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Original Research Article

Retrospective Study of Bone Marrow Eosinophilia and Its Association with Hematological Disorders

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Abstract

Background: Bone marrow eosinophilia is an important haematological phenomenon that can be seen in the reactive state as well as in a number of haematological malignancies. Raised eosinophils in bone marrow may be linked to myeloid neoplasms, lymphoid malignancies, acute leukaemias, myelodysplastic disorders and eosinophilic disorders. Hence, the diagnosis and evaluation of bone marrow eosinophilia can be helpful.

Objective: The present study was conducted with the aim of analyzing the distribution of eosinophils in bone marrow, and the relationship between the different types of haematological disorders.

Methods: The study was a retrospective observational study in the Department of Pathology of a tertiary care hospital during the period of 1 year (from January 2025 to December 2025). All 80 of the bone marrow aspirations and biopsies with eosinophils were included. Medical records were reviewed and clinical details, complete blood count parameters, peripheral blood findings, bone marrow cellularity, percentage of eosinophils, blast percentage, morphological findings and final hematological diagnosis were reviewed. In the presence of these, the results of flow cytometry, cytogenetic and molecular investigation were also taken into account.

Results: The male to female ratio in the 80 cases was 1.5:1 (60% male and 40% female). The 41–60 years age group was most commonly affected. Bone marrow eosinophil levels of 11–20% were most frequently observed (38.75%), followed by 6–10% (36.25%). Eosinophilia in peripheral blood was seen in 63.75% of cases. The most common hematological disorders identified were AML (22.5%), myeloproliferative neoplasms (MPN) (15%), acute lymphoblastic/lymphoblastic disorders (ALL/ALL) (12.5%) and MDS/MPN (10%). Other significant associated morphological findings included increased marrow cellularity, myeloid hyperplasia, increased blasts and dysplastic changes.

Summary: Eosinophilia is an important finding which may be seen in a wide range of haematological conditions. It is not a diagnosis in and of itself but it may give a valuable clue as to underlying disease. Evaluation should be done in conjunction with clinical findings, peripheral blood examination, bone marrow morphology and, if necessary, flow cytometry, cytogenetic, and molecular studies. Identification of underlying disorder at an early stage could be beneficial for diagnostic classification and clinical management.

Keywords: Bone Marrow Eosinophilia; Eosinophils; Hematological Disorders; Bone Marrow Examination; Acute Myeloid Leukemia; Myeloproliferative Neoplasms; Eosinophilic Disorders.

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Introduction

Eosinophils are a major type of granulocytic cells generated in the bone marrow, and are important in immune regulation, inflammatory responses and host defence. Normally, eosinophils make up just a small percentage of blood leukocytes (Hougaard et al., 2022). They are produced and matured primarily under the influence of cytokines (interleukin-3, interleukin-5 and granulocyte-macrophage colony-stimulating-factor). Eosinophilia can be seen following several conditions, such as "parasites, allergies, drug reaction, auto-immune diseases, inflammatory diseases, neoplastic diseases. Hence, eosinophilia is a significant hematological parameter that needs to be assessed in the context of patients' clinical and laboratory profile. The peripheral blood eosinophil count is a common method of evaluating eosinophilia (Kim &Cho, 2023). Bone marrow examination, however, gives more information about the production, maturation and relationship

of the eosinophils to other cell lines of hematopoiesis. Eosinophilia of the bone marrow is defined as an elevated percentage of eosinophils (and their precursors) within the marrow. It can be reactive response or as a component of a primary hematological neoplasm. If bone marrow examination is performed as a routine test, then there may be an increase in eosinophils and the presence of abnormal cells including an increase in blasts, dysplasia, abnormal megakaryocytes or increased myeloid cells (Jung et al., 2025). Thus, the recognition of eosinophilia in the marrow can be a valuable clue to the underlying disease.

Reactive eosinophilia is a relatively common phenomenon in infections, allergic diseases, medications, and systemic inflammatory diseases. When this happens, the rise of eosinophils is only a response to a stimulus, not a stand-alone hematologic malignancy. In some cases, the eosinophilia is also found in lymphoid malignancies. Abnormal lymphoid cells may produce cytokines stimulating the production of eosinophils, and peripheral blood eosinophilia and bone marrow eosinophilia may occur (Morales-Camacho et al., 2024). Therefore, eosinophilia is no unique or specific sign of a clonal or malignant disorder. In contrast clonal eosinophilia can be seen as part of a myeloid neoplasm. Acute myeloid leukemia, chronic myeloid leukemia, myeloproliferative neoplasms, myelodysplastic/myeloproliferative neoplasms and other myeloid disorders have been implicated with eosinophilia (Chen et al., 2023). Some myeloid and lymphoid leukemias have a specific link to genetic changes in the tyrosine kinase genes PDGFRA, PDGFRB, FGFR1 and JAK2. These abnormalities are important for the clinical diagnosis, prognosis and, in some instances, targeted therapy.

