

# Cardiopulmonary resuscitation of the newborn

**Cardiopulmonary resuscitation (CPR)** of a newborn in the delivery room must, from a physiological point of view, copy the changes associated with the transition to the extrauterine environment (above all, achieve optimal lung aeration and respect the remodeling of the fetal circulation). It is not only about survival, but also about the quality of the next life.

Currently, the recommendation of the European Resuscitation Council (ERC) from 2015, accepted by the Czech Resuscitation Council, based on the ILCOR Advisory Statement, applies.

Approximately 10% of newborns require some degree of assistance after birth to start breathing spontaneously. Less than 1% require extensive resuscitation. CPR in the delivery room is predictable in 70% of neonates; in 30% of newborns it is unpredictable.

**The most common causes of CPR after birth:** perinatal asphyxia, immaturity (<35 weeks of pregnancy), breech birth, maternal infection, multiple pregnancy,...

**According to international recommendations, CPR should not be started:** with a gestational age of up to 23 weeks, with a birth weight of up to 400 g, with significant chromosomal abnormalities (trisomy 13, etc.), with anencephaly - the recommendations of the country's council and the wishes of the parents must always be taken into account.<sup>[1]</sup>

Controlled hypothermia is recommended for neonates  $\geq 36$  gt with moderate and severe hypoxic-ischemic encephalopathy.<sup>[2]</sup> Delayed cord clamping by 1 minute is recommended for full-term and premature newborns.

**The limits of metal viability** (ability to survive outside the womb) depends not only on the fetus itself, but also on the maturity of medicine, the economy, social and cultural factors and above all on the agreement of professional societies. In the Czech Republic, a weight of 500 g at the 24th week of pregnancy is considered the limit of viability, cases from the 22nd to 23rd week must be assessed individually, taking into account the wishes of the parents.

**The act on Health Services** (372/2011 Sb. §82) defines abortion as a fetus that, after being completely expelled or removed from the mother's body, does not show any of the signs of life and at the same time its birth weight is less than 500 g, and if it cannot be detected, if the pregnancy is shorter than 22 weeks. Decree 297/2012 Coll. mentions that a stillborn baby means a fetus born without signs of life, whose weight is 500 g or more, if the birth weight cannot be determined, born after the 22nd completed week of pregnancy, and if the length of the pregnancy cannot be determined, at least 25 cm long, and it from the top of the head to the toe.

## CPR Algorithm

3 questions according to Neonatal Resuscitation Guidelines 2010 :

1. **Is the newborn due?**
2. **Is the muscle tone normal?**
3. **Is he breathing/crying?**

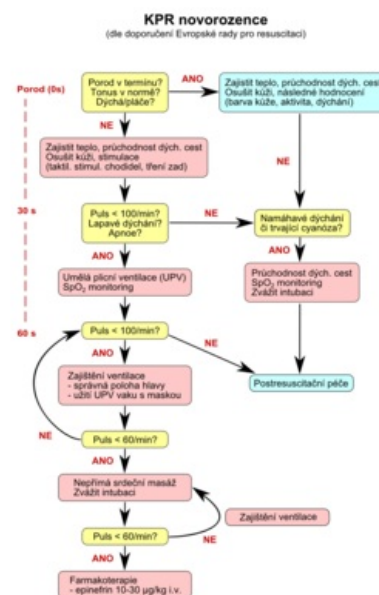
If the answer is **3x YES**, the newborn does not require resuscitation. It is necessary to ensure warmth (dry the newborn, place on the mother's chest - skin-to-skin, cover with a dry blanket), maintain the patency of the airways and continue to monitor the newborn (skin color, activity, breathing).

If **the answer is not 3x YES**, stabilization of the child must be started:

- ensure warmth (place on a heating bed, dry, place children born before the 32nd week of pregnancy in a plastic bag without drying),
- open the airways (suction only in indicated cases),
- dry skin,
- stimulate newborns (tactile stimulation of feet, back rub).
- **30 seconds after birth, heart and breathing actions are assessed** (breathing: apnea, gasping breathing, labored breathing or eupnea?; heart rate below or above 100/min.?).

