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EVALUATION OF SERUM ELECTROLYTES AND LIVER ENZYMES ALTERATIONS IN HOSPITALIZED INFANTS WITH PNEUMONIA

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Abstract

Background: *Pneumonia is a significant contributor to morbidity and mortality among infants globally; it is increasingly gaining recognition as an inflammatory disease affecting multiple body systems. This study evaluated the electrolyte imbalances and alterations in liver enzyme profile among infants admitted with pneumonia and their association with disease severity, sex, and type of pneumonia.*

Methodology: *Hospital-based cross-sectional study was carried out on 363 babies diagnosed with pneumonia in the age group of 1 to 12 months. Data on demographics, clinical, and biochemical parameters was collected and analyzed. Blood levels of serum electrolytes such as sodium, potassium, and chloride as well as liver enzymes like ALT, AST, and ALP were measured. Independent sample t-test, one way analysis of variance (ANOVA), chi square, and Pearson correlation test were employed for statistical analysis.*

Results: *Findings from the data showed that electrolyte disorders were quite common, with hyponatremia (33.1%) and hyperchloremia (58.4%) being the most common electrolyte disorder. It was discovered that most of the subjects had normal values of their liver enzymes. However, a good percentage had elevated levels of ALT (26.7%), AST (16.3%), and ALP (20.9%). The ANOVA test indicated there were no significant differences in electrolyte levels based on the severity of the illness while liver enzymes significantly elevated with the degree of illness ($p<0.001$). From the chi-square test, a considerable relationship existed between the level of illness severity, electrolyte disorder, and liver enzymes disorder. No significant correlation was observed between biochemical findings and gender and pneumonia. The correlation study found significant positive correlations between sodium and chloride as well as ALT, AST, and ALP but not between electrolytes and liver tests.*

Conclusion: *In summary, abnormalities in liver enzymes and electrolyte are common among infants with pneumonia and have a very strong association with illness severity.*

INTRODUCTION

Overview of Pneumonia and Pathophysiology in Infants

Pneumonia is an acute infectious disease of the lower respiratory tract that causes inflammation of the lung parenchyma, particularly the alveoli, which can become clogged with fluid, pus, or inflammatory exudates, impairing gas exchange, resulting in a mismatch between ventilation and perfusion, and hypoxia. Babies' illnesses are

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typically more aggressive due to anatomical and functional immaturity of the respiratory system. Inflammatory exudates build in alveolar gaps, raising airway resistance and lowering oxygen diffusion capacity, causing clinical symptoms such tachypnea, nasal flaring, intercostal and subcostal retractions, grunting, and, in severe cases, cyanosis. [1]

Pneumonia causes the production of pro-inflammatory cytokines such interleukin-6, tumor necrosis factor-α, and C-reactive protein, resulting in both local lung damage and systemic illness. This elevated inflammatory response in newborns can swiftly progress to respiratory failure due to a lack of pulmonary reserve and compensatory mechanisms. Furthermore, pulmonary capillary leak and alveolar edema worsen hypoxemia and increase the risk of acute respiratory distress, particularly in severe or untreated instances. Recent study has shown that alveolar inflammation in infant pneumonia affects pulmonary surfactant production and function, leading in decreased lung compliance, alveolar instability, and atelectasis. The reason is that the production of surfactant is naturally low in infants, especially those born prematurely, hence making it difficult for pneumonia to affect the process of respiration in such a way that the ventilation becomes less efficient. [2]

Pneumonia is one of the most prevalent and life-threatening conditions that affect neonates all over the world and place a significant burden on neonatal healthcare facilities, especially in developing countries. Although there have been efforts aimed at increasing vaccinations and treatment of infections through the use of antibiotics, pneumonia continues to be a leading cause of preventable infant deaths. Studies show that neonates were more prone to severe pneumonia and complications. [3]

Infants are highly vulnerable because of an immature immune system both at the innate and adaptive level, constricted air passages, poor respiratory muscles, and low physiologic reserves that make them vulnerable to infections and cause rapid deterioration of their condition. Due to the inability of the lower respiratory system to clear out the infection from the body, the bacteria will be able to infect the entire lung parenchyma and lead to pneumonia, bacteremia, and inflammation of the whole body [4].

Transplacental antibody transfer is vital in protecting against infections in early infancy; however, poor maternal antibody transfer in infants born prematurely, together with malnutrition and deficiencies, plays an important role in making pneumonia more severe and potentially fatal. Overcrowded conditions, pollution of indoor air, poor practice of exclusive breast-feeding, and delayed access to health care facilities are some of the factors that make pneumonia prevalent among babies in developing countries. All of these characteristics highlight why pneumonia among infants is generally associated with systemic complications, including electrolyte disturbances, liver dysfunction, and mortality risks [5].

Etiology and Clinical Presentation of Pneumonia in Infants

Infant pneumonia may arise from different pathogenic microbes like bacteria, viruses, and even some less frequent forms of fungus. Molecular advances have made great contributions to the ability to diagnose these pathogens effectively, leading to the conclusion that viruses are the main pathogenic microbes leading to infant pneumonia, especially cases leading to hospitalization. The virus responsible for pneumonia in the majority of newborns is the respiratory syncytial virus (RSV). This virus is one of the common causes of lower respiratory infection during early life. The severity of this infection may be coupled with hypoxemia and prolonged hospitalization period. Other viruses, like rhinovirus, influenza virus, parainfluenza virus, and adenovirus, are common causes of respiratory infections that are either primary or contributing infections [6].

Even as there has been better understanding of viruses as causes of pneumonia in newborns, bacteria are still significant contributors to this condition, particularly in regions with low health care resources and unimmunized or under-immunized populations. In newborns, the most common bacteria responsible for causing pneumonia and pneumonia deaths is Streptococcus pneumoniae, followed by Haemophilus influenzae type b in countries that have poor immunization coverage. Bacterial pneumonia in newborns is accompanied by additional complications including bacteremia,

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pleural effusion, and systemic inflammation, contributing to the increased severity and death rate. The presence of dual infection, involving both virus and bacteria, has been on the rise, particularly in cases involving pneumonia, and is known to be associated with worse clinical signs compared to monoinfection. Dual infections may exacerbate inflammation, leading to extensive lung injury and increased likelihood of respiratory failure. The pathogenic agent behind pneumonia is influenced by geographic location, time of year, vaccination status, dietary status, and socioeconomic status. [7].

Clinical signs of pneumonia in babies may be characterized by the presence of both respiratory and general symptoms. Commonly observed symptoms include fever, cough, tachypnea, chest indrawing, nasal flaring, grunting, hypoxia, lethargy, irritability, and poor feeding. The tachypnea remains the most sensitive sign of the presence of pneumonia in infancy, whereas hypoxia is one of the key symptoms indicating the severity of the condition, which is associated with the higher risk of mortality in children suffering from pneumonia. Impairment of feeding and activities is crucial in small babies as they are likely to occur before the onset of respiratory symptoms. Recent clinical examination guidelines pay close attention to objective symptoms like oxygen saturation, respiratory rate, and feeding abilities that may help detect babies who are likely to suffer from severe illnesses and unfavorable outcomes. It is known that low oxygen saturation in infants on arrival is one of the strong predictors of extended hospital stay, admission into ICU, and death. Due to fast progression of illness and poor physiological reserves in newborns, any symptom may progress extremely quickly, which requires urgent admission to monitor the patient's state. Neonates with pneumonia while admitted in the hospital normally receive supportive measures such as oxygen administration, IV therapy, antibiotics, and monitoring to diagnose any problems as soon as possible. This increased need for admission is linked to the nature of the condition in neonates and the difficulty in managing the disease in the community setting. Knowledge of the cause of neonatal pneumonia is essential for proper diagnosis, management, and prevention of the condition. [8]

Global Burden and Public Health Impact of Infant Pneumonia

Pneumonia ranks as a primary source of illness, admissions, and mortality among neonates and young infants across the world, especially those younger than one year old. The vulnerability of these children together with an immature defense system makes them susceptible, hence making pneumonia the number one killer among these early childhood victims across the globe. Recent global statistics indicate that pneumonia accounts for 14-15% of child deaths within the under-five years bracket, with neonates constituting the largest proportion. In spite of a significant reduction in child mortality figures during recent times, the pace of decrease in deaths from pneumonia among neonates remains sluggish compared to other age groups. [9]

In addition to mortality, pneumonia is the main cause of pediatric hospital admissions globally, accounting for a significant portion of healthcare expenditure, longer hospital stays, and increased need for critical care services. According to hospital-based surveillance studies, children hospitalized with pneumonia typically develop severe illness that necessitates oxygen therapy, intravenous antibiotics, and constant biochemical and clinical monitoring, raising treatment costs and burdening already overcrowded healthcare systems. Infant pneumonia has an economic burden that extends beyond direct medical costs, including decreased caregiver productivity, long- term morbidity, and frequent healthcare visits, particularly in resource-constrained areas. [10]

Pneumonia has a disproportionately high burden in low- and middle-income nations, where delayed diagnosis, limited access to healthcare facilities, insufficient laboratory skills, and poor nutritional condition all contribute to negative sickness outcomes. In these conditions, a lack of quick diagnostic support and inadequate monitoring of biochemical markers frequently delay the discovery of disease severity and associated repercussions, resulting in higher death rates. Furthermore, insufficient vaccination coverage and limited access to advanced supportive care continue to hamper successful pneumonia therapy in infants. [11]

Recent epidemiological data suggest that South

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Asia and Sub-Saharan Africa account for more than half of all pneumonia-related deaths in children under the age of five, with newborns being the most vulnerable. South Asia, in particular, is responsible for a major amount of neonatal pneumonia mortality due to high population density, environmental pollution, malnutrition, and socioeconomic disparity. Pediatric pneumonia remains common in Pakistan, where pneumonia is still a major reason for hospital admissions and mortality among infants, stressing the necessity of local clinical and biochemical studies. [12]

From a public health point of view, infant pneumonia is not only about being an infectious disease burden but also acts as a marker for systemic deficiencies within a healthcare system, including maternal health, nutrition, vaccination programs, and disease diagnosis. The recurrent presence of pneumonia among infants demonstrates the significance of treatment programs that encompass preventive care, timely diagnosis, effective therapy, and systemic follow-up. Epidemiological and public health knowledge about newborns with pneumonia serves as a solid basis for understanding possible biochemical imbalances. [13]

Pneumonia as a Systemic Inflammatory Disease

While pneumonia is mostly considered as an infectious disease, it is gradually being understood as a systemic inflammation disease affecting multiple systems especially the neonatal patient population. During a lung infection, pro-inflammatory cytokines such as IL-6, TNF-α, and acute-phase proteins are generated and diffuse into other parts of the body. This results in marked endothelial activation with increased vascular permeability leading to capillary leakage and tissue edema. [14]

Due to their immature immune system and low physiologic reserves, newborns normally experience a more profound systemic inflammation process. Regardless of any lack of significant radiographic pulmonary involvement, chronic inflammation may cause poor oxygen cell utilization and worsen hypoxemia. Additionally, systemic endothelium failure will lead to poor organ perfusion and expose babies to risks of acute renal impairment, liver dysfunction, and circulatory disorders. All these physiological manifestations suggest the importance of viewing pneumonia in early childhood as a systemic disease rather than just a lung disease. [15]

Hypoxemia is a hallmark of moderate and severe neonatal pneumonia, and it is very relevant for its development process. The reduction of oxygen availability to tissue leads to anaerobic metabolism, metabolic acidosis, and cellular injury, which worsen inflammation processes. Additionally, dehydration due to inadequate nutrition, fever, and fluid losses is very frequent in hospitalized children, and it may lead to electrolyte disturbances and kidney dysfunction. In combination with sepsis, these factors greatly increase the risk of organ damage and mortality. [16]

The systemic inflammatory response to pneumonia in infants has a significant association with the seriousness of illness, prolonged duration of stay in hospitals, and requirement for critical care. Even before the deterioration of the patient, infants with severe pneumonia are expected to exhibit biochemical disturbances that include electrolyte disturbances and increased liver enzymes. These biochemical alterations may indicate early involvement of organs, which will be important markers for assessing the progress of the disease. Based on recent studies, it is important to conduct laboratory tests and biochemical monitoring of neonates at risk. Monitoring of inflammatory markers, electrolytes, renal function, and liver enzymes enables prompt therapeutic interventions and may prevent the progression to severe systemic illness. Recognizing pneumonia as a systemic inflammatory illness gives a compelling foundation for a thorough clinical and laboratory evaluation in newborns, laying the groundwork for examining biochemical abnormalities and their link to disease severity and prognosis. [17]

Pathophysiological Link Between Pneumonia, Electrolyte Imbalance, and Hepatic Dysfunction

Pneumonia in babies causes a complicated systemic inflammatory response that spreads beyond the respiratory system and profoundly impairs metabolic and biochemical equilibrium.