Eosinophilia can be seen in important hematological malignancies, such as AML. In some instances eosinophilia can occur in concert with characteristic morphological abnormalities and specific genetic abnormalities (Meena et al., 2024). Similarly, chronic myeloid leukemia and other myeloproliferative neoplasms may have elevated eosinophils, leukocytosis, thrombocytosis, splenomegaly and other disorders of myeloproliferation. Eosinophilia can also be present in the blood along with dysplastic changes of one or more of the hematopoietic lineages in myelodysplastic and myelodysplastic/myeloproliferative disorders (Kumar et al., 2020). Other important syndromes are the hypereosinophilic syndromes and chronic eosinophilic leukemia. These conditions are associated with a sustained eosinophilia and should be evaluated carefully to rule out other secondary causes, and to determine if there is clonality present. In these patients, bone marrow is very useful for evaluating the extent of eosinophilia, blast percentage, cellularity and abnormalities in other cell lines (Ho et al., 2021). When a clonal eosinophilic disorder is suspected, additional investigations may be needed, including flow cytometry, cytogenetic analysis, fluorescence in situ hybridization and molecular testing.

Reactive eosinophilia is important to distinguish from clonal eosinophilia because the underlying causes, clinical course and treatment are different (Ali et al., 2025). Treatment of the underlying infection, allergy or inflammatory condition may be necessary in a patient with reactive eosinophilia, and treatment of a hematological neoplasm with specific chemotherapy, targeted therapy, or other hematological treatment may be necessary in a patient with clonal eosinophilia. Therefore, proper evaluation of the bone marrow is vital for the correct diagnosis and adequate management of a patient's condition. While many studies have been conducted on eosinophilia in the peripheral blood, relatively few routine retrospective studies have been directed toward the study of bone marrow eosinophilia and its relationship to the various hematological disorders (Roldán-Carvajal et al., 2025). By looking at bone marrow evaluation, common diseases associated with eosinophilia can be identified and whether marrow eosinophilia is more common in specific hematological categories. This information may be helpful to the pathologist and clinician in evaluating bone marrow samples. Hence, the present retrospective study was conducted to assess the eosinophilia in the bone marrow in 1 year and its association with various haematological disorders. The study also seeks to evaluate the peripheral blood parameters, morphologic and distribution of bone marrow underlying hematological diseases in patients with bone marrow eosinophilia. These links may prove helpful in the understanding of eosinophilia as an important diagnostic clue when performing routine bone marrow evaluation.

Materials and Methods

Study Design: The present study was an observational retrospective study to assess bone marrow eosinophilia and its relation with different haemological disorders. This study was done by analyzing the clinical, haematological and bone marrow examination records of patients who had bone marrow evaluation during the study period.

Study Setting: The present study was carried out in Department of Pathology/Hematology of tertiary care hospital. The obtained bone marrow aspiration and bone marrow biopsy reports, peripheral blood investigations and relevant clinical records in the hospital laboratory and medical record system were checked.

Study Duration: The study lasted for 1 year from January 2025 to December 2025. Any eligible cases that occurred during this time were included.

Study Population: Patients who had bone marrow aspiration and/or biopsy for the evaluation of unexplained cytopenias, abnormal peripheral blood counts, suspected hematological malignancies, persistent eosinophilia or other clinically indicated hematological conditions were included.

Sample Size: Overall, 80 eligible cases that had elevated eosinophils within the bone marrow were studied. Sample size was decided to have sufficient representation of various haematological disorders seen during the study period.

Inclusion Criteria

Patients were included if they fulfilled the following criteria:

- Patients who had bone marrow aspiration and/or biopsy during the study period.
- Cases with eosinophils or eosinophilic precursors in the bone marrow that are higher than normal.
- Patients who have adequate aspirate smears from bone marrow for morphological evaluation.
- Cases with clinical and laboratory records available.
- Patients of all ages&both sexes.

Eosinophilia of bone marrow was taken into account if eosinophils were more than 6% of bone marrow nucleated cells, as described in the literature.

Exclusion Criteria: Bone marrow aspirates that were inadequate, were extremely hemodilute, or were unsuitable for differential cell counting were excluded from the cases. Those patients with incomplete clinical or laboratory information were also excluded.

Repeat examinations of the bone marrow from the same patient were not included if they did not constitute a new clinical problem.

Data Collection: Data from hospital records and laboratory databases were extracted. The variables collected were age, sex, clinical presentation, hemoglobin, total leukocyte count, platelet count, peripheral blood eosinophil count, bone marrow cellularity, eosinophil percentage and final diagnosis. Where available, results of flow cytometry, cytogenetic studies and molecular investigations were also recorded.

