Approach to the Paediatric Difficult Airway in a High- Versus Low-Resource Setting: A Comparison of Algorithms and Difficult-Airway Trolleys

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KEY POINTS

- Several national bodies (American Society of Anesthesiologists, Difficult Airway Society (UK), Australia and New Zealand College of Anaesthetists, Canadian Royal College of Physicians, All India Difficult Airway Association, and others) have established adult guidelines for difficult airway management.
- While limited, paediatric-specific guidelines also exist (All India Difficult Airway Association, Polish Society of Anaesthesiology and Intensive Therapy, Polish Society of Neonatology, Association of Paediatric Anaesthetists of Great Britain and Ireland).
- Despite the existence of these guidelines, availability of difficult-airway equipment is not universal and varies by institution both in the high- and low-resource setting. Economic factors often determine the availability and frequency of their usage.
- Resource-appropriate institutional protocols should be established. Designated equipment such as a difficult-airway cart should be available in settings where anaesthesia is provided.
- Despite institutional and resource differences, principles of care and target outcomes should remain standard.

INTRODUCTION

While published data exist on the management of the difficult adult airway, clinical data regarding the difficult paediatric airway, including the incidence and optimal management, are more limited. Recommendations are often extrapolated from adult data. Fortunately, there is a lower incidence of paediatric difficult airways as compared with adults; yet, the consequences resulting from poor management are more serious.[1] The difficult paediatric airway has traditionally been anticipated by performing a thorough preoperative evaluation, but recent data suggest that 23.8% of difficult paediatric airways are unanticipated.[1] These data suggest that the incidence of difficult laryngoscopy increases under 1 year of age as compared to older infants (0.24%-4.7% in infants versus 0.07%-0.7% for children over 1 year of age).[1,2]

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Anatomy
Large occiput
Long, omega-shaped epiglottis
Vocal cords that are angled more anteriorly
Decreased subglottic diameter and stenosis
Larger percentage of narrowing of airway with same degree of oedema
Cone-shaped, cephalad larynx
Comorbidities encountered in the paediatric age group (Pierre-Robin sequence, Down syndrome)
Resources
Burden of stocking different-sized airway equipment
Scarcity of highly specialized airway experts in this age group, especially in resource-limited settings

Table 1. Challenges with Managing the Paediatric Airway Compared to the Adult Airway[3]

The management of the paediatric airway provides several challenges for the anaesthesiologist for several reasons (Table 1). These factors contribute to an overall decreased oxygen reserve and faster time to desaturation compared to adults. Exacerbating these factors is the reality that children will often not comply with awake preoxygenation, making oxygen desaturation more likely. Precipitous hypoxia can rapidly lead to bradycardia, asystole, and cardiopulmonary arrest. Additionally, the increased laryngeal sensitivity can lead to severe episodes of laryngospasm that may be resistant to first-line treatments.

As compared with adults, difficult laryngoscopy and intubation is more likely to be encountered than difficult mask ventilation in children. Several risk factors contribute to difficult laryngoscopy in children (Table 2).

As part of the preoperative anaesthetic evaluation, previous anaesthetic records should be reviewed. If there is documentation of prior difficulties in airway management, the involved providers should be interviewed if possible. For patients with past medical histories suggestive of obstructive sleep apnoea, polysomnographs, if available, can be helpful in demonstrating frequent desaturations and obstructive events and can assist in revealing occult severe pathology. This information is critical in planning, as awake or sedated approaches to intubation used in adults with difficult airways are often not practical in children. Regardless of approach, priorities during management should focus on a systematic plan agreed upon in advance, prioritizing oxygenation and ventilation, while avoiding trauma to the airway.

Anaesthesia providers are often called to assist with both anticipated and unanticipated difficult airway management outside the operating room setting such as in the emergency room and intensive care units. These are particularly challenging for anaesthesia providers as they are outside the comfort of the operating room. Vigilance in these settings focusing on a systematic approach to airway management is of utmost importance.

The purpose of this tutorial will be to describe the available national society guidelines on managing paediatric airways, and to compare the difficult-airway trolleys of 2 different institutions from different resource settings.