Frontier in Medical & Health Research

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Infection in the lungs stimulates immune cells in the alveoli, releasing pro- inflammatory cytokines such interleukin-6, interleukin-1β, and tumor necrosis factor- α. These mediators have systemic effects via influencing arterial permeability, endothelial function, and neurohormonal control, which contribute to electrolyte imbalance and hepatic dysfunction [18].

The inflammatory process leads to the deregulation of the secretion of antidiuretic hormone resulting in the pathogenesis of hyponatremia in newborns suffering from pneumonia. Increased levels of cytokines cause non-osmotically induced ADH secretion, leading to excess fluid retention and hyponatremia [19].

The role played by hypoxia in aggravating these complications is related to energy metabolism impairment at the cellular level and an increased contribution from anaerobic glycolysis, which might lead to metabolic acidosis and electrolyte imbalance. Liver damage can take place due to different mechanisms, such as hypoxia-induced cell damage, general inflammation, and oxidative stress. The limited amount of oxygen available to hepatocytes in cases of acute pneumonia leads to a dysfunction of mitochondria and liver cell membranes, causing the increase in the levels of transaminases in serum [19].

Importance of Electrolyte Homeostasis in Infants

The importance of electrolytes in physiology includes conducting impulses, muscle contractions, regulation of the heart rate, acid-base homeostasis, and cellular metabolism. However, the stability of electrolytes in the body is more difficult in newborns because of insufficient functioning of renal tubules, limited ability to change urine concentration, and relatively high total body water content compared to other individuals. Physiological characteristics of newborns make their bodies highly sensitive to fluid and electrolyte changes caused even by minor illnesses.

The baby kidney has a lower capability to store salt and eliminate excess free water, making it more vulnerable to hyponatremia and dehydration. Furthermore, increased insensible fluid losses through respiration and skin, particularly during fever and tachypnea, predispose newborns to electrolyte imbalance. As a result, even small physiological stresses like fever, decreased oral intake, vomiting, or increased respiratory effort can cause clinically significant electrolyte imbalances in this age group. Pneumonia causes electrolyte imbalance through a number of interconnected processes. Increased production of antidiuretic hormone (ADH) in response to pulmonary infection, hypoxemia, and stress causes water retention and dilutional hyponatremia, which are among the most common electrolyte abnormalities in pediatric pneumonia [23]. Metabolic stress and systemic inflammation may also affect salt and potassium processing at the renal level, while accompanying symptoms like vomiting and diarrhea increase electrolyte loss. [20]

Inappropriate fluid delivery, particularly the use of hypotonic intravenous fluids, has been recognized as a key cause to electrolyte imbalances in hospitalized babies with pneumonia. Recognizing this risk has resulted in updated pediatric recommendations advising isotonic maintenance fluids and frequent electrolyte monitoring in hospitalized children in order to limit the occurrence of hospital-acquired hyponatremia and associated problems. These guidelines are especially important for babies, who have a limited ability to correct for fluid and electrolyte imbalances.

Electrolyte imbalance in baby pneumonia has significant clinical consequences, since abnormalities such as hyponatremia and hypokalemia have been linked to increased illness severity, extended hospitalization, seizures, cardiac arrhythmias, and a greater mortality risk. Importantly, some investigations have shown that electrolyte problems can occur at admission or develop early in hospitalization, often before overt clinical worsening. It clearly shows the need for early and repeated electrolyte tests in infants suffering from pneumonia. Therefore, keeping electrolyte balance is one of the necessary components in the management of newborn pneumonia. Early detection and correction of electrolyte disturbances can assist not only physiological functions but also prevent possible complications. Knowing the consequences of electrolyte disturbance makes it clear that it is vital to examine electrolyte disorders in babies suffering from pneumonia

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and determine their relation to illness severity. [21]

Electrolyte Disturbances Associated with Pneumonia

Electrolyte disturbances are prevalent among infants admitted for pneumonia and represent one of the key indicators of the systemic nature of the disease. The electrolyte disorder that is most commonly observed in juvenile pneumonia is hyponatremia, which has also been linked with more severe disease manifestations and poor prognosis. Hyponatremia in neonatal pneumonia is usually accompanied with the syndrome of inappropriate antidiuretic hormone secretion (SIADH), which results in excessive water retention and a dilutional decline in blood sodium levels. [22]

Recent research indicates that inflammatory cytokines produced during lung infection, together with hypoxemia and pulmonary baroreceptor activation, play an important role in the dysregulation of antidiuretic hormone secretion during respiratory illnesses. Elevated levels of cytokines such as interleukin-6 cause non-osmotic ADH production, reducing the kidneys' capacity to eliminate free water. This process is aggravated in newborns by underdeveloped renal processing of water and salt, making them particularly susceptible to hyponatremia even with little fluid imbalance. Clinically, hyponatremia has been associated to longer hospital admissions, a larger need for oxygen therapy, seizures, and a higher death rate in severe pneumonia patients. Another significant electrolyte imbalance reported in newborns with pneumonia is hypokalemia. It can be caused by a variety of causes, including decreased oral intake owing to poor feeding, gastrointestinal losses from vomiting or diarrhea, and increased renal potassium excretion under metabolic stress. The use of β-agonist bronchodilator treatment in babies with respiratory distress enhances intracellular potassium shift, leading to hypokalemia. Low blood potassium levels can impair neuromuscular function, weaken respiratory muscles, and raise the likelihood of cardiac arrhythmias, aggravating the clinical course of pneumonia. [23]

Severe pneumonia may also be associated with metabolic acidosis and abnormal bicarbonate levels, indicating tissue hypoxia, anaerobic metabolism, and inadequate perfusion. Hypoxemia and sepsis reduce oxygen delivery to tissues, resulting in lactic acid accumulation and an acid-base imbalance. In the critically ill infant, electrolyte and acid base imbalance is an indication of the presence of a more serious disease, inflammation and probability of multiple organ dysfunction. Infants suffering from severe pneumonia, dehydration, and sepsis, in addition to being critical cases, tend to exhibit abnormal values when it comes to electrolytes and acid base status. More importantly, some studies indicate that these abnormalities can occur at admission or shortly after admission without any clinical signs yet. Therefore, one needs to emphasize the need for performing regular and serial electrolyte levels in infants having pneumonia in order to diagnose, correct and avoid fatal consequences. Knowledge about the variety of electrolyte imbalances associated with newborn pneumonia provides useful insight regarding the severity and systemic involvement. These imbalances are indicators both of underlying physio pathological process and important prognostic factors. Hence, the role of biochemical tests in the evaluation of neonatal pneumonia must be highlighted. [24]

Clinical Consequences of Electrolyte Imbalances

Anomalies in the levels of electrolytes among neonates may pose significant clinical implications, despite being slight, because of the immature state of brain, muscles, and heart functions that characterize them. Babies lack physiological capability to compensate for the sudden rise in electrolytes, which makes them prone to complications involving their neurological and cardiovascular system. Among the mentioned electrolyte abnormalities, hyponatremia is most often associated with unfavorable results for infants with pneumonia and has become recognized as the severity marker of the disease. Hyponatremia in infants suffering from pneumonia has also been associated with a number of neurological problems, including irritability, lethargy, seizures, and encephalopathy, particularly where rapid reductions occur in blood salt concentration. Where hyponatremia becomes

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severe and untreated, it can result in cerebral edema because of the osmotic fluid alterations, thereby increasing the intracranial pressure and causing consciousness alteration as well as need for prolonged mechanical ventilation. There have been numerous studies conducted on the connection between mortality rate and hyponatremia among infants hospitalized with pneumonia. Another important condition of electrolyte imbalance seen in relation to newborn pneumonia includes hypokalemia. This condition involves low blood potassium levels that can affect the ability of nerves and muscles to communicate. This can cause muscle weakness, inefficiency in respiratory muscles, as well as impairment of the cough reflex mechanism. Hypokalemia can also increase the probability of cardiac dysrhythmias by altering electrical potentials within the heart muscles. [25] Apart from certain electrolyte disorders, any electrolyte disorder among newborns suffering from pneumonia is associated with greater disease severity and increased healthcare utilization. It was demonstrated by recent cohort studies that infants who have pneumonia-related electrolyte disorders stay in the hospital longer, require admission to the intensive care unit more often, and have more complex respiratory therapy compared to their counterparts with a proper electrolyte profile. This implies that electrolyte disorders are more than simple lab abnormalities since they reflect certain systemic dysfunction and inflammatory burden in newborns. Moreover, electrolyte disorders may arise because of the severe pneumonia and result in further complications and deterioration of the clinical condition. Therefore, it is crucial to detect electrolyte disorders early enough and correct them for the adequate treatment of pneumonia. The use of routine biochemical testing is helpful in this regard and can significantly improve the treatment outcomes of patients with pneumonia. The knowledge about clinical consequences of electrolyte imbalance highlights the necessity of using laboratory tests for pneumonia treatment among newborns. [26]

Association of Biochemical Abnormalities with Disease Severity

Numerous studies demonstrate strong associations between biochemical derangements and the severity of pneumonia in neonates. Newborns diagnosed with severe pneumonia or respiratory failure showed substantially reduced blood salt concentrations and an increased frequency of SIADH compared to their counterparts with a mild form of disease. The development of hyponatremia is known as an independent factor predicting prolonged duration of hospital stay, necessity for intubation, and mortality in pediatric pneumonia. At the same time, elevated liver enzymes, particularly AST, indicate the presence of severe conditions in patients suffering from pneumonia due to their association with both disease severity and systemic impact. Elevated AST level denotes not only hepatic injury but muscle damage and tissue hypoxia as well, thus being an adequate marker of a serious condition. Electrolyte and liver enzyme derangements are frequently encountered among neonates admitted to critical care wards, which proves the importance of conducting routine biochemical analysis for such infants. These data prove the assumption that biochemical markers can be used as initial signs preceding the onset of clinical complications. [27]

