MANAGEMENT OF THE CHILD'S AIRWAY UNDER ANAESTHESIA: THE FRENCH GUIDELINES

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PII: S2352-5568(19)30070-0
DOI: https://doi.org/10.1016/j.accpm.2019.02.004
Reference: ACCPM 496

To appear in:

Please cite this article as: Dadure C, Sabourdin N, Veyckemans F, Babre F, Bourdaud N, Dahmani S, Queiroz MD, Devys J-Michel, Dubois M-Claude, Kern D, Laffargue A, Laffon M, Lejus-Bourdeau C, Nouette-Gaulain K, Orliaguet G, Gayat E, Velly L, Salvi N, Sola C, MANAGEMENT OF THE CHILD'S AIRWAY UNDER ANAESTHESIA: THE FRENCH GUIDELINES, *Anaesthesia Critical Care and Pain Medicine* (2018), https://doi.org/10.1016/j.accpm.2019.02.004

Expert's guidelines

MANAGEMENT OF THE CHILD'S AIRWAY UNDER ANAESTHESIA:

THE FRENCH GUIDELINES*

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ABSTRACT:

OBJECTIVE: To provide French guidelines about "Airway management during paediatric anaesthesia".

DESIGN: A consensus committee of 17 experts from the French Society of Anaesthesia and Intensive Care Medicine (Société Française d'Anesthésie-Réanimation, SFAR) and the Association of French speaking paediatric anaesthesiologists and intensivists (Association Des Anesthésistes Réanimateurs Pédiatriques d'Expression Francophone, ADARPEF) was convened. The entire process was conducted independently of any industry funding. The authors followed the principles of the Grading of Recommendations Assessment, Development and Evaluation (GRADE®) system to assess the quality of evidence. The potential drawbacks of making strong recommendations in the presence of low-quality evidence were emphasised. Few recommendations were not graded.

METHODS: The panel focused on 7 questions: 1) Supraglottic Airway devices 2) Cuffed endotracheal tubes 3) Videolaryngoscopes 4) Neuromuscular blocking agents 5) Rapid sequence induction 6) Airway device removal 7) Airway management in the child with recent or ongoing upper respiratory tract infection. Population, intervention, comparison, and outcomes (PICO) questions were reviewed and updated as needed, and evidence profiles were generated. The analysis of the literature and the redaction of the recommendations were then conducted according to the GRADE® methodology.

RESULTS: The SFAR Guideline panel provides 17 statements on "airway management during paediatric anaesthesia". After two rounds of discussion and various amendments, a strong agreement was reached for 100% of the recommendations. Of these recommendations, 6 have a high level of evidence (Grade 1±), 6 have a low level of evidence (Grade 2±) and 5 are experts' opinions. No recommendation could be provided for 3 questions.

CONCLUSIONS: Substantial agreement exists among experts regarding many strong recommendations for paediatric airway management.

Keywords: airway, management, children, guidelines

1. Introduction

Children are anaesthetised in different types of hospital by anesthesiologists whose experience in paediatric anaesthesia is variable [1]. Airway management is a critical part of paediatric general anaesthesia. Recent European data from the APRICOT study confirmed that currently more than 50% of perioperative critical events in children are respiratory [2]. Any improvement in airway management should reduce morbidity and mortality in paediatric anaesthesia.

In 2005 the French Society of Anaesthesia and Intensive Care Medicine (SFAR) published experts' recommendations concerning the anaesthetic management of tonsillectomy in children [3]. Professional Clinical Recommendations were also published in 2000 paediatric anaesthesia structures and equipment [4]. To date, no text concerning the management of child's airways has been published.

Since then, new techniques and knowledge have emerged in this field of anaesthesia that are likely to significantly change practices: new equipment (low pressure cuffed tubes, supraglottic devices), new concepts of rapid sequence induction, muscle relaxation use for routine intubation. It therefore seems important to analyse these new data to help the clinician in his daily practice.

2. Objectives

The following formalised recommendations are the result of the collaboration of the SFAR and the Association of French speaking paediatric anaesthesiologists and intensivists (Association Des Anesthésistes Réanimateurs Pédiatriques d'Expression Francophone, ADARPEF). The main goals were to improve the practice according to the technical evolutions of the upper airway management in children, and to synthetise and validate the published scientific data at the national level. In addition, a particular issue was addressed concerning the airway management of the children with airway respiratory tract infection, a significant major risk factor in paediatric anaesthesia. The ultimate goal is to consider a decrease in respiratory morbidity-mortality of children's anaesthesia.

Seven issues were addressed:

- Use of supraglottic airways in children
- Use of cuffed and uncuffed tracheal tubes in children
- Use of videolaryngoscopy in children
- Use of muscle relaxation for intubation in children
- Rapid sequence induction in children
- Airway device removal in children
- Airway management of children with a cold.

3. Methods

3.1. Literature review.

Relevant literature was collected from the PubMed and Cochrane databases, with results limited to the 15 years before 2017. For each selected question, if at least one meta-analysis was available, the literature search was carried out on subsequent publications.

3.2 Methodology for developing recommendations

First, the organising committee defined the specific issues to be analysed. Second, experts were designated for each relevant issue. The questions were formulated in the PICO (Patients Intervention Comparison Outcome) format. The analysis of the literature and the writing of the recommendations were then conducted according to the GRADE1 methodology (Grade of Recommendation Assessment, Development and Evaluation) [5]. This method enables, after a quantitative analysis of the literature, to separately determine the quality of evidence, estimate the confidence that one can have in the quantitative analysis of the effect of the intervention, and a level of recommendation. The quality of evidence was stratified into four categories:

- High: future research will most likely not change the confidence in the estimation of the effect;

- Moderate: future research will likely change the confidence in the estimation of the effect and could modify the estimate of the effect itself;

- Low: future research will most likely have an impact on the confidence in the estimation of the effect and will probably modify the estimate of the effect itself;

- Very low: the estimate of the effect is very uncertain.

The quality of the evidence is analysed for each study; following this a global level proof is defined for a given question and criterion. The final formulation of the recommendations will always be binary: either positive or negative, and either strong or weak.

