

**REVIEW**

# Preoperative risk assessment in pediatric anesthesia

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**Summary**

In general pediatric surgical population, the incidence of perioperative 30-day mortality is low. A child's physical status at the time of elective surgery and the presence of comorbidities can notably impact the perioperative risk. In order to provide quality care, preoperative evaluation should be undertaken in a timely and thorough manner.

In preoperative period, it is highly important to be able to identify the patients who are at a higher risk, with the premise that early identification of these patients will allow for additional care to be provided, thereby minimizing possible complications. The main objectives of adequate preoperative assessment are to evaluate patients' readiness for the procedure, optimize patients' health status before surgery, reduce surgical morbidity, and help patients regain their usual functions postoperatively. Routine prescription of additional tests in children should be replaced by selective and rational prescriptions, based on the patients' history and performed clinical evaluation. Surgical and anesthetic complications can have adverse effects on patients' health, and they have also been proven to be associated with increased inpatient and postoperative costs. Each member of the surgical team plays a vital role in the safe care of pediatric patients. Well known risk factors for critical events in the perioperative period in pediatric population are as follows: ASA physical status, age, emergency surgery, and the existence of an underlying disease.

This review highlights potential risks encountered in children and directs preoperative assessment towards selecting essential tests based on identified individual risk factors.

**Keywords:** anesthesia, pediatrics, preoperative testing, risk factors

## INTRODUCTION

In general pediatric surgical population, the incidence of perioperative 30-day mortality is low (1), but the incidence of perioperative morbidity is still high (2). Most common causes of anesthesia-related cardiac arrests are cardiovascular causes (36%), respiratory causes (27%), medication-related causes (20%), and equipment-related problems (5%) (3). The majority of incidents (80%) occur during the maintenance of anesthesia (4).

A child's physical status at the time of surgery and the presence of comorbidities can notably impact the perioperative risk (5, 6). While the majority of children undergoing anesthesia are of good health, it is of great importance to detect any risk factors that may lead to unanticipated adverse event in the perioperative period. Prior to any procedure that requires the use of analgo-sedation or general anesthesia, preoperative risk assessment is necessary (7, 8). Common practice that implies routine prescription of additional tests in children should be replaced by individualized approach, based on patients' history and clinical examination of every child (9, 10).

Our goal in this review article was to elucidate which pre- and intraoperative patient characteristics in children undergoing surgery are associated with an increased risk of perioperative complications. Knowledge of risk profiles in pediatric anesthesia is a starting point for risk reduction.

## PERIOPERATIVE RISK ASSESSMENT TOOLS

There has been a plethora of preoperative risk scores developed in recent years, but most of them have passed only internal validation, and to be applied in clinical settings they need to be externally validated (11). Nowadays, only a few models are used in clinical settings (12). The reasons for the aforementioned are as follows: a relatively low incidence of adverse outcomes in pediatric population, a lack of clear guidance on which score to use, barriers for their application in clinical settings, or the fact that clinicians may find the tools not to be particularly useful in everyday practice.

The American Society of Anesthesiologists Physical Status (ASA PS) classification (Table 1) is most widely used, but it has some drawbacks, such as expressed subjectivity in the assessment. It is a six-point risk stratification tool for adults and children. The ASA class is an independent predictor of perioperative morbidity and mortality (13). Another one is the pediatric risk assessment (PRAm) score, which has prognostic value in the perioperative mortality in children who undergo non-cardiac surgeries (14). It is composed of a five-variable objective score derived from the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) pediatric database. This scoring sys-

tem includes the following: an urgent surgical intervention, comorbidities, the characteristic of critical illness, age below 12 months, and the presence of malignancy (Table 2). The PRAm score is an objective instrument that can be easily used by clinicians and may potentially improve patient outcomes, but further validation is needed for it to be generally accepted (15).

