

Role of Bone Marrow Examination in Pediatric Hematological Disorders: Clinico-Pathological StudySumeet Parakh¹, Satyen Gyani², Kritika Gyanchandani³, Rupesh Kumar Agrawal⁴¹Assistant Professor, Department of Paediatric, Abhishek I Mishra Memorial Medical College and Research, Durg, Chhattisgarh, India²Assistant Professor, Department of Paediatric, Abhishek I Mishra Memorial Medical College and Research, Durg, Chhattisgarh, India³Associate Professor, Department of Pathology, Abhishek I Mishra Memorial Medical College and Research, Durg, Chhattisgarh, India⁴Associate Professor, Department of Paediatric, Abhishek I Mishra Memorial Medical College and Research, Durg, Chhattisgarh, India

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Conflict of interest: Nil

Abstract**Background:** Bone marrow examination is a vital diagnostic modality in pediatric hematological disorders, especially when clinical and peripheral blood findings are inconclusive.**Objective:** To evaluate the role of bone marrow examination in diagnosing pediatric hematological disorders and to correlate clinical and pathological findings.**Methods:** This hospital-based cross-sectional study included 150 pediatric patients (0–18 years) with suspected hematological disorders. Bone marrow aspiration was performed and analyzed along with relevant clinical and laboratory parameters.**Results:** The majority of patients were in the 0–5 year's age group (30%) with male predominance (56%). The most common indication for bone marrow examination was unexplained anemia (28%), followed by pancytopenia (24%). Fever (60%) and pallor (38%) were the most common presenting symptom and sign, respectively. Nutritional anemia (28%) was the most frequent diagnosis, followed by acute leukemia (22%) and aplastic anemia (12%).**Conclusion:** Bone marrow examination is an indispensable diagnostic tool in pediatric hematology. It plays a crucial role in identifying both benign and malignant conditions, enabling early diagnosis, appropriate management, and improved outcomes in children.**Keywords:** Bone marrow examination; Pediatric hematological disorders; Nutritional anemia; acute leukemia; Cytopenias.**DOI:** 10.25258/ijcpr.18.4.120

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Introduction

Bone marrow examination is a fundamental diagnostic tool in the evaluation of pediatric hematological disorders, providing critical insights into both benign and malignant conditions. It is essential for the diagnosis of conditions such as anemia, leukemias, thrombocytopenia, and bone marrow failure syndromes because it permits direct evaluation of hematopoiesis [1].

Bone marrow analysis is essential for precise diagnosis and prompt treatment in children, whose clinical symptoms are frequently nonspecific [2]. Globally, pediatric hematological diseases account for a substantial share of childhood morbidity and mortality. Pallor, fever, bleeding tendencies, and

organomegaly are common overlapping clinical symptoms of conditions such as acute leukemias, aplastic anemia, nutritional anemias, and infections. Peripheral blood findings might not be enough in many situations, requiring bone marrow aspiration and biopsy for a conclusive diagnosis and categorization [3, 4]. Aspiration cytology and trephine biopsy are two methods of bone marrow testing that provide complementing information.

While a biopsy assesses marrow architecture, cellularity, fibrosis, and infiltration, aspiration offers information on cellular morphology and differential counts. When combined, these methods improve the accuracy of diagnosis, especially when

pancytopenia, unexplained cytopenias, and suspected cancers are involved [5, 6]. Furthermore, the diagnostic value of bone marrow evaluation is further enhanced by auxiliary methods including cytochemistry, immunophenotyping, cytogenetics, and molecular investigations. Acute leukemias, particularly acute lymphoblastic leukemia (ALL), are the most prevalent cancers identified by bone marrow testing in adolescent populations [7]. Prognosis and treatment results are greatly impacted by early and accurate diagnosis via marrow examination. Bone marrow tests are also crucial for hematological malignancy staging, therapy response monitoring, and relapse detection [8]. When done under the right circumstances, bone marrow examinations are generally safe and well tolerated in youngsters, despite their intrusive nature [9]. It is an essential study in pediatric hematology because its diagnostic yield exceeds the low procedural risks.

