

The consensus statement of the Paediatric Section of the Polish Society of Anaesthesiology and Intensive Therapy on general anaesthesia in children over 3 years of age. Part I — general guidelines

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Key words: general anaesthesia, children, statement

Anaesthesia in children is a challenge for anaesthetists, who typically care for adults. According to Polish legal regulations, a patient can be anaesthetized by any anaesthetist possessing the relevant specialization certificate; nevertheless, the vital criterion to consider during anaesthesia in children is the clinical experience of physicians [1]. Permanent employment in a paediatric hospital as well as continuous post-graduate education allows and guarantees that hands-on experience in paediatric anaesthesia.

The Paediatric Section of the Polish Society of Anaesthesiology and Intensive Therapy (Sekcja Anestezjologii i Intensywnej Terapii Dziecięcej Polskiego Towarzystwa Anestezjologii i Intensywnej Terapii, PTaiIT) actively cooperates with national consultants and the Main Board of PTaiIT in the development of new standards and recommendations regarding anaesthesia in the paediatric population and in refining the specialization system. Thanks to this collaboration, the Specialization Program, effective since 1 October, 2014, was changed, i.e. the internship in paediatric anaesthesiolo-

gy was prolonged to 60 workdays [2]. Anatomy and physiology, psychosocial features and pharmacokinetic/pharmacodynamic (PK/PD) models in paediatric patients are different from those in adults, necessitating the introduction of and adherence to particular rules and conditions during surgical procedures. One of these rules is an appropriately prepared and trained team of physicians and nurses; another requirement is a well-equipped operating room and a recovery room. Additionally, the hospital is obliged to ensure proper conditions for child hospitalization before and after surgery by organizing paediatric departments or at least assigning paediatric beds [1]. Special care should be directed to children with complex congenital malformations and/or severe concomitant systemic diseases [2].

The perioperative risk in paediatric patients is still higher than that in adults, 0.1–1.2 vs. 0.5–0.9 per 10,000 cases of anaesthesia; however, the incidence of cardiac arrest (CA) in the peri-anaesthesia period decreased below 0.014%, which most likely resulted from withdrawal of halothane

from paediatric hospitals at the beginning of the 21st century [4]. Although the mortality rate due to CA in children remains high, i.e. up to 28%, it mainly pertains to severely ill patients (ASA III–V), particularly those after emergency procedures. According to Coté [5], the factors determining the safety of paediatric patients during procedural sedation and analgesia (PSA) primarily include the professional skills of healthcare providers performing the procedures and, to a lesser extent, the drugs used, except in cases of overdosing and drug interactions, which was also confirmed by Ungen von Sternberg and co-workers [6].

This article presents the consensus statement of the Paediatric Section of the Polish Society of Anaesthesiology and Intensive Therapy on general anaesthesia in children over 3 years of age and is an extension of the guidelines published in 2012 on general anaesthesia in children less than 3 years of age. Moreover, the article is an introduction to a more detailed section, which will include anaesthesia protocols and algorithms for this group of patients in individual diagnostic and surgical specialities [7].

PREPARATION OF CHILDREN FOR ANAESTHESIA

All the activities prior to administering anaesthesia are to provide the optimal conditions for the anaesthetic procedure and to minimize the risk of complications. The basic difference in the preparation process between adults and paediatric patients is active participation of parents and/or legal caregivers in the latter case. Anaesthetists have to gain trust of both children and parents, which should facilitate successful induction of anaesthesia. According to Polish legal regulations, a written informed consent provided by parents/legal caregivers or a patient over 16 years of age for the suggested anaesthetic management is a prerequisite for delivering anaesthesia.

PRE-ANAESTHESIA CONSULTATION

An anaesthetist should take the medical history and examine the child in the presence of his/her parents or legal caregivers at least 24 hours prior to surgery; in practice, however, history taking and physical examinations are most commonly performed on the day preceding the surgical procedure. The conversation with parents and children is to decrease their anxiety; thus, it should be adjusted to the child's age and consider the sources of anxiety characteristic of individual age groups, including separation from parents [1].

