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CLINICO-HEMATOLOGICAL AND ETIOLOGICAL PROFILE OF BICYTOPENIA AND PANCYTOPENIA IN CHILDREN: A HOSPITAL-BASED OBSERVATIONAL STUDY

Paediatric Medicine

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ABSTRACT

Background: Cytopenias are among the most significant hematological abnormalities encountered in pediatric practice. They often indicate underlying systemic, nutritional, infectious, or malignant disorders. Bicytopenia and pancytopenia, in particular, serve as crucial diagnostic markers. This study aims to analyze their clinical manifestations and etiological spectrum. **Methods:** A two-year descriptive observational study was conducted among 103 hospitalized children aged 6 months–18 years presenting with bicytopenia or pancytopenia. Clinical examination, hematological indices, peripheral smear morphology, biochemical investigations, and bone marrow findings were systematically evaluated. **Results:** Bicytopenia accounted for 85.4% of cases, while pancytopenia constituted 14.6%. Nutritional etiologies (21.4%) were the most frequent, followed by aplastic anemia (17.5%), infections (16.5%), autoimmune disorders (13.6%), hypersplenism (12.6%), and malignancies (10.7%). **Conclusion:** Most etiologies were preventable and reversible, highlighting the importance of early diagnosis and structured evaluation to reduce morbidity.

KEYWORDS

Bicytopenia, Pancytopenia, Aplastic anemia, Hypersplenism.

INTRODUCTION

Cytopenias represent one of the most frequent hematological abnormalities observed in pediatric hospital settings. They encompass reductions in one or more blood cell lines, with bicytopenia affecting any two cell lineages and pancytopenia characterized by simultaneous depression of all three hematopoietic cell lines: erythrocytes, leukocytes, and platelets. These conditions are clinically significant as they often serve as the first indication of underlying nutritional insufficiencies, infectious diseases, autoimmune dysfunction, bone marrow failure syndromes, or malignant infiltration. In children, physiological hematopoiesis undergoes age-related changes, making it essential to evaluate cytopenias using age-adjusted hematological norms [1].

The etiological patterns of cytopenias vary widely across geographical regions due to differences in nutritional status, prevalence of infectious diseases, environmental exposures, and healthcare access. Studies from low- and middle-income countries consistently highlight megaloblastic anemia, iron deficiency, malaria, dengue, and other infections as leading causes. Conversely, high-income settings report more autoimmune and malignant etiologies. Considering such regional variability, institution-specific studies become essential for guiding diagnostic priorities and clinical decision-making.

Clinically, cytopenias present with diverse manifestations depending on the affected lineage. Children with anemia often develop pallor, fatigue, tachycardia, or failure to thrive. Leukopenia predisposes to recurrent infections, while thrombocytopenia commonly results in petechiae, ecchymoses, and mucosal bleeding. The clinical complexity necessitates systematic evaluation, including complete blood count, peripheral smear, biochemical markers, and bone marrow assessment.

This study was undertaken to bridge existing data gaps by evaluating the clinico-hematological patterns and etiological spectrum of bicytopenia and pancytopenia in a tertiary pediatric hospital. By integrating clinical features, laboratory findings, and marrow morphology, we aim to provide a comprehensive understanding of these conditions.

MATERIALS AND METHODS

This descriptive observational study was conducted over a period of two years (July 2023-June 2025) in the pediatric department of a tertiary care hospital. The study included 103 children aged 6 months to 18 years who met the diagnostic criteria for either bicytopenia or pancytopenia, based on age-adjusted complete blood count (CBC) thresholds. Children who had received blood transfusions within the previous three months or whose parents declined consent were excluded.

For each participant, demographic characteristics, detailed medical history, and clinical examination findings were recorded. Hematological investigations included CBC, red cell indices, absolute neutrophil count, platelet count, and peripheral smear evaluation. Biochemical parameters such as liver function tests, renal function tests, lactate dehydrogenase, vitamin B12, folate, and iron profile were assessed. Bone marrow aspiration and biopsy were performed when indicated, particularly in cases with persistent cytopenias or suspicion of malignant or marrow failure disorders.

