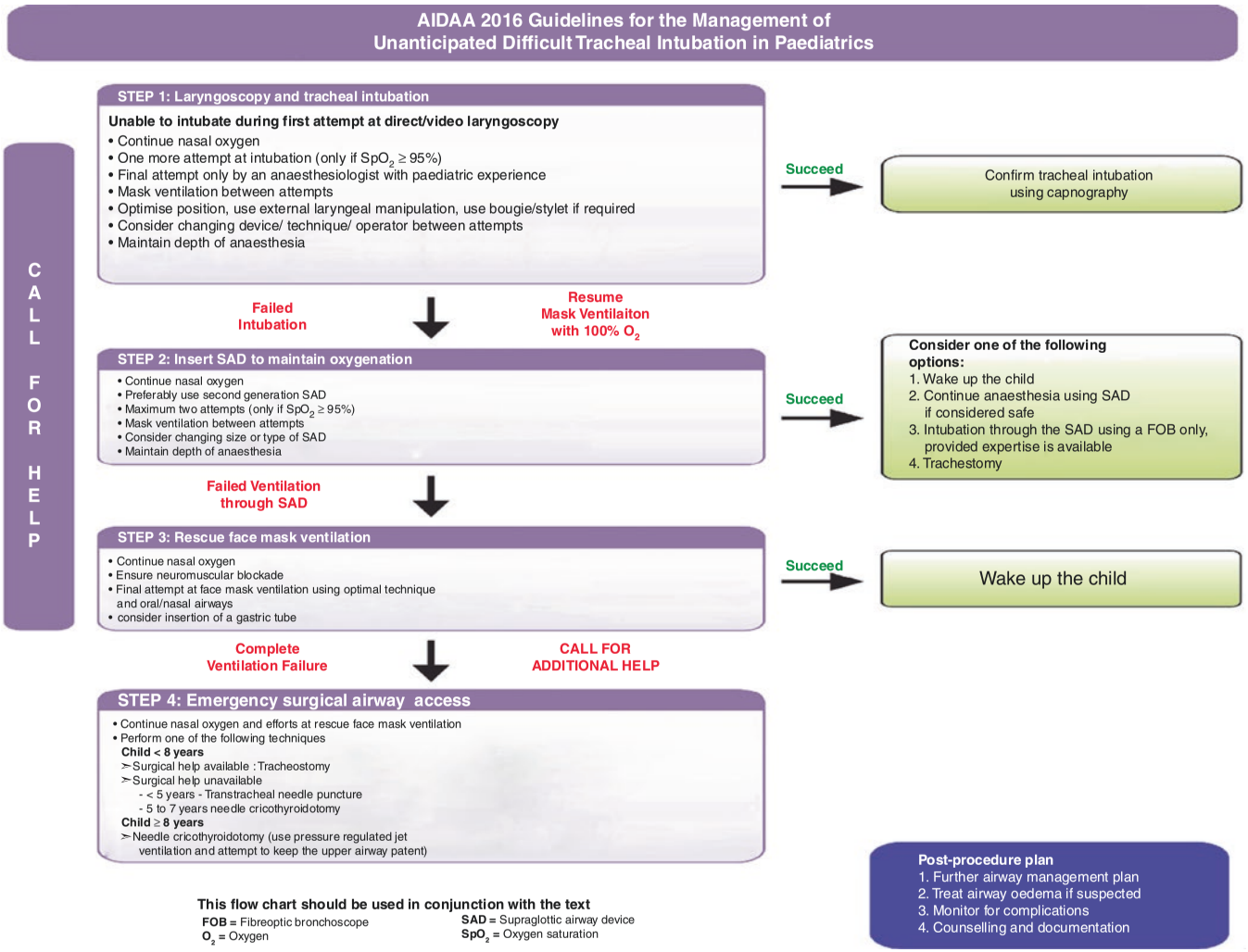

Fig. 17.18 AIDAA pediatric airway guidelines. (Reproduced with permission from AIDAA, India)

and lateral position is ideal for children with adenotonsillar hypertrophy or in whom mask ventilation is difficult in supine position [53].
7. Change to two-person bag-mask ventilation especially in obese, syndromic or babies with micrognathia.
8. Emergency surgical airway is indicated in complete ventilation failure but has to be performed before desaturation. Surgical tracheostomy is considered ideal for eFONA in children <8 years of age [55], other options being transtracheal needle puncture (<5 years) or needle cricothyroidotomy (5–12 years) followed by immediate tracheostomy (<40 min to prevent dangerous hypercarbia). Surgical cricothyroidotomy is not recommended in children <12 years of age. Oxygenation should be continued through pressure regulated jet ventilation device; provided upper airway patency is maintained and adequate time is provided for expiration.

Post-procedure complications like airway edema have to be monitored and treated. Verbal communication along with proper documentation of the difficulty in securing the airway is mandatory.

4.5 Airway Guidelines for Critically Ill Patients

NAP4 report of the Royal College of Anesthesiologist and Difficult Airway Society found >60% of airway complications in the ICU lead to brain damage or death when compared to only 14% in the operating room [56]. The factors contributing to the difficult airway management scenario in critically ill patients can be observed in the intensive care unit (ICU), emergency ward (ED), wards or any other peripheries of the hospital [57]. Following the intubation bundle reduces the significant number of complications in the perintubation period [58].

Human factors are largely responsible for effective management of airway in critically ill patients, reduction of cognitive overload to improve decision-making, performance, communication skill, and leadership quality to maintain situation awareness is important [59]. Operation of complex devices and equipment can be an additional burden on the operator [60]. Capnography is essential to confirm placement of endotracheal tube, to monitor adequacy of ventilation, as an indirect estimation of cardiac output and adequacy of cardiac resuscitation. As per NAP4 report, absence of capnography was related to 70% of ICU related deaths [56].

Adequate fluid resuscitation, choice of anesthetic drugs for intubation, proper preoxygenation, vasopressor or inotrope therapy [61] are essential to maintain hemodynamic stability. Bradycardia can be related to hypoxemia or vagal reflexes. Avoid positive pressure ventilation with high PEEP and high respiratory rate.

Based on the anatomical and physiological condition, myocardial depressants such as thiopental, propofol, and benzodiazepines should be used with caution. Ketamine and etomidate are better opted along with suxamethonium or rocuronium as muscle relaxants. Patients in ICU are expected to have delayed gut motility due to the physiologic alterations, which increases the risk of aspiration. Therefore, RSI may be preferred to prevent aspiration.

Frequent change in position like proning may require careful handling, inadequately sedated patient can have dislodgement or self-extubation of the ETT and regular checking of the tube for patency (blockage due to secretions and blood) is essential.

Ten components of intubation bundle in ICU are [58]:	
2 operators	Neuromuscular blockade for intubation
Fluid loading with 500 mL saline	Capnography to confirm placement of endotracheal tube
Sedation	Vasopressors to treat post intubation hypotension
Preoxygenation	Long term sedation
Rapid sequence induction and intubation	Lung protection strategies

4.5.1 DAS Airway Guidelines for Critically Ill Adults

The DAS along with representation from Intensive Care Society (ICS), Faculty of Intensive Care Medicine (FICM), and Royal College of Anesthetists (RCoA) derived a common protocol incorporating the vortex approach [57] which was published in November 2017.

Key features of these guidelines are:

1. Emphasis on human factors like completion of pre-induction checklist [62].
2. Incorporation of the vortex approach into the algorithm.
3. It reiterates the change in techniques and gadgets with each attempt up to a maximum of three times and the fourth attempt by an expert (not necessarily a senior) with each device [11].
4. Positive pressure ventilation or manual ventilation as pre or peroxygenation rather than nasal cannula.
5. Early use of videolaryngoscope recognizing the difficulty or failure in airway management and transition to the next step in <2 min.
6. The minimum time for effective difficult airway management from the beginning of the algorithm to FONA should be less than 15 min.

Important steps in the guidelines for critically ill patients are classified as Plan A, Plan B/C, and Plan D as shown in Fig. 17.19.

Plan A: Initial attempts of endotracheal intubation.

Preintubation planning requires a team leader to designate specific roles for each member, prepare the required drugs, gadgets, and plan the technique. Sniffing or ramped up position may be considered depending on the patient's condition. Oxygen saturation, capnography, blood pressure, heart rate, electrocardiogram (ECG), and capnogram are useful in guiding the success. Oxygenation is maintained by preoxygenation and peroxygenation techniques. Preoxygenation is by using a tight-fitting face mask with 10–15 L/min oxygen for 3 min [63], to maintain an $FeO_2 > 85\%$ is essential. Continuous positive airway pressure (CPAP) of 5–10 cmH_2O or non-invasive ventilation (NIV) may be useful to reduce absorption atelectasis. High frequency nasal oxygen (HFNO) at flows of 30–70 L/min can be used for pre or peroxygenation prolonging the safe apnea time [64]. Delayed sequence induction, i.e., administration of small doses of ketamine can be used in agitated patients [65]. Peroxygenation techniques include nasal oxygen at 15 L/min or HFNO during attempts of intubation [66]. Face mask ventilation with CPAP may prolong safe apnea time, and release of cricoid pressure may be necessary if face mask ventilation is ineffective. Prevention of aspiration is by discontinuation of oral feeds, suctioning out gastric contents and modified rapid sequence induction [67].

Induction drugs are used depending on the hemodynamic status either ketamine or co-induction with various rapidly acting opioids and neuromuscular blockers like rocuronium or suxamethonium is used. Limit the number of laryngoscopy attempts to three. Optimize the position, preoxygenate the patient, adequately sedate, and paralyze for securing the airway faster. The first failed attempt should signal the team of difficult airway and senior help should be sought. After three attempts of failed intubation Plan B/C should be initiated. An expert only handles the fourth attempt.

Videolaryngoscopy should be an option for intubations in critically ill patients and it is the first choice if difficult airway is predicted (MACOCHA score > 3) [68] or if laryngeal view is very poor. Capnography is mandatory to confirmation of tube placement, absent waves are indicative of tube obstruction, bronchospasm, pulmonary edema or misplacement of the tube. The incidence of failed intubation in critically ill patients are 10–30% [69].

