Anesthesia for ORL surgery in children

Abstract

ORL procedures are the most common operations in children – an optimal anesthetic management provides an uncomplicated, safe perioperative process with as little discomfort for the child as possible. Children at risk must already be identified preoperatively: the combination of ORL surgery, airway susceptibility and age below 3 years can increase the risk of perioperative respiratory adverse events. Postoperatively, it is important to prevent complications such as pain and PONV by dedicated prevention and treatment strategies, as well as to recognize and treat respiratory or circulatory complications competently. Interdisciplinary guidelines and agreements as well as the overall competence of the team have the potential to improve patient safety and outcome in children.

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1 Introduction

Children are often affected by diseases in the ORL area, ORL interventions are typical operations in children between the age 2 and 5 years. The anesthesiological care of these children can be challenging for the anesthetist, because often children suffer at the time of the scheduled operation from accompanying illnesses, like upper respiratory tract infections and obstructive sleep apnea which lead again to an increased anesthesia risk. To the fact comes that children, particularly infants, are rare patients in the operating theatre; the expertise and competence of the anesthesiological team is depending on the experience and routine in this age group. Beside the individual competence of the members of the medical team the institutional or structural competence also plays an essential role. Conscientious preoperative evaluation, interdisciplinary communication and cooperation, careful selection of the best of all suitable anesthesia regimen and competent postoperative care are the key parameters for a "perfect" process.

Beside the success of the operation the consequent prevention of perioperative complications has top priority. Patient's safety and patient's comfort is important from both the point of view of the children as well as parents, the aim is appropriate care for children and parents with avoidance of discomfort whenever possible.

2 Epidemiology

ORL interventions are the most frequent operations in childhood, even if children are rare patients in an operating theatre. In Germany more than 15 million stationary operations were carried out in 2011 in all age groups, only 523,000 (3%) of them were in children below the age of 15 years [1]. There is no official statistics on the amount of outpatient operations in children, estimates assume that in Germany per year approximately 100,000 outpatient operations with general anesthesia are carried out in children below the age of 5 years and approximately 30,000 ORL operations [2].

More than half of the in-patient ORL interventions are carried out within the age group of toddlers/preschool children between 1 and 5 years, only 1% of the interventions concern newborn children and infants in the first year of life. The most frequent operations are paracentesis and adeno-/tonsillectomy (ATE). A rising meaning attains the tonsillotomy [3]. Other typical, but very rare interventions in pediatric ORL are conchotomy, otoplasty, middle and inner ear surgery (see Figure 1); cochlea implantations and pediatric larynx surgery are left to special centres.

3 Preoperative evaluation

The preoperative evaluation in children prior to an ORL operation serves to identify special risk factors for perioperative complications besides accompanying diseases and to initiate adequate prevention strategies. Nowadays a detailed standardized history and clinical examination are to be called the most important screening instruments, not apparative and lab-chemical diagnostics.

Standardized questionnaire forms which are offered by different publishing companies can be helpful. Beside disorders of important organ systems, allergies, passive smoking, preexperiences with anesthesia and informal arrangements are questioned [4]. If there are hints to accompanying diseases with relevance for anaesthesia, there should be further diagnostic investigation.

A physical examination focuses on symptoms that may be relevant for anesthesia, above all of the respiratory and cardiac system:

- Clinical presentation of the child (Size and weight? Statomotoric and neurocognitive development?)
- Anatomy of the facial skull (Syndrome? Difficult airway?)
- Inspection of the oral cavity, if necessary otoscopy (Oral respiration? Acute infection signs? Size of the
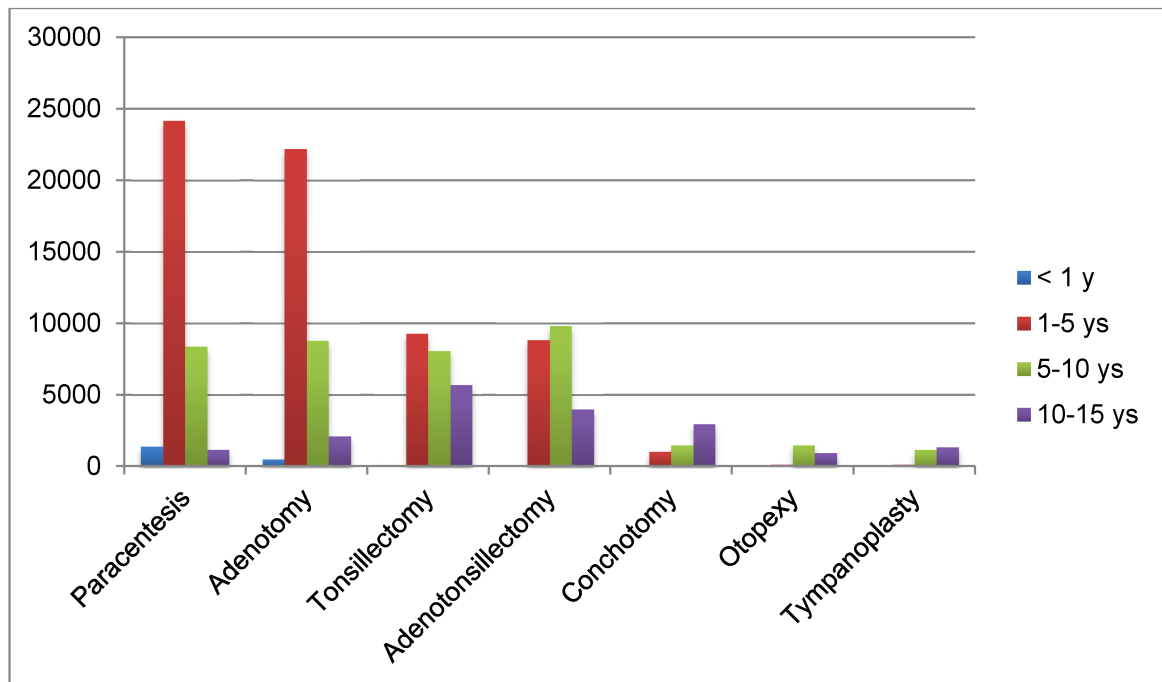
Figure 1: Number of in-patient ORL operations in childhood; procedure and age groups, Health Reporting Germany 2011 [1]

tonsils as a cause for upper airway obstruction? Otitis media?)
- Pulmonal auscultation (Pulmonal obstruction? Wheezing, rhonchuses?)
- Cardiac auscultation (Cardiac murmur, abnormal heart sounds?).