Hepatic Involvement in Infant Pneumonia

The functions performed by the liver include, among others, glucose metabolism, protein metabolism, lipid metabolism, internal and external drug detoxification, regulation of immune responses, and synthesis of acute-phase proteins. The occurrence of liver disease during pneumonia may result from a variety of interrelated factors such as inflammation, hypoxia, sepsis, and the intake of hepatotoxic drugs while treating the disease. All these factors result in hepatocellular stress, which leads to either biochemical or physiological dysfunction without any liver disease being diagnosed. [28] Systemic hypoxemia caused by moderate to severe pneumonia impairs hepatic oxygen supply, compromising hepatocellular metabolism and mitochondrial activity. In extreme cases, this might develop to hypoxia hepatitis, which is characterized by a significant although typically temporary increase of liver enzymes, notably aminotransferases. Although hypoxic hepatitis is uncommon in pediatric populations, it has been reported in newborns

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with severe respiratory infections, shock, or sepsis, and it is linked to increased morbidity and death. Systemic inflammation also contributes significantly to hepatic involvement during pneumonia. Pro-inflammatory cytokines produced during infection can change hepatic blood flow, affect bile production, and decrease hepatocyte function. Because of underdeveloped hepatic enzyme systems and insufficient hepatic reserve, neonates are more vulnerable to subclinical liver impairment during acute illness. Additionally, sepsis-related endotoxemia can worsen hepatocellular damage and lead to cholestatic or mixed patterns of liver enzyme abnormalities. [29]

Drug-induced liver impairment is another major factor to hepatic involvement in newborn pneumonia. Some of the common drugs that cause hepatotoxicity include antibiotics, antipyretic, and anticonvulsants when administered under hypoxic and systemic inflammatory conditions. The metabolism of infants' enlarging livers is relatively low, resulting in their increased susceptibility to transitory liver enzyme elevations in hospitalized children. According to recent studies in pediatrics, it is evident that the hepatic complications associated with newborn pneumonia are subclinical, hence not observed clinically. Rather, they are diagnosed through biochemical investigations, particularly those that include elevated levels of alanine aminotransferase, aspartate aminotransferase, and alkaline phosphatase. Hepatocellular dysfunction indicated by biochemical alterations could reflect the early signs of hepatic involvement in infant pneumonia and may suggest more severe conditions, long-term hospital stay, and systemic effects. Therefore, systematic investigation of liver function in hospitalized patients suffering from pneumonia can help identify multiple organ system involvement, as well as early recognition of potential complications. The occurrence of hepatic involvement in newborn pneumonia illustrates the fact that pneumonia is indeed a systemic condition that needs a comprehensive biochemical evaluation [30].

Liver Enzyme Alterations and Mechanisms

Raised liver enzymes like ALT and AST levels have been found to be quite common among infants who are admitted in hospital for pneumonia and suggests involvement of the liver and overall disease. Various pathological conditions that cause this increased enzyme levels may include liver damage mediated through inflammation, oxidative stress, as well as the toxic effect of drugs used during therapy. The systemic production of pro-inflammatory factors during inflammation leads to hepatocellular injury, leading to impairment of mitochondrial functioning and loss of cellular integrity within hepatocytes. The oxidative stress in hypoxic and inflammatory systems further increases hepatocellular damage in cases of pneumonia among infants. Free radicals generated as a result of infection and hypoxia lead to damage of the cellular membrane and intracellular organelles with leakage of ALT and AST into blood serum. This technique illustrates how all three elements of this process - lung disease, systemic hypoxemia, and liver dysfunction - are connected in the case of pneumonia in children. New studies have shown that AST activity is a better indicator of the degree of systemic sickness in cases of pneumonia in infants compared to ALT activity. The reason for this is the presence of AST not only in the liver, but also in the heart, muscles, and kidneys. Therefore, the increase in AST levels means the presence of systemic tissue damage, the development of hypoxia, and the death of cells not only in the liver, but also in other parts of the body. At the same time, ALT is produced only by hepatocytes, and an increase in this enzyme activity shows only liver damage [31].

In addition to this, the contribution made by the induction of drug-hepatotoxicity can lead to increased enzymes especially in infants taking repeated and heavy dosages of antibiotics and antipyretics when admitted into the hospital. The reason being that infant liver enzymes are not yet developed to help detoxify the drugs leading to the possible occurrence of liver cell damage.

The importance of elevated levels of liver enzymes in pneumonia cases in neonates lies in the facts that their presence has been associated with an increased length of stay in hospital, increased complications and higher chances of going into the intensive care unit. Liver involvement is detected through biochemical monitoring and hence treatment can be directed towards the problem. It is therefore important to understand the dynamics of liver enzyme

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changes. [23,30]

Clinical Significance of Monitoring Liver Enzymes

Liver enzyme monitoring in babies suffering from pneumonia is vital for early detection of any possible involvement of the liver and to avoid complications that might arise due to the administration of treatment. Hepatic dysfunction in babies suffering from pneumonia is usually asymptomatic; hence, routine liver enzyme monitoring helps in early detection of any damage that might occur to the cells of the liver. [28]. Any alterations in the normal values of enzymes in the liver might require modification of antibiotics or dosing to prevent more damage to the liver, particularly in infants receiving prolonged or repetitive drug administration. Several commonly prescribed antibiotics and antipyretics undergo metabolism in the liver, and failure of liver to perform its functions efficiently will cause drug accumulation leading to toxic effects. In addition, underdeveloped liver enzyme system in babies requires close observation of liver enzyme behavior.

Based on recent pediatric research studies, liver enzyme elevation can serve as a sign of the seriousness of the condition and high inflammatory burden in patients with pneumonia. Higher levels of aminotransferases correlate with prolonged periods of hospitalization, a higher need for support and ICU admissions. It means that elevated liver enzymes do not only reflect the presence of problems with the liver, but also demonstrate the severity of the condition and injury to other organs. Serial monitoring of liver enzymes gives important data concerning the process and treatment response. An improvement in the state of liver enzymes implies the successful resolution of systemic inflammation and hypoxemia; in contrast, unchanged or worsening liver function is a predictor of further complications, including sepsis and drug-induced liver failure. Thus, regular assessment of liver enzyme changes in pneumonia allows for a more comprehensive approach to disease management, when pneumonia is considered as a multisystem disorder, not only a respiratory infection. Monitoring hepatic changes not only provides insights regarding proper management, but also contributes to the safety of a patient [32].

Evidence from Previous Studies and Regional Variations

There is a well-established high occurrence rate for electrolyte imbalance and abnormal liver enzyme levels among hospitalized cases of pneumonia patients aged below 5 years in previous literature; however, there has been significant variation within the prevalence rate, degree of abnormalities, and their impact on patient outcomes. The design of the research work, population of interest, dietary practices, pathogens involved, and quality of healthcare services provided account for differences in findings between various parts of the world. Recent multicentered research works have revealed that biochemistry alterations occur in higher numbers in susceptible cases such as malnutrition and viral pneumonia patients. Malnutrition impacts the body's immune system, reduces the capacity of organs to perform efficiently, and increases the chances of suffering from electrolyte imbalances and dysfunction of liver enzymes. Inflammation caused by viral pneumonia, mainly RSV infection, could lead to elevated occurrences of hyponatremia and high liver enzyme values [33].

The biochemical profile is also highly dependent on the healthcare setting and the severity of the disease. Babies who receive tertiary healthcare in hospitals or critical care units usually exhibit higher rates of electrolyte disturbances as well as abnormal liver enzymes compared to those receiving primary and secondary health care. Furthermore, variations in fluid management strategies, antibiotic usage, and laboratory monitoring protocols may have an impact on biochemical results across hospital settings. [30]

Regional and socioeconomic variables have a substantial impact on the biochemical symptoms of pneumonia in babies. High-income country studies frequently indicate quicker detection and milder biochemical abnormalities as a result of timely healthcare availability and consistent management techniques. In contrast, sparse data from low- and middle-income countries, notably South Asia, indicate a larger incidence of severe illness, delayed presentation, and a higher prevalence of biochemical abnormalities. Malnutrition, pollution of the environment, overcrowding, and poor access to diagnosis are factors that increase the severity of illness among these groups of people. In spite of the

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widespread prevalence of pneumonia among children in South Asia, there is no information from this region about any alterations in the levels of electrolytes and liver enzymes among babies. The absence of data specific to this area limits the application of findings from the rest of the world to the local medical practice. Knowledge of regional peculiarities of the biochemical markers is essential to develop effective ways of diagnosis, treatment, and monitoring [34].

Knowledge Gap and Justification for the Study

Electrolyte imbalance and liver function disturbances have been noted in children with pneumonia, but there are gaps in available literature because it includes subjects of diverse age groups. It has limited relevance as far as newborns are concerned. There is also an inadequate body of literature on South Asians suffering from such conditions. Electrolyte disturbances in combination with liver enzyme disturbances associated with pneumonia have received limited attention. In this regard, the importance of indigenous and infant-specific scientific information cannot be understated when developing biochemical standards and enhancing treatment possibilities.

Pneumonia Burden in Pakistan and Clinical Gaps

Although there is much activity in relation to children's health both nationally and internationally, pneumonia continues to be among the most prevalent illnesses and causes of death in infant populations of Pakistan. It contributes significantly to infant mortality because of poverty, malnutrition, overcrowding, indoor air pollution, and limited medical services. Children often visit healthcare centers too late, at times when complications occur; this results in poor medical outcomes. Studies conducted in the recent past using data collected from national health surveys and medical centers have shown that delay in visitation, poor referral services, and diagnostic ability are some of the problems that lead to poor medical outcomes of pneumonia in Pakistan. Lack of adequate funds, absence of laboratory equipment, and high number of patients often prevent hospitals, especially secondary level hospitals, from conducting routine laboratory tests such as assessment of serum electrolyte and liver function levels. Consequently, assessments are only carried out considering respiratory signs and symptoms. The exclusive attention paid to the respiratory system may result in underappreciating important metabolic alterations like disturbances in electrolyte balance and liver abnormalities, both of which may significantly affect the course of disease and the effectiveness of management. Hyponatremia, hypokalemia, and elevation of the enzyme levels in the liver may be overlooked, posing significant risks of seizure disorders, cardiovascular issues, lengthy stays in the hospital, and strong adverse reactions to medications. [35]

Furthermore, established techniques for biochemical monitoring in newborn pneumonia are not routinely adopted across Pakistan's healthcare facilities. Variability in clinical practice, along with a lack of locally generated data, inhibits physicians' capacity to identify high-risk patients and implement prompt remedial actions. As a result, systemic problems are frequently detected only after clinical deterioration, decreasing the efficacy of treatment interventions. These clinical gaps highlight the critical need for increased awareness, routine biochemical assessments, and context- specific research in Pakistan. Local data on electrolyte imbalances and liver enzyme abnormalities in babies with pneumonia are critical for informing evidence-based guidelines, optimizing patient therapy, and ultimately lowering pneumonia-related morbidity and death in this high-burden context [36].

Implications for Clinical Practice in Resource-Limited Settings

In resource-constrained healthcare settings, such as many parts of Pakistan, pneumonia therapy frequently prioritizes respiratory assistance, while systemic biochemical problems go unnoticed. The lack of sufficient lab equipment, late diagnosis, and high numbers of patients are among the factors causing variation in the use of biochemical diagnosis in hospitalized infants. On the other hand, electrolytes and liver enzymes are cost-effective diagnostic tools with important therapeutic value.

Identifying imbalances of electrolytes early ensures targeted hydration without

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complications such as fluid overload and worsening hyponatremia. Likewise, identification of liver involvement helps in making changes to antibiotics used to prevent their hepatotoxicity. Protocols for biochemical investigation can be very effective in reducing morbidity among infants suffering from pneumonia at secondary and tertiary levels of hospitals. Improving methods of laboratory investigations is compatible with the broader goal of public health to improve the survival rate among infants in LMIC countries.