MEDICAL HISTORY

An anaesthesiological questionnaire is an essential tool facilitating history taking. The questionnaire should contain questions about previous surgical and anaesthetic proce-

dures, complications, infections of the upper and lower respiratory tract as well as allergies. It is worth remembering that respiratory tract infections result in airway hyperactivity, persisting for up to 6 weeks. Anaesthesia delivered during infections or within 2 post-infection weeks increases the risk of respiratory complications, so is passive smoking [6]. Rhinorrhoea, allergic and chronic rhinitis without general symptoms are not contraindications to anaesthesia for elective surgery [8].

Drug allergic reactions in children should be of special interest, particularly those to more than one drug. Allergies to soya, egg yolk lecithin and peanuts are not contraindications to the use of propofol [8]. Moreover, there is no rationale for modifying anaesthesia in patients with allergies to fish and seafood [8]. However, children hypersensitive to latex require special equipment; latex gloves and latex-containing devices should be avoided. Similar precautions should be taken in patients at high risk for latex allergy, which includes children with a history of more than three sensitizing allergens, an allergy to kiwi fruit or chocolate, as well as children after multiple surgical procedures, especially those with spina bifida [9].

Children with asthma are always at risk of perioperative complications, such as bronchospasm or anaphylactic reactions. To deliver anaesthesia for elective surgery in this group of children, their clinical condition should be stabilized. The drugs taken chronically should not be discontinued nor their doses reduced. The prophylactic administration of short-acting beta-2 mimetics (short-acting beta-agonists, SABAs) and/or corticosteroids should be considered [8].

During the pre-anaesthesia consultation, the principles of postoperative care should be explained, including pain management, prevention of nausea and vomiting, and timing of the first meal after surgery; generally, the child can eat and drink ad libitum, unless there are surgical contraindications. The parents/caregivers of children undergoing surgical procedures on an outpatient basis have to be provided with detailed information about where to look for help in case of alarming symptoms. Additionally, it has to be clarified whether parents/caregivers can provide private transportation home. The use of public transportation is contraindicated.

PHYSICAL EXAMINATION

The extent of the physical examination differs in each child and depends on two main factors: information from the medical history and the child's permission. The basic elements of the physical examination include inspection of the nose and oral cavity plus chest auscultation. The airway should be assessed to determine the risk of difficult intubation.

Table 1. Dosage of premedication drugs in children

Drug	Administration route		
	Oral	Intranasal	Intravenous
Midazolam	0.5 mg kg ⁻¹ (max. 15 mg)	0.2 mg kg ⁻¹	0.1 mg kg ⁻¹
Dexmedetomidine	1–2 mcg kg ⁻¹	1 mcg kg ⁻¹	–
Clonidine	4–5 mcg kg ⁻¹	2 mcg kg ⁻¹	–

LABORATORY TESTS

It is recommended to perform the basic panel of laboratory tests before elective surgery, and their range depends on the type and extent of surgery as well as the child's general state. In generally healthy children scheduled for low bleeding risk procedures, laboratory tests are not required. In the remaining cases, the results of tests performed within the past 3 months could be accepted, providing that the child's health status has not changed. The range of laboratory tests should always be assessed on a case-by-case basis.

FASTING BEFORE ANAESTHESIA

In anaesthesia for elective procedures, the "6:4:2" rule is followed, i.e. no intake of solid food and milk formula for at least 6 hours before anaesthesia, of mother's milk for 4 hours and of clear, non-carbonated fluids for 2 hours. Prolongation of fasting over the minimum requirements puts the children at risk of aspiration of low pH gastric contents [10,11].

In emergency or urgent procedures, anaesthetic procedures for "full stomach" patients should be used.

PREMEDICATION

Premedication is to reduce or eliminate anxiety and provide the optimal conditions for induction of anaesthesia. For this purpose, midazolam is most frequently used. Beside its potent anxiolytic and sedative effects, midazolam induces retrograde amnesia and the child does not recall events in the operating room [12]. Another asset of midazolam is its different routes of administration (Table 1). Paradoxically, the drug can induce agitation in some children; in such cases, it should not be used.

Another solution is the administration of agonists of alpha-2 receptors — clonidine and dexmedetomidine, which induce anxiolytic and analgesic effects (Table 1) [13, 14].