Strong: we strongly recommend (GRADE 1+) or not.

Weak: We probably recommend (GRADE 2+) or probably not.

The strength of the recommendation is determined by four key factors and validated by experts after a vote, using the GRADE 1 Grid method:

- Estimation of the effect;

- Overall level of evidence: the higher it is, the more likely recommendation will be strong;

- Balance between desirable and undesirable effects: the more it is favourable, the more likely the recommendation will be strong;

- Values and preferences: in case of uncertainty or large variability, the recommendation will more likely be weak; these values and preferences should ideally be obtained directly from the persons concerned (patient, doctor, decision maker).

In order to issue a recommendation on a criterion, at least 50% of the experts had to broadly agree and less than 20% had to express a contrary opinion. For a recommendation to be strong, at least 70% of the participants had to broadly agree. In the absence of strong agreement, the recommendations were redrafted and, again, submitted to the group of experts with the aim of achieving a better consensus. After summarising the work of the experts and applying the GRADE 1 method, twelve recommendations and 5 experts' opinions have been formalised and 3 algorithms (Figure 1, 2 and 3) have been produced.

All of the recommendations were submitted to the expert group. After three rounds of discussion and various amendments, a strong agreement was reached for 100% of recommendations. Of these recommendations, 6 have a high level of evidence (Grade 1 +/-), 6 have a low level of evidence (Grade 2 +/-) and 5 were experts' opinions. No recommendation could be provided for 3 questions.

1. Use of supraglottic airways and endotracheal tubes in apediatric anaesthesia

R1- It is probably recommended to use a supraglottic airway rather than tracheal intubation in case of short-lasting elective superficial surgery in order to reduce the incidence of laryngospasm and hypoxaemia during removal of the device.
Grade 2+, strong agreement

Discussion: Two meta-analyses studied the literature published from 1990 to 2013 comparing tracheal intubation versus supraglottic airways during elective surgery [6,7]. Their conclusions vary regarding laryngospasm and hypoxemia. Luce [6] found a significant difference in the incidence of these 2 complications in favour of the use of supraglottic airway, while Patki did not [7]. These complications occur only during emergence of anaesthesia. No difference was found during the insertion of the device. Both meta-analyses found a significantly lower incidence of postoperative cough with supraglottic airway. More recently, Acquaviva et al found no difference in terms of respiratory complications between tracheal intubation and supraglottic airway in a population of 84 children aged from 3 to 17 years undergoing gastrointestinal endoscopy [8]. Recently, Drake-Brockman et al. conducted a randomised controlled trial comparing tracheal intubation and the laryngeal mask airway (LMA) in 181 infants (2-12 months of age) undergoing minor surgery [9]. The authors

showed a significant decrease in the number of perioperative respiratory adverse events in the "laryngeal mask" group. The relative risk of these adverse effects was increased by 2.94 in the " tracheal intubation " group. The relative risk of laryngospasm and bronchospasm was 5 times greater in the same group.

NO RECOMMENDATION: In children, there is no argument to recommend removing a supraglottic airway under deep anaesthesia or fully awake.

Discussion: When using a LMA or a tracheal tube to protect the airway, the timing of device removal is a period at risk for respiratory complications. The question of the optimal conditions for device removal, under deep general anaesthesia (GA) or in a fully awake state, has been the subject of several randomised studies. All children are ASA I or II status, mostly scheduled for outpatient surgery. A meta-analysis, including 11 studies with groups of children (analysed separately) or exclusively paediatric, did not find any difference between the two techniques in terms of risk of laryngospasm or desaturation, but found an increased risk for upper airway obstruction when the LMA is removed under deep anaesthesia [10]. However, no serious events were reported, airway obstruction being quickly released with jaw thrust or insertion of an oropharyngeal airway. Among the respiratory complications, cough was more likely when the laryngeal mask airway was removed awake. The authors conclude that one technique cannot be considered superior to the other with respect to "serious" complications. However, because of the greater risk of upper airway obstruction when the laryngeal mask airway was removed under GA, they advocate an anticipation of this risk. Recently, Thomas-Kattappurathu et al. studied, in addition to the level of consciousness, the ideal position (lateral or supine) for LMA removal [11]. The authors found a greater risk of desaturation when the laryngeal mask was removed in the supine position (reporting up to 66% of episodes of stridor in the GA / supine group). The risk of airway obstruction was also greater in the GA / supine group, but without any serious consequences. In this study, the authors also evaluated the respiratory events according to a "severity score" (considering that all the events collected did not represent the same risk for the patient) and concluded that the most serious complications occurred in the supine position, whether under GA or awake. They concluded that the lateral position is preferable to the supine position, whether the laryngeal mask is removed under GA or awake. Finally, in a study on dental surgery [12], the authors recommend removing the laryngeal mask in woken children, due to a lower average SpO2 in the GA group ($p = 0.04$) and a larger number of patients with SpO2 <95% ($p = 0.003$). This is the only study that focuses on "at risk" oral surgery, given the potential presence of blood in the pharynx.

R2 - For tonsillectomy, it is recommended to protect the upper airway with a cuffed tracheal tube.

Grade 1+, strong agreement

Discussion: The review of the paediatric anaesthetic literature did not identify recent publications that warrant a change in this recommendation. Previous recommendations advocate airway control using a cuffed tracheal tube [3].

R3 - In case of unanticipated difficult intubation and ventilation, it is recommended to use a supraglottic airway to try to ensure the child's oxygenation.
Grade 1+, strong agreement

Discussion: The younger the child the shorter the time of onset of desaturation below 94%. Ventilation then quickly becomes an emergency. Numerous publications demonstrate the benefit of supraglottic devices in case of impossible facial mask ventilation [13-15]. Hypoxemia can thus be prevented or corrected quickly [16]. Using a supraglottic airway is now part of the recommendations proposed by various adult and paediatric international societies [17-20] in case of difficult intubation or difficult facial mask ventilation. The risk of malposition, local trauma and incorrect size of the supraglottic airway has to be assessed. The number of attemps for insertion of a supraglottic airway should be limited to 2 or 3. In case of failure, an alternative oxygenation technique should be chosen. In case of failure of direct or indirect laryngoscopy after 3 to 4 attemps, the supraglottic device can be used not only to oxygenate the child but also as a route of insertion of endotracheal tube. Fibreoptic intubation can be performed through the supraglottic airway by trained practitioners [21, 22]. Under these conditions, the duration of intubation is less than one minute and the success rate is high.