Role of Routine Biochemical Monitoring

Biochemical surveillance is a necessary part of the medical management of children admitted to hospital with pneumonia as it gives objective data on the extent of illness, degree of hydration, metabolic stress, and multisystem involvement. Biochemical tests of electrolytes and liver enzymes allow clinicians to establish the presence of underlying conditions that are not evident clinically. The serum levels of sodium, potassium, chloride, and bicarbonate are important indicators of fluid and acid-base balance, as well as the physiological response to pneumonia and its complications. Electrolyte testing is especially helpful for the administration of IV fluid therapy to avoid potential complications. The presence of hyponatremia or hypokalemia enables clinicians to administer immediate treatment and thus reduce the likelihood of convulsions, cardiac rhythm disturbances, and neuromuscular problems. Likewise, low serum bicarbonate levels point to metabolic acidosis that may result from poor oxygenation, poor perfusion, or infections, and thus alerting clinicians to the possibility of rapid disease progression in infants. [22] Biological monitoring is essential in the management of patients hospitalized for pneumonia since it provides objective measures of the severity of illness, hydration status, biochemical reaction, and multiorgan system dysfunction. Monitoring of electrolytes and liver function tests allows physicians to identify the underlying medical conditions that do not present clinically. Sodium, potassium, chloride, and bicarbonate serum concentrations provide information regarding fluid and acid-base balance as well as the body's reaction to pneumonia and the resulting conditions. The testing of electrolytes is particularly useful for managing IV fluid therapy to prevent complications associated with such interventions. Hyponatremia and hypokalemia are used by physicians to treat the problem quickly to prevent seizures, cardiac rhythm issues, and neuromuscular complications. Low serum concentrations of bicarbonate indicate metabolic acidosis caused by improper oxygenation, poor perfusion, or infection, suggesting the possibility of fast progress of the disease among infants [37].

Need for Infant-Specific Research

Even though there has been considerable growth in the body of literature dedicated to pneumonia in children, the weakness in this kind of research is that it considers both newborns and young children as subjects. Consequently, the results become irrelevant for infants who have specific vulnerabilities. [30] Due to the difference in the maturity of the kidney function, the development of hepatic enzymes, fluid homeostasis, and metabolism regulation in infancy, the biochemical response during pneumonia infection and systemic inflammatory state should be investigated based on the accurate age group. Infants have lower capacity of concentrating urine, immature detoxifying capability of the liver, and reduced physiological buffers, making them prone to rapid biochemical alterations during acute illness. Extrapolation of biochemical findings among older children may result in a misinterpretation of early electrolyte disturbances and involvement of the liver in babies.

Recent systematic reviews have highlighted the need for conducting age-specific investigations to obtain age-relevant biochemical markers of infants with pneumonia. Such efforts are essential to improve the accuracy of detecting disease conditions, decision-making, and management for babies admitted to hospitals [38].

Conceptual Framework of the Present Study

The conceptual framework for the ongoing research is premised on the idea that pneumonia can be viewed as a sickness of systemic inflammation rather than a respiratory infection. Pneumonia-induced inflammation leads to hypoxic and neurohormonal imbalances as well as

Frontier in Medical & Health Research

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oxidative stress. The abovementioned phenomena lead to qualitative alterations in the concentrations of blood electrolytes as well as hepatic enzymes, affecting the severity of the disease, its prognosis, and the period of hospitalization. This paper intends to conduct an analysis of the biochemical changes and their clinical relevance among hospitalized infants with pneumonia. [39]

Rationale:

It becomes even more essential to address the current knowledge gaps regarding biochemical anomalies in infant pneumonia in developing countries like Pakistan, where late presentations, poor laboratory services, and high disease burden pose constant challenges for pediatric healthcare services. The absence of biochemical testing in some healthcare institutions results in the under-diagnosis of disorders related to electrolyte imbalance and liver enzymes, thus causing unnecessary implications and prolongation of hospital stay. Discovering consistent biochemical profiles that occur in relation to the degree of severity in infants admitted to the hospital could prove helpful in risk stratification and early management of diseases.

Additionally, the development of locally based evidence is necessary to consider aspects such as nutrition, access to health care services, and severity of diseases that can potentially influence the biochemical composition of affected infants. The understanding of these changes will be vital for establishing a standard protocol of clinical practice [40].

In summary, pneumonia in infants needs to be considered as a systemic inflammatory disease that causes significant disturbance in the electrolyte balance and hepatic cell function. Diagnosing and managing metabolic disturbances is essential in order to reduce morbidity, prevent complications, and lower mortality rates. For this reason, the current research attempts to explore electrolyte and liver enzyme disturbances among hospitalized infants with pneumonia.

OBJECTIVE OF STUDY

General Objective:

In order to investigate the effects of electrolyte imbalances and liver enzyme changes in hospitalized infants suffering from pneumonia.

Specific Objectives:

1. In order to find out the concentration of serum Na^+, K^+, and Cl^- in infants with pneumonia.
2. To assess the levels of liver enzymes (ALT, AST, ALP) in hospitalized infants with pneumonia.
3. To compare the electrolyte and enzyme levels of infants with pneumonia.
4. To identify the correlation between pneumonia severity and biochemical alterations.

HYPOTHESIS OF STUDY

Research Hypothesis (H_1):

There is a marked change in the concentration of electrolytes (Sodium, Potassium, Chloride), and Liver enzymes (ALT, AST, ALP) among hospitalized children suffering from pneumonia, and these changes depend upon the severity of the disease.

Null Hypothesis (H_0):

No differences in the levels of serum electrolytes (sodium [Na^+], potassium [K^+], chloride [Cl^-]), and liver enzymes (alanine transaminase [ALT], aspartate transaminase [AST], alkaline phosphatase [ALP]) have been detected among infants hospitalized for pneumonia.

LITERATURE REVIEW

The article "Dyselectrolytemia in Children with Severe Pneumonia: A Prospective Study" by Pande, V. et al. was published in the year 2024 in the journal Cureus. This research focused on examining the occurrence of dyselectrolytemia in children suffering from severe pneumonia. It involved 80 patients aged between 2 months to 5 years admitted to a tertiary center. The study discovered that 59% of children had electrolyte abnormalities at admission, with hyponatremia (39%) being the most common abnormality, followed by hypokalemia (15%), hypernatremia (4%), and hyperkalemia (1%). Hyponatremia was mostly induced by the Syndrome of Inappropriate Antidiuretic Hormone Secretion (SIADH) and fluid imbalances associated with major diseases. A definite association between

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dyselectrolytemia and sickness severity was established in this study. Out of the 21% patients who were admitted in the ICU, 94% showed abnormalities in their electrolytes and 24% of the sick children died. The occurrence of dyselectrolytemia was associated with morbidity and prolonged hospitalization. It was recommended by the researchers that routine electrolyte monitoring and timely electrolyte adjustment is a must for patients with pediatric pneumonia. [41]

The study titled "Serum Electrolyte Levels in Children with Severe Pneumonia" was conducted in 2024 and carried out by B. D. and Bhandari R., and it aimed to determine electrolyte disturbances in children admitted to hospital with severe pneumonia. The study, which occurred at Rajindra Hospital in Patiala between July 2014 and August 2015, used 21 infants aged 2-59 months as its participants. It was established from the study findings that electrolyte abnormalities were highly prevalent among the children with severe pneumonia, and the most common electrolyte abnormality was hyponatremia while potassium abnormality disorders such as hypokalemia and hyperkalemia came second. From the findings of the research, electrolyte disturbance in children with severe pneumonia could be attributed to dehydration, insufficient oral intake, systemic inflammation, and SIADH. [42]

"A Study on Change in Serum Electrolyte Levels and Calcium in Children with Severe Pneumonia and Its Outcome" is the title of a hospital based cross sectional study carried out over a period of 24 months during 2022 at Dr. Vasantrao Pawar Medical College, Nashik, Maharashtra. The study included 100 children aged 2 months to 5 years who were hospitalized with severe or community-acquired pneumonia. The purpose was to evaluate blood electrolyte (sodium, potassium, chloride) and calcium anomalies at admission and 24 hours later, as well as their link to clinical outcomes. The data demonstrated a considerable frequency of electrolyte abnormalities, with hypocalcemia (49%) and hyponatremia (27%) being the most common upon admission. Following 24 hours, the most prevalent abnormalities were hyponatremia (40%) and hypocalcemia (43%). The bulk of the affected children (72%) were between the ages of two and twelve months. The study also found a clear correlation between electrolyte imbalance and poor clinical outcomes. Chloride abnormalities, hyponatremia, and hypokalemia have been linked to longer hospital admissions and greater mortality rates. Hyponatremia was mostly induced by the Syndrome of Inappropriate Antidiuretic Hormone Secretion (SIADH). The study discovered that electrolyte imbalances are common in juvenile pneumonia and suggested early detection and monitoring to reduce morbidity and mortality. [43]

In 2022, A prospective cross-sectional research titled "Hyponatremia as a Predictor of Adverse Outcome in Children with Severe Lower Respiratory Tract Infection in Tribhuvan University Teaching Hospital (TUTH), Nepal" investigated the effect of hyponatremia on children hospitalized with severe LRTI. Children between ages 2 months and 16 years who developed cough <3 weeks, tachypnea, and chest indrawing, and were admitted in Pediatric Emergency, ward, and PICU in TUTH were involved in this study. Measurement of serum sodium levels was done within two hours of admission and patients were closely followed for respiratory support, hypoxia resolution, duration of hospitalization, and prognosis. Findings revealed that 47.5% of the children had hyponatremia. Hyponatremia was found to be significantly correlated with increased respiratory support requirement, intubation and ventilation, prolonged hospital stay, delayed resolution of hypoxia, and mortality. All the four cases of mortality occurred in hyponatremic children. It can thus be concluded from the above study that early diagnosis, monitoring, and treatment of hyponatremia among severe LRTI affected children is essential for reducing mortality, hospitalization, and morbidity. [44]

The paper "Study of Association and Significance of Hyponatremia in Patients with Lower Respiratory Tract Infection (LRTI)" by Behera S. et al. was published in 2022 in the International Journal of Health Sciences. This paper focuses on the association of hyponatremia in children suffering from LRTIs, particularly pneumonia. The study of children with LRTIs such as bronchopneumonia was carried out at the Department of Pediatrics at S C B Medical College Hospital and SVPPPGIP, Cuttack. According to the results of the study,

Frontier in Medical & Health Research

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44.6% of the patients showed signs of hyponatremia, and the temperature of these patients was higher than normonatremics (101.9°C and 99.7°C respectively). Therefore, there is a correlation between electrolyte imbalances and the severity of illness. The conclusion made by the authors of the paper states that hyponatremia is an important finding in pediatric LRTIs, and blood sodium testing should be performed routinely. [45]

The article by Dudnyk V., Pasik V. entitled "Liver dysfunction in children with community-acquired pneumonia: the role of infectious and inflammatory markers" was published in the Journal of Education, Health, and Sport in 2021. This work focused on studying the connection between disturbed liver function and inflammation in children with community-acquired pneumonia. It was established that there was an association between the development of the disorder and an increase in pro-inflammatory cytokine levels (IL-1 and IL-6), which caused the development of abnormal fibrinogen content and raised CRP concentration. It demonstrated that there is a disturbance in the process of protein formation in the liver along with a systemic inflammatory response in the organism. Moreover, as the severity of the illness progressed, the activity of ALT and AST in the liver increased while the de Ritis ratio reduced. It means that a significant correlation exists between the levels of IL-1 and enzymes activity in the liver. [46]

