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RESEARCH ARTICLE

# Bone Marrow Examination in Pancytopenia: Patterns, Causes, and Clinical Correlation in Indian Patients

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## ABSTRACT

**Background:** Pancytopenia is a hematological condition characterized by reduction in all three cellular components of blood and often indicates underlying bone marrow pathology. Bone marrow examination remains a cornerstone in diagnosis.

**Objective:** To evaluate bone marrow findings in pancytopenia and correlate with clinical and hematological parameters in Indian patients.

**Methods:** This retrospective study included 300 patients diagnosed with pancytopenia between October 2023 and September 2025 at the Department of Pathology, M.K.C.G Medical College, Berhampur, Odisha. Clinical data, hematological parameters, and bone marrow findings were analyzed. Statistical analysis was performed using SPSS.

**Results:** Megaloblastic anemia was the most common cause (36%), followed by aplastic anemia (22%), acute leukemia (14%), and hypersplenism (10%). Significant associations were observed between etiology and hemoglobin levels and mean corpuscular volume.

**Conclusion:** Bone marrow examination is essential for accurate diagnosis of pancytopenia. Nutritional causes remain predominant in Indian settings, highlighting the need for early intervention.

**Keywords:** Pancytopenia, Bone marrow, Megaloblastic anemia, Aplastic anemia.

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## Introduction

Pancytopenia is defined as a reduction in hemoglobin concentration, leukocyte count, and platelet count below normal reference ranges and represents a manifestation of diverse underlying pathological processes rather than a disease entity itself (1). The etiological spectrum ranges from reversible nutritional deficiencies to life-threatening hematological malignancies (2).

In developing countries such as India, nutritional anemia—particularly vitamin B12 and folate deficiency—remains a leading cause, whereas in developed nations, bone marrow failure syndromes and malignancies are more prevalent (3,4). Bone marrow examination plays a pivotal role in establishing diagnosis, especially when peripheral smear findings are inconclusive (5).

The pathophysiology of pancytopenia involves decreased production, increased destruction, or sequestration of blood cells (6). Bone marrow aspiration and biopsy provide valuable insight into cellular morphology, marrow cellularity, and infiltration patterns (7).

Previous studies have demonstrated varied etiological patterns depending on geographic and socioeconomic factors (8–10). Understanding these patterns is essential for timely diagnosis and management.

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This study aims to analyze bone marrow findings in pancytopenia and correlate them with clinical and hematological parameters in an Indian tertiary care setting.

## Materials and Methods

### Study Design

Retrospective observational study.

### Study Setting

Department of Pathology, M.K.C.G Medical College and Hospital, Berhampur, Odisha.

### Study Duration

October 2023 to September 2025.

### Sample Size

300 cases.

### Inclusion Criteria

- Patients diagnosed with pancytopenia
- All age groups

### Exclusion Criteria

- Incomplete records
- Prior chemotherapy

## Statistical Analysis

Data analyzed using SPSS v25. Chi-square test applied. $p<0.05$ considered significant.

## Results

A total of 300 patients diagnosed with pancytopenia were included in the study.

### Demographic Profile

The majority of cases were in the 21–40 years age group (40%). There was a slight male predominance in the study group.

Table 1 summarizes the age-wise distribution of cases.

As illustrated in Figure 1, the majority of patients belonged to the young adult population.

### Etiological Distribution

Bone marrow examination revealed that megaloblastic anemia was the most common etiology (36%). The distribution of etiological causes is shown in Table 2.

A graphical representation of etiological distribution is shown in Figure 2.

### Hematological Parameters

The mean hematological values of the study population are summarized in Table 3.

Patients with megaloblastic anemia showed significantly higher MCV values compared to other groups.

**Table 1:** Age-wise distribution of pancytopenia cases (n = 300)

| *Age group (years)* | *Number of cases* | *Percentage (%)* |
|---|---|---|
| <20 | 60 | 20% |
| 21–40 | 120 | 40% |
| 41–60 | 75 | 25% |
| >60 | 45 | 15% |

**Table 2:** Etiological distribution of pancytopenia (n = 300)

| *Etiology* | *Number of cases* | *Percentage (%)* |
|---|---|---|
| Megaloblastic anemia | 108 | 36% |
| Aplastic anemia | 66 | 22% |
| Acute leukemia | 42 | 14% |
| Hypersplenism | 30 | 10% |
| Others | 54 | 18% |

**Table 3:** Hematological parameters in pancytopenia patients

| *Parameter* | *Mean ± SD* |
|---|---|
| Hemoglobin (g/dL) | 6.8 ± 1.5 |
| TLC ($\times 10^9$/L) | 2.5 ± 0.8 |
| Platelet count ($\times 10^9$/L) | 75 ± 30 |
| MCV (fL) | 102 ± 12 |

### Bone Marrow Findings

Bone marrow examination revealed:

- Hypercellular marrow in megaloblastic anemia cases
- Hypocellular marrow in aplastic anemia
- Marrow infiltration/blasts in leukemia

These findings are summarized in Table 4.