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

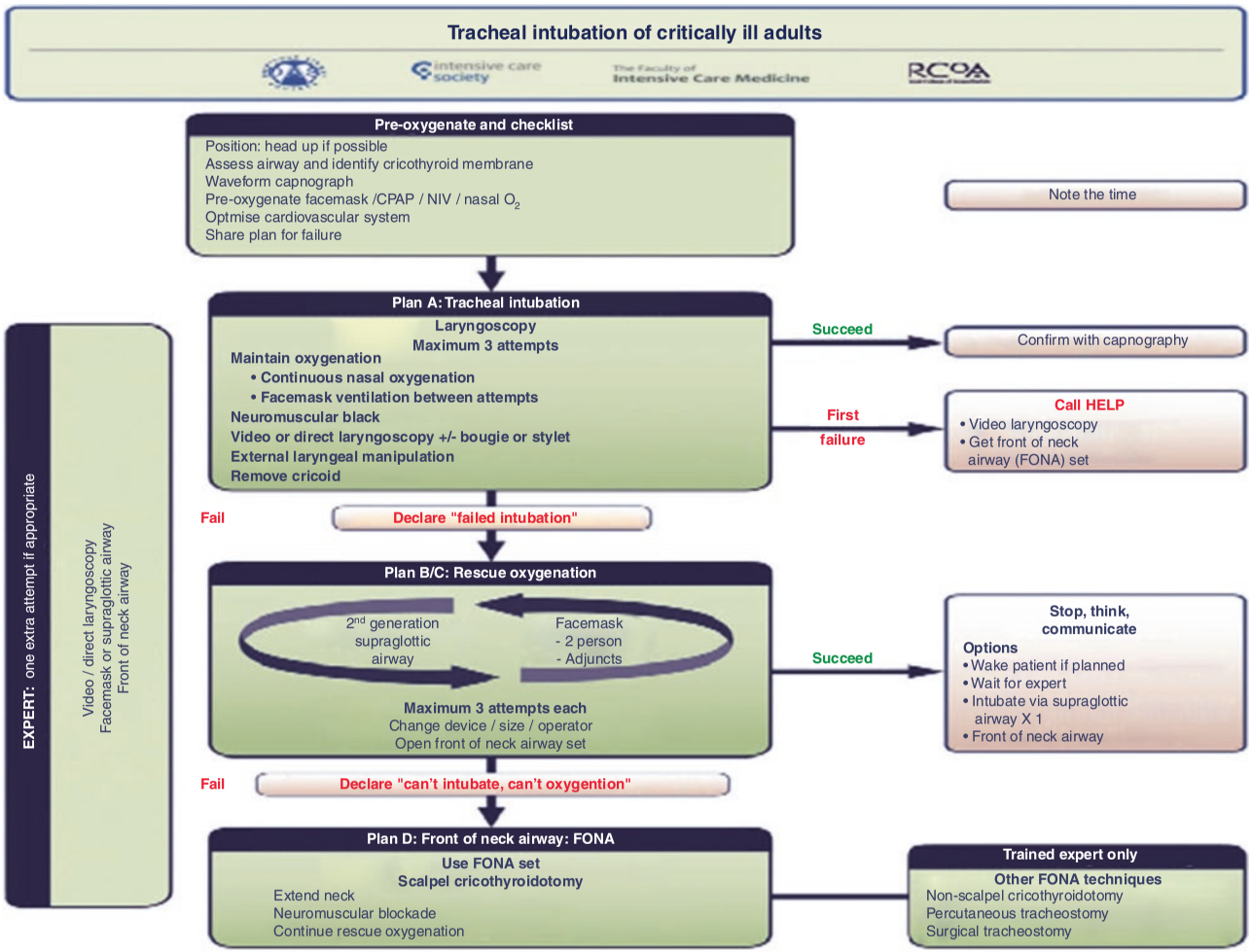

Fig. 17.19 DAS airway guidelines for tracheal intubation in critically ill adults. (Reproduced with permission from Difficult Airway Society, UK)

There is no distinction in the present guidelines between Plan B and C in clinical practice due to the emergency need for oxygenation alternating with facemask and SAD. This is the significance of incorporating the Vortex approach into the algorithm [11]. Reoxygenation using a second-generation SAD that enables oxygenation, protects against aspiration and acts a conduit for intubation using fiberoptic bronchoscope. Cricoid pressure may be removed prior to SAD placement [70]. Successful oxygenation in between attempts provides time to "stop, think, and communicate." A maximum of three attempts with the change in size, type, technique, and operator is recommended. Once oxygenation is successful, the options are: (1) wait for the expert to arrive, (2) single attempt of fiberoptic intubation through the SAD, and (3) proceed to FONA. Expert arrival during the process of reoxygenation will further provide an opportunity for one more expert attempt of SAD insertion and facemask ventilation.

Optimal head and body position, nasal or oral airway adjuncts, and two-person technique along with neuromuscular blockade [71] may be required for successful facemask ventilation. If oxygenation is possible the options are the same as above, if unsuccessful, FONA is the only option and followed as shown in Fig. 17.20.

Waking up the patient is usually not an option in critically ill. If all other methods are unsuccessful, FONA is the only option.

Plan D: Emergency FONA is the only option to prevent further deterioration.

Transition to FONA—Explicit declaration of CICO is essential without any specific desaturation threshold for transition to FONA, but confirm other remediable factors are ruled out prior to FONA. For example, (1) Airway obstruction caused by laryngeal or bronchospasm, excessive cricoid pressure, foreign body, secretion/blood equipment failure like blocked filter, (2) poor mask seal, (3) cardiac arrest.

Priming to FONA—One failed intubation attempt should warrant the need for FONA set at the bedside, one attempt of failure to oxygenate through SAD or facemask should result in opening of the FONA set. Scalpel bougie tube cricothyroidotomy is the preferred approach that is easier and faster [1].

Failed FONA—Surgical/percutaneous tracheostomy should be considered early before cardiac arrest ensues [72].

Management following FONA—Confirm placement of the tube using capnogram, chest X-ray, ultrasound, and fiberoptic guidance. After stabilization, conversion to tracheostomy is required [73].

Anticipated Difficult Airway in ICU

In the ICU when difficulty in securing the airway is anticipated along with inadequate patient cooperation and urgency, the use of induction agents and neuromuscular blockade followed by endotracheal intubation is the ultimate option [15]. This procedure demands for a double set up, i.e. one clinician attempts endotracheal intubation and if unsuccessful, the other clinician immediately secures the airway by surgical access [15]. Awake videolaryngoscopy by a skilled operator has become the recent method of securing the airway in critically ill patients [74]. However, care should be taken to prevent hypoxia by proper positioning, minimal sedation, and per-oxygenation techniques using HFNO [75]. Complete airway obstruction can occur due to over-sedation, laryngospasm, laryngeal edema, bleeding, and aspiration [76].

Extubation in the ICU

DAS extubation guidelines are applied to extubation in the ICU with a modification in the recent narrative [77]. Prolonged intubation may render the airway edematous and following extubation, subsequent reintubation if required may be difficult.

Unplanned extubation—the current algorithm is appropriate for patients without a difficult airway, but identification of cases of difficult airway

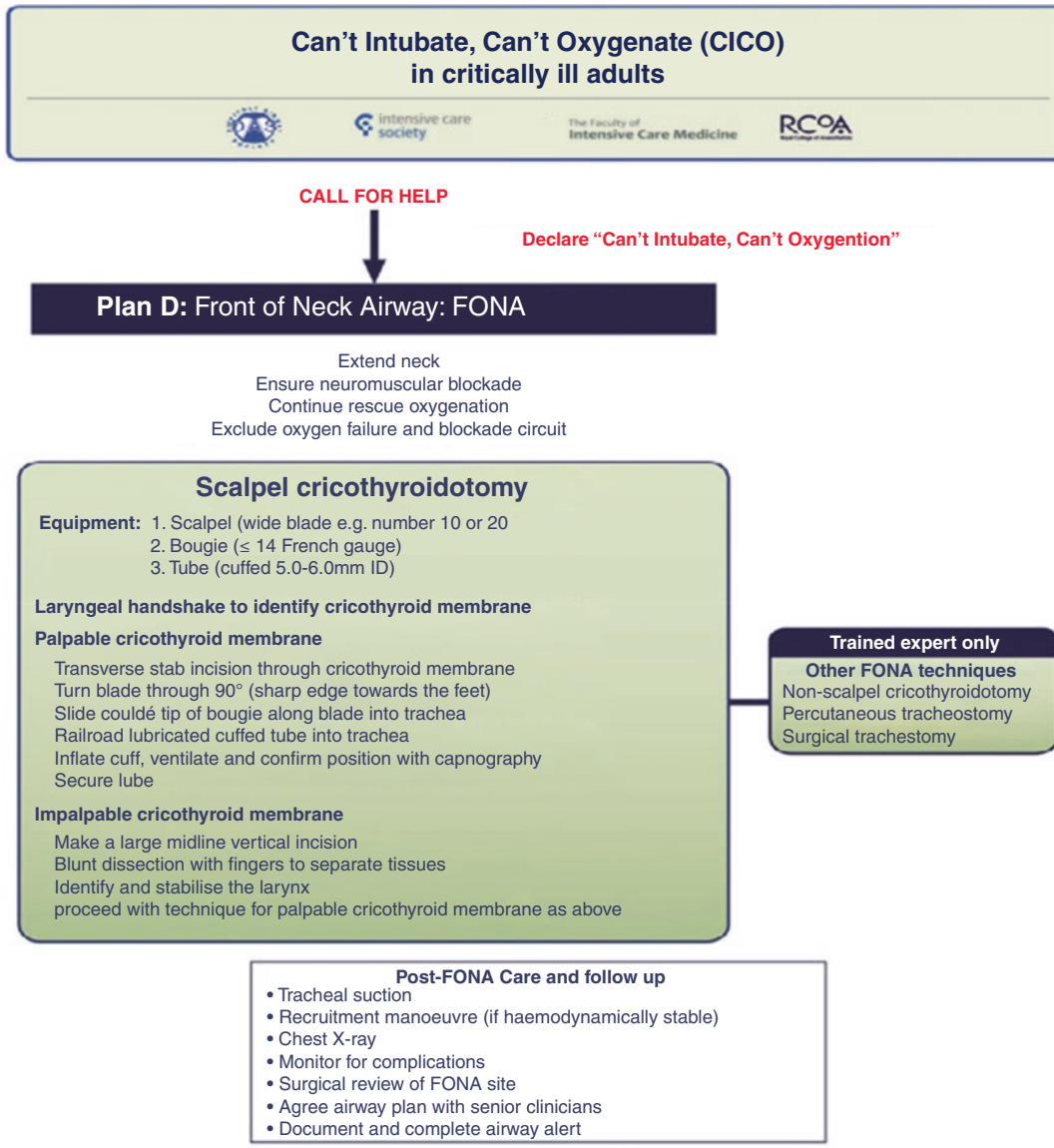

Fig. 17.20 DAS airway guidelines for CICO in critically ill adults. (Reproduced with permission from Difficult Airway Society, UK)

and suitable technique of securing the airway has to be planned in advance [78].