3.1 Routine screening?

The so-called routine screening was a common procedure in children as well as adults for decades, prior to an operation a blood count, coagulation and electrolyte testing was performed in nearly all of the patients, assuming that latent comorbidity could be detected by lab-technical examinations.

For children, taking blood samples means a considerable stress, therefore, it should be carried out only in reasonable cases. A systematic review found that routine lab examinations deliver no additional information after a conscientiously carried out history and clinical examination which showed no pathologies which would decisively influence the anesthesiologic regimen [5]. In addition, routine examinations are little sensitive and specific, i.e. there is the possibility of wrong-positive results (child is healthy, lab values deviate from the standard values, with the need of continuing diagnostics) as well as wrong-negative results (child is sick, lab values are without pathological findings, doctor weighs himself in wrong security and renounces continuing diagnostics). A working group of Meneghini et al. examined more than 10,000 children retrospectively, all patients in group (A) were taken blood samples regardless of history and clinical examination, in group (B) lab examinations were performed only after remarkable history and clinical examination [6]. It appeared as expected, the rate of "patholo-

gical lab examination values" was significantly higher in group B, anyhow the rate of postponed operations or adverse events was not higher, even lower in group B. The authors conclude that routine blood testing is not indicated in children with negative history or examination; with this action superfluous stress for the child can be avoided and costs can be saved without compromising safety and quality. There is broad consensus on this statement in pediatric as well as in adult medicine's interdisciplinary recommendations and guidelines [7], [8], [9].

3.1.1 Coagulation system disorders

Preoperative evaluation of the hemostasis and coagulation system is crucial in ORL patients in order to detect pathologies and to specify them to minimize the risk of postoperative bleeding. However, it must be highlighted that postoperative bleeding is hardly ever associated with coagulation disorders [10], [11].

The most common coagulation pathology in childhood is the autosomal dominant inherited von Willebrand-Syndrome (VWS) which appears with an incidence of 1:100. Most people with the genetic defect are clinically inapperent, at the same time symptomatic VWS is very seldom with a prevalence of 1 in 1,000,000. Because of the heterogeneity of the pathology and the clinical manifestation it matters to distinguish type and therapy of the VWS, particularly in the perioperative setting [12], [13]. VWS in his mild form is most often diagnosed far after infancy and can appear during the perioperative context of an ORL surgery for the first time. The chance to detect VWS in a routine coagulation examination, consisting of partial thromboplastin time (PTT) and prothrombin time (PT), is low [14]. Studies could confirm in the meantime

that the predictive value of a standardized coagulation history of child and parents is significantly higher than for presurgical routine screening with PTT/PT [15], [16], [17]. Eberl et al. compared 702 patients with adeno-and tonsillectomy prospectively who underwent either a routine coagulation examination or a standardized history [18]. The positive predictive value of the history was 9.2% in comparison to 6.8% for the lab examination. Standardized history forms are available on the Internet, e.g. http://www.netzwerk-von-willebrand.de/.

With negative history and clinical examination a significant disorder of the hemostatic system seems questionably, however, in doubt a differentiated coagulation diagnostics should be performed to exclude VWS [19]. In this case the patient should undergo consultation of a hemostaseologist.

An interdisciplinary consensus statement of the professional societies was published in 2006 [20]:

Routine lab investigations can lead to the dilemma that a patient has no anamnestic or clinical symptoms signs of a coagulation disorder, but a pathological PTT value. Pathologic PTT values occur in up to 15% of all routine coagulation examinations [21]. A cause for it are primarily preanalytic sources of error, like too long buildup, too small cannula, coagulation activation by "poking", stress, fridge storage, but also long transport and treatment times. Another cause is the presence of unspecific antibodies against phosphlipides (APA), particularly children with repeated infections of the respiratory tract can show a passagere post-infectious rise of the values for Lupus anticoagulant, an Antiphospholipid antibody. Phospholipids are used lab-technically, under the influence of APA these are bound, which leads to a slowing down of the chemical reaction this leads in the sum to a PT rise, without basic pathology for the purposes of a coagulation disturbance.

3.2 Supplementary diagnostics, cardiac/respiratory diagnostics

The informative value of routine electrocardiograms in healthy children is inconsiderable [4]. However, with children with unstable, known cardiac disease or new cardiac symptoms (Table 1) a pediatric cardiologist should always be consulted. With the help of the ECG and Echocardiography most questions can be answered, an invasive diagnostics is only seldom necessary. As it is to be considered that children with neuromuscular diseases can develop a secondary cardiomyopathy under chemotherapy, with this patient group an echocardiography should be always indicated in case of clinical symptoms. Asthma bronchiale is the most common pulmonal disease in childhood, with rising incidence. A preoperative X-ray of the lung is not needful in children with asthma, decisively for the anesthesiologic course are the gravity of the illness, the actual state including medication history and self-assessment by child and parents. The Peak Flow Measurement is simply to be carried out and is a valuable

parameter which can indicate an acute change of the lung function [22].

Table 1: Indications for pediatric cardiological diagnostics

• New heart sound or clinical symptoms
• Cardiac arrhythmia
• Cyanosis
• Dyspnoea
• Deterioration of a status within short time
• Functional examination of a pacemaker

3.3 Considerations in children with coexisting diseases

3.3.1 Children with upper respiratory tract infection

Upper respiratory tract infections in the childhood are frequent: children suffer on an average 6–8 times per year from an infection of the upper respiratory tract. The course of the infections is uncomplicated as a rule and within 7–10 days self-limiting.

