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Original Research Article

Incidence and Hematological Profile of Megaloblastic Anemia in Indian Adults

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Abstract:

Background: Megaloblastic anemia is a major cause of macrocytic anemia worldwide and is particularly common in developing countries due to nutritional deficiencies. In India, dietary practices, socioeconomic factors, and gastrointestinal disorders contribute significantly to deficiencies of vitamin B12 and folate. These deficiencies lead to impaired DNA synthesis and ineffective hematopoiesis, resulting in characteristic hematological abnormalities including macrocytosis and pancytopenia.

Objective: To determine the incidence and evaluate the hematological profile of megaloblastic anemia among adult patients attending a tertiary care hospital in eastern India.

Materials and Methods: A hospital-based descriptive observational study was conducted in the Department of Pathology at Patna Medical College and Hospital, Patna, India, over a period of 9 months from March 2025 to November 2025 A total of 100 adult patients aged 18–70 years diagnosed with megaloblastic anemia were included. Clinical details and hematological parameters were analyzed. Complete blood counts and red cell indices were obtained using an automated hematology analyzer, and peripheral blood smears stained with Leishman stain were examined for morphological abnormalities. The severity of anemia, presence of cytopenias, and etiological distribution of vitamin deficiencies were evaluated using descriptive statistical methods.

Results: The majority of patients were in the 31–40-year age group (32%), with a slight male predominance (58%). Vitamin B12 deficiency was the most common etiological factor, accounting for 64% of cases, followed by combined vitamin B12 and folate deficiency (21%) and isolated folate deficiency (15%). Moderate anemia was observed in 44% of patients, while severe anemia was present in 32%. The mean hemoglobin level was 8.4 ± 2.1 g/dL and the mean corpuscular volume was 108.6 ± 9.3 fL. Pancytopenia was observed in 28% of patients and bicytopenia in 36%. Peripheral smear examination revealed macro-ovalocytes in 82% of cases and hypersegmented neutrophils in 76%, confirming typical megaloblastic morphological features.

Conclusion: Megaloblastic anemia remains a common and preventable hematological disorder among Indian adults, with vitamin B12 deficiency representing the predominant cause. Routine hematological evaluation, particularly assessment of red cell indices and peripheral smear morphology, plays a crucial role in early diagnosis and management, thereby preventing potential complications.

Keywords: Megaloblastic anemia, Vitamin B12 deficiency, Folate deficiency, Macrocytosis, Hematological profile, India.

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Introduction

Anemia remains one of the most prevalent global health problems, affecting approximately 24.8% of the world's population, with the highest burden observed in low- and middle-income countries [1]. In India, anemia continues to pose a major public health challenge despite multiple national nutrition programs, particularly among vulnerable adult populations [2].

Megaloblastic anemia is a distinct hematological disorder characterized by impaired DNA synthesis resulting in ineffective hematopoiesis [3]. The condition most commonly arises due to deficiencies of vitamin B12, folate, or both, which are essential cofactors in nucleotide synthesis and cellular proliferation [4]. Defective DNA synthesis leads to nuclear–cytoplasmic asynchrony, producing characteristic morphological abnormalities in the bone marrow and peripheral blood [5].

The hematological manifestations of megaloblastic anemia are not limited to erythroid precursors alone. Granulocytic and megakaryocytic lineages are also affected, resulting in leukopenia and thrombocytopenia, and in advanced cases, pancytopenia [6]. This multilineage involvement reflects the fundamental role of vitamin B12 and folate in all rapidly dividing cells [7].

India bears a disproportionately high burden of megaloblastic anemia due to unique dietary, socioeconomic, and cultural factors [6,8]. Predominantly vegetarian diets, low intake of animal-derived foods, chronic gastrointestinal disorders, parasitic infestations, and malabsorption syndromes contribute significantly to vitamin B12 deficiency in Indian adults [9–11]. Folate deficiency, though less frequent, persists in populations with poor intake of green leafy vegetables and increased metabolic demands [12].