All data were entered into a structured proforma and analyzed using SPSS version 22. Categorical variables were expressed as percentages, while continuous variables were presented as mean ± standard deviation. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 103 children were included. The majority of participants presented with **bicytopenia**, accounting for **88 cases (85.4%),** making it the predominant hematological abnormality in the study population. The **mean age** was slightly higher in the pancytopenia group (10.60 ± 5.10 years) compared to the bicytopenia group (9.08 ± 4.87 years), which was not statistically significant ($p = 0.27$). The majority (38.8%) belonged to the 7–12year age group, followed by adolescents (31.1%) and young children aged 6 months–6 years (30.1%). Males constituted 53.4% of the study group. There was no significant difference in clinical features between bicytopenia and pancytopenia groups. **Total leukocyte count** was markedly lower in pancytopenia (6730.67 ± 2451.68 cells/μL) compared to bicytopenia (8241.42 ± 2279.83 cells/μL), showing a statistically significant difference ($p = 0.02$). **RBC count** was significantly higher in children with pancytopenia (4.41 ± 0.80 million/μL) than in those with bicytopenia (3.69 ± 0.92 million/μL), and this difference was statistically significant ($p < 0.001$). Moderate to severe anemia was observed in 92.2% of the cohort.) Both bicytopenia and pancytopenia groups had 4 cases of mild anemia (Hb 10-12gm/dl). In contrast, moderate anemia (Hb 7-9.9gm/dl), was predominantly seen in the bicytopenia group (41 vs. 7 cases), and severe anemia (Hb <7gm/dl) was also more common in bicytopenia (43 vs. 4 cases). The distribution differences were statistically significant ($\chi^2 = 9.458$, $p = 0.009$), indicating a meaningful association between hemoglobin category and cytopenia type. Neutropenia was present in nearly half the participants, with 18.4% showing severe neutropenia. Platelet counts were normal in most children, although thrombocytopenia was found in 12.6%.

Peripheral smear analysis revealed normocytic morphology in 19.4%,

hypocellular smears in 17.5%, spherocytes in 13.6%, target cells in 12.6%, reactive lymphocytes in 16.5%, macrocytes in 9.7%, and blast cells in 10.7% of children. Bone marrow examination showed markedly hypocellular marrow in 17.5%, reactive hypercellular marrow in 16.5%, erythroid hyperplasia in 13.6%, leukemic infiltration in 10.7%, megaloblastic hyperplasia in 9.7%, and maturation arrest patterns in 11.7%. Another significant difference was found in Alanine aminotransferase (ALT) enzyme level between pancytopenia (54.14 ± 34.30 U/L) compared to bicytopenia (36.82 ± 24.37 U/L), with a statistically significant difference (t value = -2.39, p = 0.02).

Etiologically, nutritional deficiencies-predominantly vitamin B12 and folate deficiency-were the most common cause (21.4%). Aplastic anemia accounted for 17.5%, infections for 16.5%, autoimmune disorders for 13.6%, hypersplenism for 12.6%, malignancies for 10.7%, and idiopathic cases for 7.8%. Bicytopenia significantly outnumbered pancytopenia (85.4% vs 14.6%).

Clinical outcomes showed complete recovery in 36.9%, partial recovery in 32%, and no improvement in 29.1%. Mortality was low at 1.9%, primarily among children with marrow failure or malignancy and majority had bicytopenia.

