

Cardiopulmonary resuscitation (pediatrics)

Cardiopulmonary resuscitation is a set of measures aimed at restoring basic vital functions - breathing, heart activity or both.

- **A = airway** → securing airway patency
- **B = breathing** → ensuring ventilation
- **C = circulation** → ensuring circulation
- **D = drugs** → pharmacotherapy and volume expansion

Indications for CPR

Indications for CPR are identical to symptoms of cardiopulmonary failure:

- **non-palpable pulse** and absence of heart sounds,
- **unmeasurable blood pressure, absence of QRS** complexes on ECG,
- **apnea** or **irregular/insufficient breathing with cyanosis**.

These symptoms are associated with varying degrees of impaired consciousness, convulsions, mydriasis, etc.

Child age distribution for CPR needs

- **Newly born** = newborn resuscitated in the delivery room;
- **newborn** = newborn outside the delivery room;
- **infants** = 28th day-1 year;
- **children** = 1-8 years;
- **adult** = children > 8 years old, i.e. for children over 8 years old, the same procedures and tools apply as for adults.

Pediatric first aid

In children, the vast majority is due to an obstruction of the airways, often due to banal causes such as a stuck tongue or regurgitation of stomach contents, i.e. causes that can be easily eliminated by lay first aid:

- **for children < 8 years, the "phone fast" rule applies** = start resuscitation and notify the emergency services as soon as possible, but in such a way that the flow of CPR is not disrupted (e.g. call only after the arrival of the 2nd rescuer);
- **for children > 8 years, the "phone first" rule applies** = first call the emergency services and then start CPR, except for drowning children and the situation when a single rescuer performs CPR.

State of consciousness

The rescuer must quickly **assess** the presence and extent of **injuries** and **determine** whether the child is **conscious**.

The level of consciousness is assessed by mechanical stimuli:

- **Shaking the child**
- **body patting**
- **loud questions to elicit a response**.

On the contrary, we must not move the child too much if there is a suspicion of a spinal injury - if there is any suspicion of a cervical spine injury, it must be completely immobilized and neck movements prevented; if it is necessary to move the child, the head and body must hold and move the child as a whole

If the child is **unconscious, without clear signs of trauma and spontaneous breathing, we ensure the patency of the airways** and if he has stable circulation (= well-palpable pulse, pink mucous membranes), we place him in a **stabilized position** and call the Emergency Medical Service. We check breathing and circulation at short and regular intervals.

Airway

the child is unconscious, the airway must be **secured immediately**. We usually do this by **tilting the head slightly** (watch out for inappropriate hyperextension) and **lifting the chin**.

⚠ If a neck injury is suspected, head tilt is not performed and the airway is secured by mandibular advancement while the C-spine is immobilized.

Tilting of the head and lifting of the mandible:

- place one hand on the child's forehead and gently tilt the head to a neutral position, the neck is in slight extension;
- place the fingers of the other hand under the bony part of the mandible on the chin and lift the jaw forward and up;
- at the same time we keep the mouth open by pressing the tip of the chin with the thumbs - we have to be careful not to close the mouth or compress the soft tissue under the mandible;
- if we see a foreign body or vomit, it is necessary to remove it.

Breathing

After securing the airway, we need to **asses if the child is breathing**

- we observe whether the chest or abdomen moves, whether exhalation is present;
- if there are breathing movements, but there are no signs of air flow, it is likely an airway obstruction → we need to re-check its patency, i.e. the position of the head and the advancement of the jaw and blindly remove the foreign material from the mouth with a semicircular movement of the index finger (we do not manipulate blindly in the hypopharynx);
- if the child is breathing spontaneously, **the airway must be kept open.**

Keep in a stabilized position:

- we move the head, arms and body at the same time;
- we turn the child on his right side and the leg that is not in contact with the mat, bend at the knee and move the knee forward for stabilization;
- if the child is not breathing spontaneously, we start artificial respiration while maintaining airways patency;
- if the patient is an infant, the **rescuer places his mouth** so that **it covers the mouth and nose of the child** and creates close contact;
- for older children, we breathe from mouth to mouth and at the same time close the child's nose with the thumb and forefinger of the hand that holds the head in position.