R4 - It is recommended to monitor cuff pressure in supraglottic airways with an inflatable cuff and to limit this pressure to 40 cmH2O.
Grade 1+, strong agreement

Discussion: The analysis of the literature did not make it possible to determine which cuff pressure should be chosen, but rather what pressure should not be exceeded to ensure adequate ventilation without excessive leakage and minimal risk of complication. A cuff pressure <40 cmH2O appears to be the threshold below which the leak pressures, the leak volumes and the incidence of oropharyngeal postoperative pain are minimal [23-26]. Increasing cuff pressure beyond 40 cm H2O is usually accompanied by increased leaking [25, 27]. Control of cuff pressure with a pressure gauge is recommended as a "standard", as pressures are too high if the cuff is inflated based on "clinical" criteria [25, 27, 28]. Cuff pressure measurement should be regularly repeated when nitrous oxide is used.

R5 - For endotracheal intubation, it is recommended to use cuffed rather than uncuffed tubes, and to monitor the cuff pressure (not to exceed 20 cmH2O).
Grade 1+, strong agreement

Discussion: Several prospective studies (2 randomised controlled trials in the operating theater, and 2 case-reports studies in intensive care) [29-32], and a meta-analysis [33] agree and suggest that the use of cuffed endotracheal tube in children, rather than uncuffed tube, reduces the rate of re-intubation change for excessive leakage, without increasing the incidence of post-extubation respiratory or laryngeal complications (stridor, tracheal intubation time, need for re-intubation after programmed extubation). In addition, the use of a cuffed tracheal tube favors low-flow ventilation and reduces the atmospheric pollution the operating theater. However, the European Paediatric Endotracheal Intubation Study Group recommends that cuffed tubes should not be used in children weighing less than 3 kg [32,34].

2. Place of videolaryngoscope in paediatric anaesthesia?

Prerequisite:
A videolaryngoscope should not be used if one of the following conditions is encountered:
1) The patient's mouth opening does not allow the introduction of the device
2) The cervical spine is fixed in flexion;
3) An obstacle producing stridor is present in the upper airway.
- It is mandatory to check the possibility of introducing a videolaryngoscope into the child's mouth before inducing apnoea.
- A desaturation < 95% requires interrupting the intubation maneuvers to allow re-oxygenation. In case of risk of hypoxemia, a videolaryngoscope should not be used as a substitute for a supra-glottic airway.

R6 - It is probably recommended to use videolaryngoscopy as first option for patients with an anticipated difficult intubation but possible mask ventilation, or after failure of direct laryngoscopy, to increase the probability of successful intubation.
Grade 2+, strong agreement

Discussion: The anticipated difficult intubation is a relatively rare situation in children, and it is defined by less precise criteria than in adults. In children with a history of difficult intubation or polymalformative syndrome [35-39], videolaryngoscopy can improve glottic vision, the Cormack-Lehane score and increase the success rate of tracheal intubation at first attempt [40,41]. The performance of the videolaryngoscopes depends on the type of device, the expertise of the operator and the individual caracteristics of the patient [41].
Today, the videolaryngoscopes are classified according to the presence or absence of a guiding channel, and their own characteristics, including handiness and technique of use.
Videolaryngoscopes should be used in patients with difficult intubation criteria by trained practitioners.

External laryngeal maneuvers to improve glottic exposure are facilitated when using a videolaryngoscope with a remote screen because their effect is directly visible by the assistant who can adjust his gesture accordingly [42].
When using a videolaryngoscope without a lateral channel, it is recommended to use of a non-traumatic preformed guide to direct the tracheal tube toward the glottic aperture.
In children who have already required the use of a videolaryngoscope for a tracheal intubation, the videolaryngoscope can be chosen as a first-option [36].
In the absence of criteria of difficult intubation, the success rate and time to intubate the trachea with a videolaryngoscopes are not significantly different from those obtained with direct laryngoscopy using a Macintosh blade [43-45].

3. Should muscle relaxants be used for tracheal intubation in children?

R7 - Except in situations when rapid sequence induction and the use of succinylcholine are indicated, it is probably recommended to use a non-depolarizing muscle relaxant to improve intubation conditions during elective intravenous induction of anaesthesia in children.
Grade 2 +; Strong agreement

Discussion: The SFAR recommendations published in 1999 did not recommend the use of muscle relaxatants for induction of elective general anaesthesia in children, whether inhalational or intravenous. As a consequence, muscle relaxants are currently rarely used in France [1], and many associations of a hypnotic and an opiate have been published [46]. However, when considering intravenous induction, a meta-analysis of randomised studies has demonstrated that the intubation conditions are improved when muscle relaxation is used [47-54]. In addition, the dose of hypnotics and/or opiates needed to perform tracheal intubation without muscle relaxation are relatively important and may have significant haemodynamic effects [50,52,55]. These results support those of a French cohort study [56]. As a result of the alert of the National Agency for Drug Safety (Agence Nationale pour la Sécurité du Médicament, ansm.sante.fr) about succinylcholine published on December 2017, a depolarizing muscle relaxant should not be used anymore for intravenous induction of anaesthesia, except in the context of rapid sequence induction.
In France, 92% of anaesthesiologists do not use muscle relaxation during inhalational induction in children [1]. With this technique, many factors are known to affect the quality of the intubation conditions and the child's haemodynamic parameters. These are mainly: the duration of exposure to sevoflurane, the end-tidal concentration of sevoflurane and the associated intravenous agents (opiate ± propofol) [46, 57-59]. In all instances, a sufficient depth of anaesthesia and apnoea are the keys of success for this technique [60]. However, using muscle relaxation during inhalational induction can be considered, at least in infants in whom a randomised controlled trial and a large quality insurance analysis have shown that muscle relaxation produces better intubation conditions and less adverse respiratory events

[61,62]. These data allow the use of muscle relaxation during inhalation induction in children and encourage further studies on the possible benefits of muscle relaxation. These benefits should be balanced against a small but unknown risk of anaphylactic reaction [63, 64) and imply that the anaesthesiologist in charge is knowledgeable about curarisation and decurarisation in children.

