Clinical science

RELATIONSHIP OF SERUM PROCALCITONIN LEVELS AND C-REACTIVE PROTEIN LEVELS IN NEWBORNS WITH SEPSIS IN DIFFERENT TYPES OF RESPIRATORY SUPPORT IN INTENSIVE CARE UNIT

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Abstract

Sepsis in newborns with RDS and asphyxia is essential; it is a life-threatening condition and still represents an important cause of mortality and morbidity. The aim of this study was to evaluate the predictive values of procalcitonin (PCT) as an early diagnostic and prognostic biochemical marker for sepsis in newborns with RDS and asphyxia. Material and methods: The study was designed as prospective and we examined 110 newborns with proven sepsis admitted in the Intensive Care Unit at the University Clinic of Pediatrics – Skopje in the period between December 2018 and January 2021. Procalcitonin levels were measured by using the immunnoassay system Vidas based on the ELFA principles. The newborns with proven sepsis were divided into two groups. The first group comprised 55 newborns with RDS and proven sepsis and the second group included 55 newborns with asphyxia and proven sepsis. The statistical analysis employed significantly different values of PCT in the analyzed time period in the first group of newborns with RDS and proven sepsis, p<0.001. The highest average values (40.37±53.79) were measured on admission with a high level of peak compared to the second group of newborns with asphyxia and proven sepsis. The statistical analysis confirmed significantly different values of PCT in the analyzed time period in the first group of newborns with RDS and proven sepsis. PCT is a promising sepsis marker in newborns with RDS, capable of complementing clinical signs and routine laboratory parameters suggestive of severe infection at the time of ICU admission.

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The author have declared no competing interests.

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ODNOSOT POMEŽU NIVOTO NA SERUMSKIJOT PROKALCITONIN I Č-REAKTIVNI PROTEIN KAJ NOVORODENČIJA ŠO SEPŠA PRI RAZLIČNI VIDOBI NA RESPIRATORNA PODDRŠKA VO EJNARCETATA ŽA INTENZIVNA NEGA I TERAPIJA

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ИЗВОД

Сепсисата кај новороденчии со респираторен дистрес синдром (РДС) и асфиксија е животозацваща состојба и го укажува на тешка инфекција за време на хоспитализацијата во ЕИНТ. Целта на оваа студија беше да се проценат предвидувачките вредности на прокалцитонинот (ПЦТ) како ран дијагностички и прогностички биохемиски маркер за сепса кај новороденчии со РДС и асфиксија. Студијата беше дизајнирана како проспективна и испитувме 110 новороденчии со докажана сепса, хоспитализирани во Единицата за интензивна нега и терапија (ЕИНТ), при Универзитетската клиника за детски болести - Скопје, во периодот од декември 2018 до јануари 2021 година. Нивото на прокалцитонин беше мерено со користење на имуноанализичкиот систем Видас базиран на ELFA методот. Новороденчите со докажана сепса беа поделени во две групи. Во првата група беа анализирани 55 новороденчии со РДС и докажана сепса, а во втората група 35 новороденчии со асфиксија и докажана сепса. Статистичката анализа потврди значително различни вредности на ПЦТ во анализираниот период во првата група новороденчии со РДС и докажана сепса, p<0.001. Највисоките просечни вредности (40.37±53.79) беа измерени за време на приемот со висок пик во споредба со втората група новороденчии со асфиксија и докажана сепса. Статистичката анализа потврди значително различни вредности на ПЦТ во анализираниот период во првата група новороденчии со РДС и докажана сепса, p<0.001. ПЦТ е ветувачки маркер за сепса кај новороденчии со РДС, како ран дијагностички и прогностички биохемиски маркер за сепса.
Introduction

Sepsis is a leading cause of mortality and morbidity in newborns. The incidence of sepsis is higher in newborns with respiratory distress syndrome (RDSy), asphyxia, in infants with low gestational week and low-birth weight. New advances in biochemical monitoring are important in assessing the risk of developing septic shock, severe sepsis, or sepsis. However, bacterial inflammation in the postnatal period is still a leading factor in morbidity and mortality.

