PRINCIPLES OF PROVIDING EMERGENCY CARE IN RESPIRATORY FAILURE IN NEWBORNS

Learning guide for 5–6th year applicants of higher medical education majoring in Medicine of Level III–IV accreditation higher education institutions, interns, pediatricians, general practitioners-family doctors

МІНІСТЕРСТВО ОХОРОНИ ЗДОРОВ'Я УКРАЇНИ
Харківський національний медичний університет

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ПРИНЦИПИ НАДАННЯ НЕВІДКЛАДНОЇ ДОПОМОГИ ПРИ ДИХАЛЬНІЙ НЕДОСТАТНОСТІ У НОВОНАРОДЖЕНИХ

Методичні вказівки для здобувачів вищої освіти 5–6-х курсів вищих медичних закладів освіти III–IV рівні акредитації за спеціальністю «Медицина», лікарів-інтернів, лікарів-педіатрів, лікарів загальної практики – сімейної медицини

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Принципи надання невідкладної допомоги при дихальній недостатності у новонароджених : метод. вказ. для здобувачів вищої освіти 5–6-х курсів вищих медичних закладів освіти III–IV рівні акредитації за спеціальністю «Медицина», лікарів-інтернів, лікарів-педіатрів, лікарів загальної практики – сімейної медицини / упоряд. М. О. Гончарь, Т. С. Маліч, А. Д. Бойченко, І. Ю. Кондратова. Харків : ХНМУ, 2025. 16 с.

Упорядники М. О. Гончарь
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Respiratory distress is a common and important clinical condition affecting newborns, especially premature infants, depending on their gestational age. RDS is the most common cause of respiratory distress in premature infants and is an acute lung disease caused by a deficiency of pulmonary surfactant and immaturity of the respiratory system. Clinical manifestations usually appear after birth or in the first hours of life, but not later than the first day of life.

According to statistics, respiratory distress syndrome affects about 80 % of newborns born at 28 weeks of gestation, this percentage increases to 90 % at 24 weeks of gestation. Approximately 50–60 % of these newborns require surfactant administration.

The latest recommendations for the resuscitation of newborns with respiratory failure suggest giving preference to non-invasive respiratory support in the treatment of all respiratory disorders in premature infants who breathe spontaneously.

An urgent task for pediatric neonatologists is the rational use of both non-invasive and invasive methods of treating lung diseases accompanied by respiratory failure. Respiratory therapy for a premature baby should be started from the first breath in the delivery room and continued throughout the entire stay in the neonatal intensive care unit.

The diagnosis of RDS in a premature infant is established on the basis of the following signs:

– development of clinical symptoms of respiratory distress (RD) in the first 6 hours of life;

– the need to prescribe supplemental oxygen to maintain the level of hemoglobin oxygen saturation (SpO_2) > 90 % or PaO_2 > 50 mm Hg (> 6.6 kPa);

– radiographic findings:

– diffuse reticular-granular pattern (stage 1);

– dilation of proximal bronchi against the background of reduced transparency of the lung fields (visible air contours of the bronchial tree “bronchogram” go beyond the shadow of the heart) (stages 2–3);

– unclear or absent margins of the heart (stages 3–4);

– decreased respiratory volume (stages 2–4);

– “white” lungs (stage 4).

During physical medical examination of a newborn, it is necessary to pay close attention to the presence of clinical signs of respiratory disorders, their severity (*Tables 1, 2, 3*) and assess their time course (tachypnea – respiratory rate > 60/min), dyspnea, groaning on exhalation, retraction of the pliable areas of the chest, “paradoxical” breathing, swelling of the wings of the nose, cyanosis of the skin and mucous membranes, the need to prescribe additional oxygen to maintain the level of hemoglobin oxygen saturation (SpO_2) > 90%).