4. Rapid sequence induction in children

R8 – It is recommended to use a rapid onset muscle relaxant during classic rapid sequence induction.
Grade 1 +, Strong agreement

R9 – During classic rapid sequence induction in children, it is probably recommended to use succinylcholine as the first choice. In case of contra-indication to succinylcholine, it is probably recommended to use rocuronium.
Grade 2 +, Strong agreement

Discussion: As in adults, it is recommended to keep the delay between loss of consciousness and protection of the upper airway as short as possible [65,66]. This period of time needs to be even shorter in children because the younger the child, the shorter the duration of apnoea without hypoxaemia [67]. As muscle relaxation improves the conditions of intubation, neither intubation without muscle relaxation nor inhalational induction is recommended in this context. Regarding the choice of muscle relaxant, the experts still favor succinylcholine. It should be kept in mind that the dose of succinylcholine varies with age: up to 1 month: 1.8 mg/kg, 1 month to 1 year: 2 mg/kg, 1 to 10 years: 1.2 mg/kg and more than 10 years: 1 mg/kg. Rocuronium at a dose > 0.9 mg/kg [68] is a good alternative to succinylcholine bearing in mind that the use of sugammadex is still not allowed in children in France in 2018. Therefore, the choice between succinylcholine and rocuronium should be based on the desired duration of muscle relaxation, the risk of difficult intubation and the presence or risk of a neuromuscular disease.

Due to its rapid peak of action and the good conditions of intubation it provides, rocuronium is the muscle relaxant the most frequently compared with succinylcholine [69,70]. Its induction dosage varies from 0.6 to 0.9 mg/kg [70]. A retrospective cohort study did not find any difference in the incidence of respiratory complications or difficult intubation between succinylcholine and non-depolarizing muscle relaxants [71]. The conclusions of the last Cochrane meta-analysis evaluating the conditions of intubation with rocuronium or succinylcholine are that succinylcholine provides as good or better intubation conditions as rocuronium despite the presence of bias in some studies [72]. It therefore concludes that succinylcholine should still be used (notably because of its shorter duration of action) and that rocuronium should be used when succinylcholine is contraindicated [72, 73]. These

contraindications are: known or suspected susceptibility to malignant hyperthermia, a neuromuscular disease at risk of rhabdomyolysis, hyperkalemia and situations at risk of it, and allergy to succinylcholine [70].

Sugammadex is useful to reverse the effects rocuronium [74,75]. A recent meta-analysis lead by Won has shown that sugammadex shortens the mean time to obtain a TOF $\geq$ 0.9 and proceed with extubation by comparison with neostigmine or a placebo [74]. Regarding the risk of anaphylaxis the results of studies are contradictory: Reddy *et al* show that the risk of anaphylaxis is similar with succinylcholine and Rocuronium [76]; while Reitter *et al* show an increased risk for succinylcholine [77]. The risk of anaphylaxis could be smaller with atracurium and cisatracurium [76, 78]. Last but not least, the risk of anaphylaxis with sugammadex is not negligible [79, 80].

5. Extubation of the child

NO RECOMMENDATION: There are no data in the current literature allowing determining whether extubation under deep anaesthesia or in a fully awake patient is safer in a child intubated without any problem and not at risk for aspiration.

Discussion: Regarding awake extubation, the usual adult criteria for extubation (regular spontanous breathing with no retractions, tidal volume $\geq$ 5–8 ml/kg, respiratory rate 12–25 b/min, full decurarisation, SpO2 $\geq$ 95 % with a FIO2 $\leq$ 50 %, PEP $\leq$ 5 cmH2O, PaO2 > 60 mmHg, PaCO2 < 50 mmHg, obtaining a motor response to simple orders, swallowing) can be adapted to the child but young children are often unable to give a motor response to simple orders [81]. A few paediatric studies described precisely which criteria should be obtained before extubation: age-appropriate tidal volume and breathing rate, grimacing, cough with an open mouth or eye opening, adapted movements [82,83]. This technique protects against a possible aspiration and upper airway obstruction because laryngeal reflexes have recovered but can be associated with cough and agitation that increase the risk of post-operative bleeding, surgical wound damage or desaturation and hypoxaemia.

Regarding extubation under deep anaesthesia, the only criteria found in almost all papers are effective spontaneous breathing (based upon its clinical evaluation or a tidal volume of at least 5 ml/kg and an age-appropriate breathing rate), and possibly an eye examination showing small central pupils [82]. Some authors even consider extubating in the lateral decubitus position, when spontaneous breathing is established without any stimulation, in order to decrease the incidence of laryngospasm, desaturation and cough [84]. In addition, in case of deep extubation, all children still received a hypnotic agent during extubation. Although some authors consider the expired fraction of the halogenated agents and other its inspired fraction, all suggest at least 1 MAC at the time of deep extubation [85-87]. The administration of the halogenated agent is stopped after extubation. The literature on this topic is rather scarce and it is difficult to decide for one or the other technique. The publications analysed for the current recommendations considered only cases of « easy » extubations, i.e.

following an easy intubation. The airway complications observed during awake extubation or during the early post-extubation period are classic: laryngospasm, bronchospasm, hypoxaemia or desaturation, cough. However, no publication allows concluding that one technique is any better than the other. It is important to be aware of risks of each technique in order to anticipate possible complications: deep extubation exposes to a risk of post-operative apnoea (mainly obstructive), while awake extubation incurs a greater risk of cough and post-operative sore throat [82,83,87,88-92].