Aims & Objectives: The purpose of this study is to assess the utility of bone marrow examination in the diagnosis of different pediatric hematological illnesses and to establish a correlation between pathological outcomes and clinical findings in a tertiary care setting.

Materials and Methods

Study Design and Setting: This was a hospital-based, cross-sectional observational study conducted in the Department of Pathology in collaboration with the Department of Pediatrics at a tertiary care center. The study was carried out over a period of 24 months from January 2024 to December 2025.

Study Population: A total of 150 pediatric patients (age: 0–18 years) presenting with suspected hematological disorders and referred for bone marrow examination were enrolled in the study.

Inclusion Criteria

- Children aged 0–18 years with both gender
- Patients presenting with unexplained anemia, pancytopenia, persistent leukocytosis or leukopenia, thrombocytopenia or Suspected hematological malignancies
- Pyrexia of unknown origin with hematological abnormalities

- Patients in whom bone marrow aspiration/biopsy was clinically indicated

Exclusion Criteria

- Patients with bleeding disorders contraindicating bone marrow procedure
- Patients already diagnosed and on treatment for hematological malignancies
- Inadequate or poorly preserved bone marrow samples

Data Collection: Detailed clinical history and examination findings were recorded using a structured proforma, including Age, gender and Presenting complaints (fever, pallor, bleeding, weakness, organomegaly, etc.). Relevant laboratory investigations (complete blood count, peripheral smear findings and other) were done by standard laboratory methods.

Bone marrow aspiration was performed under strict aseptic precautions, commonly from the posterior superior iliac spine (or tibia in infants), after obtaining informed consent from parents/guardians. Bone marrow aspirate smears were prepared immediately. Smears were stained with Leishman stain and examined under light microscopy. Bone marrow cellularity, myeloid-to-erythroid (M:E) ratio, morphology of hematopoietic cells, and presence of abnormal cells were evaluated. In suspected malignancies, further investigations such as immunophenotyping and cytogenetic analysis were considered wherever feasible

Statistical Analysis: Data were entered and analyzed using Statistical Package for Social Sciences (SPSS) version 26. Results were expressed in frequency, percentage, mean, and standard deviation. Association between clinical and pathological findings was analyzed using appropriate statistical tests such as Chi-square test, with $p < 0.05$ considered statistically significant

Results: A total of 150 pediatric patients were included in the study. The majority of cases were observed in the 0–5 years age group (30.0%), followed by 6–10 years (26.7%). Gender-wise distribution showed a male predominance (56%) [Table: 1].

Table 1: Age and gender Distribution of Patients (n = 150)

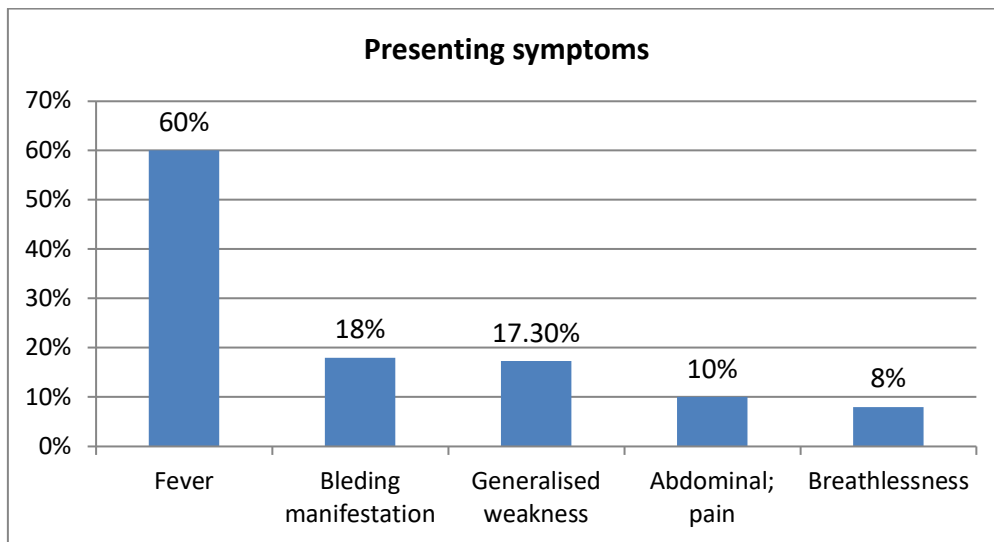
Age Group (years)	Number of Cases	Percentage (%)
0–5	45	30.0%
6–10	40	26.7%
11–15	38	25.3%
16–18	27	18.0%
Gender		
Male	84	56%
Female	66	44%