Planned extubation—extubation should be considered as a trial with the possibility of difficult reintubation [77]. All planned extubations have to be performed in the daytime preferably with an airway exchange catheter in situ that forms a conduit for reintubation [15].

4.5.2 AIDAA Guidelines for Airway Management in Critically Ill Adults

Specific considerations emphasized in the AIDAA guidelines [7] are presence of two airway operators, one as an expert in airway management and another for supervision [79]. Call for help at the first sign of difficulty in airway

management is recommended. Additional help is again summoned at the failure of rescue face-mask ventilation and when cricothyroidotomy is planned. This algorithm is shown in Fig. 17.21.

Stepwise approach of AIDAA for airway management in ICU is preoxygenation and induction, laryngoscopy and tracheal intubation, SGAD to maintain oxygenation, declaration of complete ventilation failure, and emergency front of neck access.

Preoxygenation and peroxygenation with non-invasive positive pressure ventilation (NIPPV), high flow nasal cannula (HFNC) with flow rates of 60 L/min, and apneic oxygenation using nasal cannula at 15 L/min may decrease the incidence of desaturation [64, 80].

Successful mask ventilation allows for intubation using direct or videolaryngoscope. A maximum of two attempts of intubation and a third attempt is made only if the $SpO_2 > 95\%$ with mask ventilation in between attempts, change in position and device, use of bougies, release of cricoid pressure, and adequate depth of anesthesia.

If two attempts of intubation or mask ventilation fail o, two attempts of second-generation SAD insertion is recommended provided the $SpO_2 > 95\%$. Continue adequate depth of anesthesia and nasal oxygen throughout the procedure and mask ventilate in between the two attempts, second attempt being done with a different type or size of SAD. If rescue SAD ventilation is successful, proceed with percutaneous or surgical tracheostomy. Intubation through the SAD is done by an expert and under fiberoptic guidance.

If oxygenation through SAD fails, nasal oxygen continued, adequate depth of anesthesia, and muscle relaxation are ensured. If attempt for mask ventilation is successful, proceed with surgical or percutaneous tracheostomy, if unsuccessful, declare complete ventilation failure and call for help immediately.

Step 5. Emergency FONA.

Emergency needle or surgical cricothyroidotomy has to be done to provide oxygen in case of complete ventilation failure. Ventilate either using jet ventilation or through an ETT until tracheostomy is performed.

4.6 Extubation Guidelines

Extubation is defined as purposeful removal of the tracheal tube and transition from an established airway to normal natural airway [81]. Extubation failure is defined as the inability of the patient to maintain a patent airway with effective spontaneous ventilation after purposeful removal of the previously placed endotracheal tube within a specified time [82]. Maintenance of oxygenation in the post-extubation period using THRIVE [83], HFNC, and nasal cannula is an important part of patient care in the critical care setting [84].

4.6.1 DAS Extubation Guidelines

DAS published specific guidelines for extubation of difficult airway in 2012 [20] as shown in Fig. 17.22. Approach involves four steps: plan, prepare, perform, and post-extubation care.

Plan- categorizes airway into "low risk" which implies a normal airway which remains so at extubation and "at risk" which is potentially complicated, with pre-existing difficulty, perioperative airway deterioration and restricted access based on the preoperative assessment [85]. Contribution of physiological factors to extubation such as hemodynamic instability, neuromuscular impairment, poor respiratory function, etc. are also emphasized.

Preparation—includes optimization, assessment, and clearing of airway and lastly, plan for reintubation if needed.

Optimizing the airway before extubation is the goal. Reassessment of the airway is an important step prior to extubation and for preparation of rescue plan if reintubation is required. The presence of blood clots, edema, foreign bodies, and airway distortion following surgery should alert the operator for at risk airway. The patency of the larynx and lower airway also has to be checked. Gastric decompression enables better ventilation. Since extubation is an elective procedure, it should be carried out in a controlled manner with the same standards of monitoring, equipment and assistance that is available at intubation.

Perform—Oxygen stores are maximized by preoxygenating prior to extubation. Patient

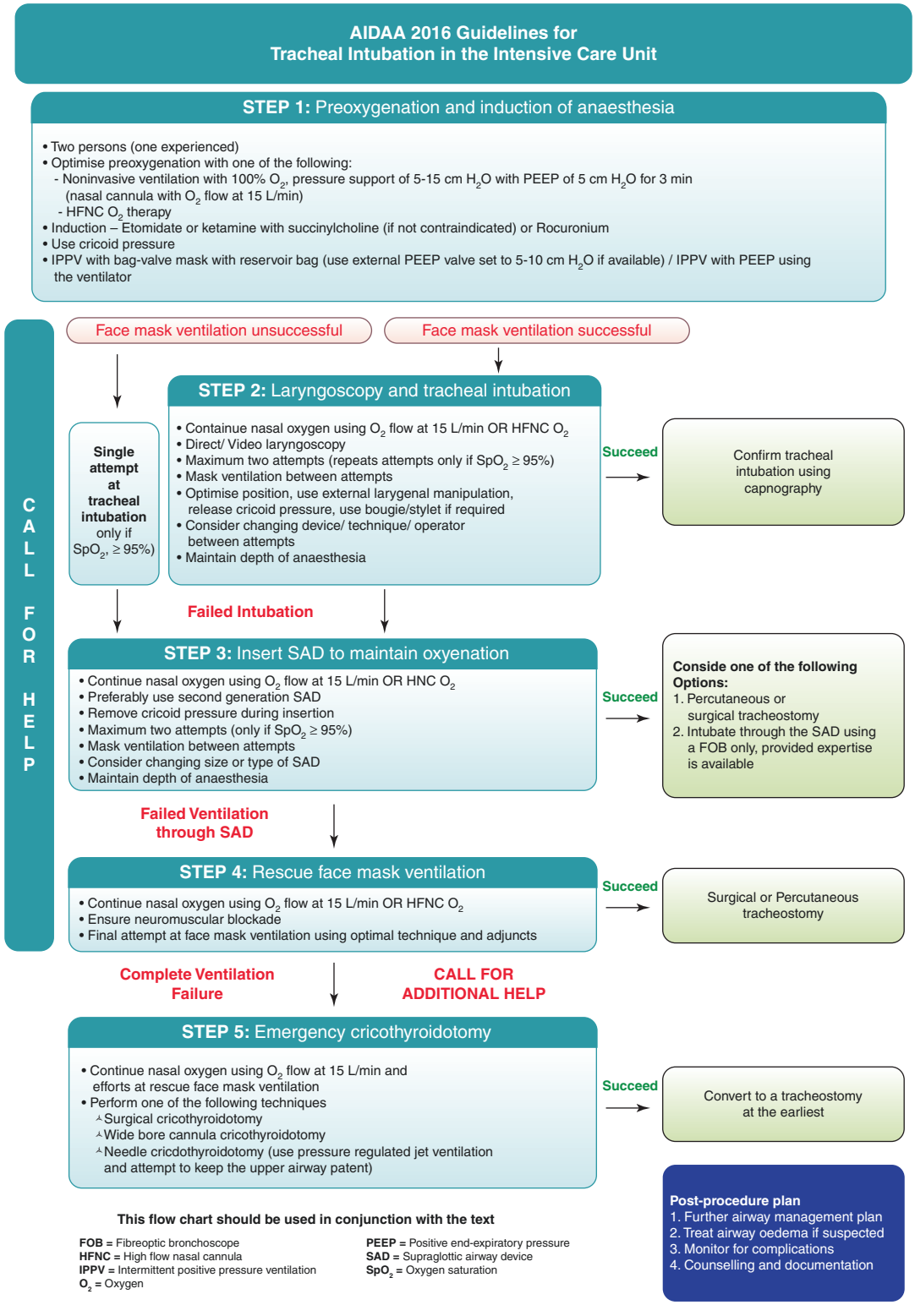

Fig. 17.21 AIDAA guidelines for airway management in critically ill adults. (Reproduced with permission from AIDAA, India)

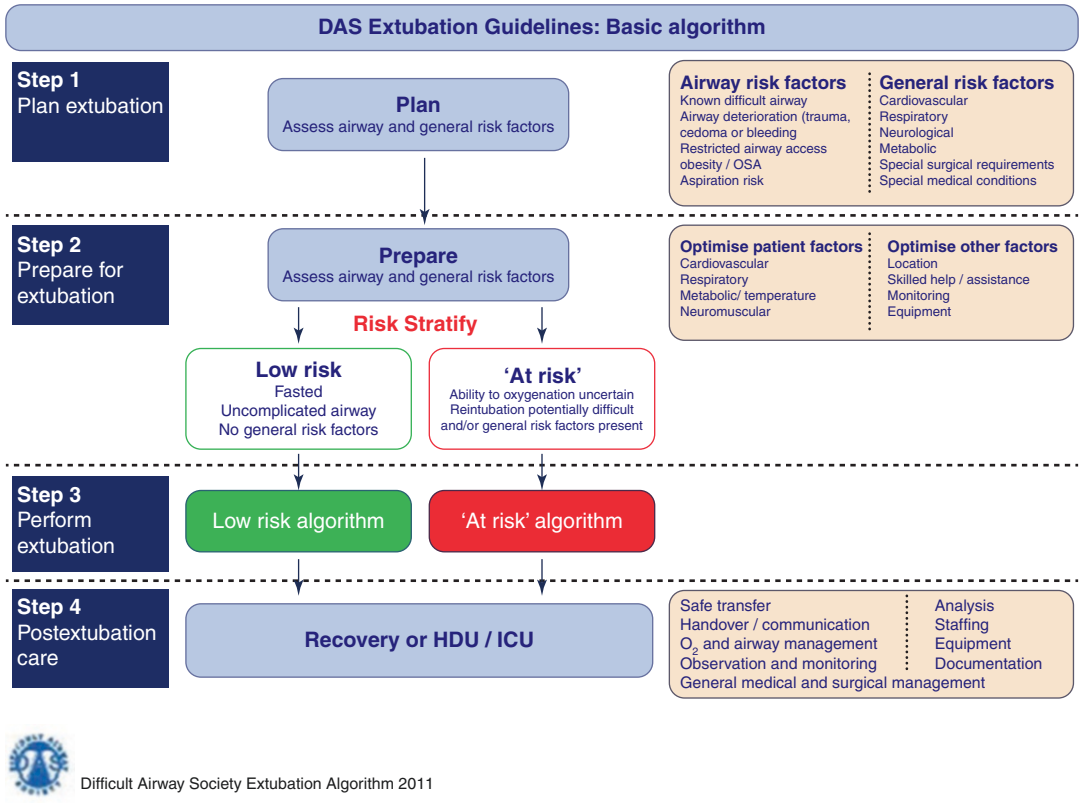

Fig. 17.22 DAS extubation guidelines. (Reproduced with permission from Difficult Airway Society, UK)

position has to be optimized as per the requirement; obese patients may have the mechanical advantage in head up position. Suctioning of the oropharynx has to be carried out in a slightly deeper plane of anesthesia, under vision to prevent inadvertent trauma to the soft tissues. Alveolar recruitment maneuver like sustained positive end expiratory pressure may temporarily reverse atelectasis. Awake extubation is safer due to the return of airway reflexes, tone, and respiratory drive, especially in "at risk" airway category patients. Deep extubation has the advantage of decreasing the incidence of coughing, bucking and the adverse hemodynamic events. Pharmacological agents that reduce the pharyngeal stimulation are ultra-short acting opioids, lidocaine, ketamine, clonidine, and β-blockers [86]. However, upper airway obstruction can be a major complication of deep extubation. Bailey's maneuver is replacement of SAD with endotracheal tube under deep anesthesia prior to reversal of neuromuscular blockade [87], that can be dangerous in patients in whom reintubation is difficult or risk of aspiration is high. Use of airway exchange catheter during difficult extubation and retaining it in the postoperative period for at least 2 h can serve as a guide to reintubate the trachea or to oxygenate the lungs [20, 88]. Elective surgical tracheostomy is considered when airway patency is compromised for a considerable period of time due to pre-existing problems, the nature of surgery, extent of tumor, swelling, edema or bleeding. Postpone extubation if the threat of airway compromise is very severe. A written emergency reintubation plan should be documented when the patient is transferred to critical care unit as per the NAP4 [56].

