



# Expected difficult airway in children

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## Purpose of review

The expected difficult airway in children is a rare, but predictable entity, which can lead to life-threatening situations, when sufficient oxygenation and ventilation cannot be achieved. This review gives an overview on current techniques and recommendations on where, who, when, and how to treat children with expected difficult airway.

## Recent findings

The equipment for a strategy on how to manage difficult airway seems to be less influential on outcomes compared with the expertise of the medical team. Nevertheless, fiberoptic intubation can be defined as the recent method of choice for the management of difficult airway in children as there is no clear evidence on supraglottic airways and indirect laryngoscope techniques.

## Summary

The expected difficult airway in children is predictable by clinical signs and medical history in most of the cases and therefore anticipative. It should always be managed in specialized centers. In emergency situations, optimized face mask ventilation (aided by an oropharyngeal/nasopharyngeal airway) or ventilation via supraglottic airway devices or a nasopharyngeal tube can be most helpful skills until definitive airway management is available. These emergency techniques should be taught regularly in all anesthesia departments where children present for elective and nonelective surgery.

## Keywords

children, difficult airway, flexible fiberoptic intubation, pediatric, supraglottic airway device, videolaryngoscopy

## INTRODUCTION

The expected difficult airway in children is a rare but challenging entity. Recognition of the difficult airway, as well as expertise, and a corresponding infrastructure are the key elements for a successful management of pediatric airway. This article gives an overview about the entities as well as the incidences of the expected difficult airway in children, provides a rational argumentation for the transferral to a specialized center whenever possible and indicated, and furthermore, highlights effective but easy-to-learn techniques to assure ventilation and oxygenation in case of an emergency with a child with an expected difficult airway.

## INCIDENCES

The definition of 'difficult airway' in children in literature is very heterogeneous. According to the authors' opinion, difficult airway encompasses the occurrence of a difficult face mask ventilation (FMV), difficult ventilation via a supraglottic airway device (SAD), difficult conventional direct laryngoscopy, and difficult endotracheal intubation.

Academically, this might even be imprecise as the umbrella term 'difficult mask ventilation' does not give information whether an oropharyngeal airway has been used or a two-hand-ventilation was applied nor whether functional problems such as too-light anesthesia or thorax rigidity were excluded. Furthermore, there is a remarkable difference regarding the definition of 'difficult intubation'. Within the literature, the inclusion of a difficult procedure depends on a variety of attempts and/or the overall time to accomplish a certain task. Additionally, an operator's expertise – certainly influencing the incidence of difficulties – is usually not controlled, nor compared.

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**KEY POINTS**

- The expected difficult airway is a challenging but, even in specialized centers, very rare entity.
- Whenever possible and indicated, a child with an expected difficult airway should be transferred to a specialized center.
- The use of flexible endoscopes under spontaneous ventilation is still the preferred method for the elective management of a child with an expected difficult airway.

Taking these scientific limitations in account, the incidence – usually based on retrospective analyses of databases – of unexpected difficult FMV in children varies from 2.8 [1] to 6.6% [2]; the incidence of unexpected difficult endotracheal intubation in children varies from 0.15 [1] to 1.4% (Cormack and Lehane grades III and IV) [3].

To the best of our knowledge, there is nowadays literally no prospective or retrospective, preferable multicenter and large cohort study available focusing on the incidence, management, and outcome of expected difficult airway in children (Table 1, causes for expected difficult airway in children). Some data from specialized pediatric centers focusing on other measures than expected difficult airway indicate a very low number of expected difficult airways of 0.5% [2]. Jagannathan *et al.* [4<sup>■</sup>] studied retrospectively the elective use of SAD for children with expected difficult airway. A Database, containing 77 272 patients, was screened for either International Statistical Classification of Diseases and Related Health Problems (ICD)-codes including diagnosis known to be associated with airway

problems (dysmorphic syndromes and storage diseases) or – independently from any ICD-code – for the keyword ‘difficult airway’. In total, 459 of 77 272 (0.6%) patients had expected difficult airway. Thus, the incidence of expected difficult airway is very low, even in specialized centers.

**Limited evidence**

In contrast to well performed clinical studies, there are numerous case reports about almost all known pre-existing conditions potentially associated with difficult airway. As an example, for the Goldenhar syndrome with an incidence of 1–5 in 25 000 births, all imaginable airway techniques and tools have been described: awake fiberoptic intubation using new drugs such as dexmedetomidine [5], retrograde intubation, use of established SAD such as the ProSeal (Teleflex Medical Europe, Athlone, Ireland) laryngeal mask airway for ventilation [6], or new SAD such as the i-gel (Intersurgical Ltd., Wokingham, Berkshire, UK) to facilitate fiberoptic intubation [7]. Additionally, mostly all kinds of even less frequently used videolaryngoscopes [8,9] have been successfully described.