**Table 1.** American Society of Anesthesiologists (ASA) classification scoring system

| ASA score | Patient preoperative physical status   |
|-----------|--|
| I         | Patient of normal health   |
| II        | Patient with a mild systemic disease   |
| III       | Patient with a systemic disease that is not incapacitating                                 |
| IV        | Patient with an incapacitating systemic disease that is a constant threat to life          |
| V         | Moribund patient who is not expected to survive the following 24h, with or without surgery |
| VI        | A declared brain-dead patient whose organs are being removed for donor purposes            |

**Table 2.** Pediatric risk assessment score for predicting postoperative mortality

| Variable       | Definition   | Value |
|----------------|--|-------|
| Urgency        | An urgent surgical procedure   | +1    |
| Comorbidity    | The presence of at least one of the following comorbidities: respiratory disease, congenital heart disease, preoperative acute or chronic renal failure, neurologic disease, hematologic disease | +2    |
| Critically ill | The presence of at least one of the following characteristics of critical illness: preoperative mechanical ventilation, inotropic support, preoperative cardiopulmonary resuscitation            | +3    |
| Age <12 mo     | Age at the time of surgical procedure below 12 months  | +4    |
| Malignancy     | Surgical procedure in a patient with a neoplasm, with or without chemotherapy  | +5    |

## ADDITIONAL ANALYSES

A routinely performed preoperative evaluation of pediatric patients usually includes history taking, physical examination, and laboratory testing. Routine preoperative laboratory analysis for all patients has been questionable over the past several years considering the efforts to decrease medical costs and at the same time preserve the quality of medical care (16). Justified medical reasons for ordering additional tests are as follows: detecting unsuspected but invariable conditions that may alter the operative risk, detecting unsuspected conditions in which interventions may lead to a lower operative risk, and getting baseline results that may be helpful in decision-making during and after surgery.

Routine blood testing in preoperative evaluation of healthy children detects about 2.5 –10% of abnormal re-

sults, but these results infrequently have an impact on the timing of surgery (17). The American Academy of Otolaryngology – Head and Neck surgery recommends screening for coagulation disorders only for patients with a clear medical indication (18). Besides, normal coagulation values do not absolutely rule out a coagulation disorder. Preoperative arterial blood gases are invasive, often difficult to perform in a child who is awake, and do not upgrade the quality of risk assessment. Biochemical analyses and electrolyte status are only justified in children with a history suggesting an underlying disease or who take medications which might affect the water/electrolyte balance, renal or hepatic function. The reason behind performing urine analysis prior to surgery is to detect children with unsuspected renal disease or urinary tract infection (19). Routine chest X-rays rarely reveal clinically important abnormalities which have not been already suggested by a thorough history and physical examination. The American Academy of Pediatrics recommends that there should be no chest X-ray unless there is a clear indication that it will notably impact the perioperative period (20). Spirometry should not be used unselectively, but only where its use could provide additional information that would change perioperative management (21). A cardiac evaluation is recommended in all patients with symptoms suggesting cardiac disease and in all asymptomatic patients with a clinical examination indicating potential for an underlying cardiac disease (22).

## PRETERM NEONATES

Neonates and premature neonates have limited physiological reserve, and are at a greater risk of complications with general anesthesia, compared to older children and adults (23). Neonatal surgery, especially in preterm babies, is associated with adverse neurodevelopmental outcomes (24). Prematurely born children are at an increased perioperative risk by the age of three. An anesthesiologist must know that prematurity is a risk factor for acute newborn complications (e.g., intraventricular hemorrhage, bronchopulmonary dysplasia, and retinopathy), as well as complications that continue into childhood (e.g., cognitive or motor delay, delayed growth and development, and heart disease) (7). Also, infants below 60 weeks of postconceptional age are at risk of apnea. It is necessary that infants are monitored until they are apnea-free for at least 12 h postoperatively, before discharge (25).

## POSTOPERATIVE NAUSEA AND VOMITING

There is a long list of etiology factors of postoperative nausea and vomiting (PONV) which remain problems in children undergoing anesthesia and surgery (26). We can influence certain etiological factors, and this primarily

refers to the anesthesia technique, the use of opioids, pain and anxiety. Opioids and pain-related causes are two of more common causes of PONV which lead to patient and family dissatisfaction (27). Essential elements of a multimodal approach to an adequate anti-emetic and pain therapy are as follows: preoperative risk evaluation and stratification, a multimodal combined anti-emetic prophylaxis, and pain management including opioid-sparing medications and regional anesthesia (28).