**Artificial lung ventilation** (PPV, *positive pressure ventilation*) is started in case of bradycardia (AS < 100/min.), apnea or gasping breathing.

- In term newborns (gt  $\geq 37$ ), ventilation is started with air (21% O<sub>2</sub>) and the oxygen fraction is increased as



Algoritmus KPR novorozence po porodu (2010).

needed according to SpO<sub>2</sub>; PIP 30 cm H<sub>2</sub>O.

- In premature neonates (gt < 35), ventilation is started with 21–30% O<sub>2</sub> and PIP 20–25 and PEEP 5 cm H<sub>2</sub>O, inspiratory time 2–3 s.
- There is no clear recommendation for newborns with a gestational age of 32–37 weeks.

Heart rate, pulse oximetry (predictably, i.e. on the right upper limb), respiration are used to check the effectiveness of PPV. A rise in heart rate is the most sensitive indicator of effective PPV.

**If bradycardia < 100/min persists for the next 30 s**, the effectiveness of PPV should be checked (chest rise?). If bradycardia persists despite effective PPV, initiate indirect cardiac massage (NCM) and consider intubation. The ratio of NSM and PPV is 3:1. With two thumbs, the distal third of the sternum is compressed by one third of the anteroposterior width of the chest.

If bradycardia lasts < 60/min. despite properly performed PPV and NSM, consider pharmacotherapy.

- **Adrenaline** (1:1000; 1 mg/ml) 10–30 µg/kg iv (= 0.01–0.03 mg/kg iv), or 0.1–0.3 ml/kg in a 1:10,000 dilution (1 mg of adrenaline in 10 ml of physiological solution or 5% glucose).
- Bicarbonate 1–2 mmol/kg iv

The heart rate can be determined by gentle palpation of the attachment of the umbilical cord, but auscultation of heart sounds using a stethoscope is more reliable. During resuscitation, it is appropriate to monitor heart rate and saturation using pulse oximetry and ECG.<sup>[1]</sup>

## Pathophysiology

If the fetus in the womb is exposed to hypoxia, it attempts to breathe. If the lack of oxygen persists, the fetus loses consciousness and shortly thereafter the respiratory center stops stimulating the respiratory effort. A period of primary apnea occurs. Subsequently, the heart rate begins to decrease due to the transition of the myocardium to anaerobic metabolism. There is a centralization of blood circulation. As a result of anaerobic metabolism, lactate is released into the circulation. If the lack of oxygen continues, gasping appears (gasping with a frequency of approx. 12/min.), which is caused by primitive spinal centers. If the fetus is still in the womb, or if gasping fails to aerate the lungs sufficiently, gasping disappears and occurs secondary (terminal) apnea. Lactic acidosis worsens the activity of the heart and the child dies. For a full-term newborn, this entire process takes almost 20 minutes.

The newborn is able to maintain effective blood circulation during the phase of primary apnea, gasping, and shortly after the onset of secondary apnea. Therefore, in all asphyxiated newborns, it is crucial to ensure the inflation of the lungs and thus the oxygenation of the blood. By oxygenating the blood in the coronary arteries, the activity of the heart improves, the heart rate increases, the brain is oxygenated and the activity of the respiratory center is restored.

Rarely is cardiac activity affected to such an extent that mere inflation of the lungs is not sufficient and indirect cardiac massage must be initiated to distribute oxygenated blood. Adrenaline is rarely needed to restore circulation.<sup>[3]</sup>

## Cardiopulmonary resuscitation of the newborn (A-B-C-D)

náhled|Novorozenec po přerušení pupečníku.