The optimal method of reassuring a child is the presence of properly prepared parents until the child falls asleep. However, the parents' anxiety and inability to control emotions could be completely counterproductive. Therefore, in each case, the presence of the parents should be meticulously considered (parental presence induction anaesthesia — PPIA) [15–17].

Recently, the role of different distractive methods has been emphasized (talking to patients about topics far re-

moved from medical reality, smartphones, tablets, toys, presence of clowns in the operating room, etc.) [18–23].

Another element of child's preparation for anaesthesia is skin anaesthesia at the site of the puncture. EMLA cream or patch (60 minutes before puncture), Ametop gel or lidocaine gel under an occlusive dressing (30 minutes before puncture) could be used [23].

INDUCTION OF ANAESTHESIA

Intravenous or inhalation induction of anaesthesia is mainly performed in children. In emergency cases, with no venous access, intraosseous induction can be applied [24]. The choice of administration route should consider the patient's safety, the anaesthetist's skills and the patient's preferences. There is no explicit evidence that the type of anaesthesia induction is correlated with the incidence of respiratory and circulatory complications, postoperative vomiting or behavioural disorders [25]. Inhalation induction requires experience; therefore, for anaesthetists who do not anaesthetise children on a regular basis, the intravenous route appears to be the better choice.

The safest and most recommended route of anaesthesia induction in children with impaired upper airway patency is inhalation induction with a mixture of sevoflurane and oxygen.

Rapid sequence induction (RSI) is indicated in full-stomach patients. Pharmacological methods to prevent aspiration in full-stomach patients, including metoclopramide, antacids and H₂-receptor antagonists, are currently not recommended, except in pregnant women (quality of evidence 1++; level of recommendation A) [11]. Since the oxygen reserve in children is limited, RSI is frequently modified, with mask ventilation and pressures not exceeding 10–12 mm Hg before endotracheal intubation. Sellick's manoeuvre is not recommended because its efficacy has not been proven [25].

INHALATION INDUCTION

Table 2 presents the indications and contraindications for inhalation induction. The anaesthetic of choice during inhalation induction is sevoflurane. It should be explained to a child how to breathe ("like an astronaut" or "like a pilot", through a mask, "blowing" a balloon). Induction under

Table 2. Indications and contraindications to inhalation induction in children

Indications to inhalation induction	Contraindications to inhalation induction
Difficult intubation expected (intravenous access should be previously ensured)	Full stomach
Fear of needle	Risk of malignant hyperthermia
Difficult vascular access (unless starting with anaesthesia without intravenous access is not connected with additional risk for patient)	Fear of mask

Table 3. Methods of inhalation induction*

Gradual increasing of anaesthetics	Usual respiratory volumes	One or three vital capacities
Long-lasting	Intubation and placing of laryngeal mask possible	Fast, smooth induction
Do not eliminate excitation phase	without muscle relaxants	Easy going through initial excitation phase
	Easy going through excitation phase	needs a child's cooperation

*it should be avoided hyperventilation and concentrations of sevoflurane over 6% for spontaneously breathing patients and 5% during support ventilation and do not exceed 1.5 MAC in maintenance phase of anaesthesia

Table 4. Dosage of anaesthetic drugs in intravenous induction

Drug	Dose (<i>i.v.</i>)
Propofol	2–4 mg kg ⁻¹
Thiopentone	4–6 mg kg ⁻¹
Etomidate	0.3 mg kg ⁻¹
Ketamine	1–2 mg kg ⁻¹

Table 5. Dosage of opioids in intravenous induction

Drug	Dose <i>i.v.</i>
Fentanyl	2–5 mcg kg ⁻¹
Remifentanyl	0.5–1 mcg kg ⁻¹
Sufentanyl	0.5–1 mcg kg ⁻¹

physical coercion should be avoided [26]. The methods of inhalation induction are presented in Table 3.

To obtain a quicker effect during inhalation induction, a mixture of nitrous oxide and oxygen could be used as a carrier gas in children without contraindications; in the remaining cases, 100% oxygen or a mixture of oxygen and air can be administered. The advantages of inhalation induction include painlessness and reversibility, while the disadvantages are the risk of laryngospasm and higher incidence of transient postoperative agitation [26].

