CPR (Paediatrics)

Cardiopulmonary resuscitation (CPR) is **a set of measures that aim to restore basic vital functions** - breathing, heart function or both.

- **A = *airway*** → ensure airway patency
- **B = *breathing*** → providing artificial ventilation
- **C = *circulation*** → ensuring circulation
- **D = *drugs*** → pharmaceuticals and volume-expansion

Indications for CPR

The indications for CPR are identical to the 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.

Childhood Age Distribution for CPR Purposes

- **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, i.e. for children over 8 years the same procedures and equipment as for adults apply.

Pediatric First Aid

In children, the vast majority of cases are airway obstructions, often due to trivial causes such as a retracted tongue or regurgitation of gastric contents, i.e. causes that can be easily eliminated by lay first aid:

- **For children < 8 years, the "phone fast" rule applies** = start CPR and notify the rescue service as soon as possible, but in such a way that the CPR flow is not disturbed (e.g. call only after the arrival of the 2nd rescuer);
- **for children > 8 years, the "phone first" rule applies** = call the rescue service first and then start CPR, except for drowning children and situations where emergency CPR is performed by a single rescuer.

State of Consciousness

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

The level of consciousness is assessed by mechanical stimuli:

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

On the other hand, **the child must not be moved too much if there is any suspicion of spinal injury** - if there is any suspicion of 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 be held and the child moved as a unit.

If the child is **unconscious, without clear signs of trauma and breathing spontaneously, ensure airway patency** and if the circulation is stable (= palpable pulse, pink mucous membranes), place the child in **a recovery position and call the ambulance**. Check breathing and circulation at short and regular intervals.

Airway

If the child is unconscious, **the airway must be secured immediately**. This is usually done by a **slight tilt of the head** (watch out for inappropriate hyperextension) and **chin lift**. **If a neck injury is suspected, head tilt is not performed and the airway is secured by advancing the mandible while the C-spine is immobilized.**

Head tilt and mandibular elevation:

- Place one hand on the child's forehead and tilt the head gently to a neutral position, with the neck 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 keep the mouth open by squeezing the tip of the chin with the thumbs - care must be taken not to close the mouth or squeeze the soft tissue under the mandible;
- if we see a foreign body or vomit, it must be removed.

Breathing

Once the airway is clear, we need to see if the child is breathing:

- we observe whether the chest or abdomen moves, whether there is an exhalation;
- in case there are respiratory movements but no signs of airflow, it is **an obstruction of the airway** → recheck their patency, i.e. head position and jaw advancement, and blindly **remove foreign material from the mouth with a semicircular movement of the index finger** (do not manipulate blindly in hypopharynx);
- if the child is breathing spontaneously, **the airway should be kept clear**.

Placing in the recovery position:

- Movement of the head, arms and body is performed simultaneously;
- turn the child onto the right side and bend the leg not in contact with the mat at the knee and move the knee forward to stabilize;
- if the child is not breathing spontaneously, start artificial respiration while maintaining airway patency;
- if the casualty is **an infant, the rescuer positions his/her mouth so that it overlaps the mouth and nose** of the infant and makes close contact;
- for larger children, mouth-to-mouth breathing while closing the child's nose with the thumb and index finger of the hand holding the head in position.

Execute 2 slow breaths with a pause for a breath. If the chest does not rise, ventilation is ineffective!

Circulation

A decision must be made within 10 s 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 great arteries - the pulse is examined at the a. carotis (in older children), the a. brachialis on the inside of the arm (in infants) or the a. femoralis (in all children).

If the child shows no signs of life and has no clearly palpable pulse above 60/min, chest compressions should be initiated and combined with artificial respiration (ERC Guidelines, 2010):

- ***newborns after birth*** - a **3:1** ratio of compressions to breaths (approximately 30 breaths and 90 chest compressions per minute)[1];
- ***older children*** - a **15:2** ratio of compressions to breaths (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 → risk of trauma to the liver, stomach or spleen! External cardiac massage must not be interrupted too often - only at the 10th proper compression of the sternum does blood reach the brain, and frequent interruption of sternal compression causes cerebral hypoperfusion!

With effective massage, we palpate the pulsations, the color of the mucous membranes improves, and mydriasis (a symptom of CNS hypoxia) subsides[3]

Techniques to Ensure Ventilation and Perfusion

Oxygen

Administer at 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 shaped anatomically to be **placed over the tongue and bent into the pharynx**. Its use is only indicated in **unconscious patients** as it irritates coughing/vomiting and in patients where simple methods to open and maintain airway patency have failed.

