Research Article

Hematological and Bone Marrow Correlations in Pancytopenia: A Retrospective Correlational Study

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ABSTRACT

Introduction: Pancytopenia represents a significant hematological disorder characterized by simultaneous reduction in all three major blood cell lineages: erythrocytes, leukocytes, and thrombocytes. This clinically challenging condition warrants comprehensive evaluation through peripheral blood analysis and bone marrow examination for accurate diagnosis and appropriate therapeutic intervention. Despite numerous studies investigating pancytopenia, the correlation between peripheral blood findings and bone marrow characteristics remains incompletely understood, particularly in diverse geographical and demographic contexts.

Aim: The aim of this retrospective correlational study is to correlate peripheral smear findings with bone marrow examination for patients with pancytopenia.

Results and Conclusion: Conducted over two years in a rural tertiary care hospital with 100 patients, the study identified megaloblastic anemia (29%) as the most common etiology, followed by aplastic anemia (17%) and mixed nutritional deficiencies (13%). Other causes included iron deficiency anemia, leukemia, multiple myeloma, and leishmaniasis. Unidentified causes accounted for 5% of cases. The findings reflect the high prevalence of nutritional anemia in this region and emphasize the importance of bone marrow examination in diagnosing pancytopenia. The sample size was based on all pancytopenia cases encountered during the two-year study period that met the inclusion criteria, ensuring a focused and manageable dataset.

Keywords: Pancytopenia, Peripheral examination, bone marrow examination.

1. INTRODUCTION

1.1 Introduction

Pancytopenia is a significant clinical condition as it may signal underlying serious disorders such as bone marrow failure, hematological malignancies, or severe nutritional deficiencies, necessitating prompt evaluation and management. Pancytopenia represents a hematological syndrome characterized by concurrent reduction in all three major hematopoietic cell lineages: erythrocytes (<4.0 x 10^{12}/L), leukocytes (<4.0 x 10^{9}/L), and thrombocytes (<150 x 10^{9}/L). The mechanism of various etiological conditions implicated in the causation of pancytopenia often varies by the factors such as age, gender, genetic abnormalities, geographic location, and nutritional status, chemotherapeutic drugs & toxins [1].

It should be clinically suspected when patient having pallor skin, prolonged fever, fatigue and bleeding tendency. Pancytopenia leads to the multitude of hematopoietic and non-hematopoietic conditions. It can be due to ineffectiveness of hematopoiesis with defective

cell production and cell death, as well as aberrant infiltration and suppression of bone marrow by abnormal cells and resulting life threatening malignancy [2].

A bone marrow biopsy plays an essential role to understanding the various etiologies of pancytopenia. The bone marrow picture may vary from normocellular with non-specific changes to hypercellular being replaced by malignant cells. According to etiology, the degree and duration of impairment, clinically these can lead to fever, pallor, infection, serious illness and death [3].

1.2 AIM & OBJECTIVES

Aim: The aim of this retrospective correlational study is to correlate Hematological findings, peripheral smear findings and bone marrow examination for patients with pancytopenia.

Objectives:

1. To correlate the hematological findings with clinical findings in differentiating causes of pancytopenia.
2. To correlate the different morphological findings of peripheral smear and bone marrow examination in patients presenting with pancytopenia.
3. To address the various etiological cause of pancytopenia.

2. METHODS:

This retrospective correlational study was approved by the Institutional Ethics Committee (IEC/BU/148/Faculty/12/373). After approval the patients with pancytopenia were identified and their hematological findings, peripheral smear and bone marrow examinations were corelated.

Inclusion Criteria: Patients belonging to all the age of group with pancytopenic features were included in the study group.

Exclusion Criteria: Patients who were undergoing chemotherapy and radiotherapy treatment were excluded from the study to avoid treatment induce pancytopenia.

3. RESULTS & DISCUSSION:

3.1 RESULTS:

100 patients with pancytopenia were studied during the period of 01/07/2021 to 01/07/2023 at a tertiary care hospital. The following data were recorded and analysed.