6. Upper airway management in children with an upper respiratory tract infection (URI)

Prerequisite:

Upper airway infections are very common paediatric pathologies. In most studies, the diagnosis of URI requires at least two of the following signs or symptoms: moderate fever, sore throat, runny nose, sneezing, dry cough, and laryngitis. The physiopathology of URIs leads to multifactorial bronchial hyper-reactivity. An ongoing or recent URI significantly increases the risk of perioperative respiratory complications (mainly bronchospasm and laryngospasm) in paediatric anaesthesia. These complications usually have a favourable outcome. However, they might sometimes lead to a life-threatening situation.

R10 – In children with an upper airway infection, it is recommended to use a facemask for airway management if the type and duration of the surgical procedure are compatible, and if the child is not at risk of aspiration.
Grade 1+, strong agreement

Discussion: The choice of the airway device depends on multiple factors (full stomach, type and duration of surgery…), for healthy children as well as for children with upper respiratory tract infection.

All prospective, descriptive and retrospective studies in healthy or infected children [93-94], along with prospective descriptive studies in children with URI [95,96] demonstrate that using a facemask is associated with less perioperative respiratory adverse events in children with an URI [97].

NO RECOMMENDATION: In children with an URI, when the use of the facemask is precluded, it is impossible to make any recommendation regarding the choice between a laryngeal mask airway and endotracheal intubation to decrease the incidence of severe perioperative respiratory adverse events.

Discussion: Laryngeal mask airways seem to be associated with less desaturation, but their superiority compared to endotracheal tubes has not been demonstrated regarding the

incidence of laryngospasm, and is still debated regarding the incidence of bronchospasm [95,98]. Although LMA are widely used in children with an URI [99), the risk of misplacement [100] and the risk of stimulation-induced laryngospasm under inadequate (too light) anaesthesia [101] should be taken into account.

R11 – In children with URI, before the age of 6, it is probably recommended to administer inhaled salbutamol before general anaesthesia.
Grade 2+, strong agreement

Discussion: This recommendation mainly relies on one prospective study [102] including 400 children with an URI, among which more than 70% had an LMA for intraoperative airway management: 200 children received a preoperative salbutamol nebulization (30 minutes before induction), and 200 children received no nebulization. Children premedicated with salbutamol had approximately 50% less perioperative cough and bronchospasm, and there was also a trend towards a decreased incidence of laryngospasm. A similar study [103], performed in an equivalent cohort of older children did not demonstrate clinical benefit associated with salbutamol premedication. However, in this second study, only 25% of the children had an URI less than two weeks before anesthesia. In addition, the LMA was removed in a fully awake state, which might increase the incidence of coughing.
Salbutamol nebulization is a non-invasive, non-painful and non-expensive therapy, which has virtually no deleterious side effects. Other studies are in favor of this recommendation: compared to a placebo, salbutamol premedication allowed limiting the increase in airway resistance observed after tracheal intubation in asthmatic children [104]. A study in adults with bronchial hyper-reactivity (reversible airway obstruction) evidenced an improvement in respiratory parameters after one day of treatment (administered as a "preparation" to general anesthesia [105]. In addition, the conclusions of two reviews of the paediatric literature are in favor of a salbutamol premedication in children with an URI [106, 107]. The recommended dose of nebulized salbutamol is 2.5 mg for children weighing less than 20 kg, and 5 mg for children over 20 kg.

R12 – In children with an URI, it is probably not recommended to use lidocaine (IV or topical) at induction to decrease the incidence of perioperative respiratory adverse events.
Grade 2-, strong agreement

Discussion: the efficacy of topical lidocaine before tracheal intubation is a matter of debate. Meta-analyses including some rather old studies are in favor of topical lidocaine administration in healthy children [108,109], but two prospective descriptive studies report an increased risk of desaturation [110], laryngospasm and bronchospasm [88] associated with its use. In these studies, children with an URI were not specifically analysed as a subgroup. The quality of the randomised controlled studies performed in children with an URI [111,112]

seems too poor to enable drawing any firm conclusion, or to recommend the use of topical lidocaine in this population.
Regarding intravenous lidocaine before tracheal intubation, its benefit was demonstrated in healthy children with a LMA to prevent experimentally induced laryngospasm [113]. Regarding intravenous lidocaine before tracheal extubation, two meta-analyses [108,109] report less post-extubation laryngospasms in healthy children. Similar results were found in studies including children with an increased risk of perioperative respiratory adverse events [114,115]. However, the benefits of intravenous lidocaine in children with an URI were not investigated in any randomised controlled study. The only available publication in this specific population compared intravenous versus a gel of lidocaine applied on the LMA before insertion: there was no significant different outcome between the groups [111].
Given the lack of negative studies, the potential benefit of intravenous lidocaine (1 – 1.5 mg/kg) in children with URI can only be extrapolated from the observations made in healthy children. Its brief effect suggests that it should be administered within 5 minutes before extubation [109,113]. The amount of lidocaine used for regional anesthesia or to decrease the level of propofol-related pain on injection should be taken into account in order to avoid local anaesthetic overdose. Randomised controlled studies focusing on children with URI are required to evaluate the potential effects of lidocaine regarding perioperative respiratory adverse events.

Experts' opinion:

The experts in charge of the recommendations issued five experts' opinions with their arguments.

1- During adenoidectomy, the experts suggest protecting the airway with a cuffed tracheal tube.
Experts' opinion

Discussion: There was no former recommendation adressing airway management during adenoidectomies. A French survey of practice, published in 2012, reported the use of a LMA and of an endotracheal tube in 7 and 26% of cases, respectively [1]. Studies comparing LMA and ETT in this indication are scarce, and of questionable quality: there are 4 observational studies [116-119] and two randomised studies. The study by Serpina [120] includes adenoidectomies and tonsillectomies, with a subgroup analysis for each type of surgery. The number of patients was low (23 in the groupe with cuffed or uncuffed tracheal tubes, 31 in the group with LMAs). The incidence of hypoxemia and of perioperative respiratory adverse events was not different between the groups, but there was more "coughing" in the ETT group (48 versus 3%). Several bias limit the conclusions of this study: incomplete subgroup analysis, no randomisation between cuffed and uncuffed tubes, no calculation of sample size, variable ventilation parameters, no data on the timing of airway device removal. The study by Aziz and Bashir [121] reports a lower incidence of coughing, stridor and laryngospasm with a

LMA versus an ETT. However, this study did not include children younger than 10 years. Airway management during adenoidectomy with only a facemask is a specific French technique, which was performed by 67% of anaesthesiologists in 2010, mainly in private practice [1]. This technique is probably still used by many practitionners. Because of this local specificity, there is no randomised study comparing facemask and LMA/ETT during adenoidectomies in terms of perioperative respiratory adverse events.