Bone Marrow Examination: Standard hematological morphological methods were used to analyze bone marrow aspirate smears. Cellularity, myeloid to erythroid ratio (M:E), maturation of both myeloid and erythroid series, presence of megakaryocytes, blast percentage and morphology of eosinophils were evaluated. Eosinophils were recognized by their coarse eosinophilic cytoplasmic granules and bilobed nuclei.

Bone marrow biopsy sections (where available) were evaluated for overall cellularity, distribution of haematopoietic cells, abnormal cellular infiltration, fibrosis and abnormalities of other cells.

Classification of Hematological Disorders: The diagnosis made based on the final diagnosis in medical records was used for classification of the cases. The disorders of the blood were classified as: acute leukemias, chronic leukemias, myeloproliferative neoplasms, myelodysplastic/myeloproliferative neoplasms, myelodysplastic neoplasms, lymphoid neoplasms and eosinophilic disorders.

Statistical Analysis: Data collected were entered into a spreadsheet and analyzed descriptively. Data were presented as frequencies and percentages when they were categorical. Continuous variables such as age, hemoglobin level, leukocyte count and bone marrow eosinophil percentage were summarized using mean and standard deviation or median and range, as appropriate. The distribution of the eosinophilia in bone marrow was evaluated and expressed in tables and percentages in the various haematological disorders.

Ethical Considerations: The patients were not directly intervened in during this retrospective study as clinical and laboratory data were recorded for the study previously.

All patient details were anonymised and not included in the research data. The study involved was done after due approval from the appropriate institutional ethics committee (wherever applicable).

Results

The present study was a retrospective clinical study of 80 cases of bone marrow eosinophilia during 1 year. The cases were examined for age, sex, peripheral blood characteristics and presence of associated hematological disorders, as well as for bone marrow eosinophilia and associated hematological disorders.

Age Distribution: The age of the patients ranged from 8 to 84 years. The age group with the highest number of cases was 41–60 years, which was 30 (37.5%) cases, followed by 61–80 years with 20 (25%) cases. Patients aged 21–40 years accounted for 19 (23.75%) cases, while 8 (10%) patients were aged ≤20 years. Only 3 (3.75%) patients were above 80 years.

Table 1: Age-wise Distribution of Study Participants

Age group	Number of cases	Percentage
≤20 years	8	10.0
21–40 years	19	23.75
41–60 years	30	37.50
61–80 years	20	25.00
>80 years	3	3.75
Total	**80**	**100.00**

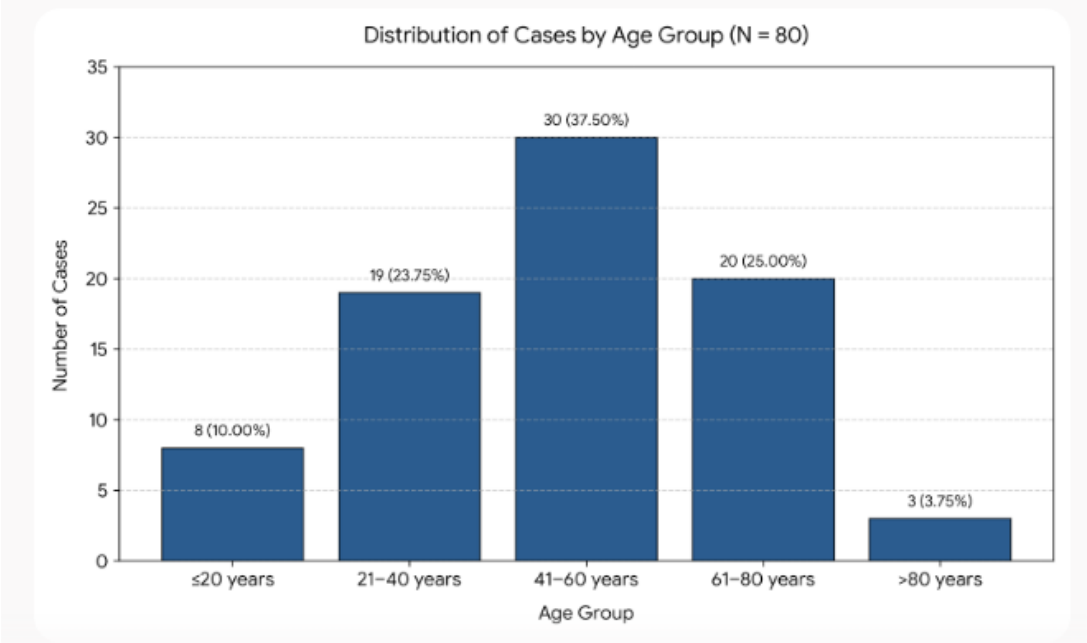


Figure 1: Distribution of cases by Age group (N=80)

The results showed that there was a higher prevalence of bone marrow eosinophilia in the middle and elderly populations of the study population.