Sepsis in newborns is present with features of clinical manifestations of infection and inflammation while severe sepsis in septic newborns is the development of hypoperfusion with multiple organic dysfunction. Multiorgan failure with hypoperfusion and persistent hypotension is found in septic shock. Sepsis is a common complication in newborns with RDS and asphyxia, because of intensive procedures during their therapy. Asphyxia is a disturbed change of respiratory gases in the placenta of the fetus during childbirth, or in the lungs of the newborn after childbirth that causes progressive hypoxia and hypercapnia. This can lead to systemic and neurological sequelae. Early consequences are observed in the first minutes of life due to the effects of hypoxia and acidemia on: the brain (primary apnea and difficulty in establishing the rhythm of breathing), heart (bradycardia), lungs (absence of vasodilation of the pulmonary arteries and retention of the fetal blood flow pattern), other organ systems that may be affected by asphyxia in the first hours and days - such as the kidneys and intestines. Late consequences of perinatal asphyxia in surviving infants may be: permanent brain damage - cerebral palsy, mental retardation, epilepsy, while other organ systems will not normally be permanently damaged.

RDSy is a disease of the hyaline membrane due to a lack of surfactant in the lungs of premature newborns. There are risk factors that lead to an increased incidence of RDSy such as male sex, white race, caesarean section, prematurity, multiple short pregnancies and preterm newborns from mothers with diabetes. Radiological studies show diffuse atelectasis which is described as ground-glass appearance with visible air bronchograms and low lung expansion. The therapy for RDSy and asphyxia consists of supportive measures and initial placement of the newborn on nasal CPAP with a PEEP of 3–8 cm H₂O. If respiratory failure persists, endotracheal intubation and mechanical ventilation are performed. Surfactant is administered in RDSy endotracheally within two hours of delivery. The aims of neonatal respiratory support is to create adequate gas exchange while minimizing the risk of lung injury. There are different forms of neonatal respiratory support: supplemental oxygen, continuous positive airway pressure (CPAP), noninvasive positive pressure ventilation (NIPPV) and mechanical ventilation (MV). In newborns who are unable to achieve oxygenation by any of these methods, techniques of high frequency oscillatory ventilation, extracorporeal membrane oxygenation, nitric oxide therapy or a combination are applied. Mechanical ventilation is one of the most common therapies in the neonatal intensive care unit and is associated with increased morbidity and mortality. The indications of mechanical ventilation in newborns are respiratory distress...
syndrome, asphyxia, meconium aspiration, congenital pneumonia, lung hemorrhage, septic shock. Bubble CPAP is a non-invasive ventilation strategy for newborns. This method reduces the complications of invasive ventilation\textsuperscript{16}. Also, any intensive respiratory support procedure performed in newborns has a higher risk of developing sepsis\textsuperscript{17}.

Biomarkers can play an important role in providing a timely diagnosis of sepsis and the decision for making the initial management. Rapid elevation in the concentration of procalcitonin (PCT) is a promising indicator of sepsis in newly admitted critically ill newborns capable of complementing clinical signs and routine laboratory parameters, hence, makes it an ideal biochemistry marker for bacterial infection\textsuperscript{18}.

Material and methods

The study was designed as prospective and we examined 110 newborns with proven sepsis admitted in the Intensive Care Unit at the University Clinic for Pediatrics – Skopje in the period between December 2018 and January 2021.

Early signs of sepsis diagnosis in newborns are frequently nonspecific and subtle and do not distinguish among organisms. Particularly common early signs include two or more of the following criteria: apnea, bradycardia, hypothermia, hyperthermia, vomiting, seizures, jaundice, especially occurring within the first 24 hours of life with a higher direct bilirubin concentration, diarrhea, abdominal distention. Diagnosis is confirmed by isolation of a pathogen in blood culture and level of PCT >0.5 ng/ml. The laboratory biomarkers were done in the Clinical Laboratory at the University Clinic for Pediatrics - Skopje. Firstly, samples for blood culture and PCT were taken on admission, and afterwards on 3-5 day and on 6-14 day. Procalcitonin was determined by immunoassay: patented ELFA (Enzyme-linked fluorescent assay) technology, automated Vidas Biomerieux immunoassay (ng/ml). CRP levels were determined by using the immunoturbidimetric method Architect c4000 Abbott(mg/L). Blood culture media were incubated at 37°C for 5 days in BactAlert 3D 360. Positive blood cultures were isolated with the new multiplex polymerase chain reaction-based rapid diagnostic test (BioFire FilmArray Blood Culture Identification).

Data were analyzed with the Statistical program 7.1 for Windows and SPSS Statistics 23.0, to compare the means of the variables, and one-way ANOVA test. For all analyses, p value < 0.05 was taken as statistically significant.

Results

In our study we examined 110 (M:F=68:42) newborns with proven sepsis admitted to the Intensive Care Unit (ICU) at the University Clinic for Pediatrics – Skopje in the period between December 2018 and January 2021.