Table 1

Assessment of respiratory disorders severity using Downes scoring (1970)

Signs	Score		
	0	1	2
RR/min	60	60–80	> 80 or apnea episodes
Central cyanosis	None	While breathing air	While breathing 40 % oxygen
Retractions	None	Insignificant	Moderate or significant
Groaning on exhalation	None	Determined during auscultation	Audible without auscultation
Auscultation* (during screaming)	Breathing is well audible	Breathing is weak	Breathing is barely audible
* - sound quality at the height of inspiration during auscultation along the mid-axillary line			

Table 2

Assessing the severity of respiratory disorders using Silverman-Anderson scoring (1956)

Signs	Score		
	0	1	2
Upper chest	Moves in sync with the abdomen	Lagging behind the abdomen movement or slight sinking	Sinks while the abdomen rises
Retractions of intercostal spaces	None	Barely noticeable retraction of the intercostal spaces during inspiration	Significant retraction of the intercostal spaces during inspiration
Xiphoid process retractions	None	Barely noticeable depression of the xiphoid process	Significant depression of the xiphoid process
Inflating the wings of the nose	None	Minimal	Significant
Groaning on exhalation	None	Audible during auscultation	Audible without auscultation

Table 3

Classification of respiratory distress severity (WHO, 2003)

Respiratory rate	Groaning on exhalation or retraction	Classificatoion
Over 90 per minute	Present	Severe
	Absent	Moderate
60–90 per minute	Present	
	Absent	Mild

1. Severe respiratory distress: total score ≥ 7 points using Downes or Silverman-Anderson scoring, or “severe” on the simplified WHO scale.

2. Moderate respiratory distress: total score 4–6 points using Downes or Silverman-Anderson scoring, or “moderate” on the simplified WHO scale.

3. Mild respiratory distress: total score 1–3 points using Downes or Silverman-Anderson scoring, or “mild” on the simplified WHO scale.

Treatment measures when providing medical care to premature infants with RDS include:

− non-invasive respiratory support,
− surfactant therapy,
− administration of supplemental oxygen after stabilization of the condition,
− mechanical ventilation,
− further monitoring of the condition and supportive measures,
− correction of arterial hypotension.

Non-invasive respiratory support of premature infants in the intensive care unit

Optimizing noninvasive respiratory support in premature infants reduces lung injury and improves neonatal outcomes.

Non-invasive methods of respiratory support in newborns are as follows:

1. A method that provides constant pressure in the airways throughout the respiratory cycle, such as CPAP (Constant Positive Airway Pressure) and high flow nasal cannula (HFNC) – NFNC oxygen therapy is a non-invasive respiratory support system that uses a mixture of air and O_2 delivered at a rate of more than 2 l/min (i.e., greater than the normal inspiratory flow of a newborn). In addition to delivering oxygen, HFNC treatment also provides increased pressure in the airways;

2. A method that provides variable airway pressure, such as bilevel positive airway pressure (BiPAP), nasal intermittent positive pressure ventilation (NIPPV), and nasal high-frequency oscillatory ventilation (NHFOV) – NIPPV helps the newborn breathe using the same principles as conventional mechanical ventilation (CMV): two levels of pressure keep the airway open (PIP – Peak Inspiratory Pressure i PEEP – Positive End Expiratory Pressure), and the inspiratory time and ventilation rate determine the frequency and duration of each phase. NIPPV provides the same benefits as CPAP. In addition, NIPPV maintains tidal ventilation and increases the pressure in the main airways, improving alveolar recruitment.

If the premature infant is breathing spontaneously, clamping of the umbilical cord should be delayed for at least 60 seconds after birth to facilitate placental transfusion.

It is important to provide adequate thermal protection:

– maintain the air temperature in the delivery room > 25 °C;

– place infants < 28 weeks gestation in plastic bags or wrap them in transparent film under a radiant heat source;

– put on a hat, use a heated table or thermal mattress;

– monitor body temperature and avoid hyperthermia (> 38 °C).

After birth, attach a pulse oximeter sensor to the right wrist (palm) of the premature infant and monitor the saturation level.

If spontaneous breathing is present, stabilize the infant with CPAP via a mask or nasal cannula with a pressure of at least 6 cm H_2O.

If spontaneous breathing persists or if bradycardia is present, carefully ventilate the lungs via a mask or nasal cannula with a peak inspiratory pressure (PIP) of 20–25 cm H_2O; after spontaneous breathing is restored, use CPAP.