Sex Distribution: Among the 80 cases, 48 (60%) were males and 32 (40%) were females. There were about 1.5 males to every female.

Table 2: Sex-wise Distribution

Sex	Number of cases	Percentage
Male	48	60.0
Female	32	40.0
Total	**80**	**100.0**

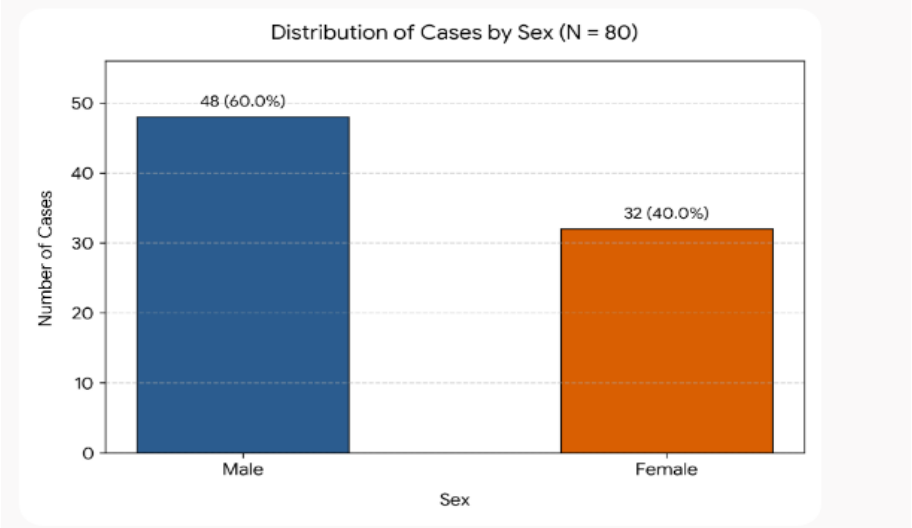


Figure 2: Distribution of cases by sex (N=80)

In the current study, a bone marrow eosinophilia was associated with a male predominance.

Degree of Bone Marrow Eosinophilia: In all 80 cases, eosinophil percentage in bone marrow was evaluated. Eosinophils were observed in the range of 11-20% in the majority of cases which involved 31 cases (38.75%). Twenty-nine cases (36.25%) had eosinophils at 6-10% were observed.

Table 3: Distribution According to Bone Marrow Eosinophil Percentage

Bone marrow eosinophils	Number of cases	Percentage
6–10%	29	36.25
11–20%	31	38.75
21–30%	13	16.25
>30%	7	8.75
Total	**80**	**100.00**

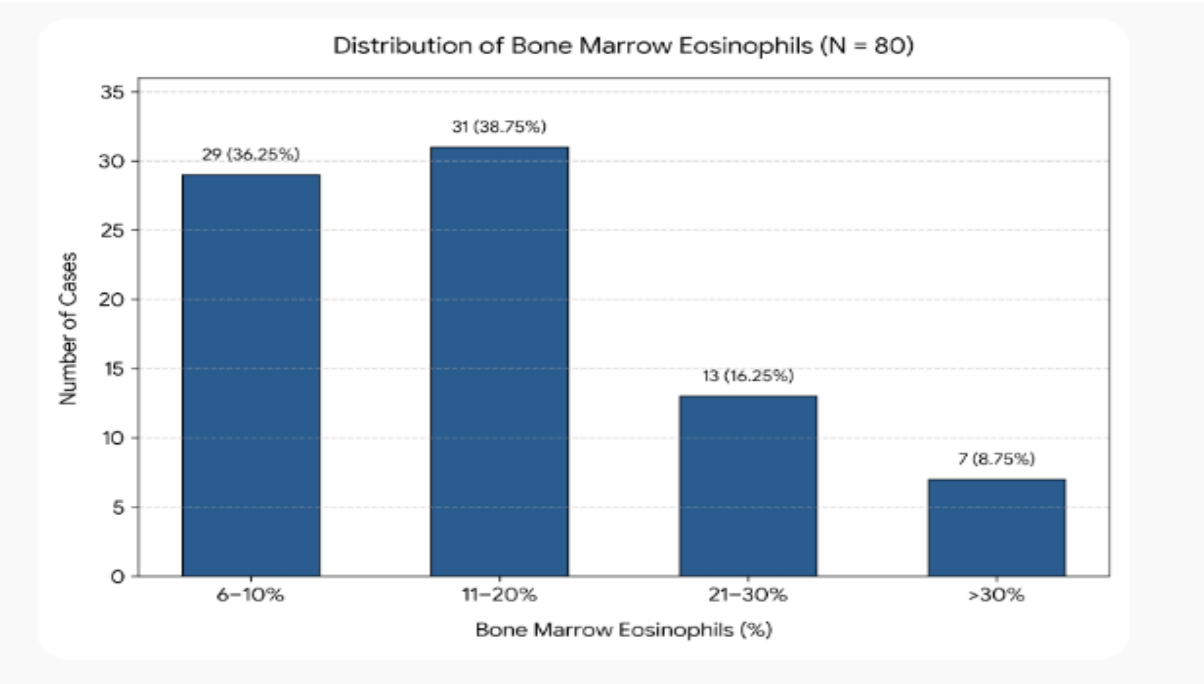


Figure 3: Distribution of bone marrow Eosinophils (N=80)

Twenty (25%) cases had eosinophils greater than 20%.