AIRWAY MANAGEMENT SOCIETIES

The following national and multinational societies of anaesthesiologists have established airway guidelines for all patients:

- American Society of Anesthesiologists' Practice Guidelines for Management of the Difficult Airway[5]
- Australia and New Zealand College of Anaesthetists PS56 2012[6]
- Canadian Airway Focus Group[7]
- Difficult Airway Society (United Kingdom), whose guidelines are also available as an iOS application[8]
- Scandinavian Society for Anaesthesiology and Intensive Care Medicine[9]

Additionally, the following national societies provide airway management guidelines specific to the paediatric patient:

- All India Difficult Airway Association (AIDAA) 2016[3]

American Society of Anesthesiologists III and IV physical status
Mallampati scores III and IV
Low body mass index
Children undergoing cardiac surgery
Children undergoing maxillofacial surgery
Children during their first year of life
Syndromal children

Table 2. Risk Factors for Difficult Laryngoscopy in Children[4]

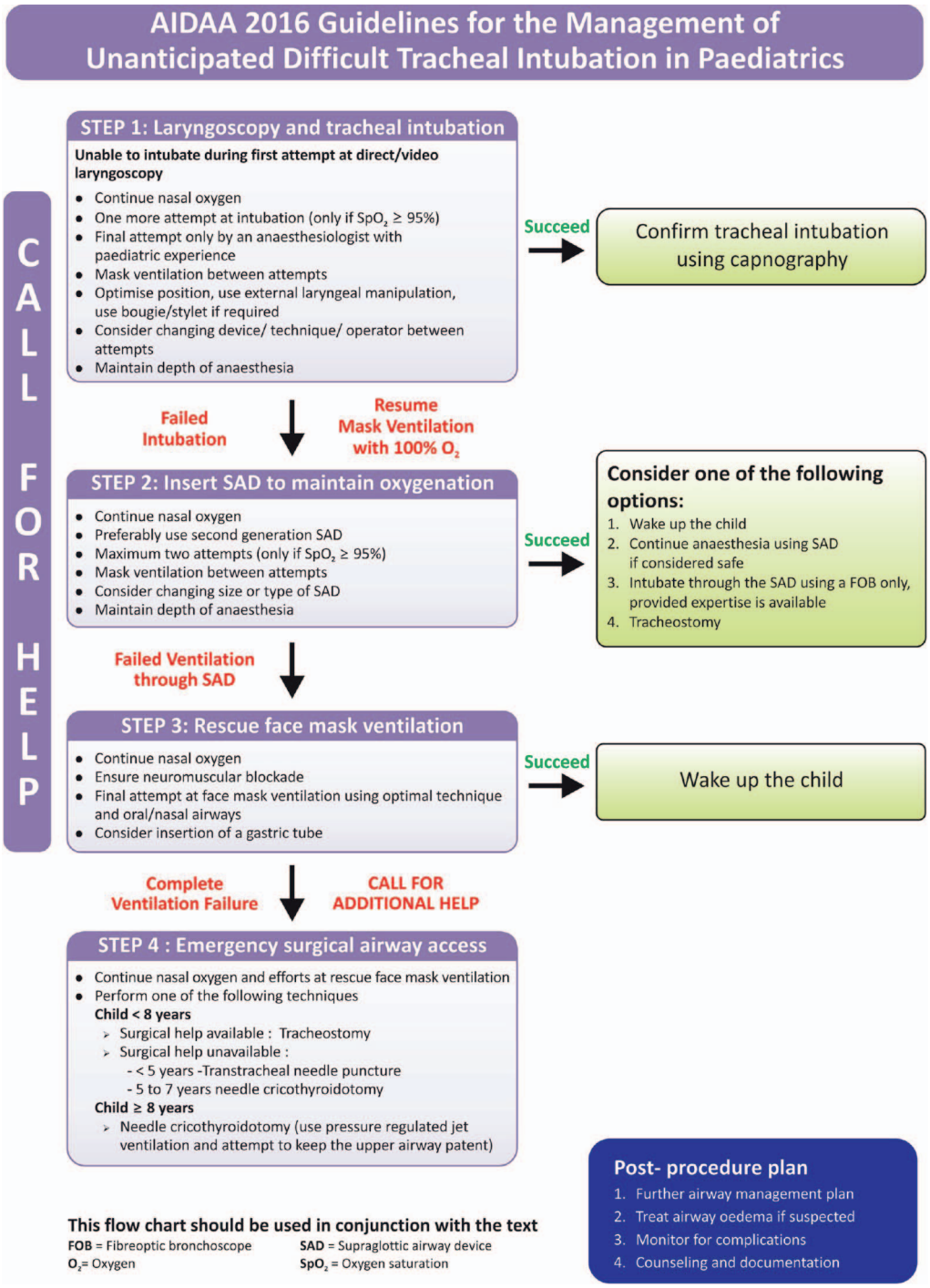

Figure 1. The All India Difficult Airway Association (AIDAA) Guidelines for the Management of Unanticipated Difficult Tracheal Intubation in Paediatrics (reproduced with permission by the AIDAA).[8]

- Association of Paediatric Anaesthetists of Great Britain and Ireland 2015[10]
- Proposal by Weiss and Engelhardt for the management of the unexpected difficult paediatric airway (Switzerland)[11]
- Paediatric Anaesthesiology and Intensive Care Section and Airway Management Section of the Polish Society of Anaesthesiology and Intensive Therapy and Polish Society of Neonatology[4]

GUIDELINES FOR DIFFICULT AIRWAY MANAGEMENT

The above societies' recommendations for the management of the difficult paediatric airway are very similar and are exemplified by the AIDAA guidelines[3] (Figure 1).

Assessment
Anticipation of Difficult Airway
Preparation
Difficult airway trolley and other emergency intubating equipment
Surgeon and surgical equipment available if difficult airway anticipated
Preinduction
Standard monitors
Intravenous access when possible
Optimize positioning
Preoxygenation
Adequate mask size and fit
100% inspired oxygen for 3 to 5 minutes prior to intubation
Induction
Paralysis may be employed (exceptions exist, refer to detailed article)
Maintain adequate depth of anaesthesia
Ventilation and oxygenation
Optimize ventilation with positioning
Maintain passive oxygenation whenever possible
Avoid gastric distention
Intubation
Improve view of vocal cords with external laryngeal manipulation
Select appropriate laryngoscopy blade
Size-appropriate endotracheal tube advancement
Malleable airway stylet as needed for assistance