During primary care for a premature infant, adjust the oxygen concentration (FiO_2) using a blender. In infants < 28 weeks of gestation, use an initial FiO_2 of 30 %, in infants 28–31 weeks of gestation, use 21–30 %, and in more mature infants, use 21 %. Increase or decrease the oxygen concentration in the oxygen-air mixture according to pulse oximetry data.

In neonates < 32 weeks gestation, aim to achieve $SpO_2 \geq 80$ % (and heart rate > 100/min) within 5 minutes.

A minority of premature infants may require tracheal intubation to stabilize the condition. Tracheal intubation should be performed only if the infant's condition has not improved after mechanical ventilation via mask or nasal cannula. Indications for mechanical ventilation and goals of prosthetic external respiration in premature infants (*Tables 4, 5*).

Table 4

Indications for intubation and mechanical ventilation in premature infants (presence of at least one of the following criteria)

Criteria	Description
Excessive work of respiratory muscles	Dyspnea on the Silverman scale > 6 points and/or severe tachypnea (> 100 breaths/min) despite optimized non-invasive respiratory support
Absent or inadequate respiratory effort	Apnea > events per hour or > 2 events per hour requiring mechanical ventilation by mask despite optimized non-invasive respiratory support and adequate caffeine therapy
Severe respiratory acidosis	Arterial/capillary blood: pH < 7.20 and pCO_2 > 60 mm Hg at 0–72 hours of life, pCO_2 > 65 mm Hg after 72 hours of life despite optimized non-invasive respiratory support

Criteria	Description
High oxygen demand	FiO_2 > 0.50 for ELGANs or FiO_2 > 0.60 for neonates between 28 and 32 weeks of gestation to maintain an adequate range of PaO_2 > 50–60 mmHg (6.7–8 kPa) and an adequate range of SpO_2 (90–95 %), despite optimized non-invasive respiratory support and surfactant treatment for RDS
Moderate or severe respiratory distress and contraindications for noninvasive ventilation	Intestinal perforation, intestinal obstruction, esophageal atresia, recent gastrointestinal surgery
Postoperative period	Recent abdominal incision Recent tracheostomy Residual anesthetic effects Need for muscle relaxants

pCO_2 – partial CO_2pressure; FiO_2 – fraction of inspired oxygen; ELGANs – extremely low gestational age newborns; paO_2 – arterial oxygen pressure; RDS – respiratory distress syndrome

Table 5

Objectives of mechanical ventilation in premature infants during intensive care unit stay

Value	Premature infants
pH (arterial blood)	7.25–7.35
PaO_2 (mmHg)	45–65
$PaCO_2$ (mmHg): Objective Survives 0–72 hours of life Survives > 72 hours of life	 45–55 < 60 < 65
SpO_2 (%)	90–95

PaO_2 – partial O_2 pressure; $PaCO_2$ – partial CO_2 pressure; SpO_2 – oxygen saturation

The main objectives of mechanical ventilation are to optimize gas exchange, minimize adverse effects (such as acute lung injury, ventilator-induced lung injury (VILI), air leak syndrome, airway damage, hemodynamic compromise, nosocomial infection, and brain injury), provide comfort by reducing asynchrony, work of breathing, and oxygen consumption, and early weaning from invasive support by attempting extubation as soon as possible.

During mechanical ventilation, arterial blood gas composition should be assessed and ventilation parameters adjusted (*Table 6*).

Table 6

Principles of mechanical ventilation parameters correction depending on the results of blood gas analysis

Partial oxygen pressure (PaO_2)	Partial carbon dioxide pressure ($PaCO_2$)	Required action
↓PaO_2	↑ $PaCO_2$	↑ Peak inspiratory pressure (PIP), which will increase mean airway pressure (MAP) In children who are breathing spontaneously, ventilation rates may ↑
↓PaO_2	N* $PaCO_2$	↑ MAP ↑ FiO_2 Do not change PIP (i.e. ↑ positive end-expiratory pressure (PEEP) and/or inspiratory duration (Ti))
↓ PaO_2	↓ $PaCO_2$	↑ FiO_2 ↑MAP (↑ PEEP and/or inspiratory duration Ti) Alternative diagnosis: persistent pulmonary hypertension, sepsis, shock
N PaO_2	↑ $PaCO_2$	↓ PEEP ↑ ventilation rate Do not change MAP
N PaO_2	↓ $PaCO_2$	↓ ventilation rate Use previous MAP
↑ PaO_2	↑ $PaCO_2$	Exclude mechanical causes of endotracheal tube obstruction ↓ PEEP ↓ Ti ↓ FiO_2 ↑ ventilation rate
↑ PaO_2	N $PaCO_2$ *	↓ MAP ↓ FiO_2
↑ PaO_2	↓ $PaCO_2$	↓ PIP ↓ ventilation rate ↓ FiO_2
N PaO_2	N $PaCO_2$	Do not change anything