The paper "A Prospective Study on Hyponatremia in Children with Lower Respiratory Tract Infections Admitted in PICU," written by Chaparala S. et al., was published in the Asian Journal of Pharmaceutical and Clinical Research in 2022. This research was focused on examining the relationship between hyponatremia and lower respiratory tract infections in children. The study included 100 children aged 2 months to 5 years who were admitted to the PICU at GITAM Institute of Medical Sciences and Research in Visakhapatnam between October 2018 and September 2019. The results showed that 32% of the children had hyponatremia, whereas 68% had normal sodium levels. There were 59 individuals with pneumonia, and 41 had severe pneumonia. Hyponatremic children had significantly higher C-reactive protein (CRP) values (7.38 mg/dL) than normonatremic children (2.30 mg/dL, $p<0.001$) and longer hospital stays, although no deaths were reported. The authors concluded that hyponatremia is a common complication of juvenile LRTI, and that regular blood salt monitoring is crucial for early identification and effective management, hence lowering morbidity and hospitalization. [47]

Sukhani V. K. et al. published a hospital based prospective research in 2022 titled "To Study the Association and Significance of Hyponatremia in Pneumonia in Paediatric Patients in RIMS, Raichur" in the International Journal of Health Sciences. This study aimed to determine the frequency and significance of hyponatremia in pediatric pneumonia patients admitted to hospitals. For the purpose of conducting this research, 120 children suffering from pneumonia were enrolled. Their serum salt concentration was measured immediately upon admission. Analysis was carried out utilizing Student's t-test and Chi-square/Fisher's exact test at a value of $p < 0.05$. It was established that the values of sodium concentration in their blood serum ranged between 124 and 145 mEq/L, and there were no instances of hypernatremia recorded. The researchers revealed that hyponatremia was the most prevalent electrolyte disorder in pediatric pneumonia patients. [48]

K. Praneetha et al., published a prospective observational study entitled, "Hyponatremia in Children of 2 Months to 5 Years of Age with Community-Acquired Pneumonia and its Correlation with Severity of Illness and Outcome," in International Journal of Pediatric Research, 2019. The authors conducted an examination of the prevalence and significance of hyponatremia among children suffering from community-acquired pneumonia. The study involved 122 children, aged between 2 months and 5 years, hospitalized at a tertiary care center during the period from 2016 to 2018. The patients were divided into groups of pneumonia and severe pneumonia depending on WHO classification. Levels of serum sodium were estimated in order to establish the relationship between illness severity and outcome. According to the results, 43.5% of the patients had hyponatremia, most of whom (66%) had moderate hyponatremia. Severe cases of pneumonia showed a frequency of 68% hyponatremia, whereas only 23% was noted

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

among those suffering from pneumonia ($p < 0.01$). In addition, the patients suffering from hyponatremia showed longer duration of hospitalization (48% more than seven days), along with an increased risk of death (12%), compared to those with normonatremic (1.5%). Therefore, frequent evaluation of serum sodium levels in such conditions is essential because prompt identification can lead to better outcomes. [49]

The descriptive cross-sectional study entitled "Relationship Between Clinical Profile, Severity, and Outcomes of Community Acquired Pneumonia with Hyponatremia in Children 2-60 Months Old" was conducted in 2023 at the Mymensingh Medical College Hospital in Bangladesh to evaluate the relationship between the clinical profile, severity, and outcomes of community acquired pneumonia (CAP) along with hyponatremia in children. In the experiment, there were 100 participants, all of whom were within the age range of 2 months to 5 years, recruited during six months from November 2016 to April 2017 through a thorough clinical examination process. The results revealed that 34% of the children had hyponatremia, especially in cases of severe CAP (45.5%). The children who had hyponatremia were observed to have higher temperature, tachypnea, tachycardia, nasal flaring, grunting, cyanosis, and poor appetite when compared to those having normonatremia. The results from lab tests showed lower serum sodium (mean 132.18 ± 1.51 mmol/L), increased leukocytosis, ESR, CRP, and reduced hemoglobin. Patchy opacity was the most frequent radiographic finding in 55.9% of children and followed by consolidation in 26.5%. None of the subjects died or developed complications during the study period. The researchers concluded that the presence of hyponatremia in pediatric CAP reflects its severity and associated clinical and lab abnormalities. [50]

In the year 2020, Mehmood Z. et al. conducted an analysis using cross-sectional research methodology called "Frequency of Hyponatremia in Community Acquired Pneumonia" in The Professional Medical Journal to determine the frequency of hyponatremia among CAP patients. The study was conducted on a total of 100 infants under the age of two years, who were admitted in the Pediatrics Department at Services Hospital, Lahore between July 2018 and January 2019. All the subjects underwent tests for collecting information about demographic factors and serum sodium concentration. As per the results, the prevalence of hyponatremia was observed to be 24%, while the rest of the children exhibited normal sodium levels. The study found that 57% of the participants were male and 43% were female, while 45% of the infants were below the age of one year. [51]

Al. Mamun A. et al. conducted a hospital-based study entitled "Serum Sodium Levels in Children with Pneumonia: A Hospital Based Study" in 2020 with the objective of assessing serum sodium level and its association with hyponatremia among children suffering from pneumonia. For this study, 125 children who presented at the Department of Pediatrics, Rangamati Medical College in Bangladesh, during the period of January and June 2017, participated. Clinical history, chest X-ray and blood electrolytes were recorded, and SPSS version 21 software was used for statistical analysis. According to the findings, the percentage of patients having a sodium level between 126-130 mmol/L, 131-135 mmol/L, 135-140 mmol/L and 120-125 mmol/L was 25.6%, 40%, 32.8% and 1.6%, respectively, suggesting that hyponatremia is an inevitable consequence of pediatric pneumonia. [52]

In 2020, Ali Sk. S. et al. conducted a study entitled "Hyponatremia in Children with Pneumonia: Study in a Tertiary Care Hospital, Dinajpur, Bangladesh" in order to determine blood salt concentration among hospitalized children with pneumonia. The study involved 125 children who sought treatment at the Department of Pediatrics in M Abdur Rahim Medical College of Dinajpur from January to December 2018. The clinical history, chest x-ray results, and serum electrolytes were collected upon admission, and analysis was performed through SPSS version 21. Results show that 24% have sodium level of 126-130 mmol/L, 40% of 131-135 mmol/L, 34% of 135-140 mmol/L, and 2% of 120-125 mmol/L, which suggests that hyponatremia is a prevalent electrolyte abnormality in pediatric pneumonia. Children having low levels of salt would experience complications like long duration of stay in

Frontier in Medical & Health Research

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hospital, morbidity, and neurological problems. Testing of the blood sodium was recommended as one of the most important things. In addition, there is need for proper management of water intake, especially when the condition is too serious. It is through doing so that the clinical deterioration can be prevented."[53]

Agarwal P., & Niswade A. K. conducted a study in 2019 entitled "Prognostic Factors and Clinical Outcome in Children Hospitalized with Severe Lower Respiratory Tract Infection" published in the International Journal of Health Sciences and Research. It was a nested case-control study aimed to determine the impact of hyponatremia and other clinical risks on disease development in pediatric patients with severe LRTI. The study monitored 150 children aged one month to five years in a tertiary care hospital for two years, categorizing them according to the presence or absence of hyponatremia. Clinical and laboratory parameters investigated included age, gender, TLC, CRP, hypoglycemia, and acidosis, as well as outcomes including hospitalization, mechanical ventilation, and mortality. The study revealed that hyponatremia was associated with a higher requirement for mechanical ventilation (OR 3.03) and a higher risk of death (OR 3.03) when compared to normonatremic people. Severe acute malnutrition (SAM) and hypoglycemia were identified as independent predictors of poor outcomes. The authors concluded that regular blood sodium monitoring and early treatment of hyponatremia, SAM, and hypoglycemia are essential for improving outcomes and survival in children with severe LRTI. [54]

Kamal, A. H. M. et al. conducted a cross-sectional study in 2019 entitled "Serum Electrolyte Profile of Children Less Than Five Years of Age Admitted with Pneumonia in a Tertiary Care Hospital" which was published in TAJ: Journal of Teachers Association. The study, which ran from July 2009 to September 2011, included 35 children aged one month to five years. Sodium, potassium, and chloride blood levels were determined, and we analyzed the differences in hospitalization duration between the normonatremic and hypornatremic groups. According to our findings, 40% of the patients were hypornatremic while 60% were normonatremic. Our analysis demonstrated a strong positive correlation ($p<0.001$) between serum sodium and chloride but not between sodium and potassium. In addition, the duration of hospitalization was significantly higher ($p<0.05$) among the hypornatremic children as compared to the normonatremic ones, which reflects greater morbidity in the former group. The conclusions reached by the authors include the high prevalence of hypornatremia in juvenile pneumonia and its routine monitoring. [55]

Literature gap:

Despite several studies having found electrolyte imbalance and elevated liver enzymes in pediatric cases of pneumonia, some important limitations still exist in existing research. First, most of the previous studies were conducted on broad age categories of children, whereas the risk of developing metabolic and systemic complications in babies is higher since their physiology has not yet matured fully. Second, many studies investigated serum electrolytes or liver enzymes separately with very little information available on the two aspects combined. Furthermore, there is a lack of extensive studies in local populations, notably on the link between pneumonia severity and combined biochemical changes. As a result, the purpose of this study was to assess serum electrolyte and liver enzyme changes together in hospitalized babies with pneumonia in order to get a better understanding of the disease's systemic impact and to aid in early identification and therapy

METHODOLOGY

Research Design

The study was designed as a hospital-based cross-sectional study. It involved observation and analysis of data from hospitalized infants diagnosed with pneumonia at a single point in time to determine associations between variables.

Sample Size

A total minimum sample size of 363 hospitalized infants with pneumonia was included in the study. The sample size was calculated using a 95% confidence level, 5% margin of error, and a population proportion of 38.2% from an estimated population of 250,000,000.

Frontier in Medical & Health Research

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Confidence Level	95%
Margin Error	5%
Population Proportion	38.2%
Population Size	250,000,000

Study Duration

The experiment was carried out within a period of three months after receiving approval for the research proposal. It took such a long time to facilitate the recruitment of participants, data gathering, and analysis.

Sampling Technique

The type of sampling technique employed in selecting the study subjects was non- probability convenience sampling. All the available hospitalized infants suffering from pneumonia and who fit the selection criteria were included in the study.

Study Setting

The study took place in the Pediatrics Department, Neonatal Intensive Care Unit (NICU) and High Dependency Unit (HDU) of Muhammad Hospital. The units have experience handling and treating cases of pneumonia among infants, hence proper identification of cases for the study.

Selection Criteria

Inclusion Criteria:

Infants who met all these requirements were recruited in the study:

- All infants admitted to the hospital and suffering from pneumonia Infants aged 0–12 months.
- Infants of both genders.
- Infants for whom blood samples for serum electrolytes and liver enzyme analysis are available.
- Parents/guardians willing to give informed consent.

Exclusion Criteria:

- Infants with known congenital metabolic or electrolyte disorders.
- Infants with pre-existing liver disease.
- Infants who have received electrolyte-modifying therapy before sample collection.
- Infants with severe dehydration due to other causes.
- Infants whose parents/guardians do not consent to participate.

Sample Collection:

- A 2–3 mL venous blood sample was collected from each infant using sterile, aseptic techniques.
- Blood was drawn into a red-top plain tube (clot activator tube), which is used for biochemical tests.
- The sample was allowed to clot at room temperature for 20–30 minutes.
- The tube was then centrifuged to obtain clear serum for analysis.
- Liver enzymes including ALT (Alanine Aminotransferase), AST (Aspartate Aminotransferase), and ALP (Alkaline Phosphatase) were measured from the serum.
- Samples were immediately transported to the laboratory to prevent hemolysis, which may falsely elevate AST levels.
- All analyses were performed using an automated chemistry analyzer following standard quality-control measures.