Post extubation care, recovery, and follow-up.

Oxygen support, good communication and staffing, monitoring for warning signs, easy

availability of difficult airway trolley, and adequate analgesia are the basic requirements for safety of the extubated patient [89]. For "at risk" patients nursing in the upright posture, administration of high flow humidified oxygen, nasopharyngeal airway insertion and CPAP for patients with obstructive sleep apnea (OSA) are the additional requirements. Documentations and airway management recommendations in the form of DAS alert forms will reduce complications in the future [90]. The DAS extubation low risk and at risk guidelines are shown in Figs. 17.23 and 17.24 respectively.

4.6.2 AIDAA Guidelines for Extubation

Extubation strategies are planned depending on the preintubation condition of the patient like neuromuscular, respiratory or cardiovascular compromise, anticipated or preintubation airway concerns, perioperative complications that can compromise the airway in the postextubation period [8]. The guidelines are shown in Fig. 17.25.

Limb 1—Hemodynamic responses are suppressed by pharmacological attenuation [91] with topical lidocaine 10%, intravenous lidocaine 1 mg/kg over 2 min, β-blockers (esmolol 1.5 mg/kg, 2–5 min before extubation), fentanyl 0.5–1 μg/kg, dexmedetomidine 0.75 μg/kg 15 min prior to extubation. Bailey's maneuver done by an expert is beneficial during deep extubation [87].

Limb 2—Extubation in difficult airway and the 4 Ds where difficult intubation cases are prone for difficult extubation are given priorities. Preexisting diseases such as OSA, obesity, rheumatoid arthritis, few airway surgical procedures, delayed recovery, and depressed consciousness are causes of extubation failure [14, 92]. Lung recruitment, preoxygenation with 100% oxygen followed by extubation

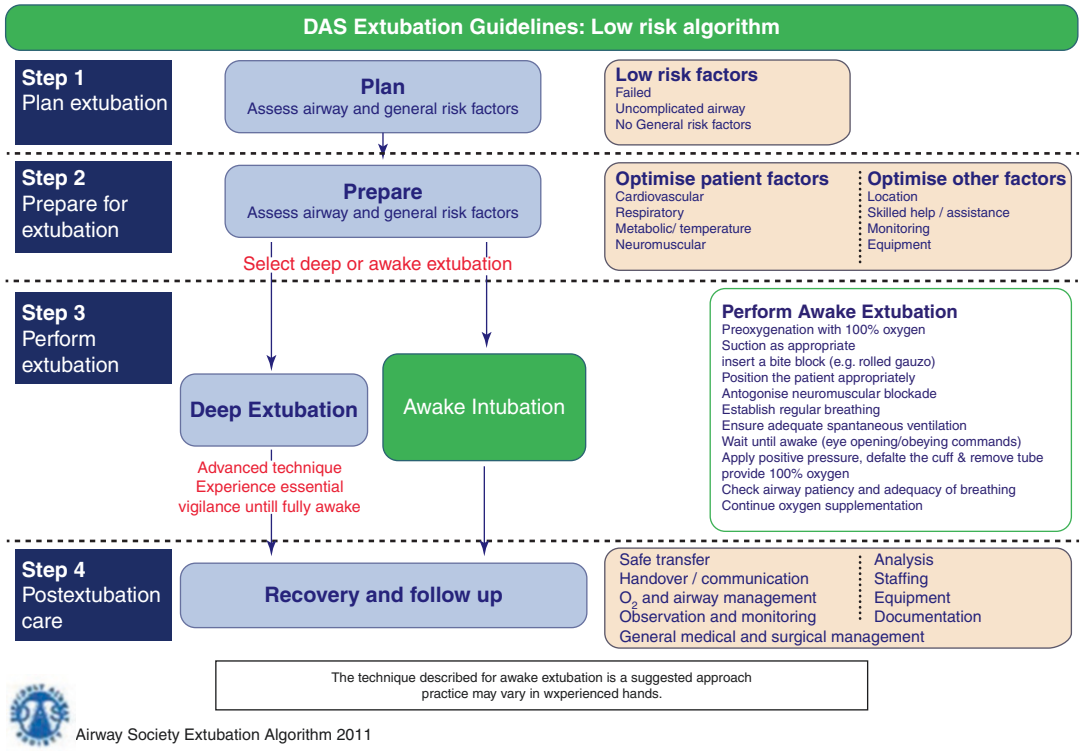

Fig. 17.23 DAS "low risk" algorithm for extubation. (Reproduced with permission from Difficult Airway Society, UK)

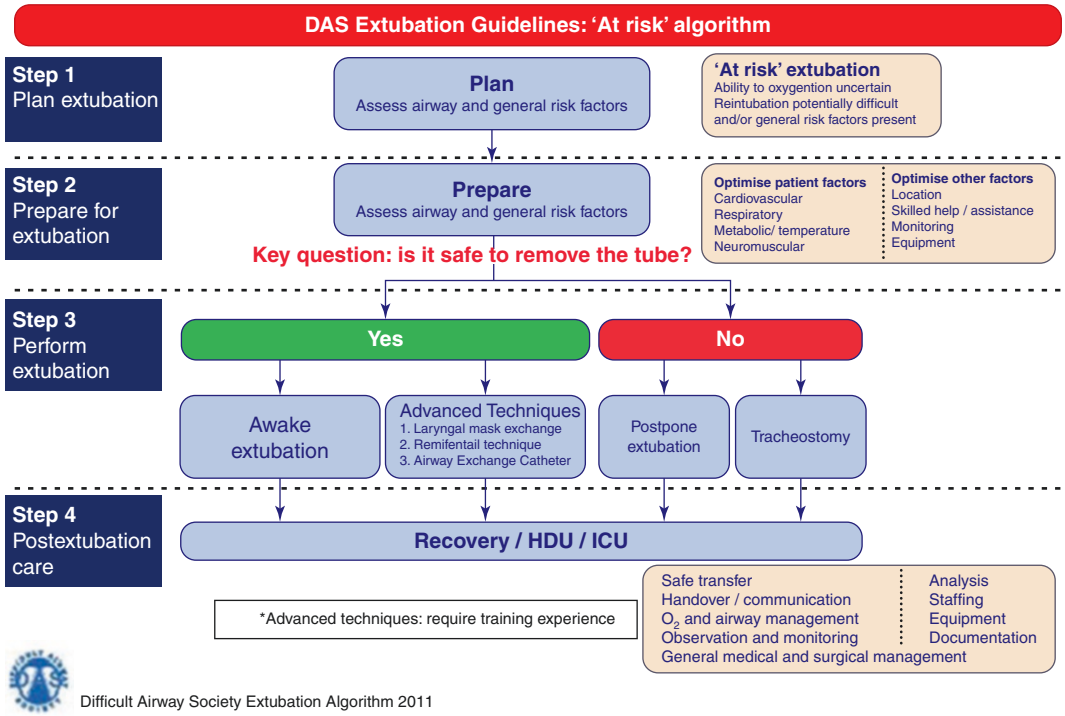

Fig. 17.24 DAS "at risk" algorithm for difficult extubation. (Reproduced with permission from Difficult Airway Society, UK)

over AEC/fiberoptic bronchoscope are other recommendations [14].

Limb 3—Another important component to be taken into account during extubation are 3Ss [92] as shown in Fig. 17.25. Perform a quantitative leak test prior to extubation to check for edema or collapsibility, which is significant if the difference between inflated and deflated exhaled tidal volumes is <10–25% or 100–130 mL [93]. If leak is present, extubation is planned in a controlled environment over an airway exchange catheter (AEC)/fiberoptic scope. If there is no leak, extubation is delayed. Ventilator support, administration of steroids (IV hydrocortisone 100 mg three times a day), nebulized adrenaline (1 mg epinephrine in 5 mL normal saline), and head up position may be required to reduce the edema [94]. Tracheostomy may be considered for airway obstruction due to inherent airway pathology or surgical intervention.

4.7 Airway Guidelines for Managing COVID-19 Patients

Airway interventions in severe respiratory syndrome-corona virus-2 (SARS-CoV-2) are required for tracheal intubation and establish controlled ventilation. All the airway procedures generate aerosols that can be quite dangerous to the health care worker attending to that patient. Emergency intubation of COVID-19 patients should be avoided as far as possible and an expert in airway management should carry out all airway interventions [95].