Common causes are viral infections (rhino-, corona-, respiratory syncytial, influenza and parainfluenza viruses), virus invasion in epithelium and mucous membrane of the respirator system lead to an inflammation reaction of the respiratory system way with edema, dyscrinism, bronchoconstriction and generalised sensitisation of the respiratory tract, among other things for volatile anesthetics [23]. In addition, viral inhibiting neuraminidases interact with cholinergic M2-receptors, which can lead to an increased excretion of acetylcholine and consecutive bronchoconstriction. The virus-induced excretion of tachykinine and neuropeptidases can lead to contraction of the smooth musculature of the respiratory tract for more than 6 weeks ("bronchial hyperreactivity", "airway susceptability"). Airway susceptability may trigger complications in the perioperative context – primarily functional obstruction of the upper airway like laryngospasm and bronchospasm.

Von Ungern-Sternberg et al. were able to show in their cohort study in more than 9,000 pediatric anesthetics that acute upper respiratory tract infection within the last two weeks with productive cough, purulent secretion of the nose and fevers leads to a significantly increase in perioperative respiratory adverse events [24]. This was the first investigation which enclosed sick children whose surgery/anesthesia would have been postponed otherwise.

Today the question whether, and if, yes, for how long an operation/anesthesia should be postponed in a child with upper respiratory tract infection can be answered more differentiated than in the past. An individual risk benefit analysis is indicated [23], [24]. Algorithms can be helpful (Figure 2, [23], [25]).

A detailed history and clinical examination forms the basis of the decision. Children with severe infection often suffer from fever >38.5°C, breathing disturbances (wheezing)
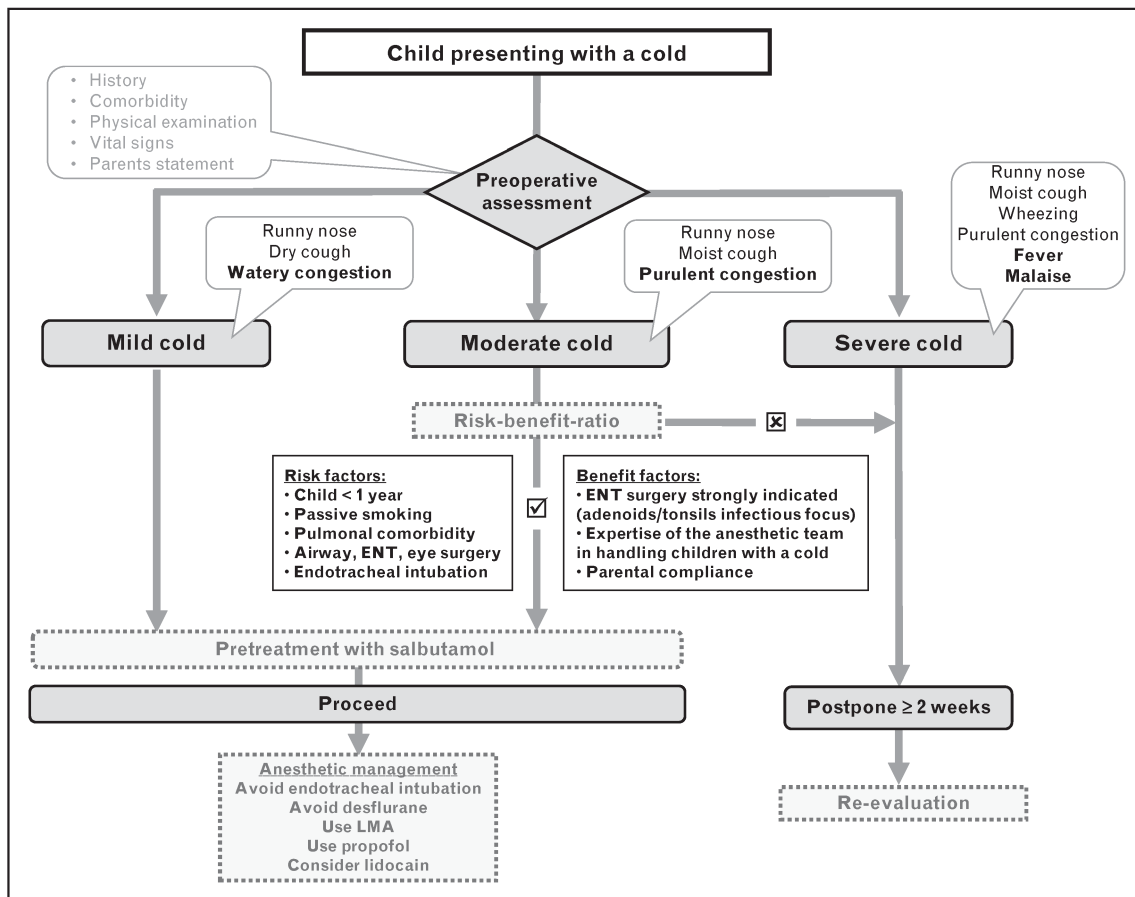
Figure 2: Algorithm "Child with a cold"
With friendly permission of Wolters Kluwer Health Lippincott Williams & Wilkins [23]

and generalised "indisposition" with headache and muscle pain, tiredness, exhaustion; the parental statement "my child is sick" is a valid predictor for complications [24], [26]. Experts agree that in these children the intervention should be postponed for at least 2 weeks [23], [24], [27].

The decision in children who suffer though from an acute infection, but feel no generalised or heavy interference, is much more difficult. Routine lab examinations as a decisive criterion are also seldom aim-leading within this patient group, neither blood count nor acute phase parameters like C-reactive protein (CrP) or Procalcitonin (PCT) are valuable in predicting the outcome of an infection or even perioperative complication risk [28]. In approx. 10% of the cases it comes to a secondary bacterial superinfection, the reliable differentiation between viral/bacterial genesis is hardly possible with the help of clinical and lab-chemical parameters. The PCT diagnostic is left to profound bacterial infections, in particular to the indication and control of an antibiotic therapy [29].

The individual risk benefit analysis whether a child with respiratory tract infection should undergo anesthesia contains the expert's assessment of the team in treating children with respiratory tract infections and the compliance of the parents. If the operation was postponed in a child already and the child is in need of the ORL intervention, operation/anesthesia must be carried out under optimized conditions. The preoperative inhalation of salbutamol can be helpful as salbutamol works as bronchodilator not only in children with asthma bronchiale, but because of the comparable pathophysiology also in children with respiratory tract infection. By means of this easy, few invasive and well accepted treatment the risk from laryngo- and bronchospasm can be reduced about at least 35% [30].