⚠ We take 2 slow breaths with a pause for inhalation. If the chest does not rise, ventilation is ineffective!

Circulation

Within 10 seconds, it is necessary to decide whether indirect cardiac massage in the form of chest compressions is indicated:

- by assessing signs of life - any movements, coughing or normal breathing (not gasping or irregular breathing);
- by checking the pulsation of the large arteries - the pulse is examined on the carotid artery (in older children), on the brachial artery on the inside of the arm (in infants) or on the femoral artery (in all children).

If the child does not show signs of life and does not have a clearly palpable pulse higher than 60/min., it is necessary to start chest compressions and combine them with artificial respiration (ERC Guidelines, 2010):

- **newborns after birth** - ratio of compressions to breaths 3:1 (approximately 30 breaths and 90 chest compressions per minute)^[1];
- **children** - ratio of compressions and breaths 15:2 (approximate rate of compressions: 100-120 per minute)^[2].

The patient must be placed **on a hard surface** and compressions are performed in the lower half of the **sternum**. We compress the **sternum to a depth of 1/3 of the anteroposterior diameter of the chest**.

⚠ **Beware of compression of the processus xiphoideus → there is a risk of trauma to the liver, stomach or spleen!**

⚠ **External heart compression must not be interrupted too often - only after the 10th appropriate compression of the sternum does blood flow to the brain, and frequent interruptions in compression of the sternum cause cerebral hypoperfusion.**

⚠ **During an effective compression, we feel pulsations, the color of the mucous membranes improves and mydriasis (symptom of CNS hypoxia) subsides.**^[3]

Techniques to ensure ventilation and perfusion

Oxygen

It is given in the highest possible concentration and should be given to all patients with signs of respiratory insufficiency or shock.

Oropharyngeal Airway

The oropharyngeal airway is a bent, flat tube anatomically shaped to **fit over the tongue** and bend into the pharynx. Its use is indicated **only in unconscious patients**, as it irritates coughing

Nasopharyngeal airway

The nasopharyngeal airway is a soft round rubber tube, partially bent **to fit the nostrils** and extend into the pharynx. A shortened endotracheal tube can also be used for this purpose. A conscious child usually tolerates it.

Bag and mask ventilation

They allow to ventilate and oxygenate the patient during spontaneous, assisted or controlled ventilation. The mask must be of suitable size to extend **from the bridge of the nose to the notch of the chin, covering the nose and mouth but leaving out the eyes**. The mask is held on the face with one hand, which at the same time keeps the head in the correct position, the other hand compresses the bag. In infants and toddlers, the chin is supported with the third or fourth finger, but pressure on the submental area must be avoided, as this can cause airway obstruction. In older children, we keep the mandible in the correct position with the third, fourth and fifth fingers and at the same time keep the head in a slight tilt. During ventilation, we can gently change the position of the head and neck to achieve optimal position and ventilation.

Endotracheal Intubation

Ventilation through an endotracheal tube is the **most effective and reliable** method of Artificial lung ventilation. **A number of drugs can also be administered endotracheally** as part of CPR.

Cricothyrotomy/Coniopuncture

Although rarely unavoidable, it may be indicated for airway security in children with complete upper airway obstruction caused by a foreign body, infection, or trauma.

Practical recommendations for life-threatening conditions

- **Determination of tracheal tube diameter:** $6 + \text{age (in years)} / 4$.
- **Determination of the child's weight in kg:** $8 + 2 \times \text{age (in years)}$.
- **Determination of normal SBP:** $70 + 2 \times \text{age (in years)}$.