Beyond hematological abnormalities, vitamin B12 deficiency has profound neurological implications. Neurological manifestations may include peripheral neuropathy, cognitive impairment, psychiatric symptoms, and subacute combined degeneration of the spinal cord [13]. Importantly, neurological damage may occur even in the absence of severe anemia and may become irreversible if diagnosis is delayed [14].

Hematological evaluation remains the cornerstone of diagnosis, particularly in resource-limited settings [15]. Elevated mean corpuscular volume, macro-ovalocytes, hypersegmented neutrophils, and pancytopenia serve as important diagnostic clues [16]. Bone marrow examination, though confirmatory, is not always necessary when classical peripheral smear findings are present [17].

Despite its clinical importance, regional hospital-based data on the incidence and hematological profile of megaloblastic anemia in Indian adults remain limited [18]. Understanding local disease patterns is essential for improving diagnostic vigilance and guiding effective nutritional and therapeutic interventions [19]. The present study was therefore undertaken to evaluate the incidence and hematological profile of megaloblastic anemia among adult patients attending a tertiary care hospital in eastern India.

Materials and Methods

Study Design: The present investigation was conducted as a hospital-based descriptive observational study aimed at evaluating the incidence and hematological characteristics of megaloblastic anemia among adult patients attending a tertiary care teaching hospital.

Study Duration: The study was carried out over a period of 9 months, from March 2025 to November 2025.

Study Setting: The research was performed in the Department of Pathology at Patna Medical College and Hospital, Patna, Bihar, India, which functions as a major tertiary care referral center catering to both urban and rural populations of eastern India. Hematological investigations were conducted in the central clinical hematology laboratory of the department.

Study Population: A total of 100 adult patients diagnosed with megaloblastic anemia were included in the study. Patients were identified during routine hematological evaluation of individuals presenting with clinical features suggestive of anemia.

The age of the participants ranged from 18 to 70 years, representing a wide spectrum of adult patients.

Sampling Method: Patients fulfilling the eligibility criteria during the study period were included using a consecutive sampling technique until the desired sample size of 100 cases was achieved.

Inclusion Criteria

The following patients were included in the study:

1. Adults aged 18 years and above
2. Patients presenting with macrocytic anemia detected during hematological evaluation
3. Peripheral smear findings suggestive of megaloblastic changes
4. Patients willing to participate in the study

Exclusion Criteria

Patients were excluded from the study if they had:

1. Anemia due to other identifiable causes such as iron deficiency anemia, hemolytic anemia, or aplastic anemia
2. Chronic systemic diseases known to affect hematological parameters
3. History of recent blood transfusion
4. Patients already receiving vitamin B12 or folate supplementation before hematological evaluation
5. Incomplete clinical or laboratory records

Clinical Data Collection: Demographic and clinical information was obtained from patient records and included:

- Age
- Sex
- Presenting symptoms
- Relevant dietary history
- Associated clinical conditions

All patient data were recorded using a structured data collection form.

Hematological Investigations

Complete Blood Count: Venous blood samples were collected under aseptic conditions in EDTA anticoagulated tubes. Complete blood counts were performed using an automated hematology analyzer in the central laboratory.

The following hematological parameters were evaluated:

- Hemoglobin concentration (g/dL)
- Red blood cell (RBC) count
- Mean corpuscular volume (MCV)
- Mean corpuscular hemoglobin (MCH)
- Total leukocyte count (TLC)
- Platelet count

These parameters were used to assess the hematological profile of the study participants.

Peripheral Blood Smear Examination: Peripheral blood smears were prepared using fresh EDTA-anticoagulated blood and stained with Leishman stain. Each smear was examined under a light microscope for morphological abnormalities.

The following features were specifically evaluated:

- Macro-ovalocytes
- Hypersegmented neutrophils
- Anisopoikilocytosis
- Nucleated red blood cells
- Howell–Jolly bodies

These morphological findings were used to support the diagnosis of megaloblastic anemia.

