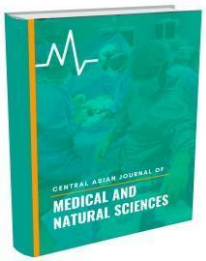

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Article

Early Prediction of Systemic Inflammatory Response Syndrome in Infants Using Procalcitonin and D-Dimer

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Abstract: Systemic Inflammatory Response Syndrome (SIRS) in infants is a life-threatening disease because of the immaturity of immune, cardiovascular and metabolic control systems during the first year of life. Systematic inflammatory response is especially difficult to detect at an early age, since the classical clinical manifestations, including fever, leukocytosis or hemodynamic instability, may be absent or poorly manifested in young children. Late diagnosis means that the patients have an increased risk of transition to serious complications, such as sepsis, dysfunction of multiple organs, and cardiovascular failure. The paper is devoted to the creation of a predictive model of the early diagnosis of SIRS in infants with the assistance of a complex of clinical risk factors and lab biomarkers. Emphasis is placed on the presence of inflammatory and coagulation markers like C-C-reactive protein, procalcitonin and D-dimer that indicate the severity of general inflammation and endothelial impairment. Perinatal history, maternal health, and neonatal analysis of the characteristics enable the identification of infants at risk of developing systemic inflammatory reactions. The suggested model of prognostics offers a sensible and objective instrument of risk stratification in infants with infectious diseases, especially pneumonia, at an early stage. Early identification of high-risk patients helps to start specialised therapeutic interventions promptly, such as close monitoring, antimicrobial treatment, and supportive care. The adoption of the mentioned predictive approach into clinical practice can help minimise infant mortality, avoid severe complications, and optimise the treatment approaches in paediatric intensive care units.

Keywords: Systemic Inflammatory Response Syndrome, Infants, Early Diagnosis, Predictive Markers, D-Dimer, Procalcitonin, C-Reactive Protein, Sepsis

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1. Introduction

SIRS is a complicated and even fatal syndrome, which is associated with a systemic inflammatory response of the body to infectious or non-infectious factors. SIRS in infants is a serious clinical issue as the immune defence mechanisms are not developed yet, physiological reserves are limited, and the dissemination of the localised infection to the systemic one occurs rapidly [1]. Even the presence of minor infectious processes in this age category can result in the excessive inflammatory cascade, which will further cause serious complications, including sepsis, heart dysfunction, and dysfunction of multiple organs.

SIRS has a challenging time being diagnosed in infants early due to the lack of manifestation or poor expression of classical clinical signs of inflammation. Fever can be lightweight or irregular, inflammatory responses of leukocytes can be anomalous, and the changes in the hemodynamics can occur quickly and without explicit symptoms [2]. This

means that systemic inflammation is often not recognised early enough, with the guidance of clinical observation and regular laboratory tests only. Such a delay has a massive morbidity and mortality burden, especially among young children, especially those who are at perinatal risk.

Over the last number of years, there has been a growing focus on the discovery of valid laboratory biomarkers that can be used to indicate an early systemic inflammatory response. Conventional indicators like C- C-reactive protein lack specificity and sensitivity in infants, and so, they often lead to a low level of diagnostic uncertainty and the inappropriate use of antibiotics [3]. Thus, new biomarkers such as procalcitonin and D-dimer are actively under investigation that can be used to predict the severity and progression of the disease. These markers are also elevated with both inflammatory intensity and endothelial dysfunction and coagulation disorders that are major factors in SIRS pathogenesis [4].

Mother and perinatal factors evaluation is another key factor in the determination of the risk of developing SIRS. Maternal anaemia, intra-uterine infections, preeclampsia, problematic birth, and asphyxia are the conditions that significantly predispose infants to systemic inflammatory reactions [5]. The systematic study of these risk areas, along with the specific laboratory examination, can possibly enable the identification of high-risk patients at an early stage.

Therefore, it is necessary to create predictive schemes that combine clinical and laboratory biomarkers to enhance the early diagnosis and therapeutic plans, and to minimise negative outcomes of SIRS in infants.

2. Methodology

This research was done as an observational clinical trial to determine predictive clinical and laboratory variables that lead to the occurrence of Systemic Inflammatory Response Syndrome in infants during the first year of life. The study design involved conducting the research in a tertiary paediatric care institution and involved infants who were admitted with acute lower respiratory tract infections during a specific period of time. The institutional review board approved the study, and the parents or legal guardians of all the participants gave their informed consent before they could be enrolled [6].