The newborns with proven sepsis were divided into two groups. The first group comprised 55 newborns with RDS and proven sepsis and the second group included 55 newborns with asphyxia and proven sepsis. Table 1 shows the distribution of the first and second group depending on birth weight.
Table 1  Distribution of first and second group depending on birth weight

<table>
<thead>
<tr>
<th>Birth weight</th>
<th>Sepsis and RDS group</th>
<th>Sepsis and Asphyxia group</th>
<th>Tested difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1000 g</td>
<td>6 10.90%</td>
<td>5 9.10%</td>
<td>Fisher exact 12.996 df=16 p=0.642</td>
</tr>
<tr>
<td>1000-1500 g</td>
<td>9 16.40%</td>
<td>12 21.80%</td>
<td></td>
</tr>
<tr>
<td>1500-2500 g</td>
<td>11 20.00%</td>
<td>9 16.40%</td>
<td></td>
</tr>
<tr>
<td>2500-3500 g</td>
<td>24 43.60%</td>
<td>23 41.80%</td>
<td></td>
</tr>
<tr>
<td>&gt;3500 g</td>
<td>5 9.10%</td>
<td>6 10.90%</td>
<td></td>
</tr>
</tbody>
</table>

There was no statistically significant difference in the average birth weight between the two groups (p<0.01).

Table 2  Distribution of first and second group depending on gestational age

<table>
<thead>
<tr>
<th>Gestational age</th>
<th>First group</th>
<th>Second group</th>
<th>Tested difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;37 weeks</td>
<td>31 56.40%</td>
<td>30 54.50%</td>
<td>Chi-square : 1,304 df=1 p=0.254 ns</td>
</tr>
<tr>
<td>&gt;37 weeks</td>
<td>24 43.60%</td>
<td>25 45.50%</td>
<td></td>
</tr>
</tbody>
</table>

Table 3 shows the distribution of the first and second group depending on type of respiratory support. There was no statistically significant difference between invasive and non-invasive respiratory support in the two groups (p<0.01).

Table 3  Distribution of first and second group depending on types of respiratory support

<table>
<thead>
<tr>
<th>Types on respiratory support</th>
<th>First group</th>
<th>Second group</th>
<th>Tested difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>MV</td>
<td>26 45.60%</td>
<td>32 56.10%</td>
<td>Chi-square : 4.105 df=2 p=0.128 ns</td>
</tr>
<tr>
<td>B CPAP</td>
<td>17 29.80%</td>
<td>13 23.60%</td>
<td></td>
</tr>
<tr>
<td>OXYGEN MASK</td>
<td>14 24.60%</td>
<td>10 18.20%</td>
<td></td>
</tr>
</tbody>
</table>

The statistical analysis confirmed significantly different values of PCT in the analyzed time period in the first group of newborns with RDS and proven sepsis, p<0.001 (Table 4). The highest average values (40.37±53.79) were measured on admission with a high level of peak compared to the second group of newborns with asphyxia and proven sepsis. After the second measure-
ment on 3-5 days, the average values of PCT in the first group of newborns with RDS and proven sepsis slowly decreased (37.06±46.19) so that after the third measurement on day 6-14 in the first group of newborns with RDS and proven sepsis, they slowly began to normalize (9.78±15.58).

**Table 4** Distribution of average PCT value in newborns with RDS and proven sepsis over time

<table>
<thead>
<tr>
<th>Average PCT value</th>
<th>First group N=55</th>
<th>Second group N=55</th>
<th>Tested difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean*sd</td>
<td>Min-max</td>
<td>median</td>
</tr>
<tr>
<td>0-24 h</td>
<td>40.37*35.79</td>
<td>0.05-198.20</td>
<td>17.68</td>
</tr>
<tr>
<td>3-5 days</td>
<td>37.05*46.19</td>
<td>1.85-163.36</td>
<td>16.73</td>
</tr>
<tr>
<td>6-14 days</td>
<td>9.78*15.58</td>
<td>0.05-88.00</td>
<td>4.55</td>
</tr>
</tbody>
</table>

There was a statistically significant difference in the average PCT between the two groups over time (p<0.05).

The statistical analysis confirmed significantly different values of PCT in the analyzed time period in the first group of newborns with RDS and proven sepsis, p<0.001 (Table 5). At the first measurement, the average values of CRP in the first group of newborns with RDS and proven sepsis slowly increased (25.40±44.37). The highest average values in the first group of newborns with RDS and proven sepsis were measured (46.17±60.81) after the second measurement on day 3-5, with a high level of peak compared with the second group of newborns with asphyxia and proven sepsis. At the third measurement in the first group of newborns with positive blood culture on day 6-14, the average values of CRP slowly decreased (21.53±29.59).