2. The experts suggest not performing anymore the cricoid pressure maneuver during rapid sequence induction to decrease the incidence of respiratory complications.
Experts' opinion

Discussion: Cricoid pressure, also called Sellick's maneuver, was described in adults in 1961 and introduced in the rapid sequence induction technique to decrease the risk of inhalation of gastric content. In paediatric anaesthesia, studies have reported cases of aspiration during induction despite cricoid pressure being applied [122]. Several surveys have shown that paediatric anaesthesiologists rarely perform cricoid pressure and that the technique is barely known [66]. Few studies have evaluated cricoid pressure in children and their aims varied. Only one study demonstrated its efficacy to prevent the reflux of clear fluids under a pressure of 100 cm H_2O from the stomach up to the pharynx of 8 paediatric cadavers and 6 children under general anaesthesia [123]. The major limitation of this study is the small number of children included. Moynihan demonstrated in 59 children that applying cricoid pressure allowed bag mask ventilation up to 40 cm H_2O peak inspiratory pressure without gastric inflation as evaluated by auscultation over the gastric area [124]. Walker evaluated the consequences of cricoid pressure on the tracheal caliber [125]: the mean force that produced some tracheal distortion was < 10 Newton in children under 8 years old and < 15 N in those who were older than 8 years old. However, this study was performed in a small series of patients and did not evaluate the conditions of layngoscopy.

A systematic review of the literature in adults has shown that there is no scientific evidence in favor of the efficacy of cricoid pressure [126]. In vivo imaging studies show that cricoid pressure produces a lateral displacement of the oesophagus in many children and that it is the hypopharynx that is in fact partially compressed [127]. Cricoid pressure compresses only the hypopharynx and does not protect the airway against inhalation of gastric content. However, it allows decreasing the risk of gastric inflation during bag mask ventilation. In situations at risk of inhalation of gastric content ("full stomach"), it is recommended to decrease the intragastric pressure by inserting a gastric tube before performing a rapid sequence induction of anaesthesia. No recommendation can be made about whether the gastric tube should be left in place or removed before performing a rapid sequence induction. The anaesthesiologist should bear in mind 1) that leaving the gastric tube in place does not decrease the efficacy of cricoid pressure and 2) that, if it is left in place, the proximal end of the gastric tube should be left open to atmosphere in order to allow it to act as a pressure valve in case of gastric

inflation. Moreover, leaving the gastric tube in place can make optimal mask seal and intubation more difficult.
In Germany, cricoid pressure is no more included in the recommendations for the induction of anaesthesia in children at risk of aspiration [128].

3. During rapid sequence induction of anaesthesia, the experts suggest ventilating the child with a $FiO_2 \geq 0,8$ and a small peak inspiration pressure (just enough to raise the chest wall and avoid inflating the stomach, ideally < 15 cmH_2O) as soon as SpO_2 is lower than 95% in order to decrease the risk of hypoxaemia during and immediately after intubation.
Experts' opinion

Discussion: Currently a "modified", "controlled" or "paediatric" version of rapid sequence induction is proposed in order to decrease the risks of hypoxaemia, haemodynamic complications and difficult intubation associated with the "classic" version. Hypoxaemia occurs indeed frequently during "classic" rapid sequence induction before complete muscular blockade is achieved because effective preoxygenation is difficult to obtain, because the alveolar ventilation/residual functional capacity ratio is increased in children, and because oxygen consumption is greater in infants [69,129]. Controlled rapid sequence induction includes preoxygenation, deep anaesthesia with an opiate and a hypnotic agent, a dose of one of the non-depolarizing muscle relaxants used in paediatric anaesthesia and gentle bag and mask ventilation before laryngoscopy [130, 131]. Retrospective studies have shown a decreased incidence of hypoxaemia and haemodynamic complications, and less difficult intubation (because muscle relaxation is effective at the time of laryngoscopy). Moreover, no aspiration of gastric content was observed [129]. As a result, many authors now consider that the current debate between succinylcholine and rocuronium has become obsolete because the "classic " rapid sequence induction should be abandoned for its "controlled" version, except perhaps in case of bleeding tonsil [73,129]. No prospective study has been performed on "controlled" rapid sequence induction except in a simulation setting [132]. Some anaesthetic societies already recommend using the "controlled" rapid sequence induction technique because the risk of hypoxaemia during "classic" rapid sequence induction is greater than the risk of pulmonary aspiration when using controlled" rapid sequence induction [129, 132].

4- The experts suggest extubating a child who was difficult to intubate when the patient is fully awake, after at least 3 minutes of spontaneous ventilation with 100% O_2, under full standard monitoring, and in the presence of trained assistant, with a difficult intubation trolley available in the room. The experts suggest extubating any child in which a difficult extubation is suspected over a hollow airway exchange catheter.
Experts' opinion

Discussion: The extubation of a child who was difficult to intubate is a rare event that must be planned and performed in optimal safety conditions, following a well-defined predefined extubation strategy, established by the medico-surgical team in charge of the patient, also anticipating the possibility of re-intubation [81,133,134]. The incidence of difficult intubation is estimated between 2/1000 and 5/1000 during paediatric general anaesthesia [135]. In a retrospective study of 99,712 anaesthetised patients, in a subpopulation of 137 patients with difficult intubation criteria, extubated within 6 hours after the end of surgery, Jagannathan et al. observed a rate of 95% successful extubation, either following a "simple extubation", or after the use to an "intermediate technique" such as ventilation on a supraglottic airway, extubation on an airway exchange catheter, noninvasive ventilation using CPAP or BiPAP, or a high flow O2 nasal canula [136]. In this study, extubation failure occurred in only 5% of cases, requiring re-intubation. Two cases of cardiac arrest and one emergency tracheostomy were reported. However children electively tracheotomised or ventilated more than 6 hours postoperatively were not analysed.