Drugs

Intravenous access is a key factor in CPR. We try to secure the **largest and most accessible peripheral vein** that cannulation does not require interruption of CPR. If 3 attempts are not successful or > 90 seconds elapse, it is necessary to ensure the entry into the bloodstream alternatively → **in newborns** we prefer umbilical vein cannulation, in children < 6 years we prefer intraosseous entry, in children > 6 years then CVC insertion.

Medicines can also be administered endotracheally: adrenaline, lidocaine, isoprenaline, naloxone, with e.t. administration, drug doses are increased 10x and diluted to 1-2 ml.

Volume expansion

We usually administer a bolus of **20 ml/kg i.v. within 10-30 min** and repeat the dose as needed. Intravascular volume expansion is a key component of resuscitation. **We clearly prefer crystalloids**, of which 1/1 FR or 1/1 Ringer soll is best. After administration of 60 ml/kg and persistent hypotension, the etiological diagnosis of hypotension should be revised.

Adrenaline

Dosage:

- **amp., 1ml/1mg, concentration 1:1000;**
- **initial dose:** 0,1ml/kg i.v. or i.o. v concentration 1:10.000, when 0,1 mg = 1 ml;
- **endotracheal dose is** 0,1 ml/kg in concentration 1:1000, when 0,1 mg = 0,1 ml;
- all subsequent doses are 1ml/kg in concentration 1:10.000.

Adrenaline is **administered every 3-5 minutes** regularly until the end of CPR. It is an endogenous catecholamine with an alpha and beta effect, and in CPR its **alpha effect is decisive** → vasoconstriction everywhere except the coronary and cerebral vessels. Its inotropic effect is secondary in CPR → intracardiac administration of adrenaline is no longer justified.

Indication:

- cardiac arrest,
- symptomatic bradycardia not improving with ventilation and oxygenation,
- normovolemic hypotension,
- ventricular fibrillation before defibrillation.

Sodium Bicarbonate

- **1 mmol/kg i.v. slowly, better to infuse within 20-30 minutes**
- 4,2% → 1 ml=0,5 mmol
- 8,4% → 1 ml=1 mmol

Indication:

- proven severe acidosis with pH < 7.1;
- conditions where severe acidosis can be expected (e.g. cardiac arrest > 10-15 minutes);
- hyperkalemia;
- poisoning with tricyclic antidepressants;
- MAC at DPM.

⚠ It is always necessary to have secure ventilation so that the organism can get rid of excess CO₂.

⚠ Bicarbonate must not be mixed with adrenaline (→ inactivation) and must not be administered e.t.

The limited indications for bicarbonate are due to 2 pathophysiological mechanisms:

1. In children, the most common cause of circulatory arrest is ventilatory failure, and since bicarbonate works through the release and elimination of CO₂, its administration in children with hypoventilation is more than risky.
2. CO₂ quickly passes into cells → aggravation of intracellular acidosis; on the other hand, worse penetration of HCO₃ into cells causes extracellular alkalosis with a decrease in ionized calcium (→ decrease in contractility) and with a shift of the Hb dissociation curve to the left → impaired delivery of oxygen by tissues

Atropine

- we administer **0.02 mg/kg per dose, min. 0.1 mg and max. 0.5 mg for a dose in children and 1 mg in adolescents**
- the dose can be repeated every 5 minutes **up to a maximum total dose of 1 mg for children and 2 mg for adolescents**

Indications:

- treatment/prevention of vagally conditioned bradycardia,
- bradycardia in AV block.

⚠ The dose must be sufficient not to cause paradoxical bradycardia.

Naloxone

- we administer 0.01-0.03 mg/kg repeatedly i.v. or bolus 0.1 mg/kg (less than 2 mg for dose) → in this case intubate first and Artificial lung ventilation /ensure normocapnia

Indication:

- Opioid overdose.

Calcium

- we administer **10% CaCl₂ 0.2 ml/kg for a dose i.v. within 10-20 minutes**

Indication:

- hypocalcemia
- hypomagnesemia
- hyperkalemia
- intoxication with Ca channel blockers.