Minimize aerosol generating procedures and patients requiring oxygen flows greater than 6 L/min should be cared in a negative pressure room [96]. Avoid manual bag-mask ventilation and the use of tight fitting noninvasive ventilation (NIV) mask is recommended for preoxygenation. Switch off the ventilator between preoxygenation

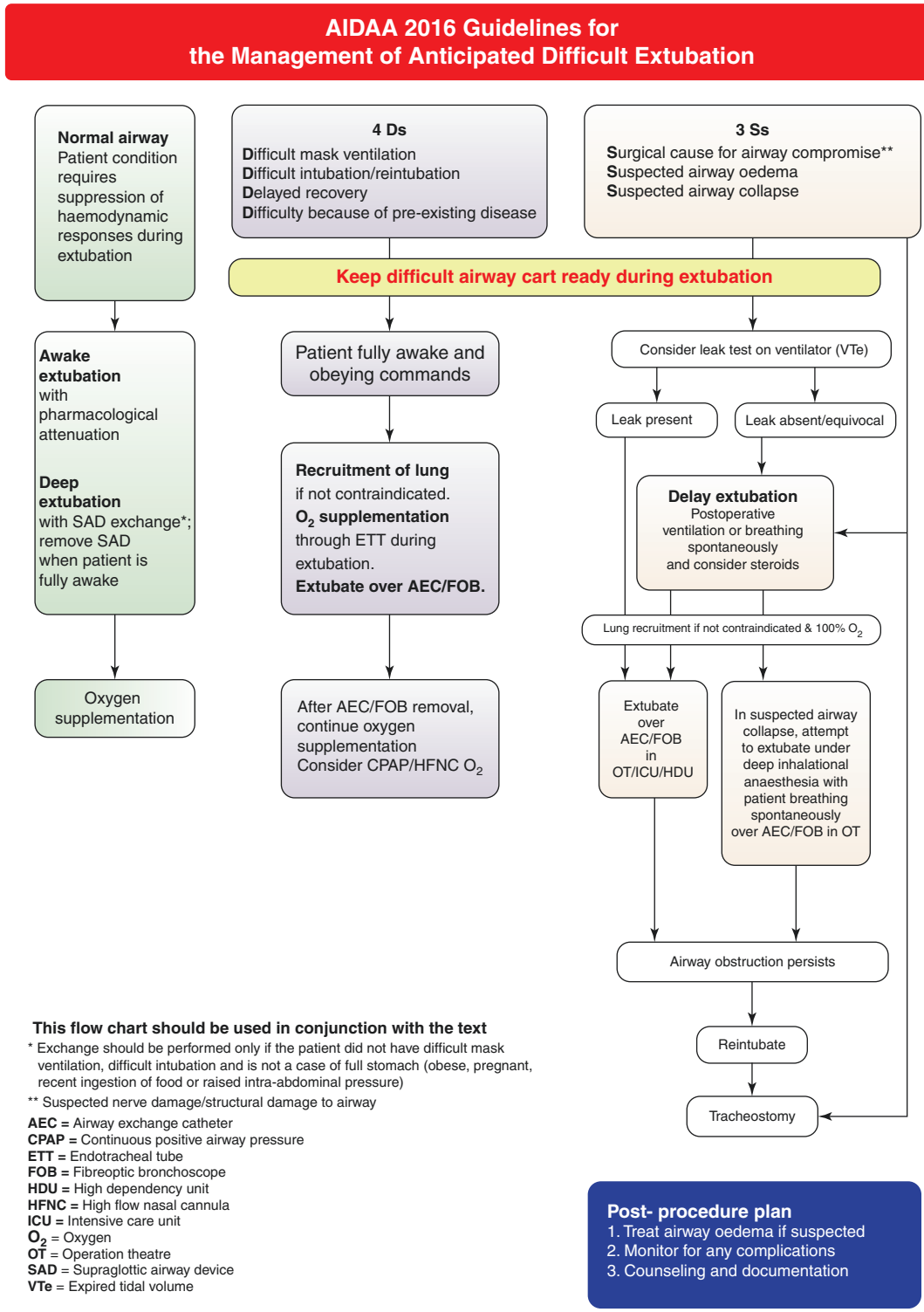

Fig. 17.25 AIDAA guidelines for extubation. (Reproduced with permission from AIDAA, India)

and intubation [97]. Awake fiberoptic intubation is avoided to prevent coughing during the procedure. Difficulty in securing the airway in COVID-19 cases can be due to the presence of personal protective equipment (PPE), advance airway equipment not being available in the OR, unfamiliar surroundings, cognitive problems in the operator, and airway edema caused by the virus [9].

4.7.1 DAS Guidelines for Airway Management in COVID-19 Patients (March 2020) [98]

These guidelines are similar to that of airway management of critically ill patients with few differences (Fig. 17.26).

Key Features

Preparation:

A checklist as given in Fig. 17.27 has to be prepared and followed prior to emergency intubation of COVID-19 patients in order to prevent the spread of infection from the highly aerosolizing procedure.

1. Availability of required gadgets like videolaryngoscope, trained team, and individual staff and PPE.
2. Separate intubation trolley or pack, decontaminated after use.
3. Plan for airway management should be clear and communicated to the rest of the team.
4. Minimal staff (an intubator, assistant, and another person to administer drugs and watch monitors).
5. MACOCHA score may be used to predict airway difficulty.
6. Emergency interventions even during a cardiac arrest have to be done only after donning a PPE. During cardiac arrest: Minimum PPE required are an FFP3 mask, eye protection gear, plastic apron, and gloves [99]. SGAD is preferred for ventilation rather than face mask.
7. Use the local familiar resources, which includes a videolaryngoscope, 2-person 2-hand mask ventilation technique, and a second-generation SAD.
8. Use the cognitive aids like the vortex approach and the DAS algorithm if difficulty arises [56].
9. Communication may be difficult with PPE, so loud and clear speech is essential.

Airway management:

1. Preoxygenation with a tight-fitting mask with a closed circuit for 3–5 min is recommended.
2. Ketamine (1–2 mg/kg), and rocuronium (1.2 mg/kg) to maintain cardiovascular stability and to provide prolonged, intense neuromuscular blockade, respectively.
3. Cricoid pressure is controversial, and removal may be necessary in difficult airway scenarios [70].
4. Delayed sequence tracheal intubation technique may be used in agitated patients.
5. After complete loss of consciousness, CPAP may be applied; alternative could be use of SAD for ventilation prior to laryngoscopy. Use of videolaryngoscopy with a separate screen is the most likely safe device to achieve faster intubation time.
6. Airway adjuncts like bougie or stylet may aid in intubation with an appropriately sized tracheal tube.
7. Secure the tube and reconfirm the position using capnography, bilateral

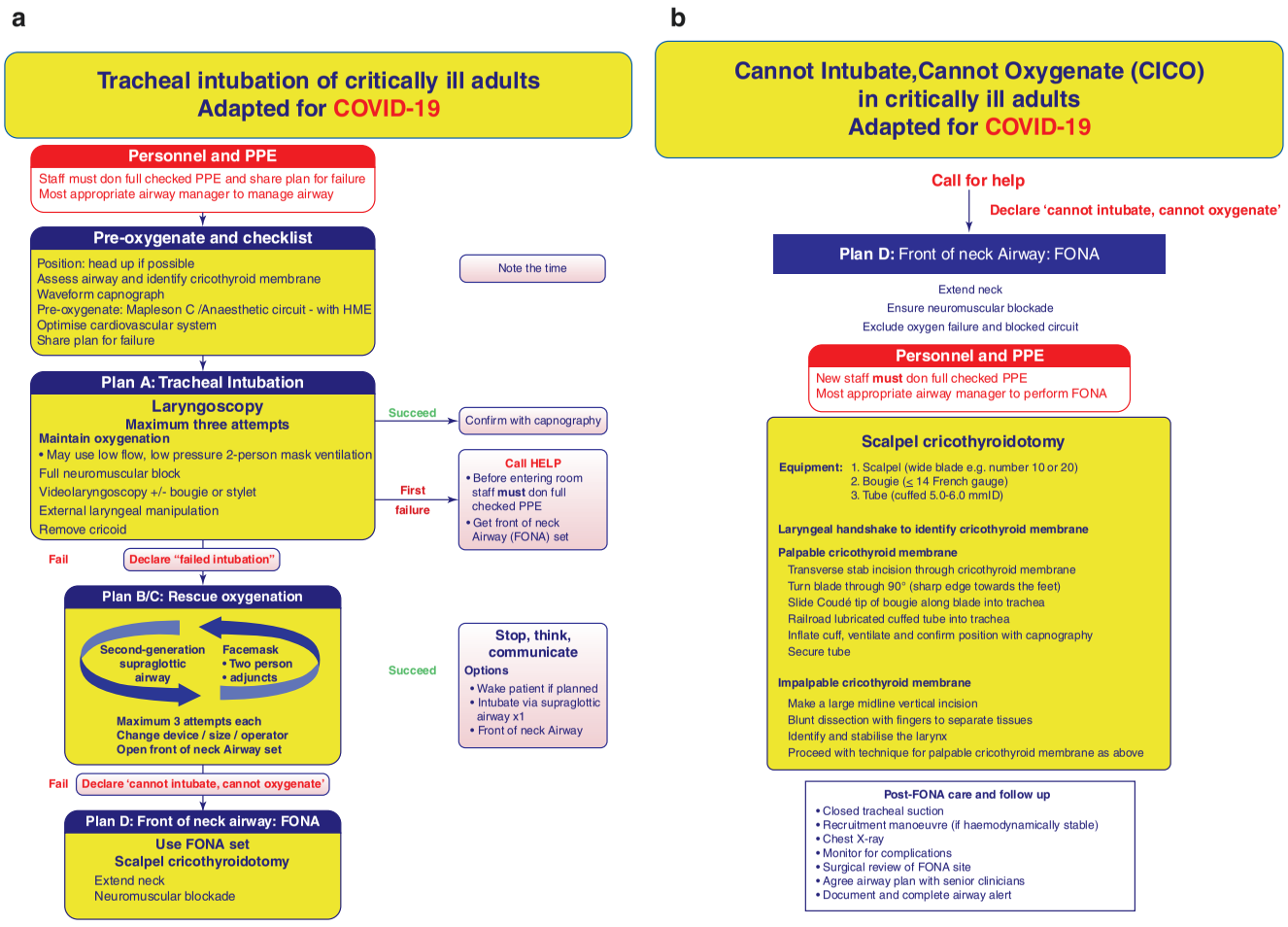

Fig. 17.26 DAS guidelines for managing unexpected difficulty in a patient with COVID-19. (**a**) Unanticipated difficult airway. (**b**) Cannot intubate, cannot oxygenate. (Reproduced with permission from Difficult Airway Society, UK)

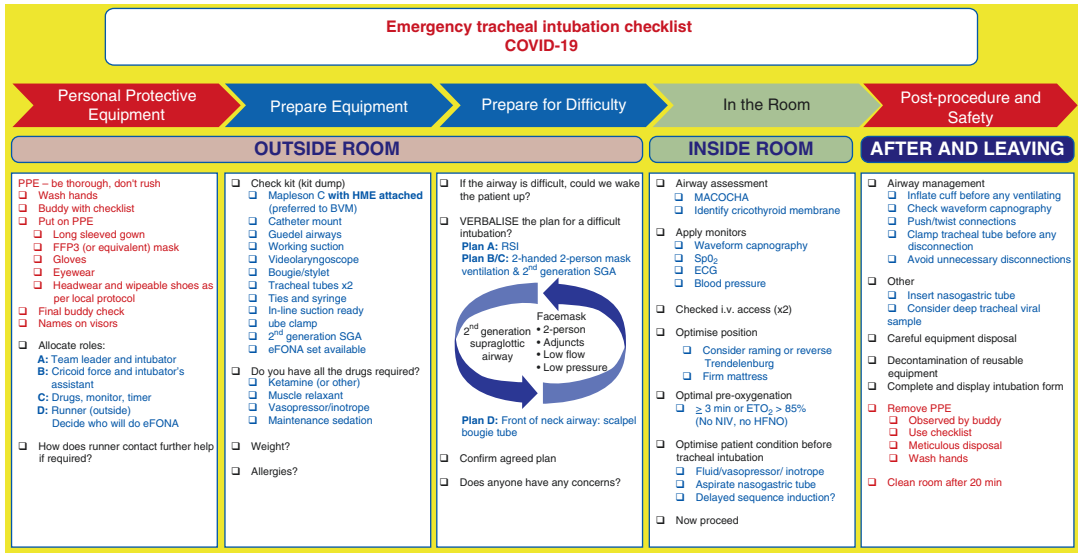

Fig. 17.27 Checklist for emergency tracheal intubation of COVID-19 patients

chest rise, and lung ultrasound after inflation of the tube cuff.