Confirm correct endotracheal placement
Failed intubation
Limit the number of intubations attempts to 2, changing the technique or provider during each attempt and calling for help. The AAGBI, Polish, and AIDAA guidelines recommend a maximum of 3 intubation attempts[4]
Consider different equipment such as video laryngoscopy, different laryngoscopy blade
Exercise great caution when blindly introducing intubation aids such as bougies into the trachea; visualize vocal cords as much as possible
Supraglottic airway devices
Select appropriate size and feature (gastric drainage for instance)
Consider as intubating conduit if intubation is desired
If intubation is desired, confirm with fibre-optic scope position
Surgical airway
Tracheostomy
Cricothyroidotomy

Table 3. Pediatric Airway Management Principles[3,10,11,12] Abbreviations: AAGBI, Association of Anaesthetists of Great Britain and Ireland; AIDAA, All India Difficult Airway Association

While recommendations for management of the paediatric difficulty airway have mostly been extrapolated from adult data, there are some notable differences. These include (1) greater emphases being placed on constant maintenance of oxygenation, which is a key factor in prevention of rapid hypoxia and subsequent bradycardia and cardiopulmonary arrest and (2) switching to the most experienced paediatric anaesthesia provider after a failed intubation. The latter modification reflects the importance of reducing attempts with low success to reduce potential airway trauma and subsequent oedema, which can result in significant obstruction in smaller airways. Another key difference in the AIDAA algorithm is in the last step, where there are different surgical airway pathways determined by age. This component highlights the poor success rate of surgical airways in small children when attempted by practitioners without surgical training.

Despite these key differences, the stepwise approach to the difficult paediatric airway is globally comparable to adult algorithms.

The Association of Anaesthetists of Great Britain and Ireland provide similar guidelines,[10] with separate algorithms for the following 3 scenarios for children aged 1 to 8 years of age:

1. Difficult mask ventilation during routine induction of anaesthesia
2. Unanticipated difficult tracheal intubation after routine induction of anaesthesia
3. Inability to intubate and ventilate in a paralyzed and anaesthetized child

Regardless of the paediatric airway algorithm, they all emphasize that anticipation and adequate preparation are key to avoiding morbidity and mortality and provide guidance on preparation and management. These points are summarized in Table 3.