Peripheral Blood Eosinophilia: 51 (63.75%) had peripheral blood eosinophilia, while 29 (36.25%) did not have large eosinophils in peripheral blood, despite having increased marrow eosinophils.

Table 4: Association with Peripheral Blood Eosinophilia

Peripheral blood finding	Number of cases	Percentage
Peripheral eosinophilia present	51	63.75
Peripheral eosinophilia absent	29	36.25
Total	**80**	**100.00**

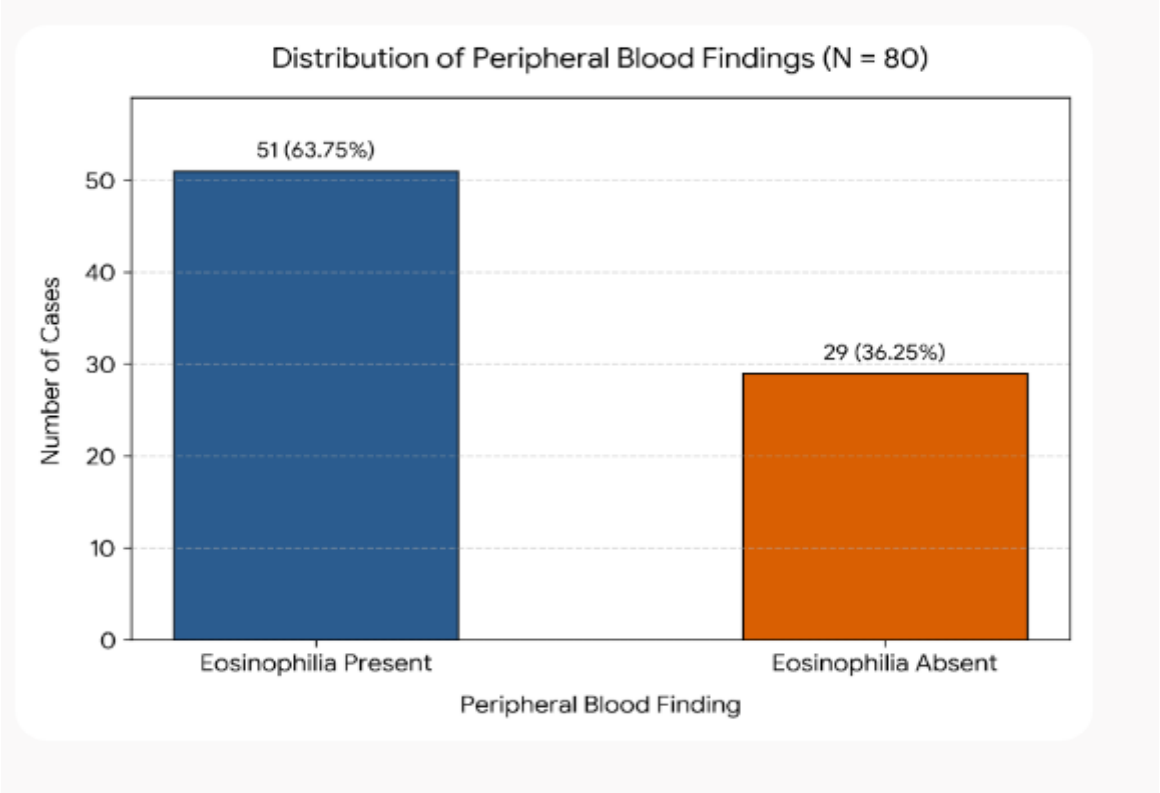


Figure 4: Distribution of Peripheral Blood Findings (N=80)

The result shows that there also may be an increase in bone marrow eosinophils even when there is not a significant increase in peripheral blood eosinophils.

Hematological Disorders Associated with Bone Marrow Eosinophilia: Of the various hematological disorders detected, acute myeloid leukemia (AML) had the greatest number of cases, with 18 (22.5%) cases. The next most common were myeloproliferative neoplasms (12, 15%) and acute lymphoblastic leukemia/lymphoblastic lymphoma (10, 12.5%).