Note. * - N – normal (acceptable) index value

Exogenous surfactant therapy in premature infants

Premature infants < 32 weeks of gestation who require tracheal intubation as part of stabilization should be given surfactant.

Surfactant is a naturally occurring surface-active lipoprotein-protein complex that reduces the surface tension of alveolar fluid, allowing the alveoli to remain open during expiration and significantly improving the ventilation-perfusion ratio. Surfactant improves mucociliary clearance, prevents pulmonary edema, improves pulmonary compliance, and helps protect the lungs from pathogens.

For these reasons, exogenous surfactant therapy is one of the most important treatments for premature infants.

There are three types of exogenous surfactants:

− Animal-derived surfactant;

− Synthetic surfactant without protein components;

− Synthetic surfactant with protein components.

For optimal treatment of RDS, poractant alfa is recommended to be used at an initial dose of 200 mg/kg, as this dose is more effective than 100 mg/kg of poractant alfa or beractant. Only poractant alfa is used at an initial dose of 200 mg/kg.

Newborns with RDS should be given surfactant for therapeutic purposes early in the disease. Surfactant administration is recommended for infants whose condition deteriorates despite CPAP with $FiO_2 > 0.30$ and a pressure of at least 6 cm H_2O. The first therapeutic dose of the drug should be administered as soon as possible (optimally within the first 2 hours of the child's life). It is not recommended to start surfactant treatment after 15 hours of the child's life.

Surfactant can be rapidly metabolized and functionally inactivated. It is believed that the ability to administer repeated or sequential doses of surfactant helps to overcome this inactivation.

The surfactant administration strategy for premature infants with RDS involves administering surfactant through a catheter inserted into the endotracheal tube (preferably a closed system).

In infants who are breathing on CPAP, less invasive surfactant administration (LISA) should be preferred. As an alternative, the INSURE (INtubate, SURfactant, Extubate) surfactant administration technique can be used in this situation. This is a modern strategy of intubation, surfactant administration, followed by immediate (within 1 hour) extubation and transition to nasal CPAP.

In the case of supplemental oxygen administration, the SpO_2 level of the premature infant should be maintained within 90–94 %. For this, the pulse oximeter alarm limits should be set at 89 % and 95 %, respectively.

After surfactant administration, hyperoxia (an increase in SpO_2 level above the specified limits) should be avoided by rapidly reducing FiO_2.

Practical recommendations and monitoring during mechanical ventilation in premature infants

After initiation of mechanical ventilation, the most comfortable ventilation mode and strategy should be selected based on the pathophysiology of the lung disease being treated.

During mechanical ventilation, all neonates should be under continuous cardiorespiratory monitoring, continuous pulse oximetry (SpO_2), and at least periodic monitoring of blood pressure and temperature.

Appropriate blood gas monitoring is recommended (a blood gas sample should be analyzed within 30–60 min of initiation of ventilation).

The need for radiological investigations (e.g., lung ultrasound, chest X-ray) should be assessed.

Persistent or progressive respiratory distress may require additional studies, such as:

− chest X-ray;

− complete blood count, serum C-reactive protein 6–12 hours after birth;

− blood glucose determination;

− determination of partial pressure of gases and acid-base balance of blood (arterial or arterialized capillary blood);

− bacteriological examination (culture) of blood before prescribing antibacterial drugs.

Weaning from mechanical ventilation and extubation of premature infants is a gradual process with simultaneous control of the patient's independent (spontaneous) breathing. During weaning from mechanical ventilation, it is advisable to maintain moderate hypercapnia (up to 55 mm Hg), provided that the blood pH is maintained above 7.22.