One hundred and ten infants, who ranged between 5 days and 12 months, were used in the research. The two groups of the study population were determined according to clinical and laboratory criteria. The primary sample was comprised of infants who had pneumonia complicated with systemic inflammatory syndrome, and the control sample included infants having pneumonia who did not fulfil the diagnostic criteria of SIRS. The exclusion criterion included congenital heart, hereditary metabolic, and primary immunodeficiency, as well as previous antibiotic treatment longer than 48 hours before admission, so as to limit confounding variables [7].

All participants were evaluated clinically comprehensively on admission. With respect to maternal and perinatal history, a detailed maternal and perinatal history was collected, which includes pregnancy complications, infectious diseases in pregnancy, anaemia, preeclampsia, mode of delivery, and the existence of birth asphyxia. Neonatal parameters, including gestational age, the weight at birth, and the anthropometric measurements at the time, were recorded. Body temperature, heart rate, respiratory rate, and oxygen saturation were the vital signs that were checked periodically throughout the hospitalisation [8].

The diagnosis of polygenic inflammatory response syndrome was made based on internationally recommended paediatric criteria, that is, at least two of the clinical manifestations are present, one of which is abnormal body temperature or changes in leukocyte count. The first 24 hours of admission involved laboratory investigations that

comprised complete blood count, C-reactive protein, procalcitonin and D-dimer. Samples of blood were taken under a sterile environment and analysed using automated immunoassay methods of analysis to provide accuracy and reliability [9].

An additional focus was put on the assessment of inflammatory and coagulation indicators as possible predictors of the severity of the disease. Higher levels of procalcitonin were considered as signs of the general inflammatory response of the body to bacteria, and higher rates of D-dimer levels were regarded as the result of the endothelial stimulation and coagulation disorders connected with the general inflammatory processes. These biomarkers were evaluated on the basis of their dynamic changes in terms of clinical progression and cardiovascular complication development.

Suitable software packages were used in the statistical analysis. The quantitative variables were indicated in terms of mean values with standard deviation, whereas the qualitative data were indicated in terms of percentages. Parametric and non-parametric tests were used in the comparative analysis of groups based on the distribution of data. A p-value lower than 0.05 was taken as statistically significant. Multivariate regression analysis was used to predict independent predictors that were related to the development of systemic inflammatory response syndrome in babies.

3. Results

Comparison of clinical and laboratory data showed that there were evident differences between infants who had Systemic Inflammatory Response Syndrome and those with pneumonia that was not systemic. The level of adverse maternal and perinatal factors, such as maternal anaemia, pregnancy-related infectious diseases, complicated labour, and birth asphyxia, was also found to be significantly higher in infants in the SIRS group. These factors were closely related to the earlier onset and more severe clinical expressions of the systemic inflammation, which means that they play an important role in the disease susceptibility and progression [10].

Anthropometric measurements showed that the current body weight of infants with SIRS was significantly lower than that of the comparison group, which either indicated a poor state of nutritional condition or it indicated a high metabolism rate in relation to systemic inflammation. Moreover, the cardiovascular complications, such as the presence of myocardial dysfunction and heart failure, were also more common in infants with SIRS, which points to the systemic nature of the inflammatory process [11].

The laboratory was used to demonstrate significant differences in inflammatory and coagulation factors between groups. Infants with SIRS had a high level of C-reactive protein, which is an indication of a robust inflammatory response. Nevertheless, procalcitonin was more diagnostic, and the high level of Insulin-like growth hormone was evident in the SIRS group, especially in children who eventually developed cardiovascular problems. This observation creates an argument in favour of procalcitonin as a precursor of severe systemic inflammation [12].

The levels of D-dimer were significantly high in the infants with SIRS compared to the pneumonia-only group and the reference value. High levels of D-dimer were linked with the severity of the disease and existed along with hemodynamic instability, which showed that the coagulation pathways and endothelial dysfunction were activated. Newborns having D-dimer levels above the set limits were predisposed to intensive attention and supportive care, which would prioritise their prognostic applicability [13].