INTRAVENOUS INDUCTION

Intravenous induction requires intravenous cannulation. Unless other methods are used, the proven way to distract a child is to request an intense cough immediately before the provision of intravenous access [27]. The drug of choice in children who are in a good general status is propofol, mainly due to quick recovery, effective suppression of airway reflexes and antiemetic action. Pain at the injection site is a disadvantage, but the pain could be alleviated by the administration of lidocaine at the dose of 0.1–0.2 mg kg⁻¹ [22].

Other induction drugs include thiopental, etomidate (recommended in children with cardiovascular risks) and ketamine. Ketamine is particularly indicated in children with shock and congenital heart failure, when the preservation of systemic vascular resistance is essential, as well as in

cases when spontaneous breathing has to be maintained (dosing in Table 4).

In addition to anaesthetics, opioids are also used during the induction of anaesthesia; in children, these drugs should be administered by a slow infusion; otherwise, cough and chest rigidity impeding ventilation can develop (see the dosage in Table 5). Muscle relaxants are usually administered before endotracheal intubation. Routinely, drugs from the non-depolarizing group are used; the choice of a drug is determined by its duration of action. Atracurium or cisatracurium are indicated in children with liver and kidney failure. When a quick onset of action is needed, e.g. during RSI, rocuronium is administered, which provides the intubation conditions similar to those induced by suxamethonium [24] (Table 6).

MAINTENANCE OF ANAESTHESIA

Anaesthesia is most commonly maintained with opioids and inhalational anaesthetics in a mixture of oxygen and air or oxygen and nitrous oxide. Due to its irritating effects on the airway, desflurane should be avoided in children with asthma [28].

Some surgical procedures require good muscle relaxation. The lungs are ventilated according to the principles of the lung protective strategy using positive end-expiratory pressure (PEEP). Low flow anaesthesia (LFA) techniques are

Table 6. Dosage of muscle relaxants in anaesthesia induction (intubation doses)

Drug	Dose (mg kg ⁻¹)	Onset of action (min)	Duration of action (min)
Vecuronium	0.1–0.15	2–3	20–40
Rocuronium	0.6–1.2	< 1–1,5	30–40
Atracurium	0.4–0.6	1,5	30–40
Cisatracurium	0.1–0.2	2	30–40
Mivacurium	0,15–0,25	2–2,5	10–30
Succinylcholine	1–2	0,5–1	3– 5

also acceptable, but not in children < 2 years of age or with body weight < 20 kg due to the risk of hypoxia [29, 30]. Alternatively, total intravenous anaesthesia (TIVA) can be performed, most commonly with propofol; however, the depth of anaesthesia should be monitored to avoid awareness during surgery. In children with hemodynamic instability, TIVA with ketamine can be used.

MONITORING

Monitoring during anaesthesia is enforced by the Ordinance of the Ministry of Health of 20 December, 2012 [1]. In cases of “non-cooperating” children, monitoring devices can be connected after the induction of anaesthesia.

INTRAOPERATIVE FLUID THERAPY

During anaesthesia, isotonic crystalloids are recommended, preferably balanced, without glucose or containing 1% of glucose. Hyponatraemic or hypotonic solutions (e.g. 5% glucose, solution 2:1, 1:1) are contraindicated due to the risk of acute hyponatraemia, leading to cerebral oedema.

WAKING UP FROM ANAESTHESIA

Waking up of a child, especially at the moment of extubation or LMA removal can be accompanied by adverse reactions, such as a laryngospasm. In such cases, a pre-established plan is needed; unless managed in a timely fashion, laryngospasm could cause hypoxia or even cardiac arrest. Extubation after complete waking up of a child is considered to be safer, but is more commonly accompanied by agitation. Extubation during sleep prevents excessive agitation after anaesthesia; however, this protocol is only recommended for experienced anaesthetists.

