Original Article

# Importance of Bone Marrow Examination in Cases of Pancytopenia: A Morphological Study

**Rumpa Das[1]* and Gorakh Nath[2]**

[1]Department of Pathology. Hind Institute of Medical Sciences. Barabanki, India
[2]Department of Otorhinolaryngology, Nath ENT Centre. Faizabad, India

***Keywords:*** *Pancytopenia, Bone Marrow Examination, Megaloblastic Anemia, Aplastic Anemia, Acute Leukemia*

## ABSTRACT

**Background:** Pancytopenia is a pathological manifestation resulting from various disease processes affecting the bone marrow. Therefore, bone marrow examination is an important diagnostic tool to evaluate the underlying causes of pancytopenia.

**Methods:** Present study was done in 64 cases fulfilling the criteria of pancytopenia over a period of two years. Bone marrow examination including bone marrow aspiration and bone marrow biopsy (only in cases of dry tap on aspiration) was performed in all the cases and morphological study along with cytochemical staining was done. The findings were correlated with peripheral blood examination. Diagnostic value of bone marrow examination in cases of pancytopenia was established.

**Result:** 61 out of 64 cases were successfully diagnosed with the morphological examination of bone marrow. The most common cause of pancytopenia in the present study was megaloblastic anemia (57.81%) followed by aplastic anemia (18.75%) and acute leukemia (9.37%). Other causes of pancytopenia were dimorphic anemia due to mixed deficiency, lymphoma, multiple myeloma, infectious disease and storage disease. The diagnostic value of bone marrow examination in cases of pancytopenia in the present study was 95.31%.

**Conclusion:** Morphological examination of bone marrow is an extremely helpful and specific diagnostic tool in cases of pancytopenia. Bone marrow aspiration and biopsy complement each other but diagnosis can solely be made in most of the cases by examining only the bone marrow aspiration smears.

***Corresponding author:**
Dr Rumpa Das, Department Of Pathology. Hind Institute of Medical Sciences. Barabanki- 225003, India
Phone: +91 918795132000, 8756860132
Email: dr.rumpadas@gmail.com

## Introduction

Pancytopenia is described as a simultaneous process of anemia, leucopenia and thrombocytopenia. It exists in adults when the hemoglobin level is less than 13.5 gm/dl in males or 11.5 gm/dl in females, leukocyte count is less than 4 x $10^9$ /L and platelet count is less than 100 x $10^9$ /L. Pancytopenia is not a disease entity but a pathological manifestation resulting from a variety of disease process affecting the bone marrow either primarily or secondarily. It usually results due to infections, toxins, malignant cell infiltration, chemotherapy and radiotherapy. However, pancytopenia can be due to peripheral destruction of blood cells as seen in cases of hypersplenism. Patients of pancytopenia can present with a variety of clinical symptoms resulting from anemia, leucopenia and thrombocytopenia.

Peripheral blood smears of patients with pancytopenia usually show a normochromic normocytic or macrocytic red blood cells (RBCs). Bone marrow cellularity and composition in cases of pancytopenia usually differ in relation to underlying etiological condition. Bone marrow cellularity is reduced in cases of pancytopenia caused by primary production defect. Bone marrow is normocellular or hypercellular in cases of pancytopenia resulting from ineffective hematopoiesis, increased peripheral destruction and bone marrow invasion. Therefore, bone marrow examination is extremely helpful to identify the cause of pancytopenia.

The most common cause of pancytopenia in worldwide is aplastic anemia [1] but the most common cause of pancytopenia in India is megaloblastic anemia.[2] Although it is a common problem, but the prevalence of the causes of pancytopenia is reported in very limited number of studies. Present study will highlight upon the prevalence, hematological parameters and utility of bone marrow examination in different causes of pancytopenia.

## Materials and Methods

The study was conducted in the department of Pathology, G.S.V.M Medical College, Kanpur, Uttar Pradesh, India from December 2008 to September 2010. A total number of 64 patients with a diagnosis of pancytopenia referred from department of medicine, pediatrics and otorhinolaryngology (patients having epistaxix with pancytopenia) were included in the study while patients having malignancy with pancytopenia developed after radiotherapy and chemotherapy were not included in the study. Informed consent was obtained from each patient prior to their enrolment. Relevant history and clinical findings of the patients were noted and all patients were subjected to complete blood count (CBC), reticulocyte count, peripheral blood smear examination including general blood picture (GBP) and bone marrow aspiration and bone marrow biopsy when there is a dry tap on aspiration. CBC was performed by 'Sysmex XP100'. Peripheral blood smears were stained with Leishman's stain.