For some entities, case series can be found in the literature. Megens *et al.* [10<sup>■</sup>] published an interesting original work evaluating 19 children, median age of 29 months, with mucopolysaccharidosis (17 children with M. Hurler) receiving a total number of 136 anesthetics. Respiratory adverse events occurred in 24% of all anesthetics. Tracheal intubation was difficult in 25% and failed in 10%. The GlideScope (Verathon Inc., Bothell, WA, USA) was successful in eight of the nine cases. The laryngeal mask airway, attempted in 52 of 136 times, was – if used – always successful.

**Table 1.** Causes of the expected difficult airway in children

Normal anatomy	Acute entities caused by bleeding, infection, edema	Epiglottitis Laryngotracheitis Pharyngeal abscess Bleeding after Ear-Nose-Throat-surgery, such as tonsillectomy Anaphylaxis Airway foreign body
Anatomical pathologies	Anatomical facial ± spine dysmorphia	Burns, tumors, radiation therapy Syndromes such as Treacher Collins, Pierre Robin, Goldenhar, Cornelia de Lange syndromes Mucopolysaccharidosis (I–VII) Spine anomalies (e.g., Klippel–Feil syndrome)

Hosking *et al.* [11] reviewed the records of a single, specialized center in Australia retrospectively over 40 years and found 59 children with a Treacher Collins syndrome occurring approximately once every 50 000 births. Of these children, 35 underwent a total of 240 anesthetics from specialist pediatric anesthesiologists during the study period. Using direct laryngoscopy, Cormack and Lehane grade of III or IV was documented in 53% of the children. Intubation techniques other than direct laryngoscopy were used in 41%. Despite being a retrospective databank analysis over 40 years, the work of Hosking *et al.* is important for two other reasons. First, the authors evaluated the degree of difficult laryngoscopy over time and found that for the Treacher Collins syndrome intubation becomes more difficult with increased age of the patient. This seems to be in contrast to patients with a Pierre Robin sequence, in which intubation usually becomes easier during adolescence as the mandibular recovers dimensions during growth. Second, the authors admirably honestly demonstrate that for many cases, adequate and sufficient documentation within the anesthesia record is missing, probably a common problem in most anesthesia charts.

Marston *et al.* [12] reviewed – again retrospectively – newborns until the age of 3 months with Pierre Robin sequence. Prior to any maxillo-facial surgery, 37% of all intubations were performed using direct laryngoscopy with a Miller blade; 63% of the cases were intubated with a flexible fiberoptic. SAD, according to Stricker *et al.* [13], however, seems also to be a valuable tool for ventilation and oxygenation in Pierre Robin sequence.

### What could be recommended?

Without doubt, the incidence of an expected difficult airway in children is rare. Thus, screening is essential, and children with expected difficult airway should be identified in advance, usually by medical history or be a decent clinical examination (Table 2).

Based on the existing literature, a clear recommendation about which technique should preferably be used in which entity and at which age would not be appropriate. We are convinced that rather the operator's expertise with a certain technique than a technique itself is the key for successful management of expected difficult airway in children.

Additionally, the existing literature needs to be read with caution. For instance, Jagannathan *et al.* [4<sup>\*</sup>] retrospectively evaluated the elective use of SAD as the primary airway device in children with expected difficult airway and found a success rate of 96%, if a SAD had been used as the primary device and – importantly – with all children spontaneously breathing. However, only 109 out of 459 children with an expected difficult airway were managed with

**Table 2.** Predictors of an expected difficult airway

Soft tissue pathologies	Tumor Abscess Scars Past radiation therapies Burns
Maxillo-facial malformations	Hypoplasia of the mandible Retrognathia/micrognathia Facial asymmetries (including ear anomalies) Mandibular joint ankylosis (reduced mouth opening)
Mouth, tongue, and teeth anomalies	Microstomia Macroglossia Overbite
Cervical spine pathologies	Reduced movement of the cervical spine Instability of the cervical spine
Airway obstruction	Stridor Obstructive sleep apnea

a SAD as the primary and intended final airway. For the majority of children with an expected difficult airway, other strategies were chosen, mainly tracheal intubation using a SAD as a conduit. Certainly, SADs have proven to be very useful devices for difficult airway situations. However, for expected difficult airway entities, the primary use of SAD needs to be balanced carefully, and the operator's expertise seems to be the key to successful management and wise judgment. As stated by Asai [14] within his accompanying editorial, '... it is apparent that such a success rate was obtained by avoiding the use of a supraglottic airway when it was not indicated'.