Classification of Anemia Severity: The severity of anemia was categorized based on hemoglobin levels as follows:

Category	Hemoglobin Level
Mild anemia	10–11.9 g/dL
Moderate anemia	7–9.9 g/dL
Severe anemia	<7 g/dL

This classification allowed evaluation of the clinical severity of anemia among the study participants.

Assessment of Cytopenias

Based on hematological parameters, patients were categorized into three groups:

- **Isolated anemia** – reduction in hemoglobin only
- **Bicytopenia** – reduction in any two hematological cell lines
- **Pancytopenia** – reduction in all three cell lines (RBCs, leukocytes, and platelets)

This classification helped determine the extent of bone marrow involvement.

Determination of Etiological Factors

The probable etiology of megaloblastic anemia was determined using clinical findings and laboratory evaluation. Cases were categorized into the following groups:

- **Vitamin B12 deficiency**
- **Folate deficiency**
- **Combined vitamin B12 and folate deficiency**

The distribution of these etiological categories was later analyzed to determine the incidence pattern in the study population.

Data Management: All collected data were entered into a structured database and carefully verified to ensure accuracy and completeness before statistical analysis.

Statistical Analysis: Statistical analysis was performed using descriptive statistical methods.

Continuous variables were expressed as mean ± standard deviation, while categorical variables were summarized as frequencies and percentages. The results were presented using tables and graphical representations to facilitate clear interpretation of the hematological findings.

Ethical Considerations: The study protocol was reviewed and approved by the Institutional Ethics Committee of Patna Medical College and Hospital. Patient confidentiality was strictly maintained, and all data were used solely for research purposes.

Results

1. **Demographic Characteristics of Study Participants**

A total of 100 adult patients diagnosed with megaloblastic anemia were included in the study. The age of the participants ranged from 18 to 70 years, with the highest proportion of patients belonging to the 31–40 year age group (32%), followed by the 21–30 year age group (28%).

Male patients constituted 58% of the study population, while 42% were females. These findings indicate a slight male predominance in the present study.

The distribution of patients according to age and sex is summarized in Table 1.

Table 1. Age and Sex Distribution of Patients (n = 100)

Age Group (years)	Male (n)	Female (n)	Total (n)	Percentage (%)
18–20	6	4	10	10
21–30	15	13	28	28
31–40	20	12	32	32
41–50	9	7	16	16
51–60	6	4	10	10
>60	2	2	4	4
Total	**58**	**42**	**100**	**100**

2. **Incidence of Megaloblastic Anemia**

During the study period, megaloblastic anemia accounted for a significant proportion of macrocytic anemia cases encountered in the hematology laboratory. Among the evaluated patients, vitamin B12 deficiency was the most common underlying cause (64%), followed by combined vitamin B12 and folate deficiency (21%), while isolated folate deficiency accounted for 15% of cases.

The etiological distribution of megaloblastic anemia is illustrated in Figure 1.

Figure 1. Etiological Distribution of Megaloblastic Anemia

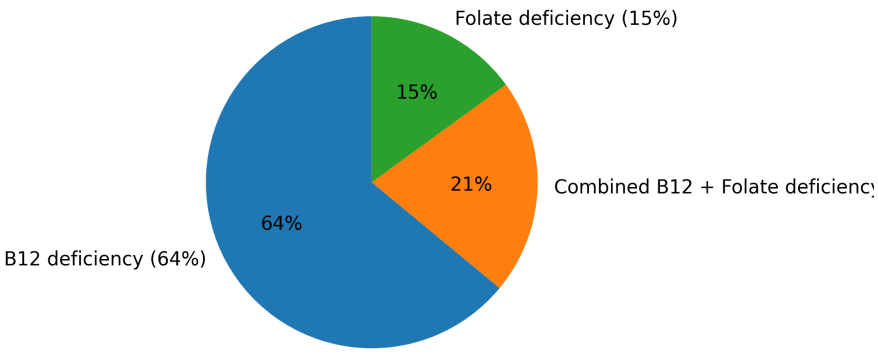

Figure 1. Etiological Distribution of Megaloblastic Anemia

3. **Severity of Anemia**

The severity of anemia among the study participants was categorized based on hemoglobin levels.