The statistical analysis was able to establish that the combination of high levels of procalcitonin and D-dimer with an unfortunate perinatal history was an independent predictor of the development of SIRS. Multivariate regression modelling has revealed that the combination of the use of inflammatory and coagulation biomarkers was statistically significant in terms of predictive accuracy than that of a single parameter. The findings

indicate that combined clinical-laboratory assessment offers a more credible model of early warning of infants who are at risk.

All in all, the results justify the clinical role of a predictive method which includes perinatal risk factors and specific biomarkers in evaluating systemic inflammatory reaction in infants. The timely therapeutic intervention would be possible due to early identification of these signs, which would allow the severity of complications to decrease and lead to better clinical outcomes.

4. Discussion

The results of the current research prove that the Systemic Inflammatory Response Syndrome in newborn infants is a complex disorder where clinical history and laboratory factors were significant in the development of the disease. Infants with SIRS had a much greater load of perinatal hazardous elements, confirming the hypothesis that childhood susceptibility has a powerful effect on systemic reactions of inflammation. Mothers with anaemia, pregnancy-acquired infectious diseases, and birth asphyxia were observed more often in favour of affected babies, which indicates that prenatal and perinatal stress can affect immune regulation and condition newborns to excessive inflammation reactions [14].

The findings indicate that the use of only conventional clinical manifestations and regular laboratory tests in infancy does not add much diagnostic importance. As in past reports, classic symptoms, e.g. fever or leukocytosis, were not consistent, and this makes it difficult to identify systemic inflammation in children at this age. This highlights the essence of applying certain biomarkers in the routine evaluation to enhance diagnostic precision and prognostic analysis [15].

High procalcitonin levels in infants with SIRS favour the use of procalcitonin as a sensitive indicator of systemic bacterial inflammation. Procalcitonin has been demonstrated to be associated with the severity of infection and progression of the disease in paediatric study groups, which has proven to be more beneficial than C-reactive protein, especially in the initial phases of the systemic involvement. Equally, the greatly augmented levels of D-dimer in the main group indicate the action of coagulation pathways and endothelial dysfunction that are known constituents of the pathophysiology of systemic inflammation and sepsis. The inflammatory markers and coagulation markers seem to offer the severity of the disease than the individual parameters [16].

There exists clinical relevance between increased D-dimer levels and cardiovascular complications in this study. Microcirculatory disruptions and endothelial injury can be a contributory factor to myocardial dysfunction and hemodynamic instability among infants with severe inflammation. Early detection of these alterations enables the implementation of supportive care in time and more frequent surveillance in the intensive care unit [17, 18].

On the whole, the findings affirm that such a predictive model of clinical risk factors and specific laboratory markers is a useful method of early risk stratification among infants with infectious diseases. Such models can be implemented in clinical practice to decrease the duration of diagnostic wait time, maximise treatment choices, and eventually achieve better outcomes. More multicentric research with increased sample sizes is justified to confirm these findings and introduce more accurate predictive thresholds that can be applied on a routine basis in paediatrics.

5. Conclusion

Systemic Inflammatory Response Syndrome in infants is a severe clinical disease with a high risk of unstable progression and deadly complications. The findings of this research prove that the pathogenesis of systemic inflammation in the first year of life depends on the combination of negative factors in perinatal care and early laboratory

deviations. Poor maternal health status, problematic pregnancy and delivery, and birth asphyxia contribute greatly to the susceptibility of infants to excessive inflammatory reactions. The results prove that clinical signs are not the most effective in identifying SIRS early in infants because the classical manifestations can be quite nonspecific or inexpressive. Combining biomarkers in the lab, including procalcitonin, C-reactive protein, and D-dimer, gives a better and objective measurement of the systemic inflammation and severity of the disease. Specifically, high levels of procalcitonin and D-dimer were demonstrated as effective predictors of the development of the disease and cardiovascular complications. The suggested predictive strategy, which involves clinical risk assessment coupled with specific laboratory assessment, presents a convenient instrument for early risk stratification among infants with infectious diseases. The patients at risk can be identified early to enable the initiation of intensive monitoring and proper therapeutic interventions, which may decrease morbidity and mortality. This strategy can be introduced into the everyday practice of paediatricians to provide better clinical results and enhance the utilisation of health services. More extensive research should be conducted to confirm these results and establish more accurate prognostic thresholds to be used in a wide clinical setting.

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