3.3.2 Children with obstructive sleep apnoea (OSA)

Obstructive sleep apnoea concerns approx. 1–3% of all children [31]. (Adeno-)tonsillectomy is one of the most frequent surgical interventions in children with OSA, it is the causal treatment of OSA [32]. Although it is known that children with OSA need an intensified anesthesiological care because of the increased risk for perioperative complications, there are no guidelines or recommendations to the care of children with OSA available up to now [33].

OSA mostly manifests itself at the age between 2 and 6 years, it is more frequent in boys than girls, as well as in obese than normal-weight children. Important clinical and anamnestic hints to an obstructive sleep apnoea are conspicuously enlarged tonsils and adenoids (e.g., "kissing tonsils"), respiratory disturbances at night,

snoring with breath dropouts, remarkable postures during the sleep, sleeping disturbances and behavioral disorders on the day, e.g. day tiredness and concentration disturbances.

Night snoring is the leading symptom for OSA with a sensitivity of 91% and a specificity of 75% for OSA [34]. If a child snores at night, additional focusing "key questions" should be put to the parents in the perioperative conversation [33], [35] (Table 2).

Table 2: Key questions for OSA

- Does your child have respiratory problems at night?
- Have you noted signs of breath dropouts?
- Does your child sweat while sleeping?
- Is the sleep of your child often interrupted?
- Does your child breathe by the mouth during the day?
- Is in the family OSA or sudden child death?
- Conspicuous behaviour?

There is the dilemma that on the one hand history and clinical investigation can differentiate insufficiently between night snoring and obstructive sleep apnoea [36], on the other hand, there is no evidence that all children with suspicion to OSA should undergo polysomnography. Polysomnography can be called gold standard for the diagnosis of OSA, however, a routine sleeping-medical diagnostics with children before ORL surgery appears neither practicable nor feasable [37] and is left currently to children with secondary co-morbidities [38].

In a pilot study to the identification of perioperative risk factors for respiratory complications in children with ATE with heavy OSA the presence of only one risk factor led to an increase to 38% compared to 4% (children without risk factors) [39] (Table 3).

Table 3: Risk factors for respiratory adverse events in OSA patients

- Age <2 years
- Intraoperative complications, e.g. laryngospasm
- Desaturation <90% in the postanesthetic care unit
- Apnoea-Hypopnoea-Index (AHI) >24

An improvement of the sleeping architecture in OSA children is to be expected after (adeno-) tonsillectomy, however, it can enter with temporally delay, children with OSA are at increased risk for postoperative hypoxia [40]. Hence, the postoperative admission to an intensive care unit is not recommended in general, it must be decided in particular cases whether a child needs an extended, intensified monitoring [40], [41]. It seems plausible to monitor children with heavy OSA at the age <2 years, and children >2 years with intra- and postoperative complications (Table 3).

Children with OSA react sensitively to opioids with μ-receptor-agonism [42]. The cause of the increased opioid sensitivity is a morphological transformation in central μ-opioid-receptors caused by repetitive night hypoxia phases. With the use of μ-agonists in children with OSA on the peripheral ward, it is to be noted that unexpected hypoventilation can occur, respiratory monitoring (pulse oxymetry, respiratory rate) is to be demanded obligatorily. As an alternative, nalbuphin is a medium potent opioid with specific κ-agonism and μ-antagonism which offers security advantages and can be used without additional monitoring [43].

3.3.3 Childhood diseases, vaccinations

If a child had contact to children with a childhood infection, it is recommended to wait for the respective maximum incubation time up to a elective operation to bend forward an additional exposition and possible infection of the medical team, however, also of other patients and parents [4], [44], [45].

Concerning the interval between vaccination and operation or anesthesia there are currently no evidence-based recommendations [46]. It is to be assumed that a vaccination leads though to immune responses which does not lead again, however, to a raised perioperative complication rate, although it is known that every form of a surgical trauma pushes a mild immune modulation in form of a transient lymphopenia [47]. There are no tips that surgery and anesthesia affect the success of a vaccination.

Postponing surgery because of a vaccination or postponing vaccination because of a planned operation is not recommended for these reasons any more in general. A clinically relevant point should be still considered: if a child shows unspecific symptoms postoperatively, like fever, myalgia and headache, it can be difficult to differentiate symptoms of either vaccination reaction or post-surgical complication. For this reason the scientific working group on pediatric anesthesia of the DGAI recommends an interval between vaccination and elective surgery between 14 days (attenuated vaccines) and 3 days (inactivated vaccines) [4].

3.3.4 Ambulant care

The ambulant care comes up to the high need of children for security and close surroundings as well as the wish of the parents to take her child after an operation again with home [48].

Today, however, the pressure to ambulant treatment of children comes increasingly from quite different sides. It must be of high priority of the team to bring together treatment, comfort, economic compulsions and security needs. A catalogue of ambulant surgery is published, e.g., adenotomy is an intervention be carried out outpatiently in general [49]. Nevertheless, this does not mean that the team is obliged to the exclusively ambulant performance. Rather the doctor is obliged to check in every individual case whether intervention, state of health and external circumstances permit the ambulant realisation of the operation and whether the patient is supplied after

Table 4: Minimum requirements for the equipment or facilities of an anesthesia working place

		Working place	Available
Mandatory/essential	Anaesthesia system	x	
	Breathing gas measurement	x	
	Pulse oxymetry	x	
	ECG monitor	x	
	Blood pressure measurement	x	
	Temperature measurement		x
	Defibrillator		x
	Relaxometry		x
	Blood glucose analyzer		x
Recommended	Respirator	x	
	Oscillometric blood pressure measurement	x	

dismission from the immediate care of the team of treatment in the domestic sphere medically as well as nursing appropriately [50].

The security of the patient enjoys certainly top priority. From anesthesiological point of view the following circumstances are valid as absolute contraindications for ambulant ORL operations [48], [51], [52], [53]:

- Chronic comorbidity with unstable course
- Disease with need of prolonged monitoring
- Increased risk of postoperative bleeding risk

The decision to perform the operation ambulantly should be always interdisciplinary. Beside factors specific for patient including age, the care situation of the child also plays an essential role (social situation at home, distance of the place of residence to the next hospital etc.).

