Anesthesia (pediatrics)

There are anatomical, physiological, biochemical and psychological differences between children and adults. Children under the age of 6 demonstrate a clearly higher anesthetic risk than adults. Children in the first year of life and children with a serious underlying disease are most at risk. The causes of death in childhood in connection with anesthesia are urgent procedures, serious underlying diseases, poor preoperative condition, insufficient anesthesia equipment (including an inexperienced anesthesiologist), aspiration into the lungs, depression of heart and circulatory function in connection with an overdose of inhalation anesthetics (especially halothane), depression of breathing (→ apnea), insufficient monitoring.

Anatomical and physiological foundations

Respiratory tract

Many **anatomical peculiarities** are important for pediatric anesthesia practice, which are most prominent in newborns and infants.

The head is relatively **large, the neck short**. The tongue is large and **tracheal intubation is difficult. The nasal passages, glottis and subglottic space are narrow**, and even a slight swelling in this area can lead to critical obstruction.

The larynx of children is **located higher** than that of adults, the epiglottis is **relatively long** and has the shape of the letter "U". **The narrowest place is in the area of the annular cartilage** = subglottic space, only in children > 8 years old does the glottic slit become the narrowest space. **Both main bronchi depart** from the trachea **at an angle of 55°** . This makes unilateral **bronchial intubation possible not only to the right, but also to the left. The cough reflex in newborns is imperfectly developed** . There is therefore a higher risk of aspiration, but tracheal intubation is also possible in awake newborns.

Physiology of respiration

The breathing of newborns is usually **irregular**, in premature babies the irregularity of breathing is more frequent and pronounced. During the first 6 weeks of life, **so-called "periodic breathing"** is not uncommon, which is characterized by rapid breaths alternating with pauses lasting 5-10 seconds. We only talk about apnea when there is a pause > 15 seconds, when we often simultaneously register bradycardia and desaturation with cyanosis.

Lung volumes of young children, relative to body surface area, correspond to volumes in adults, as well as their functional distribution. In children, the dead space of anesthesia devices and their accessories is of particular importance → in the anesthesia of children, a **special anesthesia system must be used with as little dead space as possible.**

Alveolar ventilation is higher in the smallest children than in adults due to their high metabolism. An increase in ventilation is achieved by increasing the respiratory rate and only to a small extent by increasing the tidal volume. **Functional residual capacity as a buffer, preventing fluctuations in inhaled gas and anesthetic concentrations, is less effective** in neonates and infants than in adults. Reasonably quickly, these changes are transferred to arterial gas values and blood anesthetic concentrations.

Heart rate

The younger the child, the higher the heart rate. The heart of children < 1 year is not very flexible and can only increase the stroke volume to a limited extent. Therefore, heart rate is the most important determinant of cardiac output. The higher the heart rate, the greater the minute cardiac output (applies up to a limit of approx. 210/min.). A decrease in heart rate is more important than tachycardia, especially in young children. Bradycardia occurs in connection with vagal stimulation (tracheal intubation, administration of suxamethonium). Weight-related bradycardia can be reversed with atropine. But bradycardia often comes as a result of severe hypoxia.

Tachycardia is well tolerated by newborns and small children and do not lead to a decrease in cardiac output up to a frequency of about 210/min. Medical treatment is not necessary, but precipitating factors such as pain, fever, full bladder, severe anaemia, incipient sepsis or hypercapnia must be identified and removed

Normal values of heart and respiratory rate

Age	Normal respiratory rate (per minute)	Normal heart rate (per minute)
newborns	40–60	100–180
infants	30–50	80–150
toddlers	25–40	80–130
preschoolers	25–35	80–120
younger schoolchildren	20–30	70–100
older schoolchildren	12–20	60–100
adults	12–16	60–90

Blood pressure

Arterial blood pressure changes with age: the younger the child, the lower the blood pressure. Hypoxia leads to vasoconstriction. Central venous pressure corresponds to values in adults. The value of cardiac output relative to body surface area (cardiac index, CI) is 30-50% higher in young children than in adults due to their higher metabolism. Mild hypoxia increases cardiac output, severe hypoxia reduces it. Children with a cyanotic heart defect often tolerate hypoxia without significant myocardial dysfunction (at rest), but when acidosis is added, cardiac output decreases.

Blood

Blood volume relative to body weight is higher in children than in adults. In newborns and young children, **even small blood losses lead to a life-threatening deficit in circulating blood volume**. Blood pressure drops in proportion to blood loss. **An indicator of the severity of** blood loss/hypovolemia **is tachycardia and a drop in systolic pressure**. In newborns, the value of systolic blood pressure is a guide to replace blood loss. In older children, on the other hand, the drop in blood pressure only occurs pre-terminally during hypovolemic shock.

Children usually compensate for the drop in Hb concentration well. Only when the value drops below 60 g/l, it is necessary to expect tissue hypoxia .