Most patients presented with moderate anemia (44%), followed by severe anemia (32%), while mild anemia was observed in 24% of patients.

These findings are summarized in Table 2.

Table 2. Severity of Anemia Based on Hemoglobin Levels (n = 100)

Severity	Hemoglobin Level	Number of Patients	Percentage (%)
Mild	10–11.9 g/dL	24	24
Moderate	7–9.9 g/dL	44	44
Severe	<7 g/dL	32	32

Moderate anemia was therefore the most frequently observed presentation among patients with megaloblastic anemia.

4. **Hematological Parameters**

Complete blood count analysis revealed characteristic hematological abnormalities associated with megaloblastic anemia.

The mean hemoglobin level was 8.4 ± 2.1 g/dL, while the mean corpuscular volume (MCV) was 108.6 ± 9.3 fL, indicating significant macrocytosis.

The mean leukocyte count and platelet count were also reduced in a considerable proportion of patients.

The hematological profile of the study participants is summarized in **Table 3**.

Table 3. Hematological Parameters of Patients (n = 100)

Parameter	Mean ± SD
Hemoglobin (g/dL)	8.4 ± 2.1
RBC count (million/mm³)	3.1 ± 0.7
Mean Corpuscular Volume (MCV)	108.6 ± 9.3 fL
Mean Corpuscular Hemoglobin (MCH)	34.2 ± 3.5 pg
Total Leukocyte Count	4,200 ± 1,200 /mm³
Platelet Count	1.35 ± 0.6 lakh/mm³

Elevated MCV values were a consistent hematological finding, reflecting defective DNA synthesis and macrocytic erythropoiesis.

5. **Cytopenias Observed in the Study Population**

Bone marrow suppression affecting multiple hematopoietic cell lines was observed in several patients.

Pancytopenia was present in 28% of cases, while bicytopenia was observed in 36%, and isolated anemia was seen in 36% of patients.

The distribution of cytopenias is shown in Table 4.

Table 4. Distribution of Cytopenias (n = 100)

Hematological Finding	Number of Patients	Percentage (%)
Isolated anemia	36	36
Bicytopenia	36	36
Pancytopenia	28	28

These findings highlight the multilineage hematopoietic involvement characteristic of megaloblastic anemia.

6. **Peripheral Blood Smear Findings**

Peripheral smear examination revealed classical morphological features associated with megaloblastic anemia. The most frequently observed findings were macro-ovalocytes (82%) and hypersegmented neutrophils (76%). Other findings included anisopoikilocytosis, nucleated red blood cells, and occasional Howell–Jolly bodies.

The distribution of peripheral smear findings is presented in Table 5.

Table 5. Peripheral Blood Smear Findings (n = 100)

Peripheral Smear Feature	Number of Cases	Percentage (%)
Macro-ovalocytes	82	82
Hypersegmented neutrophils	76	76
Anisopoikilocytosis	58	58
Nucleated RBCs	24	24
Howell–Jolly bodies	12	12

These morphological features strongly supported the diagnosis of megaloblastic anemia.

7. **Graphical Representation of Major Hematological Findings**

The overall distribution of major hematological abnormalities observed in the study population is illustrated in Figure 2.