## PREOPERATIVE FASTING

Adults and children should be encouraged to drink clear fluids up to 2 h before elective surgery; solid food should be prohibited for 6 h, breast milk is safe up to 4 h prior to surgery and other milks are allowed up to 6 h prior to elective surgery (29). Children should not have their surgery cancelled or delayed just because they are chewing a gum or eating a lollipop. There is insufficient evidence for recommending a routine use of antacids, metoclopramide or H<sub>2</sub>-receptor antagonists before elective surgery.

## SPECIFIC DISEASES

### Respiratory risk

Respiratory adverse events account for 77% of the total number of incidents (4). Perioperative respiratory adverse events are a main cause of morbidity and mortality and cause up to 30% of perioperative cases of cardiac arrest in pediatric population during anesthesia (30). Well known risk factors for perioperative respiratory adverse events are recent (less than 4 weeks ago) or active upper respiratory tract infection (URTI), primary pulmonary morbidity, a history of snoring, being below 6 years of age, passive smoking, the type of airway device in use, how experienced the anesthesiologist is, and the type of surgery performed.

During the preanesthetic examination, the child should have their mouth wide open to exclude insufficient mouth opening and to extend the neck to exclude cervical spine restrictions (31). Craniofacial malformations, tumors, syndromes, musculoskeletal problems or trauma can lead to difficulties in airway management (32). The incidence of a difficult airway is higher in children under the age of 1 (33).

### Respiratory tract infection

One of the most controversial questions in pediatric anesthesia relates to the decision when to proceed with anesthesia and surgery if the child has URTI. Up to 30% of children presenting for elective surgery have an active URTI (34). There is a significant positive correlation

between a URTI and the incidence of perioperative respiratory adverse events, such as cough, laryngospasm, bronchospasm, arterial oxygen desaturation, apnea or breath-holding, hospital readmission, even death (35). Up to 6 weeks following the infection patients with a URTI have modified airway reactivity. In children presenting with signs and symptoms of a lower respiratory tract infection (LRTI) or with fever  $>38.5^{\circ}\text{C}$ , elective surgery should be postponed for 6 weeks (2).

### Asthma

Recent worsening of asthma symptoms, an increase in the need for asthma medications or hospitalization for asthmatic symptoms increase the perioperative risk (36). It is characteristic that bronchial hyperreactivity frequently persists beyond the presence of asthmatic or other respiratory symptoms. Administration of corticosteroids prior to surgery reduces respiratory adverse events if started at least 48 h before surgery, as their onset of action is 6-8 hours upon administration, and they reach their maximal effect in 12 to 36 hours (37).

### Bronchopulmonary dysplasia

A suspicion of the presence of bronchopulmonary dysplasia (BPD) should occur if a child was prematurely born and was mechanically ventilated in the neonatal period. Also, during the first day of life these children retain an increased risk of perioperative bronchospasm and oxygen desaturation. Additionally, children with severe BPD may develop right ventricular dysfunction that can be worsened by the induction of anesthesia. As they get older, these children may become asymptomatic, but they still have a higher rate of bronchial hyperreactivity (5). Children with a severe form of BPD should be monitored for 24–48 hours upon surgery.

### Congenital heart disease

It is of great importance to identify patients with congenital heart disease (CHD) before surgery, even though most murmurs are of functional origin. Children with CHDs are at an increased risk of developing complications during anesthesia, and anesthesia-related cardiac arrest during a non-cardiac surgery is more common (38). Patients with the greatest perioperative risk are infants with a functional single ventricle, suprasystemic pulmonary hypertension (PH), left ventricular outflow tract obstruction and cardiomyopathy (39). Besides, the presence of cardiac failure, PH, arrhythmia, and cyanosis indicate patients with complex problems (22). Possible adverse events during procedures like cardiac catheterization interventions are coronary ischemia, cardiac arrest, low cardiac output, right ventricular failure, pulmonary hypertensive crisis, arrhythmias, cardiac perforation, and tamponade (39).