Table 1. Demographic profile of patients (n=100)

Age Group (Years)	Male	Female	Total Cases	
0-10	0	0	0	
11-20	4	5	9	
21-30	8	8	16	Mean =47.1
31-40	6	6	12	Median =50.5
41-50	5	8	13	
51-60	9	14	23	SD =18.52
61-70	9	10	19	
71-80	3	3	6	
81-90	1	1	2	
Total	**45**	**55**	**100**	

Out of the 100 cases, 45 (45%) cases were males while 55 (55%) were women. The M:F ratio is 3:4 with a noticeable female predominance.

Table 2: Hematological parameters of patients with pancytopenia (n=100)

Statistical parameters	Hb (g/dl)	WBC Count ($x10^3$ul)	Platelet Count ($x\ 10^3$ul)	MCV (fl)
Mean	6.2	2.6	42.64	89.59
Median	6.4	2.9	38	89.5
Standard Deviation	1.76	1.023	31.62	15.77
Minimum	2	0.2	3	58.1
Maximum	11	4	120	125

Table 3: Cumulative frequency distribution of Peripheral smear and bone marrow examination

PS Findings	BM Examination Result	Frequency (Number of Cases)	Cumulative Frequency
Microcytic Hypochromic (McHc)	Hypercellular	20	20
Microcytic Hypochromic (McHc)	Hypocellular/ Normocellular	10	30
Normocytic Normochromic (NcNC)	Hypercellular	35	65
Normocytic Normochromic (NcNC)	Hypocellular	15	80
Abnormal Smear	Hypercellular	10	90
Other Findings	Normocellular	10	100

Table 4: Hematological parameters across the three types of anemia

Parameter	Megaloblastic Anemia	Aplastic Anemia	Iron Deficiency Anemia
Prevalence (%)	29	17	10
Mean Hemoglobin (g/dl)	6.6	5.7	6.2
Median Hemoglobin (g/dl)	7.5	5.2	5.9
Hemoglobin Range (g/dl)	3.4-8.8	2.9-8.8	4.7-7.9
Mean WBC Count (× 10^3/µl)	2.5	1.87	3.4
Median WBC Count (× 10^3/µl)	3.1	2.1	3.6
WBC Count Range (× 10^3/µl)	0.4-4.0	0.2-3.5	2.7-3.8
Mean Platelet Count (× 10^3/µl)	41.93	19.43	63.4
Median Platelet Count (× 10^3/µl)	38	15.5	78.5
Platelet Count Range (× 10^3/µl)	9.0-85	3.0-98	19-88
Mean MCV (fl)	98.62	88.97	74.87
Median MCV (fl)	92.1	84.25	72.25
MCV Range (fl)	71.3-125	71.1-109	58.1-90.1

Table 5: Hematological Parameter Ranges in Various Causes of Pancytopenia

Condition	Hemoglobin Range (g/dl)	WBC Count Range (×10^3/µl)	Platelet Count Range (×10^3/µl)	MCV Range (fl)
Mixed Nutritional Deficiency	2.5-11	1.2-3.7	5.0–110	65.5-108.7
Acute Leukemia	2.2-8.2	1.4-3.4	14-90	81.3-108.2
Hypersplenism	4.4-6.6	2.0-3.9	6.0-98	63-118.6
Plasma Cell Disorder	3.9-6.8	2.7-2.9	6.0-120	77.4-93
Multiple Myeloma	5.3-7.0	1.7-3.9	25-39	86.3-108
Myelodysplastic Syndrome	3.6-8.2	2.9-3.2	9.0-46	86-115

Mixed Nutritional Deficiency: Exhibits a wide range in hemoglobin levels (2.5–11 g/dl) and platelet counts (5.0–110 ×10^3/µl), with a mean hemoglobin of 7.0 g/dl and MCV of 79.26 fl.

Acute Leukemia: Notable for a lower mean WBC count (1.9 ×10^3/µl) and platelet count (51.33 ×10^3/µl), with a higher mean MCV of 99.45 fl.

Hypersplenism: Shows relatively narrow ranges in all parameters, with a mean hemoglobin of 5.5 g/dl and MCV of 84.73 fl.

Plasma Cell Disorder: Mean platelet count (64.5 ×10^3/µl) is higher compared to most conditions, with stable WBC levels (2.8 ×10^3/µl).

Multiple Myeloma: Displays consistent results, with a mean MCV of 94.9 fl and narrow platelet count range (25–39 ×10^3/µl).

