1. Introduction

Newborns who are in a serious condition, quite often get disorders of vital functions of the body, which are embedded in the concept of systemic inflammatory response syndrome. The universality of the development of a systemic inflammatory response with an uncontrolled cascade of cytokine-mediator reactions leads to the formation of multiorgan failure syndrome [1–3]. As assessment of the severity of organ disorders, dynamic monitoring of the patient’s condition and the need for correction of therapeutic measures in neonatal sepsis is one of the important tasks in predicting both the immediate and long-term consequences of the disease. The number of scales for assessing organ insufficiency proposed today for newborns [4–6] are based mainly on clinical and laboratory criteria of organ disorders. Assessment of respiratory dysfunction and hemostasis is based on information about the main aspects of oxygen metabolism in the body, i.e. the determination of oxygen status, namely, indicators that reflect the absorption of oxygen by the lungs, its transport by blood and return to tissues. One of the key tasks is to obtain a sample of whole arterial blood of infants, which requires systematic monitoring of the dynamics. However, the risk of complications in arterial blood collection in this category of patients exceeds the feasibility of its use [7–9]. A review of the literature [9, 10] confirms that capillary blood parameters can be used to assess the oxygen status of premature infants. The composition of capillary blood reflects not only the function of the lungs, but also associated with the processes of delivery and consumption of oxygen to tissues.

The study included premature infants with neonatal sepsis, as this category of infants mainly determines the rates of infant morbidity and mortality, despite the use of modern perinatal technologies in the field of care and treatment.

The aim of the research – analysis of oxygen status of patients with neonatal sepsis during monitoring of premature infants.

2. Materials and methods

Indicators of the oxygen status of capillary blood were assessed in 17 premature infants with neonatal sepsis who were treated at the Regional Perinatal Center in Khmelnytsky during 2017–2018. The study included mostly preterm infants, including those with extremely low birth weight, as this category of infants is a high-risk group for adverse disease and disability. The diagnosis of sepsis was established according to clinical and diagnostic signs and determination of the level of the marker of presepsin in the serum [12, 13].

All newborns were on long-term traditional artificial lung ventilation in A/C mode. The volume of exam-
The length of stay of patients in the hospital, bed – days

Gestation period, weeks

7 (6–7)

Birth weight, grams

Duration of nCPAP, days

Apgar score for 1 minute, point

26 (24–26)

Duration of ALV , days

1240 (800–1420)

Indicators (N=17)

Apgar score for 5 minutes, point

28 (28–32)

Duration of ALV , days

3

12

13 (76.47 %) of them were discharged home, 3 (17.64 %)

The study was conducted in accordance with the
provisions of the GCP (1996) and the Helsinki Declaration
on Biomedical Research, in which humans are the subject
of subsequent revisions of the Council of Europe Conven-
tion on Human Rights and Biomedicine (April 4, 1997) and the recommendations of the Bioethics Committee at
the Presidium of the Academy of Medical Sciences of
Ukraine (2002), as well as Orders of the Ministry of
Health of Ukraine No. 690 dated 23.09.2009, No. 944
dated 14.12.2009, No. 616 dated 03.08.2012. The work
was performed with a positive conclusion of the Com-
mission on Bioethics of Higher Education Institutions of
Ukraine “Bukovynian State Medical University” (min-
utes No. 2 dated 19.10.2017) and the local commission on
biomedical ethics at the Khmelnytsky Regional Perinatal
Center (minutes No. 5 dated 3.11.2017).

In particular, these ethical requirements out-
weighed the benefits over the risk of side effects, the
informed consent of the parents of the newborn, adherence
to the principles of confidentiality and respect for the
child who is incapable of self-defense, and other ethical
principles for the children studied.

A full range of clinical and laboratory studies, in-
dcluding determination of oxygen status of capillary blood.
The study included 8 (47.05 %) boys and 9 (52.94 %) girls.
13 (76.47 %) of them were discharged home, 3 (17.64 %)
were transferred to the department for premature new-
borns of the Municipal Enterprise “Khmelnytsky City
Children’s Hospital”, 1 (5.8 %) child died. Infants with
hemodynamically significant Botal duct and necrotizing
tenterocolitis who required surgical correction were ex-
cluded from the study. Table 1 shows the characteristics
of infants with sepsis.

Studies of acid-base status of blood and oxygen
status of capillary blood were performed on each child
daily on a MEDICA Easy Stat analyzer, USA.

Analysis of capillary blood oxygen status included
the following studies: pH, pO₂, pCO₂, HCO₃⁻ (capillary
blood bicarbonate concentration), BEcf (base surplus/defi-
ciency), BSCF (standard base surplus/deficiency), SBC
(stdandard bicarbonate), % SO₂ (the amount of oxygen satu-
rating at normal PₐO₂) of hemoglobin of capillary blood), O₂ct
(oxygen content in capillary blood), AdDO₂ (alveolar-capil-
ary oxygen gradient), RI (respiratory coefficient). The cal-
culations were performed automatically by the analyzer.