The most common indication for bone marrow examination was unexplained anemia (28.0%), followed by pancytopenia (24.0%) and suspected leukemia/malignancy (20.0%) [Table: 2]. This reflects that cytopenias and suspected malignancies were the primary clinical triggers for bone marrow evaluation.

Table 2: Indications for Bone Marrow Examination in Pediatric Patients (n = 150)

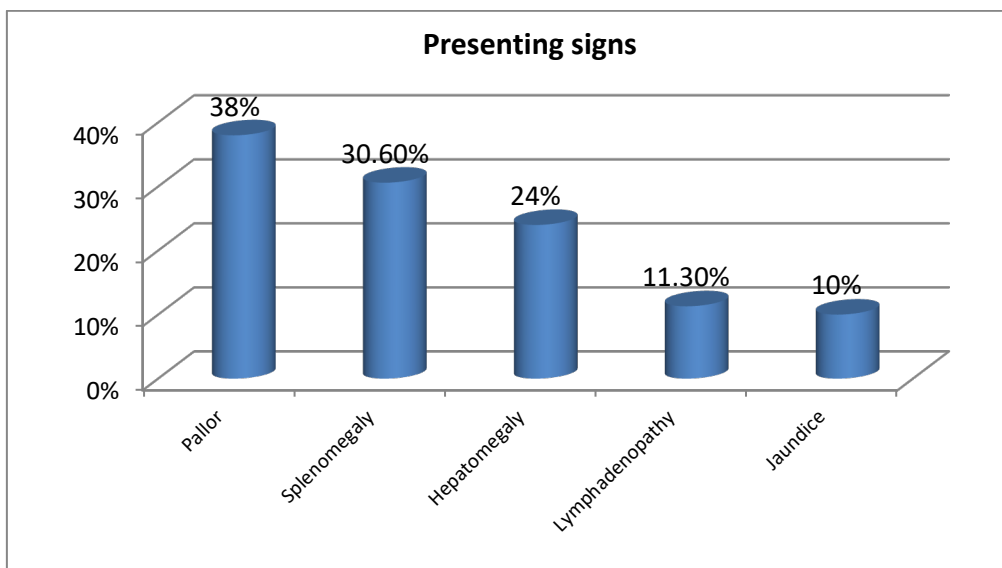
Indication	Number of Cases	Percentage (%)
Unexplained anemia	42	28.0%
Pancytopenia	36	24.0%
Suspected leukemia/malignancy	30	20.0%
Thrombocytopenia	18	12.0%
Pyrexia of unknown origin (PUO)	12	8.0%
Hepatosplenomegaly with cytopenias	7	4.7%
Unexplained leukocytosis/leukopenia	5	3.3%

The most common presenting symptom was fever (60%), followed by bleeding manifestations (18%) and generalized weakness (17.3%) [Graph: 1].



Graph 1: Distribution of main presenting symptoms

Among clinical signs, pallor was the most common finding (38%), followed by Splenomegaly (30.6%) and hepatomegaly (24%) [Graph: 2].