Bone marrow aspiration was done from anterior superior iliac spine or posterior iliac spine and bone marrow biopsy was done from posterior superior iliac spine under proper aseptic measure and local anesthesia with Sala's bone marrow aspiration needle. Approximately 0.3 ml of marrow fluid was aspirated and smears were prepared on a glass slide. Bone marrow aspiration smears were stained with Leishman's stain, Myeloperoxidase (MPO), Prussian blue and Periodic Acid-Schiff (PAS). Smears were then examined under scanner and low power to assess the cellularity, megakaryocytes and metastatic carcinoma cells. The area where the cells were well spread out was selected and under oil immersion at least 500 marrow cells were differentially counted.

Bone marrow biopsy was done from posterior superior iliac spine whenever there is a dry tap on aspiration. Jamshidi needle was used for bone marrow biopsy. 1.5 to 2.0 cm long bone marrow biopsy specimen was obtained and fixed in bouin's fixative. Biopsy specimen was decalcified processed and sections were stained with Hematoxylene and Eosin (H&E) stain.

## Result

Among the 64 cases of pancytopenia, the most common cause was megaloblastic anemia (57.81%) followed by aplastic anemia (18.75%), Acute leukemias (9.37%), dimorphic anemia due to mixed deficiency (06.25%), pancytopenia due to bone marrow involvement by primary lymphoma (3.12%), multiple myeloma (1.56%), pancytopenia due to infectious disease (1.56%) and pancytopenia due to storage disease (1.56%). (Table : 1) Total 06 cases of acute leukemias were diagnosed on bone marrow examination, out of which four cases were further typed as acute lymphoblastic leukemia (ALL) and two cases as acute myeloid leukemia (AML).

Males were more commonly affected than females (ratio 1.2:1) and most common affected age group was 16-30 years, followed by 00-15 years, 31-45 years and >60 years (Chart 1). Females of age group 16-45 years were commonly found to have pancytopenia due to megaloblastic anemia and dimorphic mixed nutritional deficiency. The most common clinical presentations were pallor and weakness; whereas other clinical features were dyspnea, bleeding tendency, fever, splenomegaly, hepatomegaly and lymphadenopathy. (Table: 2) Nine out of 12 patients of aplastic anemias were transfusion dependent.

Details of peripheral blood findings are given in table no 3 (Table 3). Peripheral blood smears of patients with megaloblastic anemia showed macro-ovalocytic red cells with presence of occasional basophilic stippling, cabot ring and Howell-Jolly bodies. Hypersegmented neutrophils were noted in 83.78% (31/37) cases. Peripheral smears of 10 out of 12 cases of aplastic anemia showed normocytic normochromic red cells; however the rest showed macrocytosis. Cases of dimorphic anemia due to mixed deficiency showed severe anisopoikilocytosis with presence of microcytic hypochromic red cells, hypochromic macrocytes and few pencil cells. Cases of ALL showed pancytopenia with presence of few immature lymphoid cells. Presence of occasional plasma cells was seen in the case of multiple myeloma.

Bone marrow cellularity was increased in all the cases of pancytopenia caused by megaloblastic anemia, dimorphic anemia and leukemias; however bone marrow cellularity was decreased in cases pancytopenia caused by aplastic anemia, bone marrow involvement in lymphomas, multiple myeloma and storage disease.

Myeloid / Erythroid ratio (M/E ratio) was reversed in all cases of megaloblastic anemia and dimorphic anemia; but M/E ratio was increased in cases of AML; however it was normal in cases of aplastic anemia. M/E ratio could not be determined in cases of ALL and lymphoma. Lymphoid / Erythroid ratio was taken in these cases and it was found to be increased.

Megaloblastic reaction with presence of megaloblasts having sieve like nuclear chromatin was noted in all cases of megaloblastic anemia. (Fig 1a) Features of dyserythropoiesis in the form of nuclear budding, nuclear fragmentation and irregular nuclei were also noted. (Fig 1b) Morphologic aberration in myeloid series was also noted in the form of giant myelocytes. (Fig 1c) Prussian blue stain showed increased iron content in 30% cases (Fig 1d) and normal iron content in 70% cases of megaloblastic anemia.