Nasopharyngeal airway

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

Bag-Valve-Mask (BVM) Ventilation

These allow the patient to be ventilated and oxygenated during spontaneous, assisted or controlled ventilation. The mask must be appropriately sized to **extend from the root of the nose to the notch on the chin, covering the nose and mouth** but leaving out the eyes. The mask is held on the face with one hand, which simultaneously holds the head in the correct position, the other hand compressing the bag. In infants and toddlers, the chin is supported by the third or fourth finger, but pressure on the submental area must be avoided as this may cause airway obstruction.

In older children, we hold the mandible in the correct position with the third, fourth and fifth fingers while keeping the head in a slight tilt. During ventilation, we can gently vary the position of the head and neck to achieve optimal position and ventilation.

Endotracheal intubation

Ventilation via an endotracheal cannula is **the most effective and reliable method** of artificial ventilation. **A number of drugs** can also be administered endotracheally as part of CPR.

Cricothyrotomy/Coniopuncture

Although rarely necessary, it may be indicated to secure the airway 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 + age (in years) / 4.
- **Determination of the child's weight in kg**: 8 + 2 x age (in years).
- **Determination of normal sBP:** 70 + 2 x age (in years).

Drugs

Intravenous access is a key factor in CPR. We try to provide **the largest and most accessible peripheral vein**, in which cannulation does not require interruption of CPR. If 3 attempts are unsuccessful or > 90 seconds elapse, alternative access to the bloodstream should be provided → **in newborns** we prefer v.umbilicalis cannulation, **in children < 6 years** we prefer intraosseous access, **in children > 6 years** we prefer CVC insertion. Drugs can also be administered **endotracheally**: adrenaline, lidocaine, isoprenaline, naloxone, in e.t. administration the drug doses are increased 10 times and diluted 1-2ml 1/1 or 1/2 physiological solution.

Volumexpansion

We usually administer a bolus of **20 ml/kg i.v. over 10-30 min** and repeat the dose as needed. Intravascular volume expansion is a key component of resuscitation. We prefer **crystalloids**, of which then 1/1 physiological solution or 1/1 Ringer sol. is best. After administration of 60 ml/kg and persistent hypotension, the etiologic diagnosis of hypotension should be reviewed.

Adrenaline

Dosage:

- **Amp., 1ml/1mg, concentration 1:1000;**
- **Initial dose:** 0.1ml/kg i.v. or i.o. at a concentration of 1:10,000, where 0.1mg = 1ml;
- **endotracheal dose:** 0.1 ml/kg at a concentration of 1:1000, where 0.1 mg = 0.1 ml;
- all subsequent doses are 1 ml/kg at a concentration of 1:10,000.

Adrenaline is administered for 3-5 minutes periodically until CPR is completed. It is an endogenous catecholamine with both alpha and beta effects, and **during CPR its alpha effect is crucial → vasoconstriction** everywhere except the coronary and cerebral circulation. Its inotropic effect is secondary to CPR → intracardiac administration of adrenaline is no longer justified.

Indications:

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

Sodium bicarbonate

- **1 mmol/kg i.v. slowly, preferably into an infusion over 20-30 minutes**
- 4.2% → 1 ml=0,5 mmol
- 8.4% → 1 ml=1 mmol

Indications:

- Proven severe acidosis with pH < 7.1;
- conditions where severe acidosis can be assumed (e.g. cardiac arrest > 10-15 minutes);
- hyperkalemia;
- tricyclic antidepressant poisoning;
- metabolic acidosis in inherited metabolic disorders.

Ventilation should always be provided to allow the body to rid itself of excess CO_2!

Bicarbonate must not be mixed with adrenaline (→ inactivation) and must not be given e.t.!

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

1. In children, the most common cause of circulatory arrest is ventilatory failure, and because bicarbonate acts via CO_2 release and expulsion, its administration in children with hypoventilation is more than risky.
2. CO_2 rapidly passes into cells → worsening intracellular acidosis; conversely, poorer penetration of HCO_3 into cells causes extracellular alkalosis with a decrease in ionized calcium (→ decrease in contractility) and a leftward shift of the Hb dissociation curve → impaired oxygen delivery to tissues.

Atropine

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

Indications:

- Treatment/prevention of vagal bradycardia,
- bradycardia in AV block.

The dose must be sufficient not to cause paradoxical bradycardia!