Parents play a crucial role in the aftercare, they must be able to perceive disturbances and interferences on time and to initiate adequate steps. In any case, the parents must also be able to reach a competent contact person round-the-clock.

After an ambulant treatment the following parameters should be fixed, documented and have been explained understandably to the parents:

- Carried out operation and anaesthesia
- Aftercare planning (e.g. wound control)
- Pain therapy (dosage, interval, maximum dose)
- Action when problems or complications occur (when, why and whom contact, contact possibilities: the next pediatric hospital or pediatrician on duty, surgeon/anesthetist after end of work).
- Phone numbers!

Perioperative complications which lead to a stationary treatment or forbid the dismission on the operation day are [54]:

- Postbleeding
- Respiratory failure
- Persistent postoperative nausea and vomiting (PONV)
- Persistent pain

4 Anesthesia

4.1 Requirements to a pediatric anesthesia working place

The German Society for Anesthesiology and Intensive Medicine has defined in 2013 minimum requirements to the anesthesia working place under special reference to the care of children [55]. Table 4 shows essential and recommended apparative minimum requirements.

Specific demands for an anesthesiologic care appropriate for children are specialist's standard as well as qualification of the anesthesiologic assistance staff: Experience in pediatric anesthesia should exist or be acquired by hospitation with pediatric anesthetics. All of the equipment must be admitted for the application in the age group to be treated, the basic equipment must be complemented with materials for the intraosseous access and the pediatric airway. For the area of head/neck interventions it is pointed out to ensure a stable pressure-free position of the head, with unlimited accessibility to the intravenous access and suitable cushions/fixture equipment for children.

4.2 Fasting times, premedication, parental presence and induction of anesthesia

Guidelines for preoperative fasting times before elective interventions are clearly defined [4], [56]: six hours for food, 4 hours for milk/breast milk/formula diet, 2 hours for clear liquids (water, tea, clear juices, lemonade).

The admission of clear liquids up to 2 h should be offered explicitly. It thereby does not come for an increase in the risk of aspiration but children are less thirsty, however and hungry, more contented and feel better than children who must fast long – what can affect very positively the introduction phase [57].

For an optimum introduction situation child and parents should be without anxiety as possible, there are different strategies to reach this. Midazolame is a benzodiazepine

which has been used for anxiolysis for years either orally, rectally as well as intranasally [58]. Midazolame leads to amnesia which is partially retrograde, what may not serve, however, as a protection before traumatising situations. Many anesthetists renounce for different reasons today midazolame and work, e.g., with distraction strategies or hypnosis [59].

Local anesthetics-containing cream allows a nearly painless puncture for the i.v. access if it is properly used. Whether the anesthesia introduction should occur in the presence of the parents, every anesthesia team must decide for itself. Parents mostly long for being present, even if from literature no advantage for parents, child or anesthetist are evident [59], [60]. It is vital that parents know their child in good hands and own anxiety is not in the foreground. Today in this respect the parental introduction is valid as a therapeutic option which is used after judgment of the anesthesia team dependent on the frame conditions and the interdisciplinary setting.

The anesthesia introduction and maintenance can occur basically inhalative or intraveneous, there is little evidence which procedure is superior [61]. However, the intravenous introduction with propofol and the maintenance of anesthesia by means of Total Intravenous anesthesia (TIVA) offers advantages particularly in the patient group of the toddlers and preschool children to ORL interventions [62]:

- Avoidance of volatile anesthetics = reduction of the risk for PONV and postoperative agitation
- Application of propofol = antiemetic properties, preventive effect in children with airway susceptability, no air contamination by airway leakage
- Availability of an intravenous access = security advantage during the critical interval of introduction

4.3 Airway management: laryngeal mask or endotracheal tube?

The discussion which airway is superior in ORL surgery in children is led for many years passionately. From anesthesiological point of view the use of the laryngeal mask can offer advantages, above all avoiding the intubation in children with airway susceptability, avoiding muscle relaxation, and rapid and smooth extubation.

The fact that laryngeal masks can be used with great success, has been shown by a sandinavian group around Gravningsbråten et al. [63]: in more than 1,100 ambulant ATE in children at the age less than 16 years the airway was protected with a conventional single use laryngeal mask. The conversion rate to endotracheal Intubation amounted to only 0.5%, no primary postbleeding appeared and only one patient had to be intubated because of pulmonal atelectasis; all the other patients could be dismissed on the same day home. A recent randomized, controlled study from the USA compared the application of the laryngeal mask to endotracheal intubation from the point of view of the ORL surgeons, anesthetist, nursing staff and patients/parents with the help of 36 different

parameters. The authors conclude that the laryngeal mask provided clear advantages concerning security, comfort, complication prevention and avoidance of postoperative problems [64].

It is to be mentioned that the study situation is not uniform, a group of authors from Portland comes in a retrospective evaluation of 1,200 patients to ATE to the end that the application of laryngeal masks leads to a higher complication rate (14.2 versus 7.7%), particularly in tonsillectomy with significantly more airway obstructions [65]. A significant point which the authors discuss are the terms of working for the ORL surgeon "round the larynx mask".

The choice of the suitable airway is determined therefore not only by patient-sided factors, but a sine qua non condition is the interdisciplinary consensus of the team just as the routine and experience in dealing with laryngeal masks. However, in children with acute infection the application of the laryngeal mask should always be taken into consideration [23], [24].

5 Perioperative complications

Prevention of complications is the priority common aim of all professional disciplines involved in the care of children for ORL operations. Typical and frequent perioperative complications with this patient's group are: postoperative bleeding, respiratory adverse events, feeling of sickness and vomiting (postoperative nausea and vomiting, PONV) as well as postoperative agitation ("emergence delirium", ED) and pain.