### Pulmonary hypertension

Children with pulmonary hypertension (PH) have a twenty times greater perioperative risk than general pediatric population. Several pediatric studies have reported that the incidence of perioperative cardiac arrest in patients with PH is between 0-5% and perioperative death around 1.5% (40). However, a precise definition of risk stratification for anesthesia in a child with PH is controversial, because of the following: as pediatric PH is not common, the overall incidence of perioperative morbidity and mortality is low, so most pediatric studies are comparatively heterogeneous and various subgroups of pediatric PH have different types of perioperative risk (41).

### Acute and chronic kidney disease

Acute kidney injury (AKI) is a common complication of cardiac and non-cardiac surgeries, and it negatively influences short- and long-term outcomes. In children with chronic kidney disease (CKD), preoperative assessment needs to be focused on the presence of cardiorespiratory problems, hypertension, hypo/hypervolemia, electrolyte disbalance and coagulation disorders. CKD increases the risk of postoperative acute kidney injury, major adverse cardiac events, and death. If in preoperative assessment we reveal underlying CKD and other risk factors for AKI, in some situations we may be able to administer preventive therapy and improve the outcomes (42).

### Neurologic diseases

Children with neurologic or neuromuscular diseases are at a greater perioperative risk (43). Anticonvulsant therapy should be optimized prior to surgery. The majority of anticonvulsant medications have a long half-time, so missing one dose of anticonvulsants does not significantly decrease the drug blood levels. The function of ventriculoperitoneal shunts should be checked preoperatively and adequate measures should be taken to avoid increased intracranial pressure. In spite of the missing causative connection between malignant hyperthermia and other neuromuscular diseases, triggering agents should be avoided in children presenting with neuromuscular disorders. In case of a positive personal or family history the patient should be tested for malignant hyperthermia.

### Obesity

Obesity is associated with pathophysiological changes affecting multiple organ systems, of which most relevant to anesthesiologists are the airway, cardiopulmonary system, the endocrine and hepatic systems. Changes in body composition also affect drug disposition and require awareness of appropriate weight scalars for dosing in obese children (44). All obese children need to



be checked for symptoms of sleep-disordered breathing. Due to the use of sedatives and opioids in anesthesia management, the perioperative period is a time of particularly high risk for patients with obstructive sleep apnea (OSA). Patients with OSA have a higher incidence of postoperative hypoxia, respiratory failure, cardiac events, and intensive care unit transfers than those without OSA (45).

## Diabetes mellitus

For optimal management of patients with diabetes mellitus during the perioperative period, pediatric anesthesiologists must carefully consider the pathophysiology of the disease, patient-specific methods of treatment, glycemic control, the type of surgery and surgery timing. The perioperative plan should be developed in consultation with a pediatric endocrinologist (46). The following pediatric issues need to be considered: body size, pubertal development and the ability to tolerate nil per os status. Attention to blood glucose monitoring and insulin therapy is required to maintain normoglycemia and avoid patient distress.

## CORTICOSTEROID THERAPY

As the adrenal glands take up to one year to recover entirely following long-term steroid treatment, endocrinologists recommend to substitute it so as to have the discontinuation of corticosteroids for a year. Prior to surgery, children on long-term steroid therapy should receive their daily dose orally or parenterally and an additional dose (stress dose) should be added dependent on the duration and the type of surgery. Patients with long-term inhalation steroids do not need an additional stress dose prior to surgery. Von Ungern-Sternberg et al. recommend their regimen for steroid replacement: for a minor surgery, the first dose of hydrocortisone 50 mg/m<sup>2</sup> intravenously is recommended and should be followed by 12.5 mg/m<sup>2</sup> every 6 h on the day of surgery. For greater surgical stress, a dose of 100 mg/m<sup>2</sup> is recommended followed by 25 mg/m<sup>2</sup> every 6 h on the day of surgery, every 8 h on the first postoperative day, and every 12 h on the second postoperative day. On the third postoperative day, an ordinary treatment dose should be given (47).