POSTOPERATIVE PAIN MANAGEMENT — GENERAL PRINCIPLES

The basic rule of postoperative pain management is multimodal analgesia, in which drugs with different modes of action are combined that can be adjusted to the pain intensity as well as the age and general health of a child

[31, 32]. Analgesics are administered at regular intervals (adjusted to the pharmacokinetic and pharmacodynamic characteristics of the drug in particular age groups) or via continuous infusions.

The prudent choice of the route of administration is mandatory — intramuscular administration in all children and rectal administration in oncology patients should be avoided (due to the risk of perirectal abscess).

Regular evaluation of pain management effectiveness is essential by using appropriate scales adjusted to the patient’s age.

POSTOPERATIVE PAIN MANAGEMENT IN CHILDREN ACCORDING TO THE EXTENT OF SURGICAL TRAUMA

Pharmacotherapy before surgery — pre-emptive analgesia:

1. Topical anaesthesia of skin (e. g. with an EMLA cream);
2. A loading dose of paracetamol or metamizole, given orally or intravenously.
3. After surgery — multimodal analgesia combining analgesics and regional anaesthesia techniques, depending on the following categories:
 - I. Surgical procedures associated with slight organ and tissue trauma – postoperative pain intensity < 4 points according to NRS or VAS:
 - 1. day — local analgesia — injections around the expected incision line with 1% lidocaine, 0.125–0.25% bupivacaine or 0.2% ropivacaine; paracetamol in combination with NSAIDs and/or metamizole orally or intravenously;
 - 2.–3. day – paracetamol or NSAID or metamizole orally.
 - II. Surgical procedures associated with moderate tissue trauma — postoperative pain intensity 4–6 points according to NRS or VAS.
 - 1. day — local analgesia — as in category I and peripheral blocks using ultrasound imaging;
 - 1. day — as in category I; additionally, low doses of opioids when requested – using nurse- controlled

Table 7. Scales for evaluation of pain intensity

Self-assessment scales	Scales based on behavior or behavior together with physiological parameters	
FACES Scale (Wong-Baker) 3.–18. years of age. Faces Pain Score Scale — Revised 4.–12. years of age. VAS (Visual Analogue Scale) and NRS (Numerical Rating Scale) ≥ 8 years of age. Pieces of Hurt Tool Scale 3.–8. years of age.	Children and adolescents without cognitive disorders Children and adolescents with cognitive disorders	FLACC (Face, Legs, Arms, Cry, and Consolability) Scale 1.–18. years of age PPPM (Parents Postoperative Pain Measure) scale NCCPC-PV (Non-Communicating Children's Pain Checklist-Postoperative Version) Scale 3.–18. years of age PPP (The Pediatric Pain Profile) Scale 1.–18. years of age. FLACC-Revised (Face, Legs, Arms, Cry, and Consolability) Scale 4.–18. years of age

Table 8. Non-opioid analgesics

Non-opioid analgesics	Body mass (kg)	Dose	Intervals between doses (hours)	Maximal daily dose	Remarks
Paracetamol	10–50	15 mg kg ⁻¹ <i>i.v., p.o.</i>	4–6	60 mg kg ⁻¹	Time of administration of maximal daily dose 48–72 hours.
	> 50	1.0 g <i>i.v., p.o.</i>	4–6	4.0 g	
Metamizole	10–50	10–15 mg kg ⁻¹ <i>i.v.</i> 5–20 mg kg ⁻¹ <i>p.o.</i>	6–8	60 mg kg ⁻¹	Registered > 15. years of age
	> 50	1.0 g <i>i.v., p.o.</i>	6–8	4.0–5.0 g	

Table 9. Non-steroidal antiinflammatory drugs (NSAIDs)

NSAID	Dose	Intervals between doses (hours)	Maximal daily dose	Remarks
Ibuprofen	5–10 mg kg ⁻¹ <i>p.o./p.r.</i>	6 — 8	30 mg kg ⁻¹	Registered > 3. months of age.
Ketoprofen	50–100 mg <i>i.v.</i> 1 mg kg ⁻¹	6 — 8 — 12	200 mg 4 mg kg ⁻¹	Registered > 15. years of age
Diclofenac	50–150 mg <i>p.o./p.r.</i> 1 mg kg ⁻¹ <i>p.r.</i>	8	150 mg 3 mg kg ⁻¹	Registered > 14. years of age
Nimesulid	100 mg <i>p.o.</i>	12	200 mg	Registered > 12. years of age

analgesia (NCA), or patient-controlled analgesia (PCA) with opioids when appropriate devices are available.