8. Place a nasogastric tube to avoid any airway maneuvers later.

Avoid multiple attempts and aerosol generating procedure whenever a suitable alternative is available.

Care after endotracheal intubation:

1. Heat and moisture exchange (HME) filter, close to the patient end. Closed tracheal suction.
2. Monitoring of tube depth during position change, zero cuff leak, avoid tube disconnection.
3. Ensure adequate sedation and neuromuscular blockade, pause the ventilator, clamp the endotracheal tube, disconnect the circuit with the HME filter attached to endotracheal tube, during changing of position. Follow the reverse steps during reconnection. Delay tracheostomy till the patient is negative.

Tracheal extubation:

Prepare well for extubation with oxygen cannula, proper physiotherapy, and suctioning before extubation. Avoid generating cough; place a facemask immediately after extubation. To avoid coughing during extubation of endotracheal tube, SAD can be used instead of endotracheal tube, replace endotracheal tube with SAD before extubation, and use intracuff or intravenous lidocaine, dexmedetomidine or opioids [100].

Unanticipated airway difficulty: Declaration of failure to secure the airway, transition through the algorithm and minimizing the number of attempts in each step is very essential. Avoid ventilation through facemask, instead SAD can be used as a means of oxygenation and scalpel-bougie-tube technique for FONA is recommended.

Anticipated difficult airway: Topicalization needs to be done with caution to prevent aerosolization; tracheal intubation is preferably with an SAD (either blind or using fiberoptic scope). However, use of fiberoptic bronchoscopy is not the first choice.

4.7.2 AIDAA Airway Algorithm for COVID-19 Patients-May 2020 [101]

The algorithm was published to enable the clinicians to effectively carry out the airway management techniques in COVID-19 patients as per the available resources and is shown in Fig. 17.28.

Planning and preparation:

1. Teaching and training of sanitization, donning and doffing of PPE, communication through sign language after donning PPE, knowledge about the disinfection of all the reusable airway gadgets as per hospital policy, and proper disposal training needs special emphasis [102]. Simulation training of various scenarios after donning the PPE will be useful in emergency situations.
2. A negative pressure OT is recommended to prevent the spread of virus [103].
3. Additional resources or innovative techniques should be adapted for self-protection such as N95 masks, face shield respirators, and powered air purifying respirators (PAPR), goggles along with PPE during airway management [104].
4. Patients should be wearing facemasks and have to be transferred to OT directly, povidone iodine gargles (0.23–1%) [105] significantly reduces viral load and preanesthetic examination has to be done with full PPE.
5. Aerosol generating procedure like mask ventilation, tracheal intubation and extubation, non-invasive ventilation, bronchoscopy, and tracheostomy should be executed with caution.

Steps of tracheal intubation:

1. Check the placement of the HME filter and capnography tubing (placed towards the machine end of HME filter) in the circuit.
2. Use the barrier device and remove the mask of the patient only before placing the facemask. Preoxygenation is with a tight-fitting face mask for 3–5 min using a closed circuit and there is no role of NIV or HFNO as they can generate aerosols [106]. Rapid sequence induction without cricoid pressure using adequate doses of rocuronium or suxamethonium is the preferred method [107]. Avoid mask ventilation, if required ($SpO_2 < 95\%$) two hand technique of mask ventilation and low flow nasal oxygenation of up to 5 L/min is preferred [108].
3. Videolaryngoscope is preferred and the endotracheal tube is loaded with a stylet for easy insertion and soon after placement of the tube, the cuff is inflated.
4. Disposable items are discarded immediately, and reusable items are dropped into the container containing disinfectant solution.

Precautions during general anesthesia:

1. Avoid unnecessary disconnections of the circuit, any warranted disconnections should be preceded by putting the machine on standby mode, using the COVID-19 box or transparent sheet on the patients face, disconnection of the circuit is only at the machine end of HME filter.

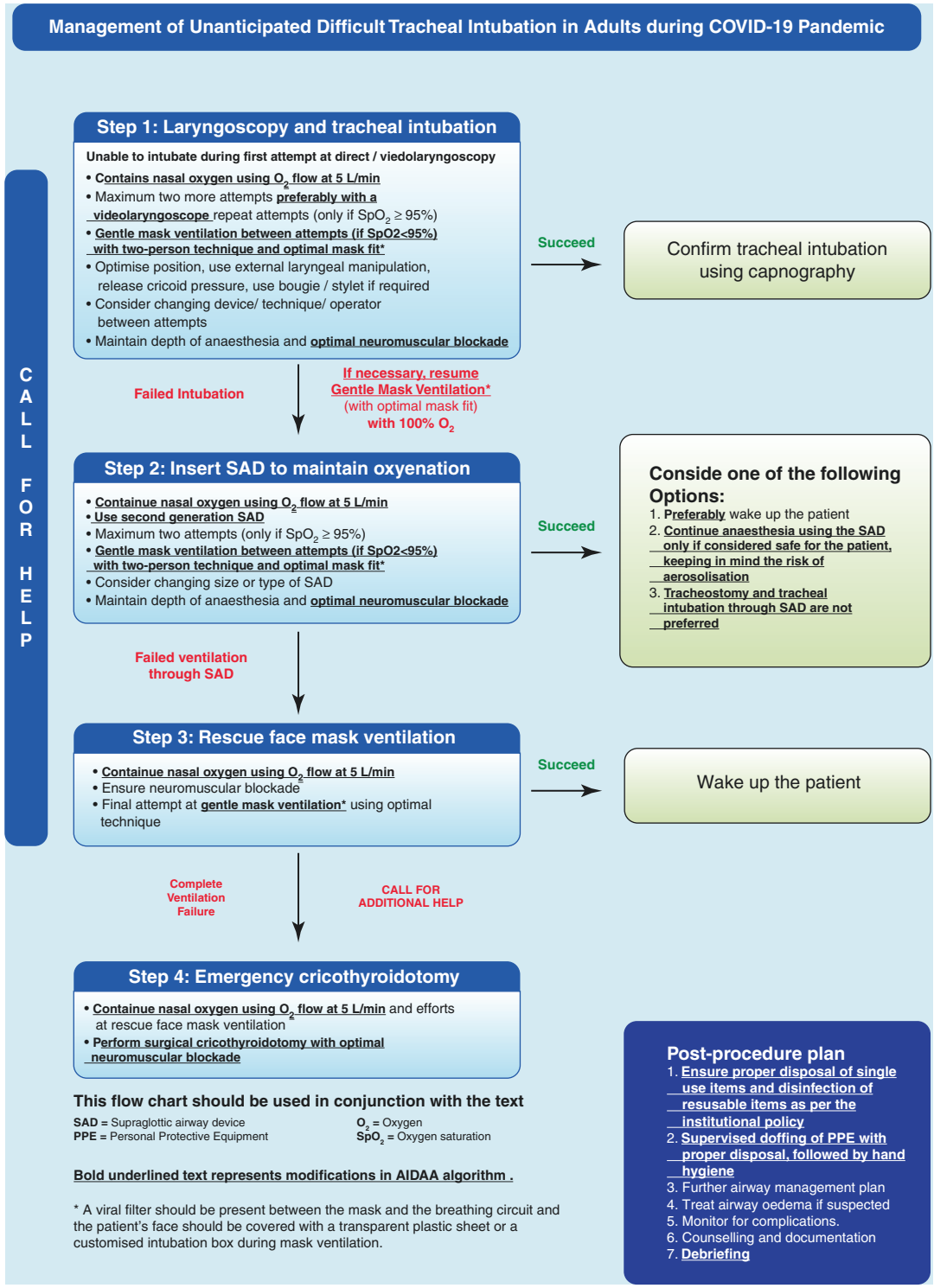

Fig. 17.28 AIDAA recommendations for airway management in COVID-19 patients. (Reproduced with permission from AIDAA, India)

Tracheal extubation:

1. Agitation, coughing, and vomiting should be avoided by pharmacological means [109].
2. In a quite normal breathing patient with barrier device, closed suction has to be used, avoid nebulization and airway exchange procedures.

Post-procedure care:

1. Surgical mask should be placed on the patient's airway soon after extubation and the patient should be covered with a plastic sheet till he is shifted to the designated place.
2. Doffing of PPE has to be supervised and is done at designated places.

Unanticipated difficult airway: Initial failure of intubation allows for two further attempts of tracheal intubation with videolaryngoscope, only if SpO_2 > 95%, with mask ventilation in between attempts. Insertion of second-generation SAD and awakening the patient are recommended options is considered if tracheal intubation is not possible. Consider performing the surgery with the SAD, considering the high risk of aerosolization. If oxygenation is not possible, proceed to surgical cricothyroidotomy. Awake intubation, if considered appropriate, is done preferably with a videolaryngoscope due to faster intubating times [110] and feasibility to use barriers. Topicalization of the airway and fiberoptic guided endotracheal intubation is a highly aerosol generating procedure and is better avoided. Disposable scope blade is preferred.

It always seems impossible until it is done!!!!