A retrospective analysis of more than 1,700 patients with ATE in a university pediatric hospital in London, UK, came to the result, that severe complications are rare in a highly specified setting all together, although many children with co-morbidities and ASA classification ≥III were treated [66]. The predictors for an unplanned admission to the intensive care unit were above all specific for intervention (adenotonsillectomy in comparison to adenotomy) and specifically for patient with severe comorbidities (Down's syndrome, congenital heart diseases, obesity, cerebral palsy, craniofacial anomalies, mucopolysaccharidosis and hemoglobinopathies). These results underpin the thesis that both institutional and individual competence can influence the outcome significantly.

5.1 Postoperative bleeding

Bleeding after ORL surgery operations in children appears as primary bleeding in the first 24h in 0.2–2.2% of the patients, as secondary bleeding after the first 24h, above all between day 5 and 10, in 0.1–3% [67], [68]. The instep width of the incidence of postbleeding explains itself by different definitions of "post-surgical bleeding" [69]. Operation-conditioned bleeding after adeno- and tonsillectomy can be a live-threatening emergency in children because of the danger of hemorrhagic shock and acute airway obstruction. It needs defined algorithms to be able

to treat bleeding complications quickly and appropriately. The only causal therapy of severe bleeding is (surgical) stopping of the bleeding with concurrent maintenance or restoration of the hemodynamic function and the oxygenation.

If the child is in a shock, is unconscious or liable to resuscitation so resuscitation measures are immediately to be initiated following the guidelines by ERC/GRC [70].

For volume resuscitation a vascular access is required, with heavy bleeding the establishment can be difficult or impossible, an intraosseous access is recommended primarily [71]. Beside balanced full electrolyte solutions (e.g. ringeracetate) hydroxyethyl starch (e.g. HAES 6% 130/0.4) can be used.

A mask bag ventilation should be avoided when possible during the anesthesia introduction to prevent that blood is ventilated into the bronchial system. First choice for securing the airway is endotracheal intubation as "Rapid Sequence Induction" with a cuffed tube which prevents the penetration of blood in the bronchial system [72]. Suction equipment must be held ready to remove blood in the pharynx. If endotracheal intubation is not successful, supraglottic airway devices can be used (e.g., laryngeal mask). The maintenance of a continuous oxygenation is of highest priority, because hypoxia has worse effects on the outcome.

The evaluation of the amount of blood loss can be difficult, above all if the child has already lost relevant amounts of blood or has swallowed preclinically. A primary clinical evaluation of the loss of blood or the circulatory function can be done by peripheral capillary refill time (standard value: <2 seconds) as well as pulsoxymetry as a value of peripheral perfusion, heart frequency and blood pressure (primarily non-invasive) and hemoglobin (Hb) values.

In dependence of the course it can be necessary to step up the monitoring gradually: invasive blood pressure measurement, transurethral catheter, temperature measurement under active warming management to preserve normothermia.

As an emergency transfusion red blood cells of the blood group 0 negative can be given, in the course of emergency treatment blood group compatible RBC as well as coagulation-effective preparations (tranexamic acid, frozen fresh plasma (GFP), fibrinogene, if necessary platelets) [73].

The post-bleeding aftercare takes place in general on an intensive care unit. After the acute intervention the secondary diagnostic of a possibly not diagnosed coagulation disorder is also to be followed.

Algorithm "Postoperative bleeding":

- Realisation of CPR measures after the guidelines of the ERC/GRC
- Arrangement of a vascular access, alternatively i.o. access
- Protection of the airway by endotracheal intubation (Rapid Sequence Induction)

- Immediate supply of red blood cells
- Infusion therapy with balanced electrolyte solutions (e.g., ringeracetate, initially 20 ml/kg of KG), hydroxyethyl starch (e.g., HAES 6% 130/0.4, 10 ml/kg of KG)
- Transfusion of RBC, FFP, coagulation preparation after clinical and lab-chemical findings
- If necessary advanced monitoring (invasive blood pressure, warming management incl. temperature measurement, etc.)
- Intensive care treatment
- Hemostaseologic follow up diagnostics for the exclusion of a coagulation disorder

5.2 Perioperative respiratory adverse events

Perioperative respiratory adverse events are still a leading cause for mortality and morbidity in pediatric anesthesia, they are responsible for approx. 30% of all perioperative cardiac arrests [74].

Clinical appearances of respiratory complications are:

- Laryngospasm (primary cause for cardiac arrests!)
- Bronchospasm
- Airway obstruction
- Apnoea
- Desaturation

Beside timely recognition of risk factors the prevention or the adequate treatment of respiratory adverse events plays a big role. There are known risk constellations which can be already questioned preoperatively and be identified [24], [33], [34], [75], [76], [77]:

Risk factors specific for patient:

- Respiratory tract infection in the last two weeks
- Pulmonal disease, e.g., asthma bronchiale
- Obstructive sleep apnea
- Upper airway obstruction (e.g., hypertrophy of the tonsils)
- Age <3 years
- Passive smoking
- Morbid obesity
- Craniofacial abnormalities, orphan diseases and syndromes
- Neuromuscular diseases

Risk factors specific for intervention:

- Surgery near the airway

Risk factors specific for anesthesia:

- Invasivity of the airway (endotracheal intubation)
- Choice of the anesthetics
- Experience of the anesthetist

Short apnoea tolerance leads quickly to hypoxia and myocardial depression in small children. Hence, a symptomatic therapy must start immediately, e.g., anesthesia

deepening and CPAP ventilation during laryngospasm, bronchodilators during bronchospasm and epinephrine inhalation in upper airway obstruction in the PACU. A key role for patient safety in the postoperative period is a continuous clinical and monitor supervision of respiration.

5.2.1 Competence of the anesthetist

A huge number of publications could indicate that the experience and competence of the anesthetist has a determining influence on perioperative outcome. Carpenter et al. found an increased risk for larnygospasm in children with respiratory tract infection if the anesthetist was inexperienced, i.e. if he had less than one year of pediatric anesthesia experience [76]. Mamie et al. in addition, could indicate that the risk was increased for respiratory complications even in absence of an infection by the factor 2.7 if children were treated by non-specialised anesthetists [77]. The children who were intubated by experienced anesthetists had a significantly decreased risk to develop stridor or laryngospasm. In the cohort study of Ungern-Sternberg et al. the risk for respiratory complications was increased in registrars by the factor 2.4 in comparison to specialists in pediatric anesthesia [24].