- 2.–3. day — as in category I.
- III. Surgical procedures associated with substantial tissue trauma — postoperative pain intensity > 7 points according to NRS or VAS.
 - 1. day — local analgesia — as in category I or regional analgesia, which is a continuation of operative anaesthesia — continuous epidural anaesthesia, spinal anaesthesia, paravertebral anaesthesia; blocks of peripheral nerves and plexuses with the use of ultrasound imaging;
 - 1. day — continuous intravenous opioid infusion — at a dose determined by titration only in ICU or PCA with opioids;

- 2.–3. day — modification of analgesic management of day 1 based on pain intensity evaluation [32–35].

EVALUATION AND MEASUREMENT OF PAIN INTENSITY IN CHILDREN

The majority of guidelines recommend using different scales for the evaluation of pain intensity that are appropriate for the age of child and the clinical situation. The most frequently used scales in children are based on self-assessment: Wong-Baker FACES scale, numerical rating scale (NRS), and visual analogue scale (VAS) or on child behaviour or behaviour together with physiological parameters, which are presented in Table 7.

Tables 8–11 present the dosage of drugs used for postoperative pain management [31–35].

Table 10. Opioids

Opioid	Administration route	Dose	Intervals between doses (hours)	Infusion	Remarks
Morphine	<i>i.v./s.c.</i>	0.05–0.2 mg kg ⁻¹	3–4	10–40 mcg kg ⁻¹ h ⁻¹	Patients monitoring mandatory
	<i>p.o.</i>	0.2–0.5 mg kg ⁻¹	4		
Fentanyl	<i>i.v.</i>	1–5 mcg kg ⁻¹		0.5–2.5 mcg kg ⁻¹ h ⁻¹	Only in intensive care units
Sufentanil	<i>i.v.</i>	0.05–0.5 mcg kg ⁻¹		0.05–1 mcg kg ⁻¹ h ⁻¹	Only in intensive care units
Tramadol	<i>i.v.</i>	1–2 mg kg ⁻¹	4–6	0.07–0.25 mg kg ⁻¹ h ⁻¹	Registered > 12. years of age
Oxycodone	<i>i.v./p.o.</i>	0.05–0.15 mg kg ⁻¹	3–4		Registered > 12. years of age
Nalbuphine	<i>i.v.</i>	0.1–0.2 mg kg ⁻¹	3–6	Bolus 0.2 mg kg ⁻¹ Infusion 0.1 mg kg ⁻¹ h ⁻¹	Registered > 18. months of age

Table 11. Patient's controlled analgesia

Drug	Initial dose	Infusion	Bolus	Maximal 4-hours dose	Time of pump blockade
Morphine	50–100 mcg kg ⁻¹	1–4 mcg kg ⁻¹ h ⁻¹	10–20 mcg kg ⁻¹	300 mcg kg ⁻¹	10–15 min
Fentanyl	0.5–1 mcg kg ⁻¹	0.5–1 mcg kg ⁻¹ h ⁻¹	0.5–1 mcg kg ⁻¹	4–8 mcg kg ⁻¹	5–10 min
Oxycodone	0.03 mcg kg ⁻¹		0.03 mcg kg ⁻¹		5–10 min
Nalbuphine	0.1–0.2 mg kg ⁻¹	0.02 mg kg ⁻¹ h ⁻¹	0.02 mg kg ⁻¹	0.4 mg kg ⁻¹ Maximal 2-hours dose	5 min

ACKNOWLEDGEMENTS

- The authors declare no financial disclosure.
- The authors declare no conflicts of interest.

Piśmiennictwo:

- Rozporządzenie Ministra Zdrowia z dnia 20 grudnia 2012 r. w sprawie standardów postępowania medycznego w dziedzinie anestezjologii i intensywnej terapii dla podmiotów wykonujących działalność leczniczą. Dz. U. 13.15, 2013.
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