### (A) Initial stabilization

#### Thermal management – prevention of heat loss

- placing under a heat source (i.e. on a heating bed), drying with a dry diaper and removing wet diapers;

#### Airway – relaxation of the airways

- position on the back with the head in a neutral position (neither in a bent nor in a forward bend), possibly slightly supporting the shoulders with a diaper (watch out for excessive tilting of the head);
- stimulation of breathing by rubbing the flats of the feet and the back;
- suction from the oropharynx and nose, or from the trachea, is indicated only in case of obvious obstruction of the airways or the need for artificial pulmonary ventilation (watch out for reflex weight-induced bradycardia during suction from the nasopharynx)<sup>[4][5]</sup>;
- meconium-clouded amniotic fluid is a risk factor for meconium aspiration syndrome (MAS) due to aspiration before birth, during labor or during resuscitation; studies have shown that suctioning from the oropharynx before delivery of arms, nor routine elective intubation and direct suctioning from the trachea, does not reduce the incidence or mortality of MAS.<sup>[6][7][8][9]</sup>

### (B) Ensuring breathing

#### Breathing – ensuring breathing

- Artificial pulmonary ventilation (PPV) is started when there is insufficient spontaneous breathing activity (apnea, gasping) or when the heart rate is < 100/min. persistent after airway clearance (ie, after initial stabilization);

- first **5 inflation breaths** (for full-term newborns, air inflation with a pressure of 30 mm H<sub>2</sub>O for 2–3 s.)<sup>[3]</sup> and then checking heart rate:
  - if the heart rate is over 100/min., but the child is not breathing - artificial lung ventilation with a frequency of 30-40/min.<sup>[3]</sup> up to 40-60/min <sup>[2]</sup>;
  - if the heart rate is below 100/min. - checking the position of the child, inspiratory pressures and chest movements, suctioning from the airways as needed; artificial pulmonary ventilation with a frequency of 30-40/min.; heart rate control;<sup>[3]</sup>
- indications for endotracheal intubation:
  - preventive aspiration of meconium-clouded amniotic fluid from the trachea in a newborn with reduced muscle tone and insufficient breathing
  - ineffective or prolonged mask ventilation
  - the need for indirect cardiac massage
  - special indication: congenital diaphragmatic hernia , extremely low birth weight , etc.
  - the timing of intubation also depends on the experience and skill of the resuscitators.<sup>[2]</sup>
- hypoxia and ischemia or, conversely, exposure to excessive oxygen concentrations during resuscitation exacerbate organ damage;<sup>[2]</sup>
- two meta-analyses of several randomized controlled trials compared initiation of resuscitation with air versus 100% oxygen and showed that initiation of resuscitation with air increased survival;<sup>[10][11]</sup>
- if an air-oxygen mixer is not available, it is recommended to start resuscitation with air and if bradycardia (< 60/min.) persists after 90 seconds of resuscitation, increase the oxygen concentration to 100% until the heart rate normalizes;<sup>[2]</sup>
- studies have shown that clinical evaluation of newborn skin color after delivery is a very poor indicator of hemoglobin oxygen saturation, therefore pulse saturation monitoring is recommended in infants who require more than 5 inflation breaths, in infants with persistent cyanosis , and in infants receiving oxygen oximetry (preductally, i.e. on the right wrist or palm).<sup>[2]</sup>
- if the newborn breathes spontaneously but with great effort, it is advisable to administer CPAP/PEEP (*continuous positive airway pressure/positive end-expiratory pressure*)<sup>[2]</sup>

## (C) Ensuring blood circulation

### Circulation – ensuring blood circulation

- indirect heart massage is started if the heart rate is below 60/min. despite sufficiently secured breathing (visible passive movements of the chest during inflation);
  - grasping the chest with both hands (inserting the fingers under the back) and compressing the lower third of the sternum with both thumbs (under the imaginary junction of the nipples), fast and firm compression of the chest by approximately one third (in the anteroposterior dimension), taking care to allow sufficient time between compressions to fill the heart;
  - artificial pulmonary ventilation (PPV) and indirect cardiac massage (NSM) in a ratio of 1:3 (approximately 30 breaths and 90 chest compressions per minute);
  - control of chest movements with each inflation; monitoring hemoglobin oxygen saturation and heart action using pulse oximetry ;
  - synchronized PPV and NSM is performed until the spontaneous heart rate reaches  $\geq 60$ /min.<sup>[3][2]</sup>

## (D) Pharmacotherapy

**Drugs – pharmacotherapy** – cannulation of the peripheral vein or vena umbilicalis and intravenous administration of drugs:

- adrenaline
  - 10–30 µg/kg i.v. (= 0,01–0,03 mg/kg i.v.)
  - i.e. 0.1–0.3 ml/kg in a 1:10,000 dilution (1 mg adrenaline in 10 ml physiological solution or 5% glucose)
  - indication: asystole or persistent bradycardia < 60/min. despite adequate ventilation with 100% oxygen (usually by endotracheal intubation) and indirect cardiac massage<sup>[2]</sup>
- volume expansion
  - 0.9% NaCl 10 ml/kg over 10–20 s
  - indication: hypovolemia (obvious bleeding, etc.)
- 4.2% sodium bicarbonate
  - 1–2 mmol bicarbonate per kg very slowly iv
  - administration of bicarbonate is controversial:
    - bicarbonate can cause extracellular alkalosis and shift the dissociation curve for Hb to the left, thus reducing oxygen scavenging from Hb
    - may induce hyperosmolality and hypernatremia => possibility of intracranial hemorrhage
    - after administration of bicarbonate, CO<sub>2</sub> is produced , which freely diffuses into the cells and paradoxically increases intracellular acidity
    - may inactivate concurrently administered catecholamines
  - bicarbonate can be administered during prolonged CPR and suspected or proven MAC, but always only with secured ventilation, routine use is not recommended; it must be remembered that the causal treatment of mixed acidosis during CPR is to restore circulation and ventilation<sup>[12]</sup>
- 10% glucose
  - 2,5 ml/kg i.v.

- indication: prevention and treatment of hypoglycemia as part of post-resuscitation care.<sup>[3]</sup>

## Notes on resuscitation according to NLS guidelines 2010/2015

For newborns who do not require resuscitation, delayed cord clamping is recommended at least one minute after birth or after the umbilical cord has been palpated.

Immature newborns born before the 32nd week of pregnancy should be placed immediately after birth without drying in a plastic film/bag and under a heat source to better maintain their body temperature. Wraps should remain throughout treatment/resuscitation until body temperature is checked on admission to the ward. The temperature in the delivery room should be at least 25°C.

Aspiration of meconium from the nose and mouth of an unborn newborn with the head on the perineum is not recommended.

If adrenaline is administered intravenously, 10–30 µg/kg is recommended. If administered intratracheally, it is likely that at least 50–100 µg/kg i.t. would be required to achieve a similar effect to 10 µg/kg iv

To verify the correct position of the endotracheal tube in newborns with spontaneous circulation, detection of exhaled carbon dioxide (capnography) is recommended.

If artificial lung ventilation with a mask is unsuccessful and the child cannot be intubated, it is possible to use a laryngeal mask in children with a birth weight of more than 2000 g and a gestational age of more than 34 weeks.

In a neonate born with asystole that persists for 10 minutes despite properly performed resuscitation, it is appropriate to consider termination of resuscitation. The cause of the asystole and the attitude of the parents should be taken into account when resuscitation is continued.<sup>[3]</sup>

## Links

- ws:Kardiopulmonální resuscitace novorozence

## Related Articles

- Advanced emergency resuscitation
- Equipment for emergency resuscitation
- Emergency resuscitation in childhood
- Pharmacology in emergency resuscitation
- Electroimpulse therapy in emergency resuscitation
- Principles of initiation and termination of emergency resuscitation
- Postresuscitation care
- Cardiopulmonary resuscitation/SŠ (nurse)
  - Basic emergency resuscitation/SŠ (nurse)
  - Advanced emergency resuscitation/SŠ (nurse)

## External Links

- Template:Akutně
- ERC Guidelines 2015 (<https://cprguidelines.eu/>)
- International Liaison Committee on Resuscitation (ILCOR) (<http://www.ilcor.org/home/>)
- Circulation journal ([http://circ.ahajournals.org/content/132/16\\_suppl\\_1/S177/](http://circ.ahajournals.org/content/132/16_suppl_1/S177/))
- Resuscitation Council (UK) – Newborn life support (<https://www.resus.org.uk/resuscitation-guidelines/>)

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