The success of extubation can also be compromised in a patient who was initially easy to intubate, if surgery (ENT, maxillofacial or spinal surgeries) induces anatomical changes, head and neck oedema, recurrent nerve or laryngeal injury, instability or immobility of the cervical spine. In these cases, an evaluation under general anaesthesia should be performed before starting the extubation process to assess the presence of any factor that could hinder the permeabilty of the upper airway or modify the “intubation criteria”: limitation of mouth opening; lingual, pharyngeal or laryngeal œdema or haematoma, deformity of upper airways, presence of blood clots. Depending on the type of surgery and the possibility to open patient’s mouth, a simple clinical examination of the oral cavity and pharynx, direct or indirect videolaryngoscopy, or oral fiberoptic endoscopy should be performed [133]. This assessment should lead to to a decision of delayed extubation if those unfavourable conditions are expected to regress at short term. The use of a hollow airway exchange catheter should be considered whenever the extubation is at risk due to a known or suspected difficult laryngeal visualisation at the end of the surgery. Extubation on a hollow airway exchange catheter (8Fr, 11Fr or 14Fr) has already been described in infants and children. These catheters are well tolerated and facilitate re-intubation if needed [137]. In adults, the use of an airway exchange catheter has been shown to decrease the risk of complications such as hypoxia and bradycardia as well as the need for rescue techniques [138]. The intra-tracheal position of the guide can be verified by the presence of expired CO2 at its proximal end, and the length of catheter measured at the corner of the mouth should be the same as the length of the tracheal tube in order to avoid the tip being too distal and an ensuing broncho-pulmonary trauma Oxygenation through this guide using a continuous flow of O_2, conventional ventilation or jet-ventilation, has been reported but should be limited to the duration of the re-intubation maneuver in order to limit the risk of barotrauma [139,140]. Using a supraglottic airway as an intermediate technique of oxygenation and ventilation between extubation and return to adequate breathing has also been described [134,135,141]. Corticosteroid therapy, with repeated doses of intravenous dexamethasone before and after tracheal extubation, has been proven useful to decrease the incidence of stridor and re-intubation in neonates at risk for laryngeal edema following traumatic or repeated intubation but this beneficial effect has not

been clearly demonstrated in older children [142]. A negative leak test (i.e. no leak when the cuff is deflated or a leak smaller than 12% of expired volume) increases the risk of laryngeal oedema, post-extubation stridor and the risk of re-intubation [81]. An epinephrine nebulization treatment may be used for post-extubation stridor caused by laryngeal oedema, as recommended for the treatment of laryngitis in children. The effectiveness of epinephrine nebulization is quick (30 minutes) but transient (2 hours), requiring monitoring in PACU or intensive care unit or even repeated administration [143]. If extubation is at risk because of a laryngeal anomaly (known anomaly, intubation trauma, laryngeal surgery) an assessment by an ENT surgeon is recommended and tracheal extubation should be performed in the operating theatre in presence of the ENT surgeon. In case of "CICO" (Cannot Intubate Cannot Oxygenate) scenario or if there is any risk of impossibility to re-intubate or oxygenate the patient following extubation [144], the presence of an ENT surgeon or practitioner trained to quickly perform a tracheotomy is justified [145-147].

5 –The experts suggest avoiding desflurane in children with upper respiratory tract infections.
Experts' opinion

Discussion: This recommendation is based on studies evidencing an increase in airway resistance associated with the use of desflurane, compared with propofol or sevoflurane. One of these studies [148] was conducted in 1-6 year-old children with increased bronchial reactivity (caused by asthma and/or URI). It is not possible to make a recommendation regarding the preferential hypnotic agent, which should be chosen on an individual case-specific basis. A paediatric study [149] reports a decrease in sub-glottic airway reactivity associated with the use of sevoflurane compared to propofol. On the other hand, propofol has been shown to decrease laryngeal reactivity, compared to sevoflurane. Propofol and sevoflurane thus have complementary properties, which might suggest that their combined use could be interesting in children with an URI. Systematic reviews, however, tend to recommend sevoflurane in this population [106, 107]. Whatever the selected technique, it is important to keep in mind that the more a child is at risk of perioperative respiratory adverse events; the more the insertion of an IV line prior to anaesthetic induction should be considered, to allow the rapid treatment of potential complications.

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FIGURES:

Figure 1: Algorithm for unexpected difficult intubation during induction of anaesthesia in a 1- 8 year-old child (adapted from Black AE et al. Development of a guideline for the management of the unanticipated difficult airway in pediatric practice. Pediatric Anesthesia 2015; 25: 346-62.)