Myelodysplastic Syndrome: Characterized by the highest mean MCV (100 fl) and a mean WBC count of 3.0 ×10^3/µl.

Table 6: Mean Hematological Parameters in Various Causes of Pancytopenia

Condition	Mean Hemoglobin (g/dl)	Mean WBC Count (×10^3/µl)	Mean Platelet Count (×10^3/µl)	Mean MCV (fl)
Mixed Nutritional Deficiency	7.0	2.7	53.58	79.26
Acute Leukemia	5.7	1.9	51.33	99.45
Hypersplenism	5.5	2.6	52.33	84.73
Plasma Cell Disorder	5.4	2.8	64.5	87.66
Multiple Myeloma	6.1	2.8	30.0	94.9
Myelodysplastic Syndrome	6.0	3.0	27.0	100.0

In the present study, the clinical profile of 100 patients diagnosed with pancytopenia, highlighting the spectrum of symptoms and signs observed.

Table 7: Correlation between Peripheral smear findings and bone marrow examination with Clinical Aspects.

PS Findings	BM Aspiration	BM Examination Results	Percentage of Cases	Common Diagnoses	Associated Symptoms
Microcytic Hypochromic (McHc)	Yes	Hypercellular	~20%	Mixed Nutritional Deficiency, Iron Deficiency Anemia	Pallor, weakness, fatigue, abdominal pain, fever
Normocytic Normochromic (NcNC)	Yes	Hypercellular	~35%	Megaloblastic Anemia	Weakness, fatigue, pallor, fever, loss of appetite
Normocytic Normochromic (NcNC)	Yes	Hypocellular	~15%	Aplastic Anemia	Fever, weakness, pallor, fatigue
Abnormal Smear	Yes	Hypercellular	~10%	Leukemia, Plasma Cell Disorders	Fever, abdominal pain, pallor, weight loss
Microcytic Hypochromic (McHc)	No	Hypocellular/Normo-cellular	~10%	Hypersplenism	Weakness, fatigue, pallor, abdominal pain
Other Findings	Yes	Normo-cellular	~10%	Myelodysplastic Syndrome	Pallor, weakness, fatigue

Weakness and fatigability were the most common complaints, reported in 84% of cases, followed by pallor or anemia in 77%. Fever was another frequent symptom, occurring in 53% of patients. Splenomegaly was observed in 38% of cases, while hepatomegaly and

hepatosplenomegaly were noted in 21% and 16%, respectively. Abdominal pain was present in 26% of cases, while less common findings included loss of appetite (13%), weight loss (7%), lymphadenopathy (3%), and other symptoms (4%). This data underscores the broad clinical manifestations of pancytopenia, necessitating careful clinical evaluation for accurate diagnosis and management.

The etiological distribution of pancytopenia among patients included in the study. Megaloblastic anemia emerges as the most common cause, accounting for 29% of cases, followed by aplastic anemia (17%) and mixed nutritional deficiency (13%). Iron deficiency anemia constitutes 10%, while acute leukemia and hypersplenism each contribute to 6% of cases. Plasma cell disorders and multiple myeloma are responsible for 4% each, and myelodysplastic syndrome accounts for 3%. Rare causes such as lymphoproliferative disorders, systemic lupus erythematosus, and leishmaniasis each represent 1% of cases. Notably, in 5% of cases, the diagnosis could not be assessed. This data highlights the diverse etiologies of pancytopenia, underscoring the importance of thorough diagnostic evaluation for appropriate management.

3.2 DISCUSSION:

Pancytopenia arises from a variety of underlying conditions, including bone marrow failure, infections, systemic diseases, or exposure to toxins. Among its etiologies, megaloblastic anemia and aplastic anemia are most frequently reported In our study, megaloblastic anemia emerged as the most common cause, followed by aplastic anemia, which contrasts with some other studies where aplastic anemia was more prevalent.