Paediatric differences exist compared to adult airways when considering surgical airway access. For patients under 8 years of age, surgical tracheostomy is the procedure of choice as cricothyroidotomy may be high risk. Of note, experiences with retrograde intubations in children are limited. Additionally, in many cases, rescue devices with evidence of success in adults are "scaled-down" versions for children and may not increase chances of success. A systematic review found no clear advantage between catheter-over-needle, scalpel, or other surgical techniques in the emergency paediatric airway, with all being associated with high complication rates.[13]

AIRWAY MANAGEMENT CARTS

The Difficult Airway Society (UK) recommends that airway equipment needed for management of a difficult airway be stocked in dedicated difficult airway trolleys (DATs).[3,5] The equipment should be of high quality and selected on the basis of favourable evidence, familiarity, and availability. Each institution should determine the precise number of carts and location of each cart. Essential airway equipment should be available in the operating room within 60 seconds of a potential "cannot intubate, cannot ventilate" scenario.[3] Users of the carts should be familiar with the contents and their location. Periodic training should be conducted to improve familiarity with the cart contents. This should include simulation of use of equipment outside the operating room setting such as in the emergency room and intensive care units. The trolley contents should be routinely inspected and replenished after each use by anaesthesia technicians and staff.

While Weiss et al suggest the minimum content of a DAT,[11] this is best directed by a locally defined algorithm. This group suggests stocking the drawers in order of increasing invasiveness from top to bottom. (Overfilling the trolleys with extra equipment can hinder accessibility and instead, specific personal preferences for equipment can be placed in an accompanying trolley.)

The ideal DAT has the following characteristics:

- Top work surface
- Four or 5 drawers that follow the sequence of the difficult-airway algorithm
- Mobility
- Robust construction
- Clear labels, preferably with pictures
- Easy to clean
- Reproducible
- Attached documentation:
  - Difficult-airway algorithm
  - Restocking checklist
  - Logbook for daily checking

CONTENTS OF THE DAT

Contents and setup for 3 DATs are illustrated below in Tables 4, 5, and 6:

1. Ideal DAT proposed by the Difficult Airway Society (UK): Table 4
2. Example of DAT from low-resource setting (Harare Children's Hospital, Zimbabwe): Table 5
3. Example of DAT from high-resource setting (Boston Children's Hospital, USA): Table 6

The DAT at Boston Children's Hospital varies from that of Harare Children's Hospital and the DAT proposed by the Difficult Airway Society. They are all in keeping with institutional practices and expectations.

At Boston Children's Hospital, each operating room is routinely equipped with oral airways of various sizes, 2 types of supraglottic airway devices in every size, cuffed and uncuffed endotracheal tubes, stylets, and bag-mask ventilation devices. The DAT contents only include additional equipment not used for routine intubations that is already available in the operating room. Emergency surgical airway equipment such as emergency airway access and tracheostomy equipment are kept in a well-demarcated area in the operating room corridor. The advantage of this setup is the availability of airway management equipment in all operating rooms if unanticipated need for them should occur during routine cases. The disadvantage includes increase in costs, resources, and manpower to continuously stock multiple rooms with this equipment.

In contrast, at Harare Children's Hospital, where resources are limited, there is only 1 DAT, which shared among all of the theatres and brought into the room as needed. When a patient with an anticipated difficulty airway is scheduled for surgery, a video laryngoscope is first borrowed from another university teaching hospital. The fibre-optic bronchoscope works only intermittently, highlighting the importance of not only the initial purchase costs, but also the difficulty with maintenance as well as costs that must be taken into consideration when choosing equipment for the DAT. AirTraq® (Prodol Meditec S.A., Vizcaya, Spain) video laryngoscopes are an example of a device well suited for use in a resource-limited settings due to their lack of

Top of trolley
Flexible intubating fiberscope
Shelf 1
Fibre-optic adjuvant tools
Side of trolley
Bougies
Intubation catheter
Airway exchange catheter
Attached documentation
Drawer 1: Plan A, intubation
Shoulder roll
Magill forceps
Different laryngoscopes
Video laryngoscope
Alternative laryngoscopes
Nasal cannula
Drawer 2: Plan B, oxygenation via SAD
SADs (sizes 1 to 4)
Intubating SAD
Drawer 3: Plan C, face-mask ventilation
Face masks of various sizes
Oropharyngeal airways of various sizes
Nasopharyngeal airways of various sizes
SADs with orogastric drainage conduit
Drawer 4: Plan D, surgical airway
Tracheostomy set
Needle cricothyroidotomy
Intravenous catheters
Jet ventilation device