## ALLERGIES

Patients are exposed to multiple agents that can trigger hypersensitivity reactions in the perioperative period. Perioperative anaphylaxis is an unexpected and

life-threatening event, but fortunately its incidence is low (48). The risk group of patients without a prior history of perioperative hypersensitivity reactions need to be recognized in pre-anesthesia examination and if necessary, be referred to an allergologist. The management of perioperative hypersensitivity reactions should be a combined effort between allergologists and anesthesiologists (49).

## VACCINATION

Many countries have routine immunization schemes, which include several vaccinations within the first year of life, therefore, every anesthesiologist should check for recent vaccinations in patients of this age. Anesthetic implications of a recent vaccination have not been well investigated, but it is known that anesthesia, stress and trauma are suppressors of the immune system. Also, many anesthetic procedures are performed in this age group without apparent consequences. To reduce the coincidence of the peak systemic reactions to the vaccine with anesthesia and surgery it is reasonable to delay elective surgery for at least 3 days following a killed vaccine or inactivated toxins and 2 weeks following an attenuated vaccine (50).

## CHICKENPOX

The question which is necessary to ask is if the child has recently contracted chickenpox or has recently been in contact with a patient suffering from chickenpox. Literature does not provide a unique answer to the question of how long it is necessary to postpone elective surgery after chickenpox; the existing recommendations are mostly based on the basic principles of anesthesiologic care of a child suffering from an infectious disease. According to some opinions, the procedure under general anesthesia should be postponed until the end of the infectious period, which would mean at least 3 months. However, the final decision on the induction of general anesthesia or the postponing of elective surgery is left to the personal assessment of the anesthesiologist in charge (51).

## CONCLUSION

Understanding and accurately estimating preoperative risk by accounting for the intrinsic risk of surgical procedures and patient comorbidities will lead to a more comprehensive discussion between patients, families and providers. Also, creating a pediatric preoperative risk assessment checklist would be very useful.

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## PREOPERATIVNA PROCENA RIZIKA U PEDIJATRIJSKOJ ANESTEZIJI

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### Sažetak

U opštoj pedijatrijskoj populaciji incidencija perioperativnog tridesetodnevno mortaliteta je niska. Opšte zdravstveno stanje deteta u vreme planirane hirurške intervencije kao i prisustvo komorbiditeta mogu značajno da utiču na perioperativni rizik. U cilju obezbeđivanja adekvatne nege, preoperativna evaluacija se mora sprovesti blagovremeno i temeljno.

U preoperativnom periodu veoma je važno identifikovati pacijente sa povećanim rizikom, uz premisu da rana identifikacija ovih pacijenata omogućava dodatnu evaluaciju i lečenje po potrebi, i na taj način rizik od komplikacija se svodi na minimum. Najvažniji elementi koji čine adekvatnu preoperativnu procenu su sledeći: procena da li je pacijent spreman za hiruršku intervenciju, optimizacija zdravstvenog stanja pred hiruršku intervenciju,

smanjenje morbiditeta operativne intervencije i potom vraćanje pacijenta u uobičajeno stanje kao pre hirurške intervencije. Rutinsko propisivanje dodatnih testova kod dece bi trebalo zameniti selektivnim i racionalnim testiranjem, baziranim na istoriji bolesti i kliničkoj proceni. Komplikacije hirurških intervencija i anestezije mogu da imaju nepovoljne posledice po zdravlje pacijenta, ali su takođe povezane sa većim bolničkim kao i postoperativnim troškovima. Svi članovi hirurškog tima imaju vitalne uloge u očuvanju bezbednosti deteta.

Ovaj pregled literature ukazuje na potencijalne rizike sa kojima možemo da se susretnemo u dečjoj populaciji i usmerava preoperativnu procenu prema selektivnim testovima zavisno od individualnih faktora rizika.

**Ključne reči:** anestezija, pedijatrija, preoperativno testiranje, faktori rizika

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