⚠ We must monitor the EKG during the application.

Glucose

- we administer **2-5 ml/kg 20% glc i.v.**

Indications:

- proven hypoglycemia,
- unclear disturbances of consciousness

⚠ We avoid "blind" administration of glucose, as hyperglycemia worsens the ischemic lesion of the CNS.

Adenosine

- we administer **0.1 mg/kg for a dose as quickly as possible followed by a bolus of FR**

Indication:

- paroxysmal supraventricular tachycardia.

⚠ We monitor the EKG during the application.

Amiodarone

- we administer **5 mg/kg i.v. within 30 minutes, can be repeated in 15-20 minutes**

Indication:

- ventricular fibrillation.

Note: As an alternative, 1% mesocaine/lidocaine 1 mg/kg i.v. can be administered. as a bolus followed by 20–60 µg/kg/min as a continuous infusion.

Rhythm disturbances from the point of view of CPR

After examining the central pulse, **we divide arrhythmias into:**

- tachyarrhythmias,
- bradyarrhythmia/asystole ,
- electromechanical dissociation according to the ECG curve

Tachyarrhythmia

Supraventricular tachycardia (SVT)

The treatment of choice is synchronized cardioversion, especially in conditions with cardiac decompensation. Synchronization of the delivery of the electric shock with the ECG is necessary to avoid the QRS complex and the possibility of inducing ventricular fibrillation. If there is no cardiac decompensation, we administer adenosine 0.1 mg

Ventricular tachycardia(VT)

VT without palpable pulses is treated as ventricular fibrillation. For palpable pulses with concomitant shock, cardioversion is the therapy of choice. Note: Lidocaine increases the threshold for ventricular fibrillation → if we have i.v. approach, we will administer lidocaine before cardioversion

Ventricular fibrillation (VF)

It is a rare dysrhythmia in children during circulatory arrest.

Etiology:

- Congenital developmental defects of the heart;
- ionic imbalance of potassium, calcium and magnesium;
- TCA or digitalis poisoning.

Oxygenation, ventilation and chest compressions should be provided. **The therapy of choice is defibrillation. Defibrillation is an unsynchronized electrical shock that depolarizes the myocardium and allows spontaneous, organized contraction to resume.** Defibrillation, unlike cardioversion, does not require the presence of QRS complexes. The starting dose is 2J.

Bradycardia /Asystole

Asystole is the most common ECG pattern in children with circulatory arrest, often preceded by bradycardia. During CPR, it is not important to accurately diagnose the type of rhythm, it is important to recognize that the rhythm is too slow for age. HR < 60/min in infants even with normal BP is associated with decreased systemic perfusion and should be treated. We administer 100% O₂, start chest compressions and add medication (adrenaline, atropine) as needed.

Note: Bradycardia is often caused by hypoxia during respiratory distress, therefore administration of 100% O₂ is a causal therapy.

Electric mechanical Dissociation (EMD = pulseless electrical activity = PEA)

It is 'the presence of electrical activity on the EKG, but with the absence of a pulse.

Links

External links

- ERC Guidelines 2010 (<https://cprguidelines.eu/2010/>)
- International Liaison Committee on Resuscitation (ILCOR) (<http://www.ilcor.org/en/about-ilcor/about-ilcor/>)
- Resuscitation Council (UK) – Newborn life support (<https://www.resus.org.uk/resuscitation-guidelines/>)

Reference

1. Resuscitation Council (UK). *Newborn Life Support : Resuscitation guidelines 2010* [online]. Resuscitation Council (UK), ©2010. [cit. 2013-03-12]. <<https://www.resus.org.uk/resuscitation-guidelines/>>.
2. <https://cprguidelines.eu/2010/>
3. HAVRÁNEK, Jiří: Kardiopulmonální resuscitace.

Source

- HAVRÁNEK, Jiří: *Kardiopulmonální resuscitace*.