Bone marrow aspiration (BMA) smears of aplastic anemia were diluted with peripheral blood and showed severe reduction of hematopoietic precursors with increased marrow fat. (Fig 2a)There were focal cellular areas with presence of lymphocytes, plasma cells and occasional mast cells. (Fig 2b) Gelatinous transformation of bone marrow was noted. (Fig 2c) Bone marrow iron content was increased in all of the cases. (Fig 2d)

BMA smears of ALL were hypercellular with severe reduction of erythroid, myeloid and megakaryocytic series with presence of >20% lymphoblasts (Fig 3a), showing PAS positivity. The cases of AML showed severe reduction of erythroid and megakaryocytic series with presence of >20% myeloblasts (Fig 3b), showing positivity for MPO. Cases of dimorphic anemia due to mixed deficiency showed erythroid hyperplasia with presence of micronormoblasts and megaloblsts. Features of dyserythropoiesis were also observed. Prussian blue stain showed decreased iron content in all the cases of dimorphic anemia.

The case of multiple myeloma showed increased number of lymphoid cells and presence of atypical plasma cells with severely hypocellular marrow.

Patients with bone marrow involvement by lymphoma showed severe suppression of all three lineages with presence of medium sized lymphoid cells.(Fig 3c-d) A possibility of bone marrow involvement by lymphoproliferative disorder was suggested in those cases.

One case of tuberculosis with bone marrow involvement showed presence of granulomas in the bone marrow aspiration smears.

Bone marrow aspiration revealed dry tap in the case of storage disease which was diagnosed on bone marrow biopsy. Bone marrow biopsy of the case showed large foamy Nieman Pick cells.

Among the 64 cases of pancytopenia; 61 cases was diagnosed on the basis of bone marrow examination; whereas three cases including two cases of lymphomas and a case tuberculosis needed further diagnostic workup. So, the diagnostic value of morphological examination of bone marrow in cases of pancytopenia in the study was 95.31%.

**Table 1: Different causes of pancytopenia.**

| Diagnosis | Number of cases |
|---|---|
| Megaloblastic anemia | 37 (57.81%) |
| Aplastic anemia | 12 (18.75%) |
| Acute leukemia | 06 (9.37%) |
| Dimorphic anemia due to mixed deficiency | 04 (6.25%) |
| Bone marrow infiltration by lymphomas | 02 (3.12%) |
| Multiple myeloma | 01 (1.56%) |
| Infectious disease | 01 (1.56%) |
| Storage disease | 01 (1.56%) |
| **Total** | **64** |

**Table 2: Details of clinical manifestation:**

| Diagnosis (total number) | Pallor | Weakness | Bleeding | Fever | Splenomegaly | Hepatomegaly | lymphadenopathy |
|---|---|---|---|---|---|---|---|
| Megaloblastic anemia (37) | 37 | 37 | 11 | 07 | 08 | 02 | - |
| Aplastic anemia (12) | 12 | 12 | 10 | 04 | 01 | - | - |
| Acute leukemia (06) | 06 | 06 | 04 | 03 | 04 | 03 | 04 |
| Dimorphic anemia (04) | 04 | 04 | - | 01 | - | - | - |
| Lymphoma (02) | 02 | 02 | 01 | 01 | 01 | - | 01 |
| Multiple myeloma (01) | 01 | 01 | - | - | - | - | - |
| Infectious disease (01) | 01 | 01 | - | 01 | - | - | 01 |
| Storage disease (01) | 01 | 01 | 01 | 01 | 01 | 01 | - |
| **Total = 64** | **64** | **64** | **27** | **18** | **15** | **06** | **06** |

**Table 3: Details of peripheral blood findings.**

| Diagnosis (total number) | Anisocytosis | Dimorphic smear | Erythroblasts | Lymphocytosis | Hypersegmented neutrophils | Immature cells |
|---|---|---|---|---|---|---|
| Megaloblastic anemia (37) | 35 | 18 | 07 | - | 31 | - |
| Aplastic anemia (12) | 02 | - | - | 04 | - | - |
| Acute leukemia (06) | - | - | 01 | 04 | - | 06 |
| Dimorphic anemia (04) | 04 | 04 | 02 | - | 01 | - |
| Lymphoma (02) | 01 | - | 01 | 01 | - | - |
| Multiple myeloma (01) | 01 | - | - | - | - | - |
| Infectious disease (01) | 01 | - | - | 01 | - | - |
| Storage disease (01) | 01 | - | 01 | - | - | - |
| **Total = 64** | **45** | **22** | **12** | **10** | **31** | **06** |