References

1. Heidegger T, Hagberg CA. Algorithms for management of the difficult airway. In: Hageberg and Benumof's Textbook of airway management. 4th ed. Amsterdam: Elsevier. p. 185–215.
2. American Society of Anesthesiologists Task Force on Management of the Difficult Airway: practice guidelines for management of the difficult airway: a report. Anesthesiology. 1993;78:597–602.
3. Fourth National Audit project of the Royal College of Anaesthetists and the Difficult Airway Society. Major complications of airway management in the United Kingdom. In: Report and findings. London: Royal College of Anaesthetists; 2011.
4. Myatra SN, et al. All India Difficult Airway Association 2016 guidelines for the management of unanticipated difficult tracheal intubation in adults. Indian J Anaesth. 2016;60(12):885–98.
5. Ramkumar V, et al. All India Difficult Airway Association 2016 guidelines for the management of unanticipated difficult tracheal intubation in obstetrics. Indian J Anaesth. 2016;60(12):899–905.
6. Pawar K, Rajan J, Ubaradka R, Singaravelu R, Sumalatha S, et al. All India Difficult Airway Association 2016 guidelines for the management of unanticipated difficult tracheal intubation in paediatrics. Indian J Anaesth. 2016;60(12):906–14.
7. Myatra SN, Ahmed SM, et al. The All India Difficult Airway Association 2016 guidelines for tracheal intubation in the intensive care unit. Indian J Anaesth. 2016;60(12):922–30.
8. Kundra P, et al. All India Difficult Airway Association 2016 guidelines for the management of anticipated difficult extubation. Indian J Anaesth. 2016;60(12):915–21.
9. Bajwa SJ, Kurdi M, Stroumpolis K. Difficult airway management in COVID times. Indian J Anaesth. 2020;64(14):116–9.
10. Edelman DA, Perkins EJ, Brewster DJ. Difficult airway management algorithms: a directed review. Anaesthesia. 2019;74(9):1175–85.
11. Chrimes N. The vortex: a universal 'high acuity implementation tool' for emergency airway management. Br J Anaesth. 2016;116(1):i20–7.
12. Chrimes N, Fritz P. The vortex approach. Management of the unanticipated difficult airway. Smashwords; 2013. http://www.vortexapproach.org.
13. Chrimes N, Higgs A, Rehak A. Lost in transition: the challenges of getting airway clinicians to move from the upper airway to the neck during an airway crisis. Br J Anaesth. 2020;125(1):e38–46. https://doi.org/10.1016/j.bja.2020.04.052.
14. Frerk C, McNarry MAF, Mendonca C, Bhagrath R, Patel A, O'Sullivan EP, Woodall NM, Ahmad I. Difficult Airway Society 2015 guidelines for management of unanticipated difficult intubation in adults. Br J Anaesth. 2015;115(6):82848. https://doi.org/10.1093/bja/aev371.
15. Law JA, Broemling N, Cooper RM, Drolet P, Duggan LV, Griesdale DE, et al. The difficult airway with recommendations for management—part 1—difficult tracheal intubation encountered in an unconscious/induced patient. Can J Anaesth. 2013;60:1089–118.
16. Apfelbaum JL, Hagberg CA, et al. American Society of Anesthesiologists Practice Guidelines for man-

agement of the difficult airway. Anesthesiology. 2022;136:31–81.
17. Ahmad I, El Boghdadly K, et al. Difficulty Airway Society guidelines for awake tracheal intubation (ATI) in adults. Anaesthesia. 2020;75:442–6.
18. Ingrande L, Lemmens HJM. Dose adjustment of anaesthetics in the morbidly obese. Br J Anaesth. 2010;105:i16–23.
19. Johnston KD, Rai MR. Conscious sedation for awake fibreoptic intubation: a review of the literature. Can J Anesth. 2013;60:584–99.
20. 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.
21. Jiang B, Ju H, Zhao Y, Yao L, Feng Y. Comparison of the efficacy and efficiency of the use virtual reality simulation-based training of fibreoptic bronchoscope manipulation. Simul Healthc. 2018;13:83–7.
22. 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.
23. Delgado C, Ring L, Mushambi C. General anaesthesia in obstetrics. BJA Educ. 2020;20(6):201–7.
24. Macfie AG, Magides AD, Richmond MN, Reilly CS. Gastric emptying in pregnancy. Br J Anaesth. 1991;67:54–7.
25. Scrutton MJL, Metcalfe GA, Lowy C, Seed PT, O'Sullivan G. Eating in labour. A randomized controlled trial assessing the risks and benefits. Anaesthesia. 1999;54:329–34.
26. Hignet R, Fernando R, McGlennan A, et al. Does a 30° head up position in term parturients increase functional residual capacity? Implications for general anaesthesia. Int J Obstet Anesth. 2008;17:S5.
27. Kristensein MS, Teo WH, baker PA. Percutaneous emergency airway access; prevention, preparation, technique and training. Br J Anaesth. 2015;14:357–61.
28. Russel EC, Wrench I, Feast M, Mohammed F. Preoxygenation in pregnancy: the effect of fresh gas flow rates within a circle breathing system. Anaesthesia. 2008;63:833–6.
29. Mir F, Patel A, Iqbal R, Cecconi M, Nouraei SAR. A randomized controlled trial comparing transnasal humidified rapid insufflation ventilator exchange (THRIVE) preoxygenation with facemask preoxygenation in patients undergoing rapid sequence induction of anaesthesia. Anaesthesia. 2017;72:439–43.
30. Pandit JJ, Andrade J, Bogod DG, et al. 5th National Audit Project (NAP5) on accidental awareness during general anesthesia: summary of main findings and risk factors. Anaesthesia. 2014;69:1069–101.
31. Brown JP, Werrett GC. Bag-mask ventilation in rapid sequence induction—a survey of current practice among members of the UK Difficult Airway Society. Eur J Anaesthesiol. 2015;32:446–8.
32. McGuire B, Lucas DN. Planning the obstetric airway. Anaesthesia. 2020;75(7):852–5.
33. Tunstall ME. Failed intubation drill. Anaesthesia. 1976;31:850.
34. Mushambi MC, Kinsella SM, Popat M, Swales H, Ramaswamy KK, Winton AL, Quinn AC. Obstetric Anaesthetist's Association and Difficult Airway Society guidelines for the management of difficult and failed tracheal intubation in obstetrics. Anaesthesia. 2015;70(11):1286–306.
35. Cook TM, Kelly FE. Time to abandon the 'vintage' laryngeal mask airway and adopt second-generation supraglottic airway device as first choice. Br J Anaesth. 2015;115:497–9.
36. Bick E, Bailes I, Patel A, Alj B. Fewer sore throats and a better seal: why routine manometry for laryngeal mask airways must become the standard of care. Anaesthesia. 2014;69:1304–8.
37. Royal College of obstetricians and Gynecologists. Maternal collapse in pregnancy and the puerperium. Green-top Guideline No. 56. London: RCOG; 2011.
38. Fitzegerald E, Hodzovic I, Smith AF. 'From darkness into light': time to make awake intubation with videolaryngoscopy the primary technique for an anticipated difficult airway? Anaesthesia. 2015;70:387–92.
39. Amathieu R, Combes X, Abdi W, Housseni LE, Rezzoug A, Dinca A, et al. An algorithm for difficult airway management, modified for modern optical devices (Airtraq laryngoscope, LMA CTrach): a 2 year prospective validation in patients for elective abdominal, gynecologic, and thyroid surgery. Anesthesiology. 2011;114:25–33.
40. Lavonas EJ, et al. Guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2015;132:S501–18.
41. Krishna SG, Bryant JF, Tobias JD. Management of the difficult airway in the pediatric patient. J Pediatr Intensive Care. 2018;7(3):115–25.
42. Huang AS, Hajduk J, Rim C, Coffield S, Jagannathan N. Focused review on management of the difficult paediatric airway. Indian J Anaesth. 2019;63(6):428–36.
43. Weiss M, Engelhardt T. Cannot ventilate-paralyze! Paediatr Anaesth. 2012;22(12):1147–9.
44. The Association of Paediatric Anaesthetists (APA) guidelines for difficult airway management in children. 2012. http://www.apagbi.org.uk/publications/apa-guidelines.
45. Engelhardt T, Virag K, Veyckemans F, Habre W. Airway management in paediatric anaesthesia in Europe-insights from APRICOT (Anaesthesia Practice in Children Observational Trial): a prospective multicenter observational study in 261 hospitals in Europe. Br J Anaesth. 2018;121(1):66–75.
46. Mutlak H, Rolle U, Rosskopf W, Schalk R, Zacharowski K, Meininger D, et al. Comparison of the TruView infant EVO2 PCD and C-MAC videolaryngoscopes with direct Macintosh laryngoscopy