Table 4. Example of Difficult-Airway Trolley Contents From the Difficult Airway Society[3]
Abbreviation: SAD, supraglottic airway device

Top of trolley
Different facemasks
Magill forceps
Different laryngoscopes
Different facemasks
Side of trolley
Bougies
Attached documentation
Drawer 1: Plan A, intubation
Shoulder roll
Magill forceps
Video laryngoscope (AirTraq)
Alternative laryngoscopes
Drawer 2: Plan B, oxygenation via SAD
SADs (sizes 1 to 4)
Drawer 3: Plan C, face-mask ventilation
Face masks of various sizes
Oropharyngeal airways of various sizes
Nasopharyngeal airways of various sizes
Drawer 4: Plan D, surgical airway
Tracheostomy set
14- and 16-gauge intravenous catheters

Table 5. Difficult-Airway Trolley Contents at Harare Children's Hospital, Zimbabwe Abbreviation: SAD, supraglottic airway device

Tool kit on shelf 1
Tools for airway topicalization including nasal atomizer and local anaesthetic sprays including cetacaine, lidocaine
Bite guard, mouthpiece
Ovassapian airway, bronchoscope airway
Side of trolley
Intubation catheter
Airway exchange catheter
Attached documentation
Drawer 1
Endoscope masks
Drawer 2
Intubating SADs

Table 6. Contents of the Difficult-Airway Cart at Boston Children's Hospital, USA Abbreviation: SADs, supraglottic airway devices

dependence on a power, relying instead on batteries. The particular example in Figure 6 has been adapted with a light wand due to a broken light source (Figure 6).

It is important to highlight that while DATs may be organized differently and contain different equipment, the goal of providing safe anaesthesia in an urgent setting must be met. Calder et al[12] describe that the DAT should be tailored to the needs of the institution. Prepackaged, weight-based kits are an additional consideration for inclusion in a DAT. These allow the added advantage of faster access to appropriately sized equipment. In the uncommon situation where 2 difficult paediatric airways occur simultaneously and only 1 DAT is available, appropriately sized packs can be grabbed simultaneously. Regardless of resource setting, a surgeon skilled in paediatric tracheostomies should be available and possibly in the theatre with a suitable tracheostomy set available in known very difficult airways.

RESOURCE MANAGEMENT

Airway equipment is often costly as it must meet high quality standards for medical use. Disposable items must be restocked, and the absence of 1 piece, such as the blade, may render the rest of the equipment, such as a video laryngoscope, worthless. Nondisposable equipment must be cleaned after each use and repairs may be costly and limited by the availability of skilled personnel. The decision of an institution to stock disposable or nondisposable options where both options exist (such as laryngoscope blades) will depend on the costs of labour, reliability of turnover and cleaning, and efficacy of the device. The majority of equipment used at both Boston Children's Hospital and Harare Children's Hospital is reusable.