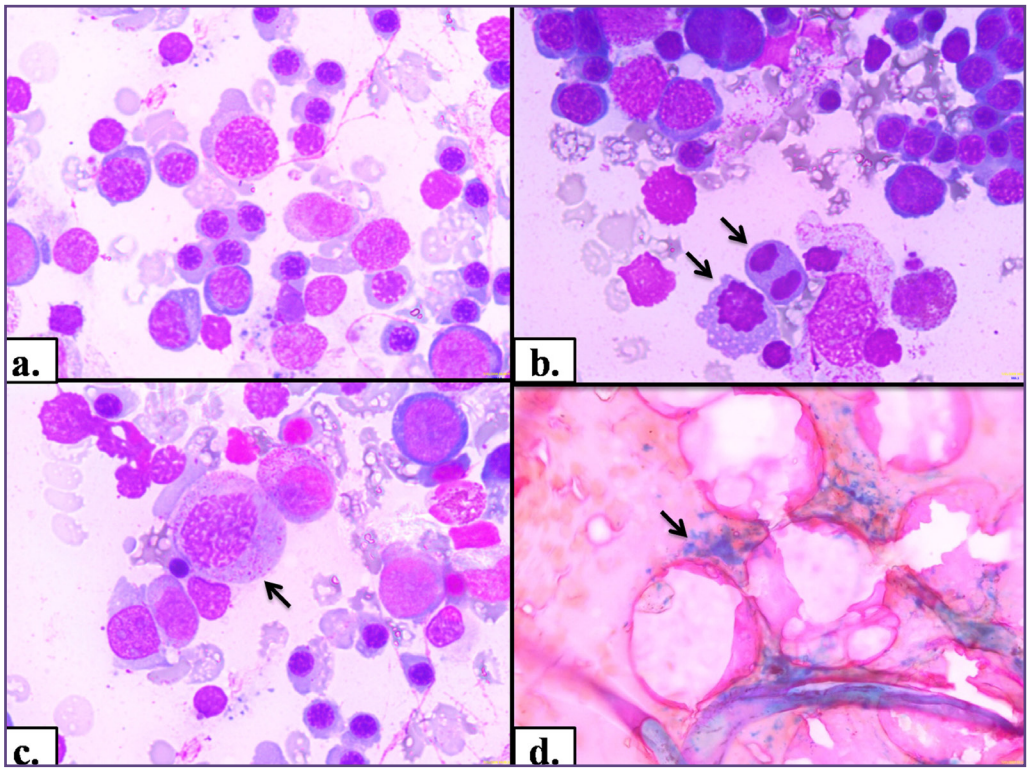


**Fig. 1: Megaloblastic anemia showing (a) Megaloblasts having sieve like nuclear chromatin (Leishman, X1000), (b) Features of dyserythropoiesis in the form of nuclear fragmentation and irregular nuclei (arrow) (Leishman, X1000), (c) Giant myelocyte (arrow) ) (Leishman, X1000), (d) Increased bone marrow iron (Prussian blue X400).**