### Statistical Analysis

Statistical analysis showed significant associations between etiology and hematological parameters:

- Hemoglobin levels varied significantly across etiologies ($p < 0.001$)
- Mean corpuscular volume (MCV) showed strong association with megaloblastic anemia ($p < 0.001$)
- Platelet count differences were statistically significant ($p = 0.02$)

Chi-square analysis demonstrated a significant association between bone marrow diagnosis and MCV category ($\chi^2 = 32.6$, $df = 4$, $p < 0.001$).

## Discussion

The present study highlights megaloblastic anemia as the most common cause of pancytopenia, consistent with findings from other Indian studies (11–13). Nutritional deficiencies remain prevalent due to dietary habits and socioeconomic factors (14).

Aplastic anemia was the second most common cause, aligning with previous reports (15,16). Bone marrow examination revealed hypocellularity in these cases, confirming diagnosis.

Acute leukemia constituted a significant proportion, emphasizing the importance of early bone marrow evaluation (17). Morphological analysis remains crucial in resource-limited settings (18).

**Table 4:** Bone marrow cellularity patterns

| *Diagnosis* | *Cellularity pattern* | *Key morphological features* |
|---|---|---|
| Megaloblastic anemia | Hypercellular | Megaloblastic erythropoiesis, nuclear-cytoplasmic asynchrony |
| Aplastic anemia | Hypocellular | Marked reduction in hematopoietic cells, fatty marrow |
| Acute leukemia | Hypercellular | Presence of blasts, suppressed normal hematopoiesis |
| Hypersplenism | Normocellular | Normal marrow with peripheral destruction |

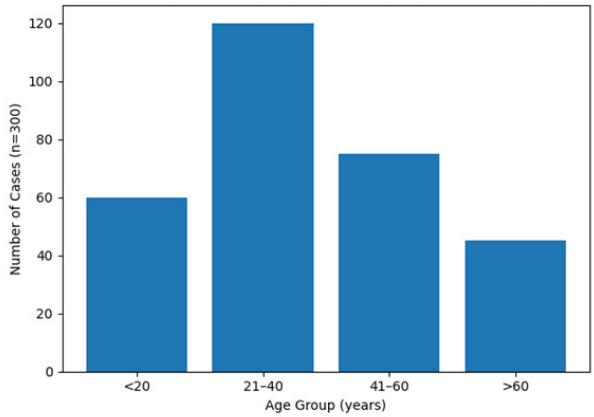


**Figure 1:** Age-wise distribution of pancytopenia cases

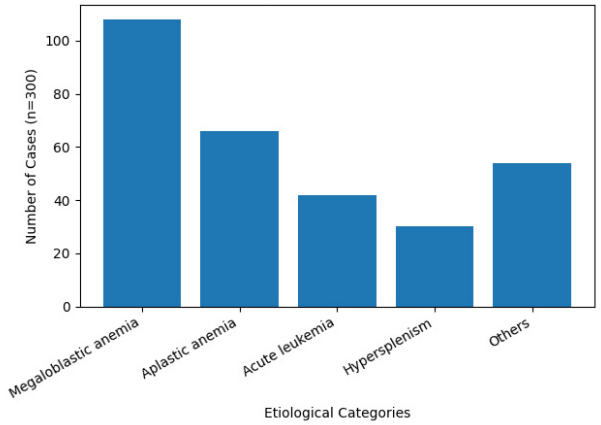


**Figure 2:** Etiological distribution of pancytopenia

Statistically significant correlation between MCV and megaloblastic anemia supports its diagnostic utility (19). Similarly, thrombocytopenia severity varied significantly across etiologies (20).

Comparisons with global studies reveal differences in etiological patterns, highlighting regional variability (21–23). Early diagnosis through bone marrow examination can significantly improve outcomes (24,25).

## Conclusion

Bone marrow examination is indispensable in evaluating pancytopenia. Megaloblastic anemia remains the leading cause in Indian patients. Early diagnosis and intervention can reduce morbidity and mortality.

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