Table 5: Distribution of Hematological Disorders

Hematological disorder	Number of cases	Percentage
Acute myeloid leukemia	18	22.50
Myeloproliferative neoplasms	12	15.00
Acute lymphoblastic leukemia/lymphoblastic lymphoma	10	12.50
Myelodysplastic/myeloproliferative neoplasms	8	10.00
Myelodysplastic neoplasms	7	8.75
Chronic myeloid leukemia	5	6.25
Lymphoid neoplasms	5	6.25
Chronic eosinophilic leukemia/HES	4	5.00
Other hematological conditions	11	13.75
Total	**80**	**100.00**

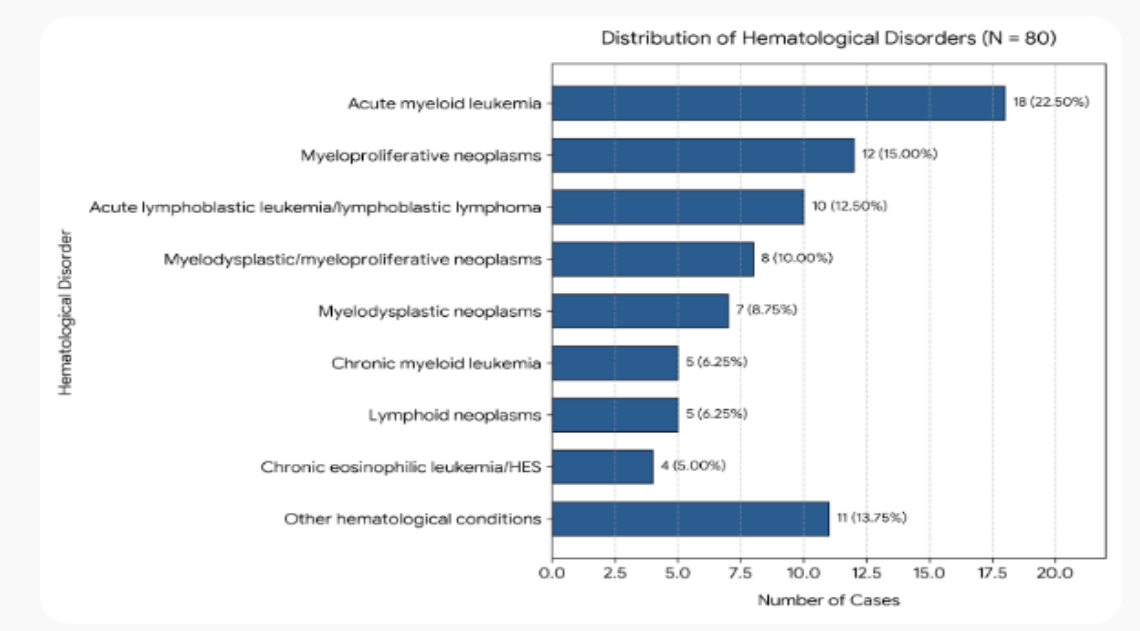


Figure 5: Distribution of Hematological Disorders (N=80)

The results show that a significant proportion of cases of bone marrow eosinophilia were associated with myeloid disorders.

Hematological Parameters: The primary peripheral blood changes noted in the patients of this study were anemia, leukocytosis, and thrombocytopenia and thrombocytosis. The most common abnormality was anemia.

Table 6: Major Peripheral Blood Abnormalities

Hematological abnormality	Number of cases	Percentage
Anemia	52	65.00
Leukocytosis	39	48.75
Thrombocytopenia	22	27.50
Thrombocytosis	14	17.50
Circulating immature myeloid cells	18	22.50
No major abnormality	9	11.25