Based on what is published in the literature as well as according to the author's opinion, the use of flexible fiberscopes is of significance for the management of expected difficult airway. This might be achieved either directly with the aid of a designated face mask (endoscopic face mask according to Frei *et al.* [15]) or by using a SAD as a conduit for flexible intubation [16]. Spontaneous breathing should be maintained for safety reasons until ventilation of a child's lungs is doubtless possible either via face mask or via SAD.

The recommendation to prioritize the flexible fiberoptic as described is supported by data recently presented by Nykiel-Baily *et al.* [17<sup>\*\*</sup>]. The author's need to be applauded for the implementation of specialized pediatric 'difficult airway consultation service', serving the entire hospital with all disciplines as an adviser as well as the manager of an expected difficult airway. Two thirds of all cases have been managed using the flexible fiberoptic.

Videolaryngoscopes will certainly gain more influence for airway management, particularly for supervision of trainees, but also for managing the unexpected and maybe the expected difficult airways too. However, a final judgment cannot be made. Karsli and co-workers [18] have shown in a small cohort of children with craniofacial dysmorphic syndromes that videolaryngoscopes – the GlideScope videolaryngoscope in the study by Karsli and co-workers – are not fail-safe and do not always improve view on the laryngeal structures. In three of the 18 patients (17%), the use of the GlideScope videolaryngoscope did not improve the view as compared with direct laryngoscopy, and in two patients the flexible fiberoptic was used (once directly and once via a laryngeal mask airway).

Nowadays, there are many different indirect laryngoscopy concepts in the market; however, based on the current literature, there is not a single videolaryngoscope that on the basis of evidence might be superior to its competitors [19].

### Anesthesia management

Today there is no evidence on the ‘preferred anesthesia management’ for children with expected difficult airways. However, the primary goals of induction, maintenance, extubation, and postanesthetic care can be defined as follows:

- (1) Maintenance of spontaneous breathing until definitive airway management and/or until doubtless verification of possible ventilation via face mask or via a SAD regardless of which anesthetic is used.
- (2) An intravenous or intraosseous line should be immediately available to ensure the application of emergency drugs.
- (3) The extubation after a difficult intubation should be performed under defined precautions, either in the odds ratio or later in the postanesthesia care unit/ICU. If there is any doubt of a clear airway after extubation, a ‘reversible extubation strategy’ should be attempted, such as by using airway exchange catheters or designated extubation sets.
- (4) A child with a difficult airway should be monitored for at least 2–3 h postoperatively.
- (5) There should be a careful documentation of all measures taken, with a copy for the patient.

### Recommendations

We need to acknowledge that rather the operator’s expertise than a certain technique leads to successful

management. However, one can postulate that in specialized pediatric centers, the personal and infrastructural parameters are more likely to be adequate for the management of children with expected difficult airways. These encompass equipment (SAD, flexible endoscopes, videolaryngoscopes, and so on) in adequate pediatric sizes as well as appropriate provision of postoperative care structures, such as pediatric postanesthesia care unit and ICU. Additionally, pediatric surgical disciplines with expertise in the establishment of a tracheal access should be present within the institution.

Designated centers should organize regular theoretical teaching and practical training of basic and advanced airway skills. Indeed, all techniques that might be applied to a child with an expected difficult airway can be taught and trained during regular perioperative pediatric care.