Chemistry Analyzer (Microlab 300):

Principle:

The Microlab 300 is a semi-automated clinical chemistry analyzer that works on the principle of photometry (colorimetry and UV-kinetic absorbance measurement). It measures the concentration or activity of analytes by detecting how much light is absorbed by a sample.

LIVER ENZYMES (ALT, AST, ALP):

1. ALT (Alanine Aminotransferase):

Principle:

- ALT transfers an amino group from alanine to α-ketoglutarate, producing pyruvate and glutamate.
- Pyruvate is then converted to lactate by LDH, using up NADH → NAD^+.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

- Because NADH absorbs at 340 nm, its decrease in absorbance is measured.
- The rate of decrease = ALT activity.

Procedure (Microlab 300):

1) ALT reagent was pipetted into cuvette.
2) Serum sample was added.
3) The mixture was placed into the Microlab 300.
4) The analyzer measured absorbance at 340 nm at regular intervals for 2–3 minutes.
5) ALT activity was calculated in U/L using the kinetic method.

Reference Range (Infants 1–12 months):

- 5-40 U/L

2. AST (Aspartate Aminotransferase):

Principle:

- AST transfers an amino group from aspartate to α-ketoglutarate, forming oxaloacetate and glutamate.
- Oxaloacetate reacts with MDH and NADH producing malate and NAD^+.
- This reaction consumes NADH → absorbance at 340 nm decreases.
- The rate of decrease indicates AST activity.

Procedure (Microlab 300):

1) AST reagent was added to the cuvette.
2) Serum sample was added.
3) The cuvette was loaded into the analyzer.
4) The Microlab 300 monitored absorbance decrease at 340 nm kinetically.
5) AST activity was displayed in U/L.

Reference Range (Infants 1–12 months):

- 5-40 U/L

3. ALP (Alkaline Phosphatase):

Principle:

- ALP hydrolyzes p-nitrophenyl phosphate (pNPP) into p-nitrophenol (pNP) in alkaline conditions.
- P–Nitrophenol is yellow and absorbs light at 405 nm.
- The rate of color formation is directly proportional to ALP activity.

Procedure (Microlab 300):

1) ALP reagent was added to the cuvette.
2) Serum sample was added.
3) The cuvette was inserted into the Microlab 300.
4) The analyzer measured the increase in absorbance at 405 nm.
5) ALP activity was automatically calculated in U/L.

Reference Range (Infants 1–12 months):

- 100–480 U/L (physiologically higher due to bone growth)

Electrolyte Testing in Infants

Principle of (K-Lite 8 Series) Electrolyte Analyzer:

K-Lite 8 Series Electrolyte Analyzer makes use of Ion Selective Electrode (ISE). It quantifies particular ions (Na^+, K^+, Cl^-) from electrical potentials created by ion- selective membranes. The potentials are then converted into ion concentrations via the Nernst equation.

Serum Electrolytes:

1) Sodium (Na^+):

Principle:

- Measured using a sodium-selective electrode.
- Sodium ions in serum interact with a glass membrane, generating a potential difference.
- The potential is proportional to sodium concentration.

Procedure:

1. The serum sample was introduced to the analyzer.
2. The sodium electrode measured the voltage change.
3. The analyzer measured the amount of sodium ions in mmol/L based on calibration curves.

Reference Range (Infants 1–12 months):

- 135–150 mmol/L

2. Potassium (K^+):

Principle:

- Measured using potassium-selective electrode with valinomycin membrane.
- K^+ ions selectively bind to valinomycin,

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

creating a potential difference.

- Analyzer calculates K^+ concentration via the Nernst equation.

Procedure:

1. Serum was drawn into the analyzer.
2. The K^+ electrode measured the voltage produced.
3. The analyzer calculates the potassium concentration as mmol/L.

Reference Range (Infants 1–12 months):

- 3.5–5.5 mmol/L

3. Chloride (Cl^-):

Principle:

- Measured using chloride-selective electrode, usually a silver-silver chloride electrode.
- Cl^- ions interact with the electrode, generating a potential proportional to serum chloride.

Procedure:

1) Serum was placed in the analyzer.
2) Cl^- electrode measured voltage.
3) Analyzer calculated Cl^- concentration in mmol/L.

Reference Range (Infants 1–12 months):

- 94–111 mmol/L

Data Analysis

- Data were summarized using mean ± standard deviation (SD) for biochemical parameters, including sodium, potassium, chloride, ALT, AST, and ALP levels.
- Independent sample t-test was applied to compare electrolyte levels (Na, K, Cl) between male and female infants.
- One-way ANOVA was used to compare biochemical parameters (Na, K, Cl, ALT, AST, ALP) across different pneumonia severity groups (mild, moderate, severe) and pneumonia types.
- Chi-square test was used to determine the association between categorical variables, including gender, pneumonia severity status, and pneumonia type.
- Pearson correlation analysis was used to evaluate the relationship between electrolyte levels and liver enzyme levels (ALT, AST, ALP).
- A p-value < 0.05 was considered statistically significant.
- Statistical analysis was performed using SPSS software.

RESULTS

This chapter describes the results of the statistical analysis carried out on the data that was collected. The data were examined using descriptive and inferential statistics to determine the connection between test parameters and clinical factors. The research population's characteristics were summarized using descriptive statistics, while differences and relationships between variables were assessed using inferential tests such as one-way ANOVA, independent samples t-test, Pearson correlation, and chi- square test. The results have been presented in an organized manner based on the objectives of the research, including comparison between levels of electrolytes and liver enzymes with respect to severity of illness, pneumonia types, and gender.

Table 1: Distribution of Study Participants According to Age, Gender, Pneumonia Type, and Severity

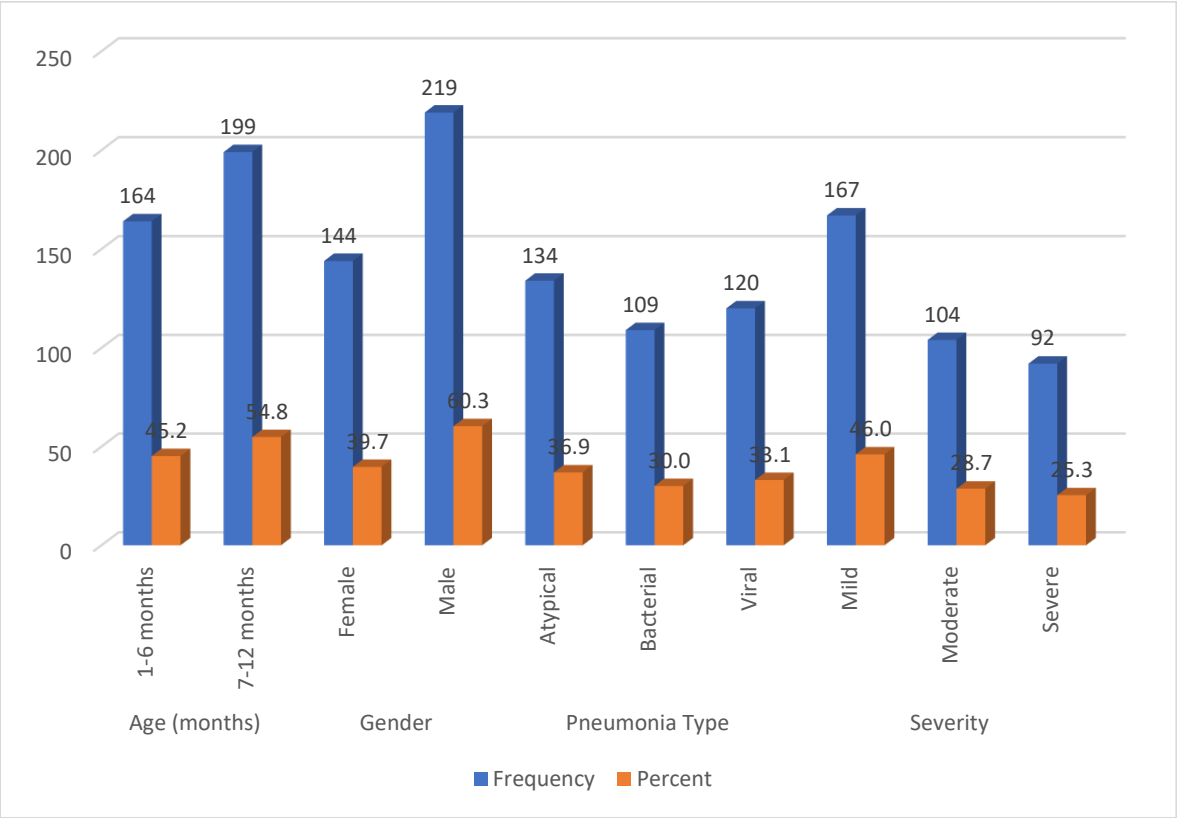
		Frequency	Percent %
Age (months)	1-6 months	164	45.2
	7-12 months	199	54.8
Gender	Female	144	39.7
	Male	219	60.3
Pneumonia Type	Atypical	134	36.9
	Bacterial	109	30.0
	Viral	120	33.1
Severity	Mild	167	46.0
	Moderate	104	28.7
	Severe	92	25.3

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

	Total	363	100.0

The following is the description of demographics and clinical features of the research participants. The sample comprised 363 participants altogether. As for age distribution, 164 people (45.2%) were within the age range from 1 to 6 months and 199 people (54.8%) belonged to the age group 7-12 months old. As far as gender distribution is concerned, the majority of participants turned out to be male, constituting 219 (60.3%) people, while 144 (39.7%) were female participants. It can be stated that atypical pneumonia was the leading type of pneumonia (134 people, or 36.9%), followed by viral pneumonia (120 people, or 33.1%) and bacterial pneumonia (109 people, or 30.0%). With regard to the disease severity, more than half of the patients suffered from mild pneumonia (167 people, or 46.0%). 104 people (28.7%) had moderate pneumonia, while 92 people (25.3%) experienced severe pneumonia. In general, the results reveal a higher percentage of older babies, male participants and pneumonia types distribution



Graph 1: Age, Gender, Pneumonia Type, and Severity of Study Participants

Table 2: Distribution of Biochemical Parameters Among Study Participants

		Frequency	Percent %
Sodium Status	Hyponatremia	120	33.1
	Normal	187	51.5
	Hypernatremia	56	15.4
Potassium Status	Hypokalemia	106	29.2
	Normal	202	55.6
	Hyperkalemia	55	15.2
Chloride Status	Hypochloremia	34	9.4
	Normal	117	32.2
	Hyperchloremia	212	58.4