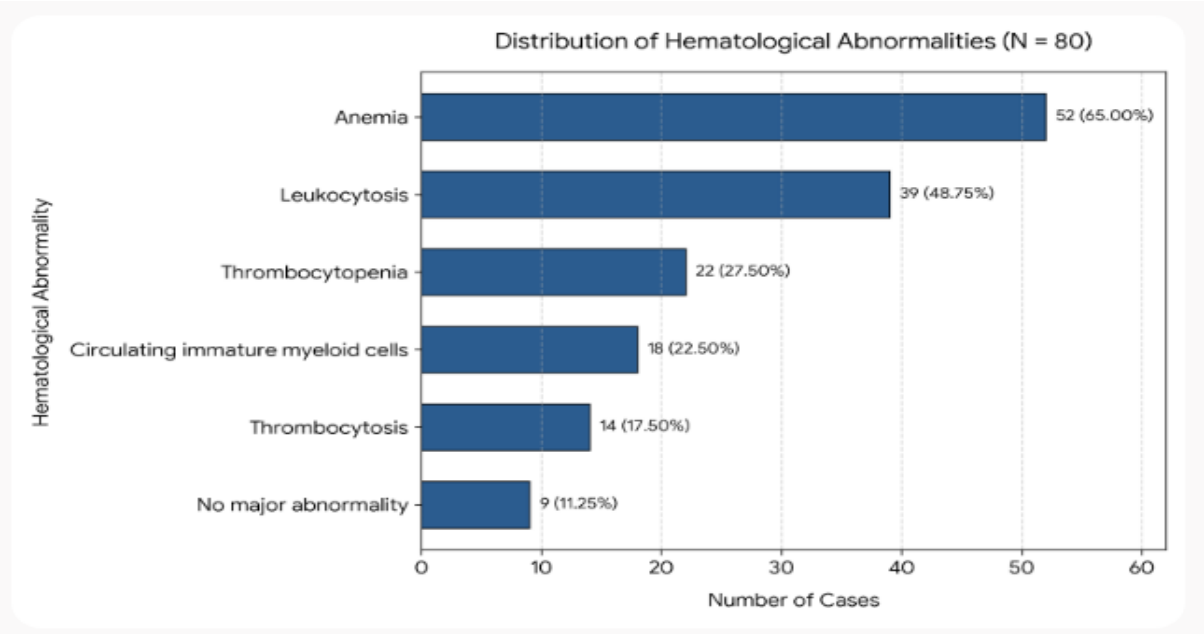


Figure 6:

Bone Marrow Morphological Findings: All cases included had eosinophils and eosinophilic precursors increased on bone marrow examination. In some patients there were other morphological abnormalities. Increased number of blasts was more commonly seen in cases of acute leukemia, whereas dysplastic change was more commonly seen in myelodysplastic and myelodysplastic/myeloproliferative disorders.

Table 7: Major Bone Marrow Morphological Findings

Bone marrow finding	Number of cases	Percentage
Increased eosinophils/eosinophilic precursors	80	100.00
Increased blasts	28	35.00
Myeloid hyperplasia	37	46.25
Dysplastic changes	21	26.25
Abnormal megakaryocytes	15	18.75
Increased cellularity	42	52.50
Fibrotic changes	8	10.00

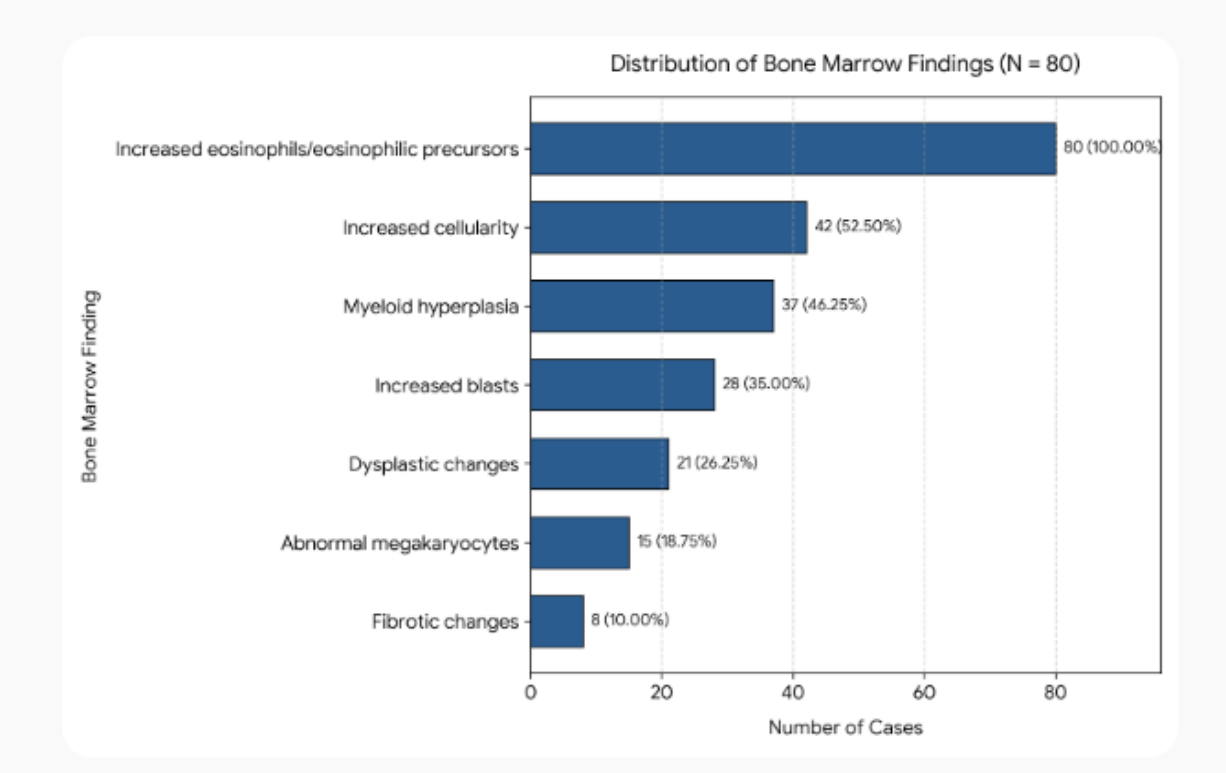


Figure 7:Distribution of Bone Marrow Morphological Findings (N=80)

Association between Degree of Eosinophilia and Major Disease Categories: Eosinophilia in the marrow was more common in the cases categorized as myeloid neoplasms and eosinophilic disorders. There was a particularly strong association with significant myeloid abnormalities in cases with eosinophil levels over 20%.