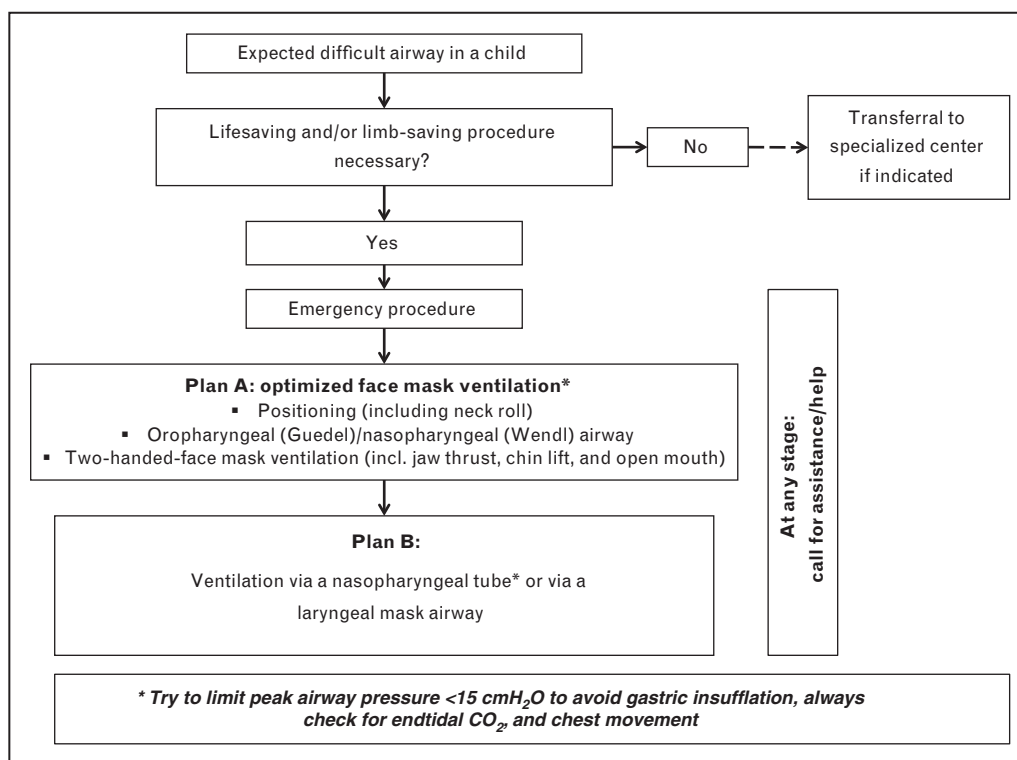
Information on the strategies of managing expected difficult airway should be available for all team members, such as checklists for preoperative evaluation, airway equipment (e.g., airway trolley), preparation of anesthetics and emergency medication, as well as for extubation/postanesthetic care.

Whenever possible, children with an expected difficult airway should be treated in specialized centers (Fig. 1). Thus, it is highly recommended to transfer a child to a center described above if the corresponding preconditions are not available. Consequently, the only clinical conditions that prevent transferral are urgent risk of respiratory depression or limb/lifesaving procedures.

### EMERGENCY MANAGEMENT OF A CHILD WITH AN EXPECTED DIFFICULT AIRWAY

Either for the expert or for those who do not regularly work on the pediatric airway, the following techniques might help to assure ventilation and oxygenation in a child with an – but not only – expected difficult airway (Fig. 1). Please note that all techniques can be taught and practised during daily airway management.

- (1) One-hand or two-hand FMV with or without the additional use of an oropharyngeal (Guedel tube) or nasopharyngeal tube (Wendl tube); both tubes help to overcome upper airway obstruction. Caution needs to be taken care of regarding adequate sizing as well as adequate depth of anesthesia during insertion.
- (2) Direct ventilation via a tracheal tube placed in the nasopharynx, with the distal end of the placed tube right above the laryngeal inlet; assisted or controlled ventilation can be



**FIGURE 1.** Flow chart for the handling of a child with an expected difficult airway.

achieved when the contralateral nostril as well as the mouth are closed. This technique promises to be successful even in children with reduced mouth opening. However, the operator needs to be aware that iatrogenic gastric insufflation is possible as a result of too deep (esophageal) insertion of the tube or – like during FMV – by application of higher airway pressure.

- (3) If mouth opening and oropharyngeal space are not compromised, SAD can be inserted for ventilation.

It is the author's experience that ventilation via a tracheal tube placed in the nasopharynx is a very powerful technique in neonates and children as well as adults. In clinical practice, nasopharyngeal ventilation will probably be used rather in neonates or newborns than in older children, where use of a SAD will be the primary choice.

## CONCLUSION

Expected difficult airway in children is an entity with a very low incidence. Case series are helpful to gain some kind of knowledge about these challenging airways. However, larger prospective cohort studies are warranted to allow more robust and in the best case evidence-based recommendations regarding a preferred airway management technique considering also different entities and ages.

Without any doubt, successful management relies on the operator's expertise. Especially in anatomically fixed airways, maintenance of spontaneous breathing until definitive airway is secured as well as the use of flexible endoscopes is nowadays the preferred technique in children with expected difficult airways. The definitive value of videolaryngoscopes can currently not be balanced sufficiently.

In case of a lifesaving or limb-saving procedure, there are emergency techniques to assure oxygenation (FMV, ventilation via a tracheal tube placed in the nasopharynx, or the use of SAD) that should be trained in everyday practice.

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## Conflicts of interest

There are no conflicts of interest.

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- of special interest
- of outstanding interest

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