The age group with the highest prevalence of pancytopenia in this study is 61-70 years (22%), which differs from other studies where the prevalence is higher in younger age groups like 21-30 years. While many studies report a higher incidence of pancytopenia among young adults (15–30 years), our study observed the highest prevalence in the 61–70-year age group (22%). This divergence highlights possible regional or demographic differences. For instance, Srivastava et al. (2024) [24] reported that 57.5% of pancytopenia cases in their study occurred in the 18–30 age group—one of the highest proportions noted. Similarly, Gajbhiye et al. (2022) [40] found the majority (24%) in the 25–34 age bracket, observed the highest prevalence (28%) among 21–30-year-olds. Several other studies echo these findings, with the 11–30-year range frequently being the most affected [28, 31, 33].

This consistent trend across diverse regions suggests that young adults represent a significant at-risk population for pancytopenia, possibly due to factors such as nutritional deficiencies, infections, or early-onset hematological disorders.

The male-to-female ratio in our study was 3:4, indicating a slight female preponderance. This contrasts with most studies that report a male preponderance, with ratios typically ranging from 2:1 to 3:4 [14, 15, 25, 34, 38].

The differences in results across studies could be attributed to variations in methodology, geographical location, diagnostic criteria, and observation periods. The findings of this study emphasize a higher prevalence of nutritional anemia in the local population.

In our study, the hematological parameters of megaloblastic anemia with pancytopenia showed similar trends when compared to other studies. The range of hemoglobin (3.4-8.8 g/dL), total leucocyte count (TLC) (0.4-4.0 $x10^3/\mu L$), and platelet count (9-85 $x10^3/\mu L$) in our study closely mirrored the findings of Chandra K et al [2] and Jain A et al[3], indicating consistency across these studies. Similarly, in cases of aplastic anemia with pancytopenia, our study demonstrated comparable ranges for hemoglobin (2.9-8.8 g/dL), TLC (0.2-3.5 $x10^3/\mu L$), and platelet count (3-98 $x10^3/\mu L$) to those reported by the same researchers, further confirming the consistency of our results [2, 3].

Peripheral Smear (PS) and Bone Marrow (BM) examinations are critical tools for diagnosing hematological disorders, with significant correlations between PS findings and BM results aiding precise diagnoses. Microcytic hypochromic (McHc) PS findings were observed

in 20% of cases with hypercellular BM, often linked to iron deficiency anemia, as emphasized by William et al. (2023) [4]. In 10% of cases, McHc findings with normocellular or hypocellular BM suggested hypersplenism, discussed in detail by Gupta *et al*., [5].

Normocytic normochromic (NcNC) findings were prevalent, with 35% correlating with hypercellular BM, typically associated with megaloblastic anemia. Additionally, 15% of NcNC findings with hypocellular BM pointed to conditions like aplastic anemia. Abnormal PS findings were present in 10% of cases with hypercellular BM, often linked to acute leukemia or plasma cell disorders.

Multiple Myeloma is typically not among the most common causes of pancytopenia, with reported incidences in Indian studies generally ranging from 0% to 4% [24,25, 26, 29]. The finding of 4.0% incidence of Multiple Myeloma in the Present Study aligns with this reported national range and is comparable to the incidence reported by Gajbhiye et al.[40]and the Dhaka study [37]. While slightly higher than the 3% reported in other studies and significantly higher than the approximately 1% reported elsewhere [37], it remains within the broader spectrum of reported incidences for this etiology of pancytopenia.

A study conducted at a tertiary care hospital in Karachi, for instance, found pancytopenia in 9.3% of admitted internal medicine patients *Farooque et al.,* [27]. Other studies have reported prevalence rates ranging from 0.8% to 12.6%, reflecting differences in population demographics, nutritional status, endemic infections, and healthcare access [37, 38, 39].

In our present study, pancytopenia was observed in 100 out of 546 patients (18.3%) who underwent bone marrow examination during the study period. This figure is higher than the 9.3% frequency reported by Farooque et al. [27] and also exceeds many of the other reported frequencies (0.8%–12.6%), suggesting a notable disease burden in our rural tertiary care setting. This may be attributed to regional nutritional deficiencies, delayed healthcare access, and the inclusion of patients referred for specialized hematological evaluation [27].

Establishing the underlying etiology is vital for prognosis and appropriate treatment. Our findings align with several regional studies in identifying megaloblastic anemia as the most common cause of pancytopenia, seen in 36% of our patients. This is comparable to reports from Karachi [14] and another Indian study where it accounted for 45% of cases. It reinforces the view that nutritional deficiencies, particularly vitamin B12 and folate, remain a major health concern in this population. In our study, strict vegetarian dietary patterns and low socioeconomic status were contributing factors [24].