The studies were performed on the first day after
birth, on the third day in the intensive care unit, when the
newborns were mostly on oxygen donation, and on the
seventh day, which is associated with stabilization. When
calculating the respiratory index (RI) instead of the pa-
rameters of PaO₂, the level of pO₂ of capillary blood +20
mmHg was used [5]. Respiratory index was evaluated by the
ratio: RI=pO₂/FiO₂, where pO₂—partial pressure of
capillary blood oxygen +20 (mmHg); FiO₂—inspiratory
oxygen fraction (%). The degree of dysfunction of the
respiratory system was studied by mechanical ventilation
by inspiratory pressure (PIP) and FiO₂ in the inhaled
mixture, which was obtained by multiplying these indi-
cators (PIP*FiO2). This indicator allows us to simultan-
eously assess the degree of respiratory disorders and the
need for respiratory support in premature infants with
the impossibility of frequent invasive interventions. Cri-
teria for respiratory support were assessed individually
according to the clinical protocols “Initial, resuscitation
and resuscitation of newborns” protocol of the Ministry
of Health of Ukraine No. 225 from 28.03.2014 and Clini-
ical protocol “Assistance to newborns with respiratory
disorders” No. 484 from 21.08.2008.

The non-parametric method of statistical analysis
was used for statistical calculation: U Mann-Whitney test
and computer program of statistical analysis STATISTI-
CA 6. Descriptive statistics are presented in the form of
medians and percentiles.

5. Results

Homogeneity of the group by gestational age and
birth weight allowed to exclude the influence of these
indicators on the degree of maturity of the respiratory
and central nervous system, the formation of bronchopul-
monary dysplasia, duration of mechanical ventilation,
oxygen status of capillary blood.

The main characteristics of the oxygen status of cap-
illary blood and the calculated respiratory indices in prema-
ture infants with neonatal sepsis are given in Table 2.

Table 1

<table>
<thead>
<tr>
<th>No.</th>
<th>Indicators (N=17)</th>
<th>Me (25–75 %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Birth weight, grams</td>
<td>1240 (800–1420)</td>
</tr>
<tr>
<td>2</td>
<td>Mother’s age, years</td>
<td>26 (24–26)</td>
</tr>
<tr>
<td>3</td>
<td>Gestation period, weeks</td>
<td>28 (28–32)</td>
</tr>
<tr>
<td>4</td>
<td>Apgar score for 1 minute, point</td>
<td>4 (3–5)</td>
</tr>
<tr>
<td>5</td>
<td>Apgar score for 5 minutes, point</td>
<td>5 (4–6)</td>
</tr>
<tr>
<td>6</td>
<td>Duration of ALV, days</td>
<td>6 (3–7)</td>
</tr>
<tr>
<td>7</td>
<td>Duration of nCPAP, days</td>
<td>7 (6–7)</td>
</tr>
<tr>
<td>8</td>
<td>The length of stay of patients in the hospital, bed – days</td>
<td>45 (38–64)</td>
</tr>
</tbody>
</table>
6. Discussion

There were statistically significant changes in oxygen status depending on the day of life for pCO₂, HCO₃⁻, Bécf, SBC, O₂ct, AdDO₂, RI, PIP x FiO₂. Differences for indicators pH, pO₂, BEb, %SO₂, PI were not found.

Despite the constant pO₂ values during the three days of observation, the statistical difference in HCO₃⁻ on the one hand, may indicate a deterioration in the general condition of infants, which is associated with the manifestation and increase in clinical signs of generalized infectious-inflammatory process with a simultaneous increase in partially compensated metabolic acidosis [6, 7]. These indicators were also influenced by the fact that the oxygen status of capillary blood was determined in only 10 infants who needed an oxygen subsidy due to the severity of the condition.

Changes in BE values coincide with the data of Turkish scientists Arayici S., Şimşek G. K., Canpo-lat F. E., [7] and indicate that the BE value <−5 mmol/l indicates a deterioration in patients and may be the first diagnostic indicator of the implementation of the septic process.

It is known that the content of oxygen in capillary blood depends on two components: the amount of oxygen coming from the lungs and the rate of its utilization by tissues. The decrease in this indicator on the seventh day may be due to impaired tissue utilization, which coincides with the identified metabolic disorders. In most cases, in clinical practice, various disorders of oxygenation are manifested in the form of reduced transcutaneous oxygen saturation of hemoglobin and partial tension of blood oxygen [8, 9, 11]. Our results allow us to conclude that while the above indicators do not change significantly, the trouble can be detected with indicators such as AdDO₂, RI, which reflect the state of oxygenation with impaired ventilation-perfusion ratios, increased blood shunting and delivery processes and oxygen consumption at the tissue level. Similar results were also obtained by Perestoronina M. V., who was one of the few researchers to determine the oxygen status in premature infants [5]. The calculated indicator “PIP×FiO₂” was less sensitive to assess changes in the lungs and did not correspond to the clinical picture of the severity of the condition of patients with sepsis, in contrast to patients with respiratory pathology according to Petrenko Yu. V. and others [5, 10].

Study limitations. The studies were performed in a small group of patients.

Prospects for further research. To date, there are no clear data on the use and interpretation of the use of capillary blood for long-term monitoring of oxygen transport disorders in premature infants with neonatal sepsis. There are no clear data on the specificity and sensitivity of capillary blood oxygen gradients in patients with neonatal sepsis of varying severity and complications. The decision of these problems will allow to substantiate probability of use of indicators of capillary blood for an assessment of weight of disturbances of transport of oxygen at such patients, reduction of term of stay on fat ventilation, and decrease in lethality.

6. Conclusions

Capillary blood oxygen status indicators can be used as alternative indicators of the severity of the condition in monitoring the function of premature infants.

Increases in the indicators on the seventh day AdDO₂>70 mm Hg (p<0.05), RI>1 (p<0.05) indicate deterioration, even in the temporary absence of clinical signs in children with neonatal sepsis.

Data calculation of the indicator “PIP×FiO₂” is less sensitive to assess the severity of premature infants with neonatal sepsis.

Conflict of interest

The authors declare that they have no conflicts of interest.
References


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