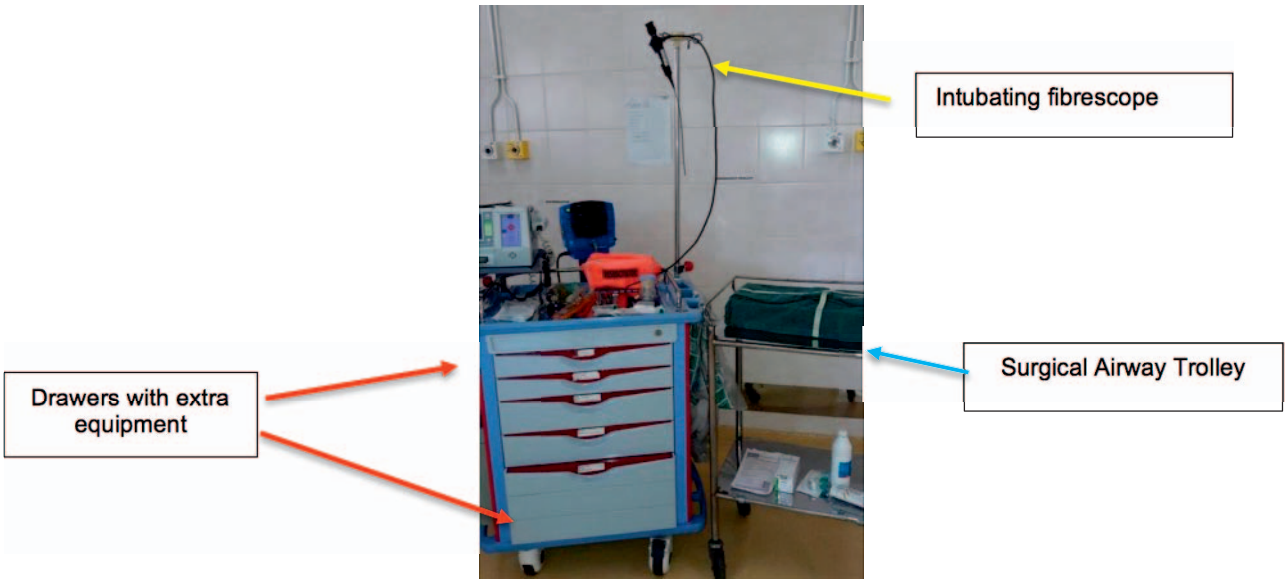

Figure 2. The Difficult-airway trolley at Harare Children's Hospital (Harare, Zimbabwe).

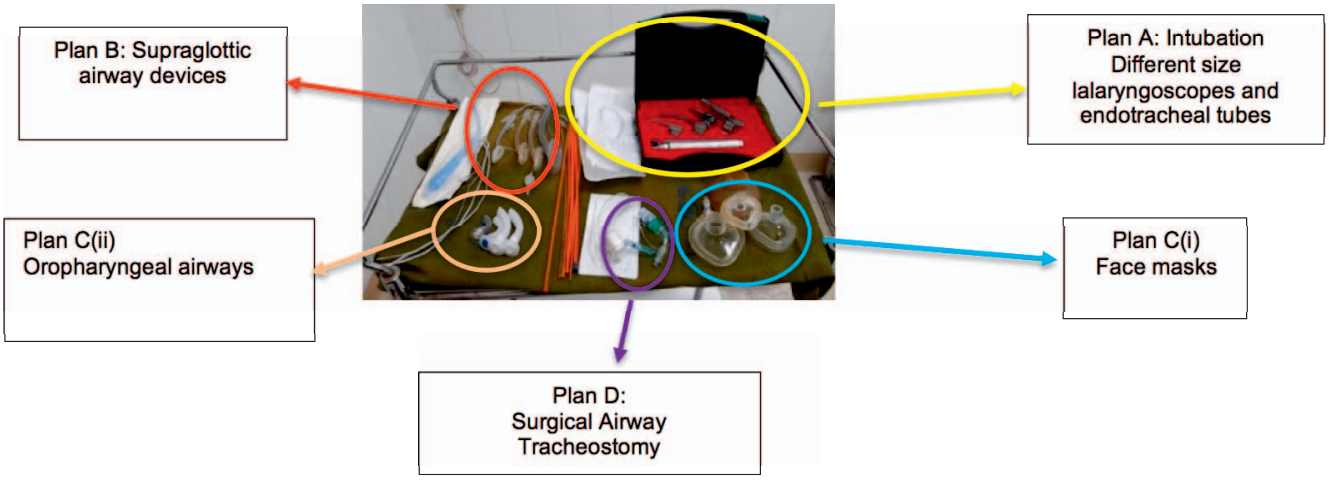

Figure 3. Top working shelf for airway trolley at Harare Children's Hospital. A video laryngoscope is available upon request from nearby hospital for anticipated difficult airways.

Figure 4. The difficult-airway trolley (DAT) at Boston Children's Hospital suited for Olympus® (Shinjuku, Japan) fibre-optic bronchoscopes contains the light source for the fibre-optic scope as well as the monitor and cables to project to the operating room monitors. The blue box and 1 drawer contain specialized fibre-optic adjunct equipment including airway devices. As discussed, the rest of the equipment typical of a classic DAT is available in each anaesthetizing location as part of the standard cart, providing a different institutional model and reflecting the adaptability of institutional DATs.