5.3 Postoperative nausea and vomiting [PONV]

Patient's safety has been improved in the area of pediatric anesthesia in last decades; today patient's satisfaction and comfort are in the focus, too. Postoperative feeling of sickness and/or vomiting shows one of the most frequent post-surgical complications in childhood, if no anti-emetic interventions are used, the incidence can amount to more than 50% [78]. Besides, it is known that PONV is top on the negative hit list of the complications urgently to be avoided from child and parental view [79], [80].
PONV is age-dependent, children less than 3 years are concerned only seldom, the summit of the PONV incidence is between 6 and 10 years and decreases with puberty to approach adult's values [81]. PONV differs in children in some points from PONV in adults: with small children it is difficult to grasp feeling of sickness without vomiting as a symptom, because children <4–5 years cannot properly articulate this sensitivities disturbance yet; the application of standardized instruments, e.g., KUSS (pediatric dyscomfort and pain scale) [82] is recommended.
PONV does not only mean dyscomfort, but can lead to severe complications: electrolyte losses and dehydratation with disturbances of the blood gas analysis, bleeding complications, pulmonal aspiration, airway obstruction and emphysema are serious, but known results of PONV [83].

Risk factors for PONV in the infancy are known [84]:

- Operation duration >30 min
- Age ≥3 years
- ORL, eye surgery
- Positive PONV history/travel sickness with the child or with relatives of 1st degree

With every factor the PONV risk rises by 10 – the PONV risk is 70% [85] amounts by the presentation of 4 factors! The children who undergo ORL surgery can be defined as risk patient group, hence, a standardized preventive regime (Table 5) and an algorithm is recommended for rescue therapy [86].

Table 5: Preventive regime for PONV [86]

- TIVA
- Avoidance/reduction of opiods, use of a multimodal pain regime [non-opioid analgesics, co-analgesics]
- Avoidance of emetogenic substances
- Anti-emetics, e.g.
  - Dexamethason 0.15 mg/kg of KG, max. 4 mg
  - Ondansetron 0.1 mg/kg of KG, max. 4 mg
  - Dimenhydrinat 0.5 mg/kg of KG

Common anti-emetics can be used in principle, with only some modifications in children, they reduce the PONV risk about 30% [87] in each case. The higher the risk, the more antiemetic interventions should be used perioperatively. Today a pragmatic fixed 2-fold prophylaxis is used increasingly with all patients [85]. The implication in the clinical everyday life with such standardized approaches is easier, however, there remains to think that high risk patients must be evaluated as those in the approach, because they need 3-fold prophylaxis.
All of these drugs can be used within the regimen of prophylaxis, if a certain drug has already been given, it should be changed in case of treatment to a substance of another class.
In 2008 the interresults of a dose finding study on dexamethasone to the prophylaxis of PONV in AT/TE of a Genevan working group were published [88]. The group found an increase in postoperative bleeding rate of 24%(!) in the group of the patients with "high-dose dexamethasone", i.e. 0.5 mg/kg dexamethasone i.v. In consideration of the present results and the available evidence the scientific working group on pediatric anesthesia recommends [89]: "The prophylactic dose of 0.15 mg/kg dexamethasone i.v. in children undergoing AT/TE leads to a reliable PONV-prophylaxis as well as to a clinically relevant reduction of post-surgical pain and, hence, should be applied further. An increase of the postoperative bleeding risk does not exist with this dosage according to the recent study situation. A general change of the indication of dexamethasone in AT/TE cannot be recommended at the moment. The high dose application 0.5 mg/kg in comparison to 0.15 mg/kg i.v. dexa-

5.4 Postoperative agitation, "emergence delirium" (ED)

The term "postoperative agitation" or "emergence delirium" (ED) describes a *"dissociated state of consciousness in which the child is motoric hyperactive without recognizable reason touchy, and uncooperative, cries disconsolately, shouts and/or hits around himself "* [90].

The incidence of ED is between 2 and 80%, the big instep width depends above all on the capture methodology [91]. It must be stated that it concerns not only one of the frequent, but also one of the clinically relevant complications in the perioperative interval, because children can suffer from longer term persistent postoperative behavioral disorders [92].

Emergence delirium appears typically 30–60 min after the end of anesthesia, the duration can amount between 5 and 60 min, the event is limiting in itself.

Children in this state neither have direct contact with the environment nor with the parents or the medical staff, they are very worried and motoric hyperactive, however, without focused movements, and cannot be calmed. The easy to perform "Watcha scale" (Table 6) [93] is suited for a first standardized appraisal of the child and capture of an ED in the emergence interval, in addition, a differentiation and classification of the degree of the ED can performed best of all by the validated PAED (Pediatric Anaesthesia Emergence delirium) score of Sikich and Lerman [94], [95] in which the criteria eye contact, perception of the environment, restlessness, purposeful movements and consolability are included (Table 7).

Table 6: Watcha scale [93]

1. Child sleeps
2. Child awake and quietly
3. Child cries, can be comforted
4. Child cries, cannot be comforted
5. Child agitated, hits around
(≥3 points ED probable)

ED is a multi-factor event (Table 8), patient-related risk factors are age and temperament of the child. Children at age between 2 and 5 years are defined as a risk group [96], probably on account of the psychological developing moment: toddlers are not able to abstract the hospital situation, and to understand that the operation and all measures linked with it are necessary. Aggravatingly children are affected in the emergence situation in their cognition and in memory, e.g., by retrograde amnesia due to midazolame. Children with a high activity or temperament level are particularly endangered to suffer from ED [97], [98].

Operations with a high risk of ED are typically ORL or ophthalmological interventions. Besides, the level of pain caused by the operation seems to play an essential role [99]. Especially sensory sensations after tonsillectomy and adenotomie (swelling, taste etc.) seem to be one of the triggers.

Anesthesia-related risk factors are the application of volatile anesthetics which lead to quick emergence (sevoflurane, desflurane) [100]. There is still no final explanation for the mechanism, the influence of volatile anesthetics on the central nervous system activity possibly plays a role, while the balance is affected between neural synaptic inhibition and excitation.