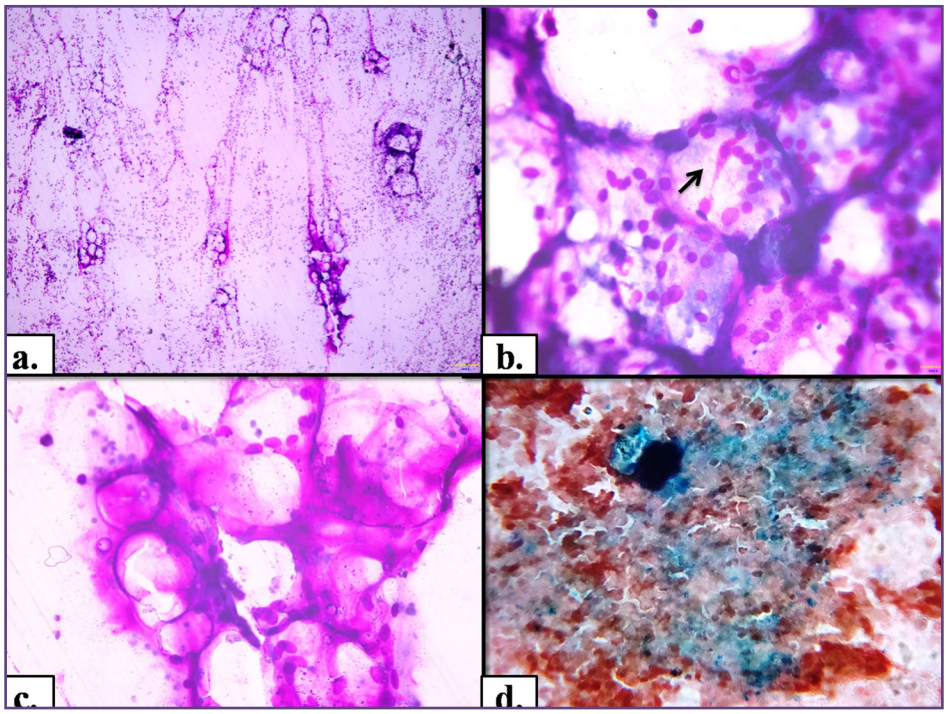


**Fig. 2: Aplastic anemia showing (a) severe reduction of hematopoietic precursors with increased marrow fat(Leishman, X40), (b) Focal cellular area with presence of lymphocytes, plasma cells and mast cell (arrow) (Leishman, X1000),, (c) Gelatinous marrow transformation(Leishman, X1000), , (d) Increased bone marrow iron (Prussian blue X100).**

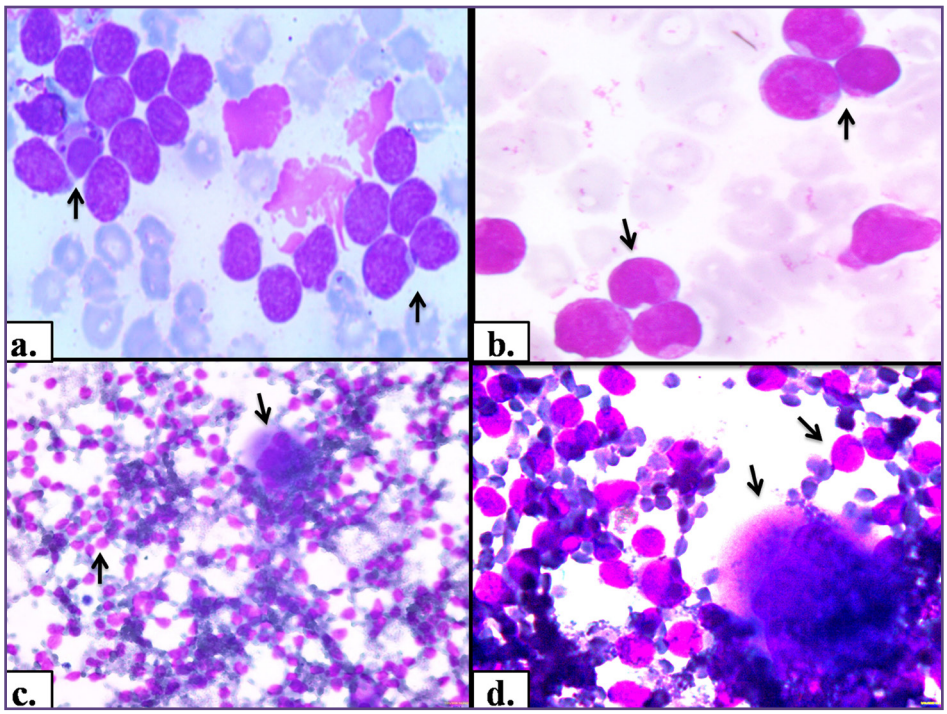


**Fig. 3: (a) ALL with presence of lymphoblasts (arrow) (Leishman, X1000), (b) AML with presence of myeloblasts (arrow) (Leishman, X1000), (c) Marrow involvement with lymphomas showing severe suppression of all three lineages with presence of medium sized lymphoid cells and a megakaryocyte (arrow) (Leishman, X400), (d) lymphomas with presence of medium sized lymphoid cells and a megakaryocyte (arrow) (Leishman, X1000).**