Figure 5. The difficult-airway trolley (DAT) at Boston Children's Hospital adapted for use with the Storz® (Tuttlingen, Germany) C-MAC laryngoscope blades and video bronchoscope. The monitor is smaller compared to that depicted in Figure 4. The advantage of this cart is its small size. Additionally, video laryngoscope blades or video bronchoscopes can be used interchangeably, unlike the DAT in Figure 4, which is reserved for use with fibre-optic bronchoscopes only. Both DATs can be fitted for bronchoscopes appropriate to the patient's size.

In resource-limited settings, expensive yet beneficial equipment with unique advantages may be obtained by sharing resources with other institutions, such as borrowing video laryngoscopes, prior to anticipated difficulty. Equipment that depends on constant high-pressure wall oxygen sources, such as jet ventilation, may need to be replaced by manual jet ventilation. Wall oxygen is often not available and manual jet ventilation can provide similar pressures using an oxygen cylinder. Settings with

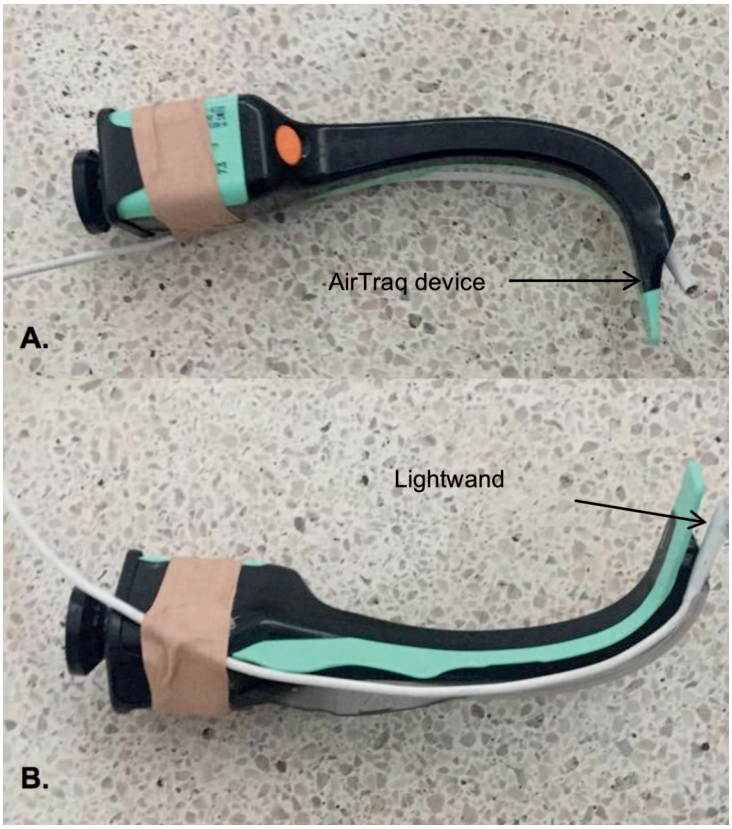

Figure 6. AirTraq (Prodol Meditec S.A., Vizcaya, Spain) device adapted with Light Wand (Vital Signs, Totwa, NJ, USA) due to nonfunctioning light source as an alternative indirect laryngoscope at Harare Children's Hospital. The Light Wand is a lighted stylet that is designed to verify correct endotracheal intubation and has been adapted here to provide a light source for the AirTraq device.

nonreliable power sources may benefit from using battery-powered, portable versions of equipment such as fibre-optic scopes and video laryngoscopes.

SUMMARY

- Several national bodies have established guidelines for difficult airway management, including specific paediatric guidelines.
- The paediatric airway has different considerations and challenges compared to adult airways, and anaesthesia providers should be familiar with these concepts.
- Contents and organization of DATS vary by institution, and the availability of difficult-airway equipment remains a challenge in low-resource settings.
- Economic factors often determine availability and frequency of use of this equipment.
- Resource-appropriate institutional protocols should be established and designated equipment such as a DAT should be available in settings where anaesthesia is provided.
- Key elements of setting up a DAT include clearly labelled drawers following a difficult-airway algorithm, attached difficult-airway algorithm, and locally available equipment.
- Despite institutional and resource differences, standards of care should be followed.

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