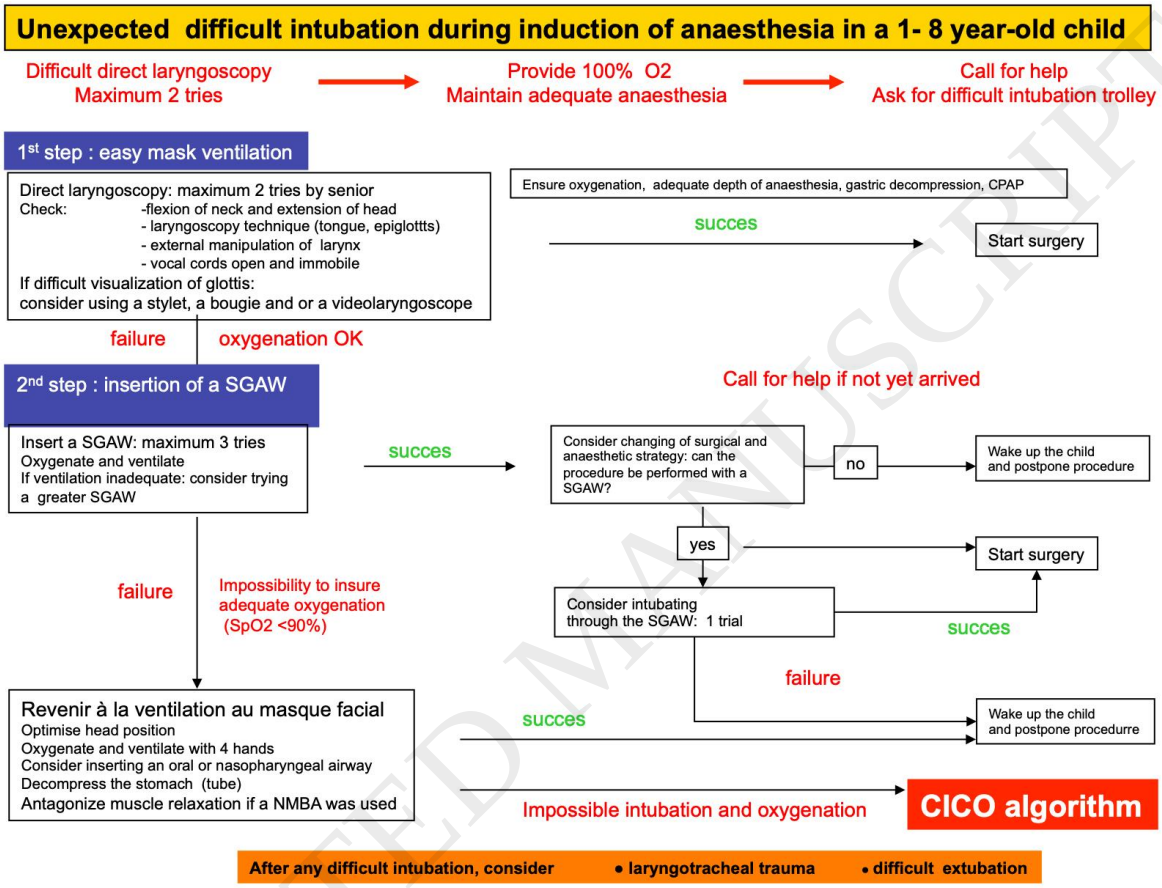

Figure 2: Algorithm for unexpected difficult mask ventilation during induction of anaesthesia in a 1-8 years old child (adapted from Black AE et al. Development of a guideline for the management of the unanticipated difficult airway in pediatric practice. Pediatric Anesthesia 2015; 25: 346-62.)

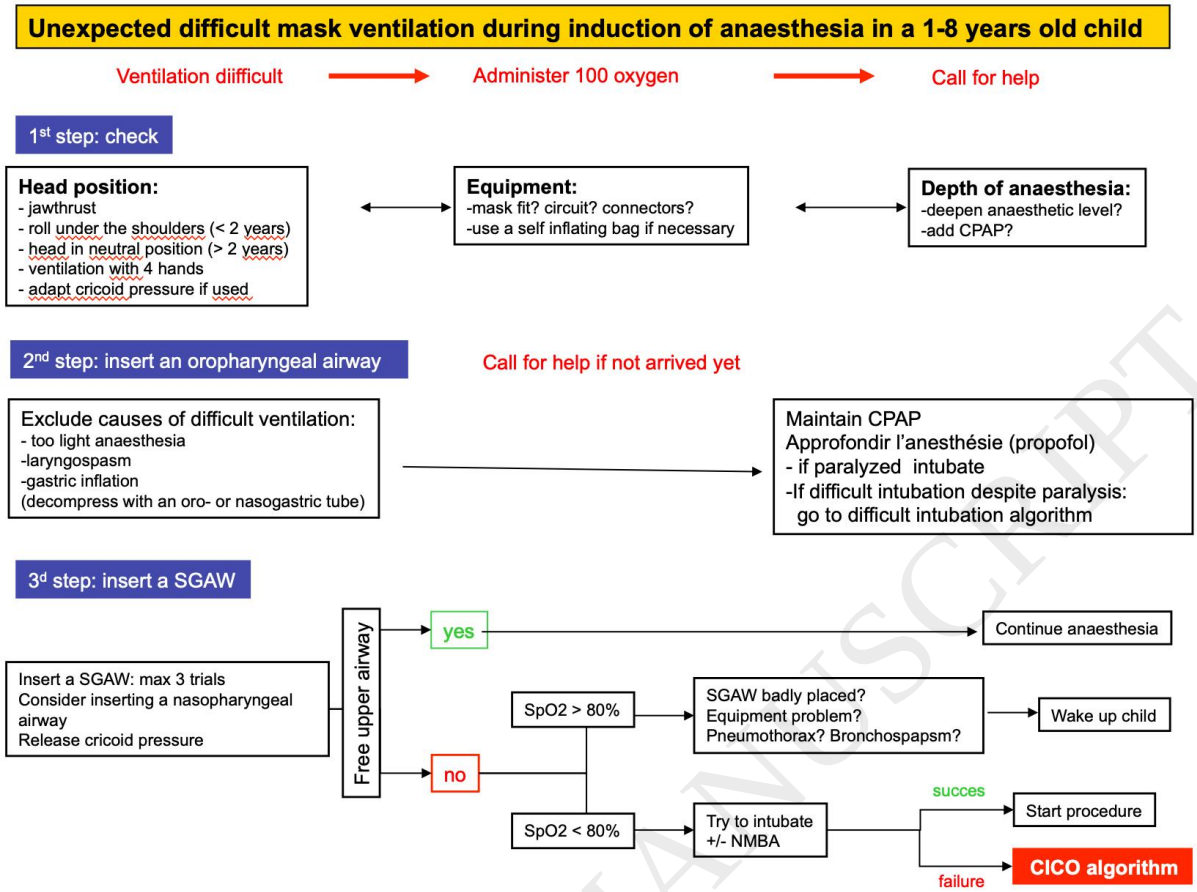

Figure 3: Algorithm for impossible intubation and oxygenation in a paralyzed 1-8 year-old child (CICO) (adapted from Black AE et al. Development of a guideline for the management of the unanticipated difficult airway in pediatric practice. Pediatric Anesthesia 2015; 25: 346-62.)