ED is stressful to children, parents, and medical team; it can endanger the surgical result. Beside a consequent prevention strategy an immediately starting, dedicated rescue therapy is indispensable. In a meta analysis of Dahmani et al. [91] it could be shown that effective prevention strategies exist, firstly perioperative pain therapy. The pre- and intraoperative application of propofol instead of volatile anesthetics, analgesics like fentanyl, ketamine as well as alpha2 receptor agonists (clonidine or dexmedetomidine) show preventive effects, however, for an effectiveness of midazolame there is no evidence.

In case of ED, medicamenteous strategies should be used, e.g. ketamine, propofol or clonidine i.v., there is currently no evidence, which measure is the most effective one.

6 Postoperative pain therapy

Post-surgical pain affects the outcome, it can lead to pain chronification due to modulation processes, it has the potential to affect the psychosocial development of children and can lead to patient's and parental discontent [101].

Pain should therefore be avoided from the beginning; if stronger pain is to be expected, all disciplines involved in the patients' care should work together to grasp pain by consented action. A standardized and at the same time individualized "multimodal pain therapy" is valid as a gold standard [102].

The regular measurement of the individual pain level is an obligatory pre-condition for the adequate therapy of pain in children. For this, validated pain scales exist for different age groups, e.g., Children and Infants Postoperative Pain Scale (CHIPPS) (Table 9) [103], self-assessment/visual analog scale [104]. A basic principle of all scales is, that a pain value >3 needs for action, the therapy should be always checked by controlling measurements.

Interventions in the ORL area often lead to stronger pain which express themselves above all in traumatic pain and gulp pain. A recent evaluation of a worldwide acute pain registry in with more than 50,000 patients with 179 different interventions involved could show that tonsillectomy is one of the most painful interventions [105], though it is known as "small surgery". A prospective study of Stewart et al. showed that children suffer from significant pain and massive limitation in their everyday life after tonsillectomy on average for more than 7 days [106].

Tabelle 7: PAED-Score [94]

	"not at all"	"just a little"	"quite a bit"	"very much"	"extremely"
Eye contact	4	3	2	1	0
Purposeful movements	4	3	2	1	0
Perception of the environment	4	3	2	1	0
Restlessness	0	1	2	3	4
Inconsolability	0	1	2	3	4

(≥10 points ED probable)

Table 8: Risk factors for ED

- Patient-related risks
  - Age
  - Temperament
  - Preoperative anxiety
- Anaesthesia-related risk factors
  - Application of volatile anesthetics
  - Rapid emergence
- Surgery-related risk factors
  - Interventions in ORL/ocular area
  - Interventions with high level of post-surgical pain/insufficient pain therapy

These results were confirmed by the working group around Ungern-Sternberg reluctantly, she could also show that pain persisted after tonsillectomy up to the 7th post-surgical day [107].

Table 9: Children and Infants Postoperative Pain Scale (CHIPPS) [103]

Item	Structure	Points
Crying	None	0
	Moaning	1
	Screaming	2
Facial expression	Relaxed/smiling	0
	Wry mouth	1
	Grimace (mouth and eyes)	2
Posture of the trunk	Neutral	0
	Variable	1
	Rear up	2
Posture of the legs	Neutral, released	0
	Kicking about	1
	Tightened	2
Motor restlessness	None	0
	Moderate	1
	Restless	2

Recommendations and guidelines for perioperative pain therapy exist [108], [109], [110] [111], [112], [113], [114]:

- Regulation of the responsibilities
- Regular, standardized assessment and documentation of pain level
- Pain therapy (see Table 10)
  - Local anesthesia, if feasible and possible
  - Non-opioid analgesics (e.g., metamizol, ibuprofen)
  - Opioids (e.g., piritramid, nalbuphine)
  - Co-analgesics (clonidine, dexamethasone, ketamine)
- PONV prophylaxis
- Training/supervision
- Quality assessment/improvement

When pain values exceed frequently >4 a PCIA (patient controlled intravenous analgesia) with piritramid or morphine should be considered.

To avoid rare, but drastic side effects and complications of pain therapy, few basic rules are to be followed: if μ-agonists (e.g., morphine, piritramid) are used on the ward, a clear, written information is obligatorily, concerning the dose and application manner as well as respiration monitoring to avoid hypoventilation and hypoxia. Nalbuphin is a μ-antagonist and κ-agonist who does not lead to respiratory depression and offers, hence, in children after ORL surgery, advantages [43].The application of paracetamol must be defeated by a documented maximum daily dose (max. 60 mg/kg/d) and limited therapy interval (as a rule maximum 3 days). Paracetamol-overdosage is one of the most frequent causes for acute liver failure in childhood [115]. If ibuprofen is used, dehydration must be avoided due the danger of acute renal failure [116].

Table 10: Example for intra-and post-operative pain therapy in adenotonsillectomy

- Intraoperatively:
  - Opioid, e.g., piritramid 0.1 mg/kg i.v.
  - Co-analgesics: dexamethasone 0.15 mg/kg i.v., max. 4 mg; clonidine 2 µg/kg KG i.v.
  - Non-opioid analgesic before the end of surgery: e.g., metamizol 20 mg/kg
- Postoperatively, PACU:
  - Opioid when pain value >3: piritramid 0.05 mg/kg i.v.
- Postoperatively, ward:
  - Basic therapy
    - Metamizol 60 mg/kg/d, continuously i.v. or p.o.,
    - Ibuprofene 3x10 mg/kg/d p.o.
  - Rescue therapy when pain value >3
    - Nalbuphin 0.1–0.2 mg/kg i.v.

7 Conclusion

The challenges for pediatric anesthesia in ORL surgery arise above all from the combination of young age, airway susceptibility due to respiratory tract infections and surgery near the airway.

A careful preoperative history and clinical examination form the basis of the presurgical evaluation and choice of the appropriate anesthesia regimen. OSA and respiratory tract infections play an essential role to determine the anesthesia related risk. Perioperative respiratory adverse events are frequent complications, competence and experience of the pediatric anesthesia team are crucial to quickly recognising and adequate treatment. Postoperative complications like PONV, emergence delirium and pain are frequent with children after ORL operations, standardized preventive regimes exist and should be strictly moved.

Notes

Competing interests

The author declares that she has no competing interests.

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