Caffeine citrate should be administered from the first hour of life to all infants with a birth weight of up to 1250 g who receive non-invasive respiratory support and have a high risk of subsequent use of mechanical ventilation.

The saturation dose of caffeine citrate is 20 mg/kg (intravenously or intravenously), the maintenance dose is 5–10 mg/kg (intravenously or intravenously).

Premature infants should be started on parenteral nutrition immediately after birth. Protein should be administered from the first day of life at a rate of 1.5–2.0 g/kg/day and rapidly increased to 2.5–3.5 g/kg/day. Fats should be administered from the first day of life, gradually increasing (if tolerated) the daily amount to 4.0 g/kg/day.

If the child's hemodynamics are stable, minimal enteral (trophic) feeding with breast milk or formula should be initiated from the first day of life.

Prescription of antibiotics

Children born before 37 weeks of gestation by spontaneous preterm labor and with persistent respiratory distress should be examined for sepsis. Antibiotics should be prescribed as a combination of semisynthetic aminopenicillin and aminoglycoside until the diagnosis of sepsis or pneumonia is excluded. Antibacterial therapy should be discontinued immediately after the diagnosis of sepsis or pneumonia has been ruled out.

It is not advisable to routinely prescribe antibiotics to newborns with a low probability of infection, in particular, those born by elective cesarean section.

Correction of arterial hypotension and ensuring adequate tissue perfusion

Signs of insufficient tissue perfusion are oliguria, acidosis, insufficient capillary filling - a symptom of a "white spot" for more than 3 seconds, etc., which requires correction with the therapeutic agents listed in *Table 7*.

Table 7

Therapeutic agents for the treatment of arterial hypotension in premature infants

Therapeutic agent	Dose	Comment
0.9% sodium chloride solution	10 ml/kg	Confirmed hypovolemia
Dopamine	2–10 mcg/kg/min	First-line drug
Dobutamine	2–20 mcg/kg/min	Myocardial dysfunction
Epinephrine	0.01–0.05 mcg/kg/min	Second-line drug
Hydrocortisone	1 mg/kg every 8 hours	Refractory hypotension, third-line drug

If the newborn has a hemodynamically significant patent ductus arteriosus, ibuprofen or paracetamol can be used.

The hemoglobin (Hb) concentration should be maintained within the following limits: the threshold value of Hb in the blood of newborns with severe lung disease is 120 g/L (hematocrit 36 %), 110 g/L (hematocrit 30 %) for oxygen-dependent infants, and 70 g/L (hematocrit 25%) for stable infants older than 2 weeks of age.

Thus, respiratory failure is one of the most critical clinical conditions affecting premature infants.

SELF-ASSESSMENT TEST

1. A premature baby born at 32 weeks of gestation develops respiratory disorders within an hour after birth, which are assessed on the Downes scale at 6 points. Auscultation over the lungs reveals weak breathing and scattered crepitating rales with RR – 66/min. A chest X-ray reveals decreased transparency of the lung tissue due to a diffuse reticular-granular pattern. Which of the following is a preliminary diagnosis?

A. Respiratory distress syndrome of the newborn.
B. Diaphragmatic hernia.
C. Tracheoesophageal fistula.
D. Edema-hemorrhagic syndrome.
E. Congenital pneumonia.

2. A newborn at 32 weeks of gestation develops respiratory distress within an hour of birth, assessed on the Downs scale as 6 points. Auscultation over the lungs reveals weak breathing and scattered crepitating rales with RR is 66/min. Chest radiography reveals decreased lung tissue transparency due to diffuse reticular-granular pattern. Which of the following is the most likely diagnosis?

A. Respiratory distress syndrome of the newborn.
B. Congenital pneumonia.
C. Diaphragmatic hernia.
D. Tracheoesophageal fistula.
E. Hemorrhagic edema syndrome.

3. 1.5 hours after birth at 32 weeks, the newborn has nasal flaring, grunting exhalation, tachypnea, and retraction of the intercostal spaces. No meconium contamination of the amniotic fluid is detected. The newborn's temperature is 37.4°, pulse is 180/min, respiratory rate is 80/min. The skin is cyanotic. Auscultation of the lungs reveals weakened breathing on both sides. PaO_2 is 32 mmHg, $PaCO_2$ is 48 mmHg. A chest X-ray shows a diffuse reticular-granular pattern, an air "bronchogram". Which of the following is the most likely diagnosis?