Frontier in Medical & Health Research

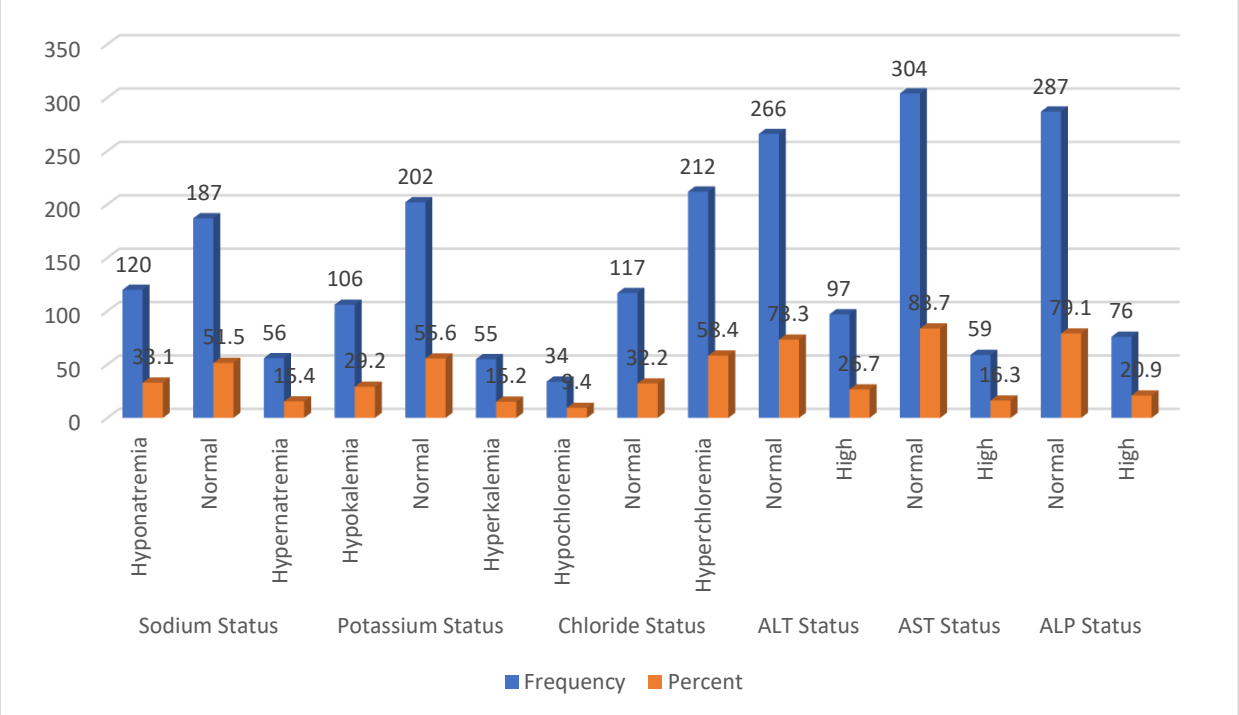
ISSN: (e) 3007-1607 (p) 3007-1593

ALT Status	Normal	266	73.3
	High	97	26.7
AST Status	Normal	304	83.7
	High	59	16.3
ALP Status	Normal	287	79.1
	High	76	20.9
	Total	363	100.0

As illustrated by the table above, this represents the distribution of biochemical parameters amongst research subjects. Concerning sodium concentrations, there were 187 (51.5%) with normal sodium, 120 (33.1%) had hypotonic levels, while 56 (15.4%) had hypertonic concentrations. The largest number of subjects, 202 (55.6%) had normal potassium levels, hypokalemia was observed among 106 (29.2%), while hyperkalemia was observed amongst.

In terms of chloride status, hyperchloremia was the most prevalent result, involving 212 participants (58.4%). 117 (32.2%) children had normal chloride levels, whereas 34 (9.4%) had hypochloremia. The majority of participants had normal enzyme levels when their liver function indicators were assessed.

Alanine aminotransferase (ALT) levels were normal in 266 (73.3%) individuals, but high in 97 (26.7%). Similarly, 304 (83.7%) individuals had aspartate aminotransferase (AST) values within the normal range, whereas 59 (16.3%) had high levels. Alkaline phosphatase (ALP) was normal in 287 (79.1%) of individuals and high in 76 (20.9%). Overall, the results show that the majority of individuals had normal electrolyte and liver enzyme levels, however a significant number had electrolyte imbalances, including hyperchloremia and hyponatremia, as well as some degree of liver enzyme elevation.



Graph 2: Distribution of Electrolytes and Liver Enzymes in Study Participants

Frontier in Medical & Health Research

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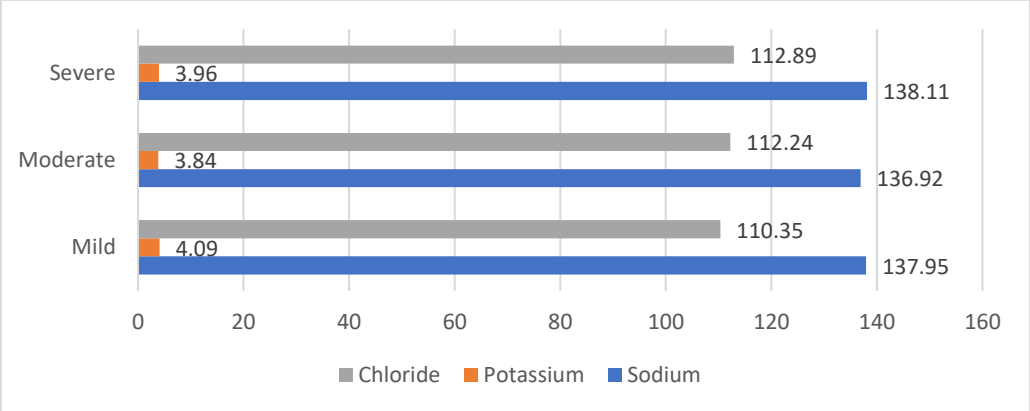
Table 3: Comparison of Laboratory Parameters Across Disease Severity Using One-Way ANOVA

Parameter	Mild (n=167) Mean ± SD	Moderate (n=104) Mean ± SD	Severe (n=92) Mean ± SD	p-value
Sodium (mmol/L)	137.95 ± 5.49	136.92 ± 10.64	138.11 ± 10.99	0.562
Potassium (mmol/L)	4.09 ± 0.76	3.84 ± 1.28	3.96 ± 1.26	0.171
Chloride (mmol/L)	110.35 ± 8.93	112.24 ± 15.23	112.89 ± 15.02	0.242
ALT (U/L)	23.86 ± 11.58	33.64 ± 39.04	468.18 ± 711.30	.001
AST (U/L)	15.34 ± 5.28	19.28 ± 11.11	114.28 ± 147.61	.001
ALP (U/L)	350.84 ± 104.28	365.11 ± 129.21	577.33 ± 302.70	.001

A one-way analysis of variance (ANOVA) was used to evaluate laboratory parameters across severity levels (mild, moderate, and severe). The research found no statistically significant difference in serum sodium ($p = 0.562$), potassium ($p = 0.171$), or chloride ($p = 0.242$) levels between the three groups. On the other hand, liver enzymes showed significant variation across different severity grades. The serum levels of ALT, AST, and ALP enzymes were relatively high among patients who experienced severe cases as opposed to mild or moderately affected ones ($p<0.001$).



Graph 3: Comparison of Electrolyte Levels Across Disease Severity

Frontier in Medical & Health Research

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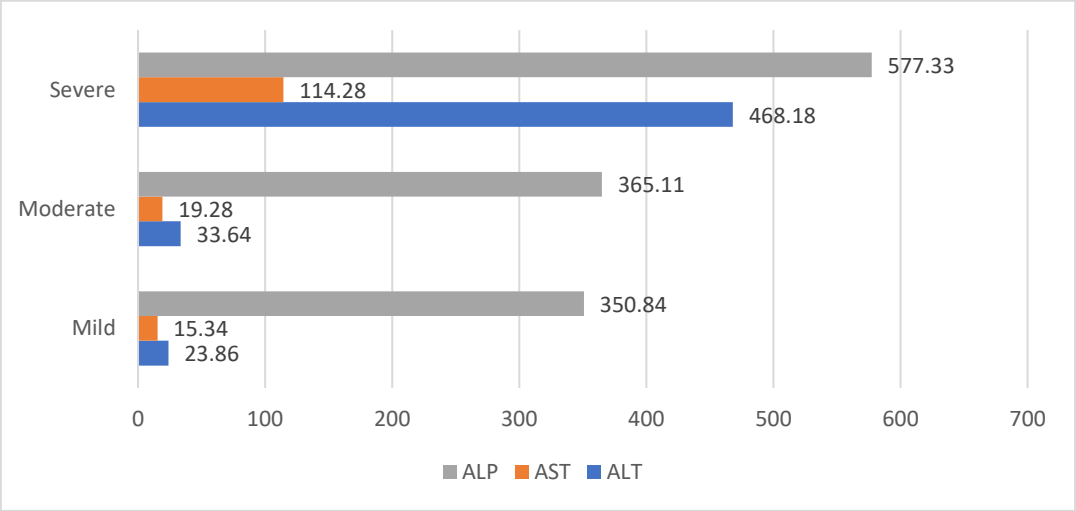

Graph 4: Comparison of Liver Enzyme Levels Across Disease Severity

Table 4: Comparison of Laboratory Parameters Across Pneumonia Types Using One-Way ANOVA

Parameter	Atypical (n=134) Mean ± SD	Bacterial (n=109) Mean ± SD	Viral (n=120) Mean ± SD	p-value
Sodium (mmol/L)	136.99 ± 7.88	137.64 ± 7.45	138.54 ± 10.59	0.368
Potassium (mmol/L)	3.91 ± 1.14	4.07 ± 0.99	3.99 ± 1.06	0.521
Chloride (mmol/L)	111.33 ± 13.28	111.08 ± 10.12	112.18 ± 14.06	0.787
ALT (U/L)	151.07 ± 491.78	194.97 ± 450.08	75.51 ± 198.10	0.076
AST (U/L)	44.55 ± 98.91	51.54 ± 96.47	29.11 ± 51.53	0.123
ALP (U/L)	410.96 ± 188.74	416.14 ± 172.02	410.40 ± 247.59	0.973

One-way analysis of variance (ANOVA) was conducted to analyze the differences between laboratory variables in individuals suffering from different types of pneumonia such as atypical, bacterial, and viral. The study findings revealed no statistically significant differences between the groups as regards serum sodium concentration ($p = 0.368$), potassium concentration ($p = 0.521$), and chloride concentration ($p = 0.787$). In addition, there were no statistically significant differences between pneumonia types with regard to liver enzymes such as ALT ($p = 0.076$), AST ($p = 0.123$), and ALP ($p = 0.973$).

Table 5: Comparison of Electrolyte Levels Between Male and Female Patients Using Independent Samples T-Test

Parameter	Male (n=219) Mean ± SD	Female (n=144) Mean ± SD	p-value
Sodium (mmol/L)	137.24 ± 8.26	138.39 ± 9.45	0.223
Potassium (mmol/L)	3.98 ± 1.06	3.99 ± 1.09	0.969
Chloride (mmol/L)	111.13 ± 12.02	112.15 ± 13.61	0.457

A paired t-test was carried out to determine the presence of any differences in electrolytes among males and females. No significant difference was observed in serum sodium ($p=0.223$), potassium

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

(p=0.969), and chloride (p=0.457) among the two sexes. The above results indicate that gender does not affect electrolyte levels in the population under investigation.

Table 6: Pearson Correlation Between Electrolytes and Liver Enzymes

Variables	Sodium	Potassium	Chloride	ALT	AST	ALP
Sodium	1	0.041	0.770**	-0.022	-0.01	0.003
Potassium	0.041	1	0.129*	-0.015	-0.02	0.062
Chloride	0.770**	0.129*	1	-0.019	-0.015	-0.039
ALT	-0.022	-0.015	-0.019	1	0.954**	0.484**
AST	-0.01	-0.02	-0.015	0.954**	1	0.499**
ALP	0.003	0.062	-0.039	0.484**	0.499**	1

Correlation analysis of Pearson was carried out to evaluate the link between serum electrolytes and liver enzymes. A high positive correlation was observed between sodium and chloride ($r = 0.770$, $p < 0.001$), and there was a low positive correlation of potassium ($r = 0.129$, $p = 0.014$). Liver enzymes ALT and AST correlated positively ($r = 0.954$, $p < 0.001$). Also, there was a positive correlation between ALT and ALP ($r = 0.484$, $p < 0.001$) and AST and ALP ($r = 0.499$, $p < 0.001$). No statistically significant correlations were established between electrolytes and liver enzyme parameters.