Naloxone

- administer **0.01-0.03 mg/kg repeatedly i.v. or 0.1 mg/kg** (less than 2 mg for dose) in a burst → in this case intubate and perform mechanical ventilation/ensure normocapnia beforehand

Indications:

- Opioid poisoning

Calcium

- Administer **10% $CaCl_2$ 0.2 ml/kg per dose i.v. over 10–20 minutes**

Indications:

- hypocalcemia,
- hypomagnesemia,
- hyperkalemia,
- Ca channel blocker intoxication.

Monitor ECG during application!

Glucose

- Administer **2–5 ml/kg 20% glc i.v.**

Indications:

- proven hypoglycemia,
- unclear disturbances of consciousness.

Avoid administering glucose "blind" as hyperglycemia exacerbates ischemic CNS lesions!

Adenosine

- Administer **0.1 mg/kg per dose as rapidly as possible followed by a bolus of physiological solution**

Indications:

- Paroxysmal supraventricular tachycardia.

Monitor the ECG during application!

Amiodarone

- Administer **5 mg/kg i.v. over 30 minutes, repeat in 15-20 minutes**

Indications:

- Ventricular fibrillation.

Note: Alternatively, 1% mesocaine/lidocaine 1 mg/kg i.v. as a bolus followed by 20-60 µg/kg/min in a continuous infusion.

Rhythm Disorders from a CPR Perspective

After examination of the central pulse, **arrhythmias** are divided into:

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

Tachyarrhythmias

Supraventricular tachycardia (SVT)

The therapy of choice is **synchronized cardioversion**, especially in conditions with cardiac decompensation. Synchronization of the administration of the electrical discharge with the ECG is necessary to avoid QRS complex and the possibility of induction of ventricular fibrillation. If cardiac decompensation is not present, administer adenosine 0.1 mg/kg i.v. as a rapid bolus followed by a 5-10 ml bolus of physiological solution → if SVT is not interrupted, double the dose.

Ventricular tachycardia (VT)

VT without palpable pulses is treated as ventricular fibrillation. In palpable pulses with concomitant shock, cardioversion is the therapy of choice.

Note: Lidocaine raises the threshold for ventricular fibrillation → if we have i.v. access, administer lidocaine/mesocaine 1 mg/kg prior to cardioversion and start with a continuous infusion of 50 ug/kg/min, but do not delay cardioversion by waiting for lidocaine. More recently, amiodarone 5 mg/kg i.v. over 30 minutes is recommended as an alternative to electrical 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, digitalis poisoning.

Oxygenation, ventilation and chest compressions should be provided. **Defibrillation** is the therapy of choice. Defibrillation is an unsynchronized electrical discharge that depolarizes the myocardium and allows the resumption of spontaneous, organized contraction. Unlike cardioversion, defibrillation does not require the presence of QRS complexes. The initial dose is 2 J/kg, if VF continues, 4 J/kg must be administered, and all subsequent discharges are also already 4 J/kg, the time between discharges is short, used only to detect the type of rhythm. If after 3

discharges the VF continues, adrenaline and lidocaine/amiodarone are administered before further discharges and defibrillation follows again within 30-60 sec. This is done by placing one electrode in the tip area and the other under the right clavicle.

Bradyarrhythmia/Asystole

Asystole is the most common ECG picture in circulatory arrest in children and is **often preceded by bradycardia**. During CPR, **the exact type of rhythm is not important**; it is important to recognize that the rhythm is too slow for age. **A heart rate < 60/min in infants even at normal BP is associated with a decrease in systemic perfusion and should be treated.** Administer 100% O2, start chest compressions and add pharmaceuticals (epinephrine, atropine) as needed.

Note: Bradycardia is often induced by hypoxia in respiratory distress, so administration of 100% O2 is the causal therapy.

Pulseless Electrical Activity = PEA

This is the presence of electrical activity on the ECG but with absence of a pulse.

Literature

Related articles

- Cardiopulmonary Resuscitation of the Newborn
- Advanced Emergency CPR
- Emergency CPR Equipment
- Pharmacotherapy in Emergency CPR
- Electro-pulse Therapy in Emergency CPR
- Principles of Initiation and Termination of Emergency CPR
- Cardiopulmonary Resuscitation/HS (nurse)
  - Basic CPR/HS (nurse)
  - Advanced CPR/HS (nurse)

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/)

References

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.

Sources

- HAVRÁNEK, Jiří: *Kardiopulmonální resuscitace*.