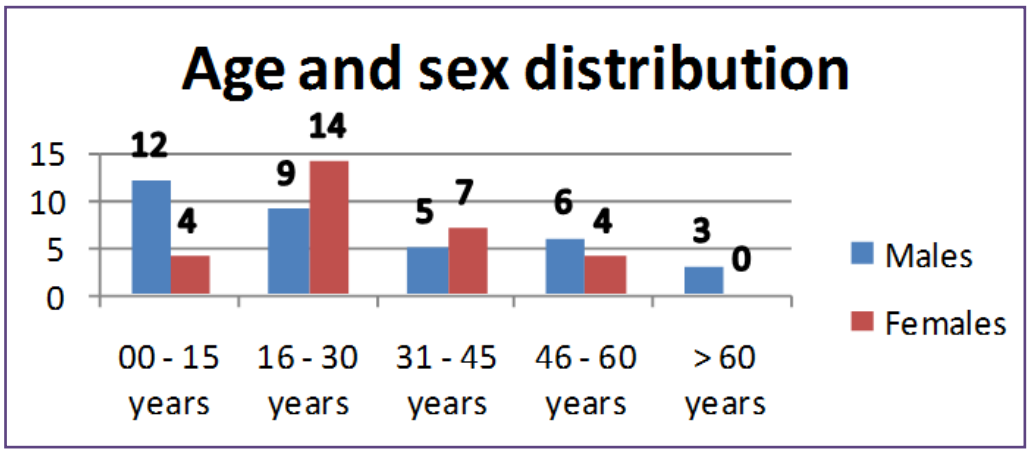


**Chart 1: Age and sex distribution.**

## Discussion

The most common cause of pancytopenia in the present study was megaloblastic anemia (57.81%). Different studies conducted in India also showed megaloblastic anemia as the most common cause of pancytopenia.[2,3,4] Megaloblastic anemia was also the most common cause of pancytopenia in other study conducted by Devid et al in 1999 in Zimbabwe.[5] It was the second most common cause of pancytopenia in other studies conducted by Jha et al and Tariq et al in Nepal and Pakistan respectively.[6,1] Etiological factors of megaloblastic anemia in a developing country like India could be a diet poor in cobalamine and folate, increased requiremint during growth period and pregnancy and also the use of acid supperessing medication.[7] Other contributing factors for development of megaloblastic anemia could be geographical factor, socio-economic factor, food habit and religious factor. Findings of CBC like MCV, MCH and MCHC were not well correlated with the bone marrow morphology in the cases of megaloblastic anemia. This finding was similar to the findings of Bhatiya et al where they conducted a study in 117 patients of vit- B12 deficiency to see the usefulness of MCV in cases of vit-B12 deficiency and concluded that the MCV as a screening parameter in cases of macrocytic anemia may be misleading.[8] Increased marrow cellularity with decreased M/E ratio, presence of megaloblasts, features of dyserythropoiesis and giant myeloid precursor were the diagnostic features in cases of megaloblastic anemia in the present study and were also mentioned as diagnostic features of megaloblastic anemia in other studies.[7]

Aplastic anemia was the second most common cause of pancytopenia in the present study. Similarly, it was the second most common cause of pancytopenia in different studies conducted by Devid et al in Zimbabwe[5] and Khunger et al in India[3]. However; it was the most common cause of pancytopenia in studies conducted by Gupta et al[9] and Tariq et al[1]. No definite etiological factor was found in the cases of aplastic anemia. Increased incidence of aplastic anemia may be due to environmental factors like increased exposure to toxic chemicals like pesticides, hydrocarbons from motor vehicles, viral infection, radiation exposure, use of toxic ban-drugs by quacks or some genetic factors.[10] Cases of aplastic anemia were diagnosed solely upon the findings of bone marrow examination; however clinical features helped us to reach our diagnosis. Diluted smears with increased marrow fat along with severe reduction in all the lineages and gelatinous marrow transformation were the features favoring aplastic anemias; which were also mentioned in other studies similar to our study.[11] Increased marrow iron in cases of aplastic anemia was due to repeated blood transfusion and previously received iron therapy for anemia.