Blood volume in children

Age	Blood volume (ml/kg)
newborns	80–85
1 month - 2 years	75
2-15 years	72

Hemoglobin and hematocrit value in children

Age	Hemoglobin concentration (g/l)	Hematocrit (%)
2 weeks	130–200	0,42–0,66
3 months	95–145	0,31–0,41
6 months–6 years	105–140	0,33–0,42
7-12 years	110–160	0,34–0,40
Adults		
women	120–160	0,37–0,47
men	140–180	0,42–0,52

Thermoregulation

The essence of rapid heat loss in newborns is the relatively large surface area of the body and the lack of subcutaneous fat tissue. The ideal environmental temperature for an unclothed newborn is **32–34° C** – we are talking about a **so-called thermoneutral environment** (= a stable body temperature is maintained only by changes in blood circulation to the skin, without an increase in metabolism and oxygen consumption).

Unlike newborns and young children, older children react to anesthesia and surgery with a rise in body temperature. Therefore, **it is important to monitor body temperature with a** temperature sensor and take appropriate measures to prevent heat loss.

Clinical principles

Clinical evaluation

When taking an **anamnesis**, it is necessary to pay attention to the following factors:

- Has the child already undergone surgery and anesthesia in the previous period? With what progress? Did you develop a high temperature during the operation?
- What serious illnesses has the child experienced so far?
- Circulatory system: ability to cope with physical load, signs of heart failure, cyanotic attacks?
- Respiratory system: asthma, pneumonia ? Is the child prone to respiratory tract infections?
- Does the child have allergies?
- What medications was taken before the operation?

During **the examination itself** , it is necessary to pay attention to the growth and development of the child, the upper respiratory tract, the condition of the teeth, the function of the heart and blood circulation, breathing and the condition of the veins:

- age, height and weight,
- arterial blood pressure, heart rate, heart sounds,
- dental condition
- upper respiratory tract (infection, presumed difficulties with intubation),
- hydration status: Is the child dehydrated?,
- state of the venous bed.

As part of the **pre-operative laboratory examination** for routine procedures, we determine: blood count, blood group, urine examination, coagulation tests (if there are signs of increased bleeding in the anamnesis or in case of serious procedures). In the case of anemia with a value of Hb < 100 g/l, it is necessary to search for the cause, but as a rule it is not necessary to postpone even an elective procedure.

Preoperative fasting

Fasting time (in hours) in children

Age	Solid food including milk	Clear liquids
0-6 months	4	2
6 months–3 years	6	3
> 3 years	8	3

Premedication

Children under the age of 1 usually do not receive premedication. Benzodiazepines, namely **midazolam**, are most commonly used in older children.

Routes of administration and dosage of midazolam

Oral	Rectal	Nasal	Sublingual
0.4–0.6 mg/kg	0.5–1.0 mg/kg	0.4 mg/kg	
duration of effect 45 min	effect time 30 min	fast onset of effect	

Due to the risk of respiratory depression, or even suffocation of children, midazolam injections may only be given in conditions of emergency care and in the presence of a doctor with experience in emergency care.

Neuroleptics are no longer so popular, because premedication with a neuroleptic alone is insufficient (combination with opioids is necessary), the advantage is the antiemetic effect. They use:

- promethazine 0.5–1 mg/kg + piritramide (opioid) 0.1 mg/kg po
- chlorprothixene 2 mg/kg, max. 45 mg po

Anticholinergics are beneficial in pediatric anesthesia , as they prevent or reduce bradycardia caused by stimulation of the vagus nerve (intubation, application of suxamethonium). At the same time, they also reduce the production of saliva and thus facilitate the course of intubation. Most often used:

- atropine 0.02 mg/kg in small children (but minimum 0.1 mg), 0.01 mg/kg in older children, max 0.5 mg pro dosi.

In children with high suspicion of intracranial hypertension, some authors recommend **lidocaine** , which reduces ICP and at the same time reduces airway reactivity, suppresses the cough reflex:

- lidocaine 1.00–1.5 mg/kg even at least 2 minutes before intubation.

Premedication should basically be painless, if possible without intramuscular or intravenous injection. For children < 3 years, we prefer rectal premedication, for older people we prefer after the trip. The dosage per kilogram of body weight is only indicative, it does not suit all children. Therefore, we should dose premedication individually according to the intensity of the child's fear and agitation.

Basal anesthesia

In this way, we induce sleep, or basal anesthesia by rectal administration of barbiturates or ketamine. This procedure is most often indicated **for** very **uncooperative children** (see introduction to anesthesia for more information).

As part of the choice of anesthesia, general anesthesia is the most advantageous for children. **We prefer inhalation anesthesia** for easy availability and good manageability. Supplemental anesthesia using opioids or pure TIVA (total intravenous anesthesia) have special indications, e.g. major procedures or seriously ill children.

Links

Related Articles

- Anesthesia
- Inhalation anesthesia
- Neuroleptics (pediatrics)
- Benzodiazepines (pediatrics)
- Intravenous anesthetics (pediatrics)
- Opioids (pediatrics)
- History of anesthesia

External links

- Anesthesia of the newborn — interactive algorithm + test (https://www.akutne.cz/algorithm/cs/300--/)

Source

- HAVRÁNEK, Jiří: *Anesthesia in children*.