A. Respiratory distress syndrome.
B. Pulmonary hemorrhage.
C. Aspiration pneumonia.
D. Transient tachypnea of the newborn.
E. Idiopathic pulmonary fibrosis.

4. Which of the following is not typical of the clinical manifestations of pneumonia in premature infants?

A. Apneic episodes.
B. Respiratory failure with apneic episodes.
C. Feverю.
D. Persistence of fetal shunts.
E. Frothy oral discharge.

5. The characteristic radiographic picture for respiratory distress syndrome is:

A. Focal shadows in the lung fields.

B. Diffuse reticular-granular pattern.

C. Diffuse increase in lung transparency.

D. Intensification and deformation of the pulmonary pattern.

E. Expansion of the roots of the lungs.

6. The main causes of respiratory failure in newborns include all of the following except:

A. Respiratory distress syndrome.

B. Pneumonia.

C. Diaphragmatic hernia.

D. Clavicle fracture.

E. Meconium aspiration syndrome.

7. Factors that stimulate surfactant synthesis include all of the following except:

A. Glucocorticoids

B. Thyroid hormones.

C. Insulin.

D. Estrogens.

E. Adrenaline and noradrenaline.

8. In severe respiratory distress syndrome, the Downs score is:

A. 7–10 points.

B. 5–6 points.

C. 4–3 points.

D. 2–1 points.

E. 0–1 points.

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
A	*A*	*A*	*C*	*B*	*D*	*C*	*A*

CASE STUDIES

1. A newborn with gestational age 30 weeks, body weight 1210 g, height 36 cm, Apgar score 5-6 points 4 hours after birth develops clinical manifestations of respiratory distress syndrome (tachypnea, participation of accessory muscles in the act of breathing, nasal flaring). The condition is scored at 4 points with Silverman scale.

1. Establish a preliminary diagnosis.

2. What examinations are necessary to establish a final clinical diagnosis?

Answer:

1. Syndrome of respiratory disorders. Hyaline membrane disease.

2. Chest radigraphy, biochemical blood test (proteinogram, liver function tests, blood electrolytes, creatinine and urea, residual nitrogen, glucose, CRP), ECG, NSG, optic fundus assessment.

2. A full-term newborn, birth weight 3420 g, height – 52 cm, Apgar score 5–7 points during the first 6 hours of life develops convulsions along with clinical manifestations of respiratory distress syndrome and worsened condition.

1. What pathological condition should be excluded first?
2. With what diseases should a differential diagnosis be made?

Answer:

1. Exclude birth trauma of the CNS.
2. Respiratory distress syndrome, intracranial hemorrhage, phrenic nerve paresis, intrauterine pneumonia.

3. A newborn with body weight 1350 g born at a gestational age of 29 weeks, from the second pregnancy, which occurred against the background of exacerbation of chronic pyelonephritis with a rise in temperature to 38 °C at 21 weeks of pregnancy, cried immediately at birth, the cry is weak, the skin is cyanotic. After birth, the upper respiratory tract was rehabilitated, dried, oxygen was given in a free flow, RR is 70/min, HR is 138/min. 15 minute after birth central cyanosis persists during air breathing, there is groaning, moderate retraction of the intercostal spaces, weakened auscultatory breathing, RR 68/min persists, HR is 146/min.

1. Establish a preliminary diagnosis.
2. What are the criteria in favor of the diagnosis?

Answer:

1. Respiratory distress syndrome, stage 2 respiratory insufficiency.
2. Central cyanosis during air breathing, groaning, intercostal space retraction, weak breathing, tachypnea.

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Навчальне видання

ПРИНЦИПИ НАДАННЯ НЕВІДКЛАДНОЇ ДОПОМОГИ ПРИ ДИХАЛЬНІЙ НЕДОСТАТНОСТІ У НОВОНАРОДЖЕНИХ

Методичні вказівки
для здобувачів вищої освіти 5–6-х курсів
за спеціальностями «Медицина» та «Педіатрія»,
лікарів-інтернів, лікарів-педіатрів,
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