Acute leukemia was the third most common cause of pancytopenia in the present study. The cases of ALL and AML presented with pencytopenia were diagnosed in bone marrow smears with the presence of >20 lymphoblasts and myeloblasts respectively. Peripheral blood smears of these cases showed pancytopenia with presence of occasional blasts. The findings were similar to the findings described by Shon et al for ALL [12] and Marcovic et al for AML [13]. Pancytopenia in cases of AML could be due to bone marrow necrosis due to immune T cell response in cases of subclinical AML.[13] Leucocyte cytochemistry was helpful in these cases. Acute leukemias including ALL and AML were third most common cause of pancytopenia in the present study which were also an important cause of pancytopenia in other studies.[1,2,14]

Dimorphic anemia due to mixed deficiency was the next common cause of pancytopenia in our study. It is

predominantly seen among the women of child bearing age suggesting the nutritional deficiency of the women of that age group. Menon et al and Chen et al also mentioned about the coexistence of megaloblastic and iron deficiency anemias in their studies.[11, 15] Cases of dimorphic anemias showed presence of microcytic hypochromic red cells and hypochromic macrocytes in the peripheral blood smears with normal to decreased reticulocyte count. Bain BJ conducted a study on hypochromic macrocytes and mentioned that an increased hypochromic macrocytosis could be seen in cases having strong drive to erythropoiesis leading to iron deficient erythropoiesis; indicating the possibility of reticulocytosis or dyserythropoiesis present in cases of megaloblastic anemia or myelodysplastic syndrome.[16] All the cases of dimorphic anemia in the present study showed the presence of hypochromic macrocytes which could be due to increased erythropoietic drive in a iron deficient state. Erythroid hyperplasia along with presence of micronormoblasts and megaloblasts were noted in all of the cases. We did not include these cases into the category of megaloblastic anemia because all of these cases had low bone marrow iron content. Other studies also mentioned the similar bone marrow findings in cases of dimorphic anemia.[11,15]

Other causes of pancytopenia were lymphoma, multiple myeloma, infectious disease and storage disease which were mentioned as the cause of pancytopenia in different other studies.[1,2, 4-6,9] Severely hypocellular marrow was noted in the case of multiple myeloma with increased lymphoid cells and atypical plasma cells. The finding was similar to the findings described by Medhi et al in 2008.[17]

The most common affected age group was between 16-30 years and overall males were more commonly affected than females. However; females were more commonly affected between the ages of 16- 45 years. Megaloblastic anemia and dimorphic anemia due to mixed deficiency was the most common cause of pancytopenia among the females of 16-45 years. The most common presenting features were pallor and weakness followed by dyspnea in cases of megaloblastic anemia and bleeding in cases of aplastic anemia. Other studies also mentioned the most common clinical features to be pallor, weakness and dyspnea in cases of megaloblastic anemia.[2,11,18] Bleeding, fever and dyspnea were the other associated clinical presentation mentioned in other studies in cases of aplastic anemia.[4,18] History of transfusion dependency was also present in 09 out of 12 cases of aplastic anemia.

Overall; the bone marrow examination in cases of pancytopenia was diagnostic in 95.31% cases. Diagnostic value of morphological examination of bone marrow in cases of pancytopenia was 55%, 84.26% and 76.5% in the studies done by Imbert et al,[19] Prajuli et al,[20] and Jha et al[21] respectively.

All the cases of megaloblastic anemia, aplastic anemia, dimorphic anemia due to mixed deficiency, ALL, AML, multiple myeloma and storage disease were diagnosed by bone marrow examination. Findings of bone marrow examination were not conclusive in two cases of lymphomas and one case of tuberculosis. Bone marrow smears of the cases of lymphomas suggested a possibility of bone marrow involvement by lymphoproliferative disorder and the case of tuberculosis suggested a possibility of granulomatous lesion and only these three cases needed further diagnostic workup.

## Conclusion

The present was designed to analyze the underlying pathology, different clinic-hematological features and importance of bone marrow examination in cases of pancytopenia. High percentage of bone marrow examination for pancytopenia in our study may be due to unavailability of specified sophisticated investigations. As a consequence we had to rely on bone marrow examination and morphological features. The most common cause of pancytopenia in our study was megaloblastic anemia and there was no case of myelodysplastic syndrome present in our study; therefore most of the cases were diagnosed only on the bone marrow aspiration smears without the need of topographical examination of hematopoietic cells in bone marrow biopsy, as morphological details are best studied in bone marrow aspiration smears. Our observation supports the morphological examination of bone marrow as an extremely helpful and specific diagnostic tool in the diagnosis of pancytopenia.

## Acknowledgements

I want to express my deep sense of gratitude towards my teachers Dr. Mahendra Singh, Dr. P.K Singh, Dr. Asha Agrawal and my friend Dr. Usha Dubey who helped and wished for the successful completion of this work. I am equally thankful to the technical staff Mr. Balram Singh, Mr. B.K Dubey, Mr. G.N Bajpai and Mr. N.P Shukla for their valuable advice and worthy guidance.