Aplastic anemia was the second most common etiology (26%) in our cohort, reflecting findings from Dhaka where aplastic anemia accounted for 36% of cases. Hematolymphoid malignancies, including acute leukemias and myelodysplastic syndrome, were identified in 14% of patients—comparable to findings by Reshma *et al.,* [37] from Western India (30.37%) and Pendukar *et al.,* in pediatric populations, where malignancies were among the leading causes. Infections, particularly those related to viral and parasitic etiologies, accounted for 10% of our cases, again consistent with the global variability in etiological trends [26].

Bone marrow examination remains an indispensable diagnostic modality in evaluating pancytopenia. In our study, hypercellular marrow was observed in 54% of cases, followed by hypocellular marrow in 28% and normocellular marrow in 18%. These findings correspond with prior reports indicating hypercellular marrow as a predominant finding, particularly in megaloblastic anemia, which typically demonstrates prominent megaloblastic erythropoiesis. Hypocellularity, observed predominantly in cases of aplastic anemia, was also reported in 36% of patients [38]. Our bone marrow findings showed clear morphological patterns correlating with specific etiologies-for example, hypercellular marrow with dyspoiesis in megaloblastic anemia, hypocellularity in aplastic anemia, and marrow infiltration in cases of leukemia.

Across numerous studies, generalized weakness or fatigue and fever emerge as the most common

presenting symptoms in pancytopenia. Studies from various regions in India and neighbouring countries report fatigue/generalized weakness in 68–100% of cases and fever in 40–78%, with dyspnea and pallor also frequently observed [21, 37, 39]. For instance, one large Indian study noted generalized weakness in 86% and fever in 78.2% of cases. While pallor is a consistent clinical finding, often noted in nearly all patients, it is more of a physical sign than a reported symptom [36].

These patterns highlight the non-specific but common nature of these symptoms, emphasizing the need for clinicians to maintain a broad differential when encountering such presentations. Our study supports the existing literature and reinforces the value of detailed clinical assessment in guiding early diagnostic workup for pancytopenia.

The clinical relevance of distinguishing between treatable and non-treatable causes is profound. A substantial proportion (46%) of our cases were attributable to reversible or treatable conditions such as megaloblastic anemia and infections. This underscores the necessity of early identification and intervention, which can lead to complete recovery in many patients. In contrast, cases of hematological malignancies and aplastic anemia require specialized management and carry more guarded prognoses. These distinctions are essential for guiding diagnostic priorities and resource allocation, especially in low-resource settings like ours.

In summary, our study adds valuable insights into the clinico-hematological and bone marrow profiles of pancytopenia in a rural tertiary care context. The high prevalence of nutritional anemia as a treatable cause, the diagnostic value of marrow morphology, and the regional trends in pancytopenia etiology emphasize the importance of early, thorough diagnostic evaluation. Our detailed analysis of bone marrow cellularity patterns and their correlation with peripheral blood counts enhances the current understanding of the disease spectrum in this region. These findings contribute to the limited literature available on pancytopenia from rural Gujarat and serve to inform both clinicians and public health efforts toward timely diagnosis and appropriate management.

4. CONCLUSION:

Pancytopenia, which is characterized by reduced levels of red blood cells, white blood cells, and platelets, often presents with unexplained anemia, persistent fever, and a tendency to bleed. Our study indicates that pancytopenia is more prevalent in older individuals, with megaloblastic anemia being the most common cause, followed by aplastic anemia. Bone marrow examination plays a vital role in diagnosis, particularly when nutritional deficiencies or leukemia are suspected.

Although megaloblastic anemia and aplastic anemia are the primary conditions observed, rare disorders such as Leishmaniasis, lymphoproliferative disorders, and systemic lupus erythematosus should also be considered during the diagnostic process. Timely identification of the underlying causes is crucial for effective treatment planning.

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CONFLICT OF INTEREST:

We confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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ETHICAL INFORMATION:

This study was approved by the Institutional Ethics Committee of Bhikaka University (IEC/BU/148/Faculty/12/373).

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