Graph 1: Distribution of main presenting signs

The most common diagnosis established on bone marrow examination was nutritional anemia (28.0%), followed by acute leukemia (22.0%) and

aplastic anemia (12.0%) [Table: 3]. This demonstrates that non-malignant conditions, particularly nutritional anemia, constituted the

largest group, although malignancies like acute leukemia formed a significant proportion,

underscoring the importance of bone marrow examination in early diagnosis.

Table 3: Spectrum of Hematological Disorders

Diagnosis	Number of Cases	Percentage (%)
Nutritional anemia	42	28.0%
Acute leukemia	33	22.0%
Aplastic anemia	18	12.0%
Immune thrombocytopenic purpura (ITP)	16	10.6%
Infective etiology	13	8.7%
Marrow in lymphoma	6	4.0%
Others	22	14.7%

Discussion

The present study evaluated the role of bone marrow examination in pediatric hematological disorders, highlighting its diagnostic utility across a wide spectrum of conditions. The findings emphasize that bone marrow examination remains an indispensable tool for definitive diagnosis, particularly in cases with nonspecific clinical and hematological presentations.

In this study, the highest proportion of patients belonged to the 0–5 years age group, with a male predominance, this pattern is consistent with previous studies Jain et al [5] and Lalita Y, et al [10], which report higher vulnerability of younger children to hematological disorders due to nutritional deficiencies and increased incidence of acute leukemias in early childhood.

Unexplained anemia emerged as the most common indication for bone marrow examination, followed by pancytopenia and suspected leukemia. These findings align with studies by Khan SP et al [11] and Atla B, et al [12]. Cytopenias often represent underlying marrow pathology, including nutritional deficiencies, marrow failure, or malignancy, necessitating direct marrow assessment for accurate diagnosis. In the present study fever was the most common presenting symptom, followed by bleeding manifestations and generalized weakness. Pallor was the most frequent clinical sign, followed by Splenomegaly and hepatomegaly. These findings are similar with the Balasubramanian M, et al [13] and Kumar V, et al [14], where nonspecific symptoms like fever and pallor are common across both benign and malignant conditions. The high frequency of fever also reflects the inclusion of infective etiologies and malignancies in the study population.

The most common diagnosis in the present study was nutritional anemia, followed by acute leukemia and aplastic anemia. The predominance of nutritional anemia highlights the continued burden of micronutrient deficiencies in developing countries, particularly iron, vitamin B12, and folate deficiencies. Similar findings have been reported by Sharma et al [5] and Malviy P, et al [15],

identified nutritional anemia as a leading cause of bone marrow examination in children. Acute leukemia was the second most common diagnosis, underscoring the importance of bone marrow examination in early detection of pediatric malignancies. Acute lymphoblastic leukemia (ALL) is known to be the most common childhood cancer, and bone marrow evaluation is essential not only for diagnosis but also for classification and prognostication [8].

Aplastic anemia and immune thrombocytopenic purpura were also significant contributors to the disease spectrum. Bone marrow examination plays a crucial role in differentiating aplastic anemia from other causes of pancytopenia and in confirming diagnoses like ITP. These findings are in concordance with previous studies Bhatnagar, et al [6] and Hossain MJ, et al [16], highlighting the diagnostic value of marrow examination in cytopenic disorders.

Infective etiologies and marrow involvement in lymphoma further demonstrate the broad applicability of bone marrow examination beyond primary hematological diseases [9]. Bone marrow assessment is particularly valuable in cases of pyrexia of unknown origin (PUO) and suspected systemic infections, where it can reveal infiltrative or granulomatous pathology.

Conclusion

Bone marrow examination is a crucial diagnostic tool in pediatric hematological disorders, particularly in cases of unexplained cytopenias and suspected malignancies. Nutritional anemia was the most common finding, while a significant proportion of cases included acute leukemia and other serious conditions. The study highlights that bone marrow evaluation provides definitive diagnosis when clinical and peripheral findings are inconclusive. Overall, it plays a key role in early diagnosis, guiding treatment, and improving outcomes in children.

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