## Funding

None.

## Competing Interests

None

## Reference


1. Tariq M, Khan N, Basri R, Amin S. Aetiology of pancytopenia. Professional Med J 2010;17(2):252-256
2. Khodke K, Marwah S, Buxi G, Yadav RB, Chaturvedi NK. Bone Marrow Examination in Cases of Pancytopenia. Indian Academy of Clinical Medicine 2001;2(1-2): 55-59
3. Khunger JM, Arulselvi S, Sharma U, Ranga S, Talib VH. Pancytopenia. Indian J Pathol Microbiol 2002;45(3):375-9
4. Bhatnagar SK, Chandra J, Narayan S, Sharma S, Dutta AK. Pancytopenia in children: etiological profile. J Trop Pediatr 2005; 51(4):236-9
5. David G, Allen, Robert H, Ganaidzo, Innocent T, Levy, Lorraine M, Gwanzura, Christine F, Moyo, Alpha F, Mudenge, Boniface F, Kiire, Clement, Mukiibi, Joshua, Stabbler, Sally P, Lindenbaum, John. Pancytopenia in Zimbabwe. American Journal of the Medical Sciences 1999;317(1):22-32
6. Jha A, Sayami G, Adhikari RC, Panta AD, Jha R. Bone marrow examination in cases of pancytopenia. J Nepal Med Assoc 2008;47(169):12-7
7. Khanduri U, Sharma A. Causative and prevelance of megaloblastic anemia. Natl Med J India 2007;20(4):172-5
8. Bhatia P, Kulkarni JD, Pai SA. Vitamin B12 deficiency in India: Mean corpuscular volume is an unreliable screening parameter. The national medical journal of india 2012; 25(6): 336-38
9. Gupta V, Tripathi S, Singh TB, Tilak V, Bhatia BD. A study of bone marrow failure syndrome in children. Indian Journal of Medical Sciences 2008;62(1):13-18
10. Hayat AS, Khan AH, Baloch GH, Shaikh N. Pancytopenia; study for clinical features and etiological pattern of at tertiary care settings in Abbottabad. Professional Med J 2014;21(1): 060-065.
11. Memon S, Shaikh S, Nizamani MA. Etiological spectrum of pancytopenia based on bone marrow examination in children. J Coll Physicians Surg Pak 2008;18(3):163-7
12. Sohn SK, Suh JS, Lee J, Lee KB. Pancytopenic Prodrome(pre-ALL) of Acute Lymphoblastic Leukemia in Adults : Possible Pathogenesis. The Korean Journal of Internal Medicine 1998;13(1):64-67
13. Markovic SN, Phyliky RL, Li CY. Pancytopenia Due to Bone Marrow Necrosis in Acute Myelogenous Leukemia: Role of Reactive CD8 Cells. American Journal of Hematology 1998;59:74-78
14. Alkhouri N, Ericson SG. Aplastic Anemia: Review of etiology and treatment. In Practice Stragies 1999;46:52
15. Chen SH, Hung CS, Yang CP, Lo FS, Hsu HH. Coexistence of megaloblastic anemia and iron deficiency anemia in a young woman with chronic lymphocytic thyroiditis. Int J Hematol 2006;84(3):238-41
16. Bain BJ, Cavil IAJ. Hypochromic macrocytes: are they reticulocytes? J Clin Pathol 1993;46:963-64
17. Medhi K, Kalita D, Chopra A, Anand M, Raina V, Kumar R. Multiple myeloma presenting with coexisting severe marrow hypoplasia. Indian Journal of Pathology and Microbiology 2008;51(4):543-545
18. Osama I, Haider ZB, Anwer F, Nisar H. Pattern of pancytopenia patients in a gerneral medical ward and a proposed diagnostic approach. J Ayub Med Coll Abbottabsd 2004;16:8-13
19. Imbert M, Scoazec JY, Mary JY, Jouzult H, Rochant H, Sultanc. Adult patients presenting with Pancytopenia. Hematol Pathol 1989;3(4):159-67
20. Parajuli S, Tuladhar A. Correlation of bone marrow aspiration and biopsy findings in diagnosing hematological disorders – a study of 89 cases. Journal of Pathology of Nepal (2014) Vol. 4, 534 – 538
21. Pathak R, Jha A, Sayami G. Evaluation of bone marrow in patients with pancytopenia. Journal of Pathology of Nepal (2012) Vol. 2, 265-271