for routine tracheal intubation in infants with normal airways. Clinics (Sao Paulo). 2014;69:23–7.
47. Balabon O, Tobias JD. Videolaryngoscopy in neonates, infants and children. Pediatr Crit Care Med. 2017;18(5):477–85.
48. Humphreys S, Lee-Archer P, Reyne G, Long D, Williams T, Schibler A. Transnasal humidified rapid insufflation ventilator exchange (THRIVE) in children: a randomized controlled trial. Br J Anaesth. 2017;118(2):232–8.
49. Jagannathan N, Sohn L, Fiadjoe JE. Paediatric difficult airway management: what every anesthetist should know! Br J Anaesth. 2016;117(1):i3–5.
50. Burjek NE, Nishisaki A, Fiadjoe JE, Adams HD, Peeples KN, Raman VT, et al. VL versus fiber-optic intubation through a supraglottic airway in children with a difficult airway: an analysis from the multicenter paediatric difficult intubation registry. Anesthesiology. 2017;127:432–40.
51. Koers L, Janjatovic D, Stevens MF, Preckel B. The emergency paediatric surgical airway: a systematic review. Eur J Anaesthesiol. 2018;35(8):558–65.
52. Karsli C. Managing the challenging pediatric airway: continuing professional development. Can J Anaesth. 2015;62:1000.
53. Black AE, Flynn PE, Smith HL, Thomas ML, Wilkinson KA, Association of Pediatric Anaesthetists of Great Britain and Ireland. Development of a guideline for the management of the unanticipated difficult airway in pediatric practice. Paediatr Anaesth. 2015;25(4):346–62.
54. Association of Pediatric Anaesthetists of Great Britain and Ireland. Recommendations for standards of monitoring during anaesthesia and recovery. 4th ed. London: Association of Anaesthetists of Great Britain and Ireland; 2007.
55. Santaro AS, Cooper MG, Cheng A. Failed intubation and failed oxygenation in a child. Anaesth Intensive Care. 2012;40:1056–8.
56. Cook TM, Woodall N, Harper J, Benger J. Fourth National Audit Project—major complications of airway management in the UK: results of the fourth national audit project of the Royal College of Anaesthetists and the difficult airway society. Part 2: intensive care and emergency departments. Br J Anaesth. 2011;106:632–42.
57. Higgs A, McGrath BA, Goddard C, et al. Guidelines for the management of tracheal intubation in critically ill adults. Br J Anaesth. 2018;120(2):323–52.
58. Jaber S, Jung B, Corne P, Sebbane M, Muller L, Chanques G, et al. An intervention to decrease complications related to endotracheal intubation in the intensive care unit; a prospective, multiple-center study. Intensive Care Med. 2010;36:248–55.
59. Flin R, Fioratou E, Freck C, Cook TM. Human factors in the development of complications of airway management: preliminary evaluation of an interview tool. Anaesthesia. 2013;68:817–25.
60. Greenland KB. Art of airway management: the concept of 'Ma' (Japanese: when 'less is more'). Br J Anaesth. 2015;115:809–12.
61. Heffner AC, Swords DS, Nussbam ML, Kline JA, Jones AE. Predictors of the complication of postintubation hypotension during emergency airway management. J Crit Care. 2012;27:587–93.
62. Haerkens MH, Jenkins DH, van der Hoeven JG. Crew resource management in the ICU: the need for culture change. Ann Intensive Care. 2012;2:39.
63. Pandey M, Ursekar R, Aphle S. 3 minutes tidal breathing—a gold standard technique of preoxygenation for elective surgeries. Innov J Med Health Sci. 2014;4:194–7.
64. Jaber S, Monnin M, Girard M, et al. Apnoeic oxygenation via high flow nasal cannula oxygen combined with non-invasive ventilation preoxygenation for intubation in hypoxemic patients in the intensive care unit: the single centre, blinded, randomized controlled OPTINIV trial. Intensive Care Med. 2016;42:1877–87.
65. Weingart SD. Preoxygenation, reoxygenation, and delayed sequence intubation in the emergency department. J Emerg Med. 2011;40:661–7.
66. Heard A, Toner AJ, Evans JR, Aranda Palacios AM, Lauer S. Apneic oxygenation during prolonged laryngoscopy in obese patients: a randomized, controlled trial of buccal RAE tube oxygen administration. Anesth Analg. 2017;124:1162–7.
67. Lyon RM, Perkins ZB, Chatterjee D, Lockey DJ, Russell MQ. Significant modification of traditional rapid sequence induction improves safety and effectiveness of pre-hospital trauma anaesthesia. Crit Care. 2015;19:134–611.
68. Jong De A, Molinari N, Terzi N, et al. Early identification of patients at risk for difficult intubation in the intensive care unit: development and validation of the MACOCHA score in a multicenter cohort study. Am J Respr Crit Care Med. 2013;187:832–9.
69. Bernhard M, Becker TK, Gries A, Knapp J, Wenzel V. The first shot is often the best shot: first-pass intubation success in emergency airway management. Anesth Analg. 2015;121:1389–93.
70. Cook TM. The cricoid debate-balancing risks and benefits. Anaesthesia. 2016;71:721–2.
71. Ikeda A, Isono S, Sato Y, et al. Effects of muscle relaxants on mask ventilation in anesthetized persons with normal upper airway anatomy. Anesthesiology. 2012;117:487–93.
72. Pracy JP, Brennan L, Cook TM, et al. Surgical intervention during a can't intubate can't oxygenate (CICO) event: emergency front-of-neck airway (FONA)? Br J Anaesth. 2016;117:426–8.
73. Macedo MB, Guimaraes RB, Riberiro SM, Sousa KM. Emergency cricothyrotomy: temporary measure or definitive airway? A systematic review. Rev Col Bras Cir. 2016;43:493–9.
74. Ahmad I, Bailey CR. Time to abandon awake fibreoptic intubation? Anaesthesia. 2016;71:12–6.

75. Badiger S, John M, Fearnley RA, Ahmad I. Optimizing oxygenation and intubation conditions during awake fibre-optic intubation using a high flow nasal oxygen-delivery system. Br J Anaesth. 2015;115:629–32.
76. Ho AMH, Chung DC, To EWH, Karmakar MK. Total airway obstruction during local anesthesia in a non-sedated patient with a compromised airway. J Can Anesth. 2004;51:838–41.
77. Sturgess DJ, Greenland KB, Senthuran S, Ajvadi FA, van Zundert A, Irwin MG. Tracheal extubation of the adult intensive care patient with a predicted difficult airway—a narrative review. Anaesthesia. 2017;72:248–61.
78. Astin J, King EC, Bradley T, Bellchambers E, Cook TM. Survey of airway management strategies and experience of non-consultant doctors in intensive care units in the UK. Br J Anaesth. 2012;109:821–82.
79. Schmidt UH, Kumwilaisak K, Bittner E, George E, Hess D. Effects of supervision by attending anesthesiologists on complications of emergency tracheal intubation. Anesthesiology. 2008;109:973–7.
80. Green RS, Turgeon AF, McIntyre LA, Fox-Robichaud AE, Fergusson DA, Doucette S, et al. Postintubation hypotension in intensive care unit patients: a multicenter cohort study. J Crit Care. 2015;30:1055–60.
81. Varshney S, Karmaker S. Tracheal extubation. Contin Educ Anaesth Crit Care Pain. 2008;8:214–20.
82. Kulkarni AP, Agarwal V. Extubation failure in intensive care unit: predictors and management. Indian J Crit Care Med. 2008;12:1–9.
83. Patel A, Nouraei AR. Transnasal humidified rapid insufflation ventilator exchange (THRIVE): a physiologic method of increasing apnoea time in patients with difficult airways. Anaesthesia. 2015;70:323–9.
84. Batuwitage B, Charters P. Postoperative management of the difficult airway. Br J Anaesth. 2017;17(7):235–41.
85. Cooper RM. Extubation and changing endotracheal tubes. In: Hagberg CA, editor. Benumof's airway management: principles and practice. Philadelphia: Mosby; 2007. p. 1164–80.
86. Arar C, Colak A, Alagol A, et al. The use of esmolol and magnesium to prevent haemodynamic responses to extubation after coronary artery grafting. Eur J Anaesthesiol. 2007;24:826–31.
87. Nair I, Bailey PM. Use of the laryngeal mask for airway maintenance following tracheal extubation. Anaesthesia. 1995;50:174–5.
88. Duggan LV, Law JA, Murphy MF. Brief review: supplementing oxygen through an airway exchange catheter: efficacy, complications and recommendations. Can J Anesth. 2011;58:560–8.
89. O'Sullivan E, Laffey J, Pandit JJ. A rude awakening after our fourth 'NAP': lessons for airway management. Anaesthesia. 2011;66:544–9.
90. Difficult airway Society. Airway alert form. http://www.das.uk.com/guidelines/downloads.html.
91. Nho JS, Lee SY, Kang JM, Kim MC, Choi YK, Shin OY, et al. Effects of maintaining a remifentanil infusion on the recovery profiles during emergence from anaesthesia and tracheal extubation. Br J Anaesth. 2008;103:817–21.
92. Artime CA. Tracheal extubation. Respir Care. 2014;59(6):991–1002.
93. Epstein SK. Decision to extubate. Intensive Care Med. 2002;28:535–46.
94. Jaber S, Jung B, Chanques G, Bonnet F, Marret E. Effects of steroids on reintubation and post-extubation stridor in adults. Meta-analysis of randomised controlled trials. Crit Care. 2009;13:R49.
95. Cheung JC, Ho LT, Cheng JV, Cham EYK, Lam KN. Staff safety during emergency airway management for COVID-19 in Hong Kong. Lancet. 2020;8(4):84–9.
96. Sullivan EH, Gibson LE, Berra L, Chang MG, Bittner EA. In-hospital airway management of COVID-19 patients. Crit Care. 2020;24:292.
97. Frat JP, Ricard JD, Quenot JP, et al. Non-invasive ventilation versus high flow nasal cannula oxygen therapy with apneic oxygenation for preoxygenation before intubation of patients with acute hypoxemic respiratory failure: a randomized, multicenter, open-label trial. Lancet Respir Med. 2019;7(4):303–12.
98. Cook TM, Boghdadly K, McGuire B, McNarry AF, Patel A, Higgs A. Consensus guidelines for managing the airway in patients with COVID-19. Anaesthesia. 2020;75(6):785–99.
99. Resuscitation Council. Resuscitation Council UK statement on COVID-19 in relation to CPR and resuscitation in healthcare settings; 2020.
100. Tung A, Fergusson NA, Ng N, Hu V, Dormuth C, Griesdale DEG. Medications to reduce emergence coughing after general anaesthesia with tracheal intubation: a systematic review and network meta-analysis. Br J Anaesth. 2020;124:480–95.
101. Patwa A, Shah A, et al. All India difficult airway association (AIDAA) consensus guidelines for airway management in the operating room during the COVID-19 pandemic. Indian J Anaesth. 2020;64(14):107–15.
102. Wong J, Goh QY, Tan Z, Lie SA, Tay YC, Sy N, et al. Preparing for a COVID-19 pandemic: a review of operating room outbreak response measures in a large tertiary hospital in Singapore. Can J Anesth. 2020;67:732. https://doi.org/10.1007/s12630-020-01620-9.
103. Malhotra N, Bajwa SJ, Joshi M, Mehdiratta L, Trikha A. COVID operation theatre-advisory and position statement of Indian Society of Anaesthesiologists (ISA national). Indian J Anaesth. 2020;64:267–74.
104. Myatra SN, Patwa A, Divatia JV. Critical language during an airway emergency: time to rethink terminology? Indian J Anaesth. 2020;64:275–9.
105. Loftus RW, Dexter F, Parra MC, Brown JR. Importance of oral and nasal decontamination for patients undergoing anaesthetics during the

COVID-19 era. Anesth Analg. 2020. https://doi.org/10.1213/ane.0000000000004854.
106. Respiratory Therapy Group, Respiratory Medicine Branch, Chinese Medical Association. Expert consensus on protective measures related to respiratory therapy in patients with severe and critical coronavirus infection. Chin J Tuberc Respir Dis. 2020;17:E020.
107. Luo M, Cao S, Wei L, Tang R, Hong S, Liu R, et al. Precautions for intubating patients with COVID-19. Anesthesiology. 2020;132:1616–8.
108. Lockardt SL, Duggan LV, Wax RS, Saad S, Grocott HP. Personal protective equipment (PPE) for both anaesthesiologists and other airway managers. Principles and practice during the COVID-19 pandemic. Can J Anesth. 2020;1–11:1005.
109. Amminejad R, Salimi A, Saedi M. Lidocaine during intubation and extubation in patients with coronavirus disease (COVID-19). Can J Anaesth. 2020;67:759.
110. Jiang J, Ma DX, Li B, Wu AS, Xue FS. Videolaryngoscopy versus fibreoptic bronchoscope for awake intubation—a systematic review and metanalysis of randomized controlled trials. Ther Clin Risk Manag. 2018;14:1995–63.