Table 7: Summary of Pearson Correlation Coefficients Between Selected Biochemical Parameters

Variables	r - value
Sodium - Chloride	0.770
Potassium - Chloride	0.129
ALT - AST	0.954
ALT - ALP	0.484
AST - ALP	0.499

This table offers a succinct presentation of Pearson correlation coefficients for a selected set of biochemical indicators. The relation between ALT and AST showed very strong statistical significance ($r = 0.954$); on the other hand, there were moderate positive correlations between ALT and ALP ($r = 0.484$) and between AST and ALP ($r = 0.499$). There was also considerable correlation between sodium and chloride ($r = 0.770$).

Table 8: Association Between Gender and Laboratory Status Variables Using Chi-Square Test

Variable	χ^2 Value	df	p-value	Result
Sodium status	2.977	2	0.226	Not significant
Potassium status	0.971	2	0.615	Not significant
Chloride status	1.208	2	0.547	Not significant
ALT status	0.016	1	0.9	Not significant
AST status	0.014	1	0.906	Not significant
ALP status	0.321	1	0.571	Not significant

In this experiment, the Chi-square analysis was done to show the correlation between gender and laboratory status variables. According to the findings, there is no statistically significant correlation between gender and sodium status (p-value of 0.226), potassium status (p-value of 0.615), chloride status (p-value of 0.547), ALT status (p-value of 0.900), AST status (p-value of 0.906), or ALP status (p-value of 0.571).

From the above findings, we can conclude that the occurrence of electrolyte and liver enzymes abnormalities is gender-independent.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Table 9: Association Between Disease Severity and Laboratory Status Variables Using Chi-Square Test

Variable	χ^2 Value	df	p-value	Result
Sodium status	41.833	4	0.001	Significant
Potassium status	49.014	4	0.001	Suggestive/Sig. (p<0.001)
Chloride status	13.921	4	0.008	Significant
ALT status	188.276	2	0.001	Highly significant
AST status	164.171	2	0.001	Highly significant
ALP status	97.431	2	0.001	Highly significant

The Chi-Square test was conducted to test the relation between the severity of illness and the lab status variables. According to the research results, there is a strong correlation between the severity of illness and sodium status ($p < 0.001$), potassium status ($p < 0.001$), and chloride status ($p = 0.008$).

There is a significant correlation between the severity of illness and the status of liver enzymes, such as ALT ($p < 0.001$), AST ($p < 0.001$), and ALP ($p < 0.001$). It means that increased illness severity is directly related to increased cases of electrolyte and liver enzyme abnormalities.

Table 10: Association Between Pneumonia type and Laboratory Status Variables Using Chi-Square Test

Variable	χ^2 Value	df	p-value	Result
Sodium status	6.384	4	0.172	Not significant
Potassium status	3.384	4	0.496	Not significant
Chloride status	1.874	4	0.759	Not significant
ALT status	2.4	2	0.301	Not significant
AST status	5.254	2	0.072	Not significant
ALP status	2.393	2	0.302	Not significant

Chi-square test was employed to establish the link between pneumonia type and laboratory status variables. According to the findings of the research, there is no statistically significant association between pneumonia type and sodium status (p=0.172), potassium status (p=0.496), chloride status (p=0.759), ALT status (p=0.301), AST status (p=0.072), and ALP status (p=0.302). This evidence implies that there are no marked variations in electrolyte and liver enzyme abnormalities among pneumonia types.

DISCUSSION

Electrolyte disturbances and changes in liver enzymes were studied in infants with pneumonia admitted in the hospital and their relationship with the severity of the disease, gender, and the type of pneumonia in this research. In addition, it is becoming evident that pneumonia in infancy is a condition that is systemic in nature affecting various organ systems of the body instead of being a local infection involving only the respiratory system. The results obtained in this study provide important insights regarding the metabolic changes associated with neonatal pneumonia in a resource- constrained setting. The demographic characteristics of the study sample indicated that the predominant age group included was from 7-12 months with males predominating. This trend corroborates previous studies that have revealed that male infants are more vulnerable to respiratory infections probably owing to various physiological and environmental reasons.

The findings of this study showed electrolyte disturbances as one of the common features observed in hospitalized neonates suffering from pneumonia. The presence of hyponatremia was noted to be common in many children, supporting previous studies showing its occurrence as the most common disturbance in

Frontier in Medical & Health Research

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pediatric pneumonia. According to the results obtained by Pande et al. in 2024, hyponatremia was noted in 39% of children with pneumonia while Kamal et al. observed its presence in 40% of children in 2019. Hyponatremia is mainly caused due to the presence of SIADH in pneumonia, leading to accumulation of fluid in the body and thus a dilution of sodium ions in the bloodstream. In addition to this. [41,55]

Low potassium levels were evident in many individuals who participated in this study. This discovery is consistent with prior research, which suggests that potassium abnormalities might arise as a result of low dietary intake, gastrointestinal losses, and intracellular alterations during systemic sickness. Although less commonly mentioned than hyponatremia, hypokalemia has serious clinical consequences, including respiratory muscle weakening and an increased risk of cardiac arrhythmias, which can worsen clinical outcomes in newborns with pneumonia. [42,43]

Hyperchloremia was identified as the most prevalent electrolyte imbalance in the current investigation. While there is less research on chloride imbalance in pediatric pneumonia, it may be associated with dehydration, metabolic acidosis, or intravenous fluid treatment. The substantial positive association discovered between sodium and chloride levels adds to the dependency of both electrolytes in maintaining fluid and acid–base balance. [23,25]

Despite the presence of electrolyte imbalances, a one-way ANOVA analysis found no statistically significant variations in mean electrolyte levels between severity groups. However, chi-square analysis revealed a strong relationship between illness severity and electrolyte status, showing that while mean values do not change much, the number of aberrant cases increased with severity. This apparent disparity indicates that categorical evaluation of electrolyte imbalances may be more therapeutically meaningful than comparing mean values alone. Previous investigations, like those by Behera et al. in 2022 and other investigators, have revealed similar relationships between electrolyte imbalance and illness severity, with hyponatremia identified as a sign of severe disease and a bad prognosis. [45]

With regard to the functionality of the liver, the current study reported high levels of ALT, AST, and ALP among subjects with severe pneumonia. The above finding can be used to reinforce the concept that pneumonia is indeed a systemic inflammatory condition that affects multiple organs, with the liver being one such organ. The increased levels of enzymes can be attributed to several factors, such as hypoxic injury of hepatocytes, systemic inflammation, oxidative stress, and drug-induced hepatotoxicity. The current study provides important evidence of the association between the extent of the disease and liver enzymes.

The correlation of ALT and AST observed in this experiment is consistent with previous findings, as both enzymes have been found to be produced together when hepatic cells undergo injury. The weak relationship between both enzymes and ALP is consistent with evidence of involvement of both hepatocytes and bile in the process. More importantly, it was found that there was no correlation between the electrolytes and the enzymes in liver functions.

Levels of electrolytes and liver enzymes did not show any statistical differences among cases of atypical, bacterial, and viral pneumonia. No statistically significant correlation was found between type of pneumonia and the factors related to laboratory status. The results of this study clearly illustrate that the biochemical reaction of pneumonia is more related to its severity rather than its etiological classification. Such findings are particularly relevant for clinical practice as they highlight the importance of monitoring illness progress rather than its classification.

Gender analysis in the present study indicated the absence of significant differences in electrolyte imbalance and abnormalities in liver enzymes among the males and females. In addition, the chi-square test indicated that the biochemical anomalies were gender neutral. These results were similar to the results reported previously and indicate that gender is not an important factor in metabolism associated with childhood pneumonia. Conclusion and Implications of Findings

These findings have important implications for medicine. This is especially true since the prevalence of electrolyte abnormalities, mainly hyponatremia, points out that electrolyte assessment should be considered frequently among infants suffering from pneumonia. Prompt rectification of these abnormalities will

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ISSN: (e) 3007-1607 (p) 3007-1593

help avoid complications like nerve-related diseases or heart arrhythmias. In addition, the marked increase in liver enzymes suggests that liver function should be assessed too.

The current research provides additional evidence to support the hypothesis that baby pneumonia should be considered a systemic infection affecting various organs. Considering the link between biochemical derangements and the severity of the disease, it seems logical to assume that such factors may serve as important criteria for stratifying patients into different risk groups.

On the other hand, several limitations should be accounted for when evaluating the findings. First, the research in question has been conducted in one facility only, which may limit its potential applicability. Besides, the cross-sectional approach prevents researchers from exploring the time course of changes in biochemical indices as well as their causative relationship. It would be interesting to analyze the dynamics of changes in electrolytes and liver enzymes during illness.

Conclusion

From the foregoing analysis, it can be concluded that electrolyte disturbances and abnormal changes in liver enzymes occur frequently among children with pneumonia, and that both are closely correlated with the disease course. Although there appears to be no influence from pneumonia etiology and gender on the biochemical profile, there is a marked correlation between the degree of severity and an increased incidence of abnormalities. The results underscore the importance of periodic biochemical assessment and reinforce the classification of pneumonia as a systemic inflammatory disease.

CONCLUSION

In this current study, the researchers explored issues concerning electrolyte imbalances as well as changes in the level of liver enzymes in infants admitted due to pneumonia and also their correlation with the severity of the disease, gender of patients, and the type of pneumonia. The results of this study indicate that pneumonia in infants is not only an inflammation in the airway of the baby; it is rather a systemic disease having a major impact on metabolism of the baby. From the findings of the study, it can be stated that electrolyte imbalance was prevalent among the population used in the study and hyponatremia as well as hyperchloremia were found to be the most frequently occurring abnormalities.

An elevated amount of ALT, AST, and ALP has been proven to be closely related to the intensity of the disease. Patients with pneumonia who experienced its severe form showed increased levels of these enzymes, which means hepatic affection is present due to hypoxia, systemic inflammation, or metabolic stress. This finding supports the hypothesis of multisystem participation in pneumonia at birth. No statistically significant difference could be observed in electrolyte and liver enzyme values depending on the type of pneumonia and patient's gender. It indicates that biochemical indices are related to disease severity rather than etiological classification or gender features.

The correlation analysis demonstrated significant associations between electrolyte values and liver enzymes, especially sodium and chloride and ALT, AST, and ALP correspondingly, but there was no significant correlation between electrolytes and liver enzymes. This means these indicators can reflect different physiological reactions to systemic disease.

Generally, the research indicates that imbalances in electrolytes as well as changes in the enzymes of the liver play a significant role in infants suffering from pneumonia, being directly related to disease severity. The regular assessment of such parameters will help in detecting potential risks at an early stage.

Limitations of the Study

The following limitations can be identified:

- The research used the single-center approach, which can limit the possibility of generalization of results;
- The cross-sectional design makes it impossible to identify the cause-and-effect relationship and make assessments from a temporal point of view;
- The results are based only on single-time measurements in the laboratory;
- Significant aspects, such as nutrition and hydration, were not considered.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Recommendations

- Electrolytes and liver enzyme status should routinely be monitored in babies with pneumonia, particularly if their condition is moderate to severe.
- Recognizing and rectifying electrolyte imbalance early on may help in preventing possible complications.
- Testing the liver function should form part of the general clinical evaluation of cases of pneumonia.
- Further multicenter and longitudinal studies are recommended to validate and expand upon these findings.

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