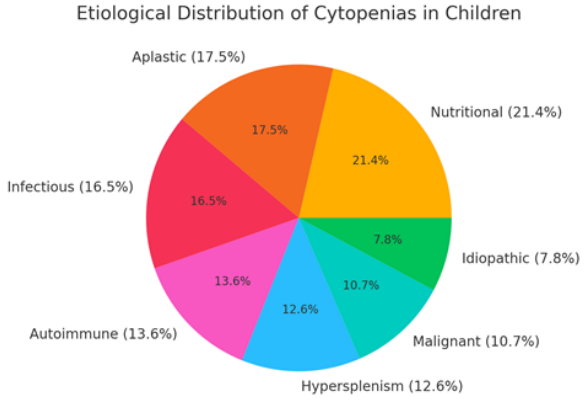

Figure 1. Etiological Distribution (Pie Chart)

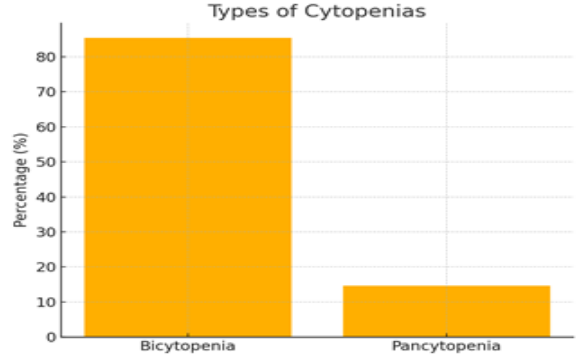

Figure 2. Types of Cytopenias (Bar Graph)

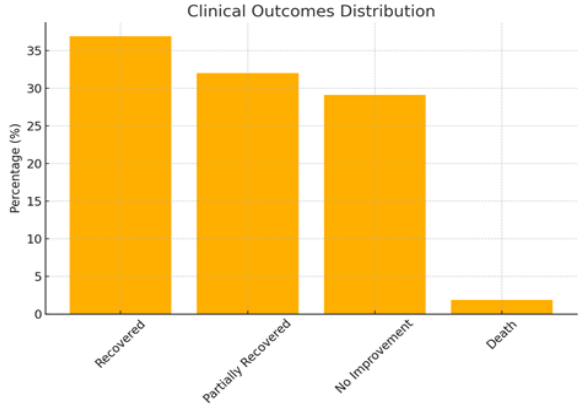

Figure 3. Clinical Outcomes (Bar Graph)

DISCUSSION

The findings of this study reaffirm that cytopenias in children frequently arise from reversible and treatable causes, most notably nutritional deficiencies, consistent with recent Indian and global pediatric hematology data [2,3]. Despite multiple nutritional programs, deficiencies in vitamin B12 and folate remain prevalent, as echoed in other studies by [4,5]. The relative predominance of bicytopenia suggests early clinical detection before full marrow suppression, paralleling findings from other studies [6,7].

Aplastic anemia emerged as the second most common etiology in this cohort, similar to another study [8]. This aligns with the pathophysiological patterns described in classic marrow failure literature [9]and regional studies from tertiary centers across South Asia. Its association with hypocellular marrow further underscores the necessity of early bone marrow evaluation, as recommended by Mahapatra et al [10].

Infectious etiologies-including viral, bacterial, and parasitic infections-also contributed significantly, mirroring recent data from African and South Asian pediatric studies [11]. Leukemic infiltration seen in 10.7% of children reinforces the importance of prompt diagnostic marrow evaluation, especially when peripheral smear findings are inconclusive.

Recovery patterns showed favorable outcomes for reversible etiologies, comparable to observations in multicenter studies across India and Southeast Asia [12]. The 29.1% non-improvement rate highlights persistent gaps in early detection and referral pathways, especially for marrow failure syndromes. Strengthened diagnostic algorithms, improved nutritional programs, and early referral to pediatric hematology units are essential steps to improve outcomes.

CONCLUSION

This study demonstrates that bicytopenia and pancytopenia in children result from a complex interplay of nutritional, infectious, autoimmune, marrow failure, and malignant causes. The predominance of reversible etiologies offers a strong opportunity for early intervention. Incorporating structured evaluation protocols—including CBC, smear morphology, biochemical markers, and bone marrow examination—is essential for timely diagnosis. Strengthening nutritional programs, improving infection control measures, and enhancing pediatric hematology services will contribute to better outcomes in children presenting with cytopenias.

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