**Table 4** Distribution of average PCT value in newborns with RDS and proven sepsis over time

<table>
<thead>
<tr>
<th>Average PCT value</th>
<th>First group N=55</th>
<th>Second group N=55</th>
<th>Tested difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean*sd</td>
<td>Min-max</td>
<td>median</td>
</tr>
<tr>
<td>0-24 h</td>
<td>12.81*35.59</td>
<td>0.00-180.00</td>
<td>1.5</td>
</tr>
<tr>
<td>3-5 days</td>
<td>28.94*46.85</td>
<td>0.20-212.00</td>
<td>11</td>
</tr>
<tr>
<td>6-14 days</td>
<td>17.37*33.34</td>
<td>0.20-160.00</td>
<td>5</td>
</tr>
</tbody>
</table>

There was a statistically significant difference in average PCT between the two groups over time (p<0.05). The statistical analysis confirmed significantly different values of PCT in the analyzed time period in the first group of newborns with RDS.
and proven sepsis with mechanical ventilation (MV) and bubble continuous positive airway pressure (BCPAP) compared to the second group of newborns with asphyxia and proven sepsis p<0.001.

The statistical analysis confirmed significantly different values of CRP in the analyzed time period in the second group of newborns with asphyxia and proven sepsis with MV and BCPAP, p<0.001, compared to the first group of newborns with RDS and proven sepsis.

**Discussion**

Sepsis is an important cause of mortality and morbidity in newborns. It is a systemic response to infection by microbial organisms and it is a life-threatening condition. For pediatricians the early identification of infections is a challenge. The etiology of sepsis in this situation is not always clear\(^{20,21}\). The highest incidence occurs among newborns with asphyxia, respiratory distress syndrome (RDSy), newborns with low gestational week and low birth weight. Sepsis in newborns with asphyxia and RDSy is essential life-threatening condition and still represents an important cause of mortality and morbidity\(^ {22,23} \). Sepsis is a common complication in newborns with RDS and asphyxia, because of the intensive procedures during their therapy. Also, asphyxia and RDSy are a common cause of hospitalization in the ICU. It is the leading cause of death in newborns\(^ {24,25} \). Newborns with asphyxia and RDSy have a higher risk of developing a septic condition with severe clinical presentation, longer duration of mechanical respiratory support, and worse outcome. Risk factors for sepsis in the postnatal period include: male gender, birth weight <1000 grams, hypogammaglobulinemia, central venous catheters, intravenous alimentation and prolonged duration of mechanical ventilation\(^ {26,27} \). Also, any intensive respiratory support procedure performed on newborns poses a higher risk of developing sepsis. Therefore, early recognition, early diagnosis and timely treatment to improve outcome are important issues in septic newborns with these two conditions. Early biomarkers to diagnose sepsis in ICU are widely used in clinical practice and they are useful in monitoring the infectious process, and can reduce the risk of death in newborns with asphyxia and RDSy. Ideal biomarkers for sepsis should have high sensitivity and specificity with early phase elevation, low cost and quick result\(^ {28,29} \). The diagnostic performance of PCT in numerous studies from the literature has suggested PCT to be a useful marker in the diagnosis of sepsis in newborns with RDSy\(^ {30} \).

In our study we examined PCT and CRP values in newborns with asphyxia and RDSy with proven sepsis. The statistical analysis confirmed significantly different values of PCT in the analyzed time period in the first group of newborns with RDS and proven sepsis, p<0.001. The highest average values (40.37±53.79) were measured on admission with a high level of peak compared to the second group of newborns with asphyxia and proven sepsis. The statistical analysis confirmed significantly different values of CRP in the analyzed time period in the first group of newborns with RDS and proven sepsis, p<0.001. At the first measurement, the average values of CRP in the first group of newborns with RDS and proven
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**Conclusion**

In critically ill newborns admitted to the ICU and who are on invasive respiratory support, rapid identification and treatment of the septic condition has a major impact on clinical course, management, and outcome. Our study found that PCT values in the analyzed period were higher in newborns with RDSy on invasive respiratory support, compared to newborns with asphyxia on respiratory support. CRP values in the analyzed period were higher in newborns with proven sepsis and asphyxia and those who were on invasive respiratory support, compared to newborns with proven sepsis and RDSy who were on respiratory support. PCT as an early predictive marker can be used in newborns with a clinical picture of sepsis and with RDSy who are on respiratory support. CRP measurement is of significant clinical significance in newborns with asphyxia and clinical picture of sepsis who are on respiratory support.

**References**


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