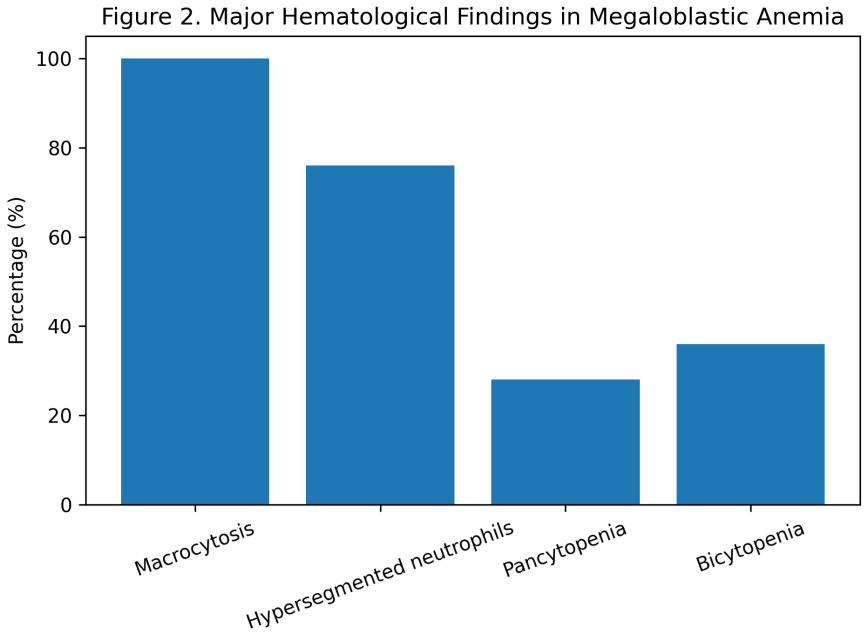

Figure 2. Major Hematological Findings in Megaloblastic Anemia

Macrocytosis was present in all patients, confirming it as a hallmark hematological feature of megaloblastic anemia.

Summary of Key Findings

The present study demonstrated that megaloblastic anemia predominantly affects young and middle-aged adults, with a slight male predominance. Vitamin B12 deficiency emerged as the most common etiological factor, and most patients presented with moderate anemia accompanied by macrocytosis. Peripheral smear examination revealed classical morphological features, while pancytopenia and bicytopenia were observed in a significant proportion of cases, highlighting the systemic hematopoietic involvement characteristic of the disease.

Discussion

The present study demonstrates that megaloblastic anemia continues to represent an important hematological disorder among adult patients in India. The predominance of vitamin B12 deficiency observed in this study is consistent with previously published Indian data and reflects the impact of dietary practices and nutritional insufficiency within the population [17].

Macrocytosis and elevated mean corpuscular volume were prominent findings in the current study. These observations highlight the central role of impaired DNA synthesis in the pathogenesis of megaloblastic anemia and emphasize the usefulness of red cell indices as an initial screening tool in routine hematological investigations [18].

A considerable proportion of patients in the present study exhibited pancytopenia, suggesting severe ineffective hematopoiesis. Similar findings have been reported in earlier studies conducted in India, indicating that megaloblastic anemia should be considered an important differential diagnosis in patients presenting with unexplained pancytopenia [19].

Peripheral blood smear examination revealed characteristic morphological features including macro-ovalocytes and hypersegmented neutrophils. These findings remain highly valuable diagnostic indicators and are particularly important in resource-limited healthcare environments where advanced biochemical tests may not always be readily available [20,21].

The high prevalence of vitamin B12 deficiency observed among the study participants may largely be explained by dietary patterns. Vegetarian dietary habits, reduced consumption of animal products, and socioeconomic limitations are important contributing factors in the Indian population. Additional factors such as malabsorption disorders, chronic gastrointestinal disease, and increased physiological requirements may further aggravate deficiency states [22].

Delayed diagnosis of vitamin B12 deficiency can lead to serious neurological complications that may persist even after hematological recovery. Therefore, early recognition through routine hematological evaluation and prompt initiation of vitamin supplementation are essential to prevent irreversible neurological damage and improve overall clinical outcomes [23–25].

The findings of this study highlight the importance of improving nutritional awareness, strengthening diagnostic services, and promoting early screening strategies for anemia at both hospital and community levels.

Conclusion

Megaloblastic anemia remains a common and preventable cause of anemia among Indian adults. Comprehensive hematological evaluation enables early diagnosis, timely treatment, and prevention of serious complications.

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