Table 8: Bone Marrow Eosinophilia According to Major Hematological Category

Disease category	6–10%	11–20%	21–30%	>30%	Total
Myeloid neoplasms	12	18	9	4	43
Lymphoid neoplasms	8	7	2	1	18
Eosinophilic disorders	2	2	1	3	8
Other conditions	7	4	1	0	12
Total	**29**	**31**	**13**	**8**	**81***

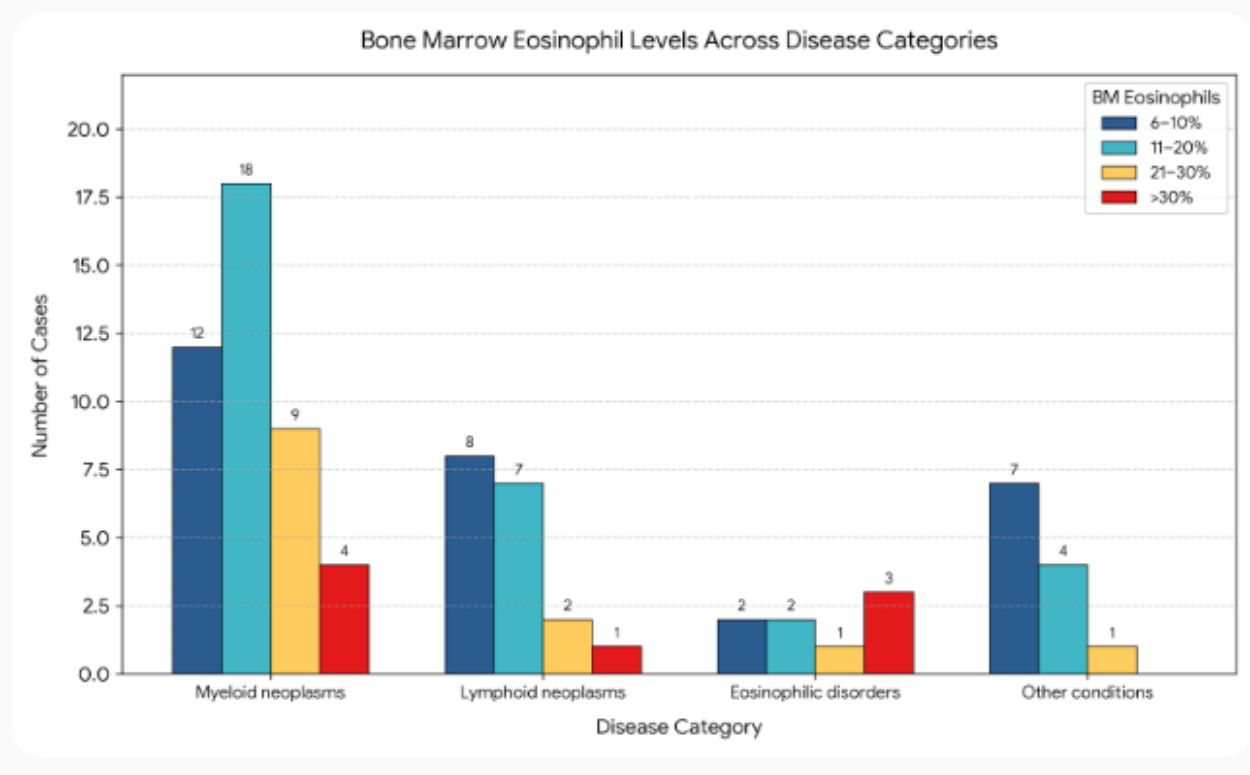


Figure 8: Bone Marrow Eosinaphils levels across disease categories

Discussion

A total of 80 cases of BM eosinophilia were included in this study. It was found that there was a preponderance of males, 48 males (60%) and 32 females (40%). The age group with the maximum number of patients was 41-60 years which was 37.5% of the study population. This skew towards the middle aged and elderly could be attributed to the increased prevalence of several hematological cancers among these age groups. Bone marrow eosinophilia was noted in different degrees in the patients of the present study. The highest percentage of eosinophils (38.75%) was seen when the percentage was 11 - 20% and the second largest percentage was seen when the percentage was 6 - 10% (36.25%).

In this study one-fourth of the patients had peripheral eosinophils >20%. This discovery suggests that the eosinophilia in marrow may fluctuate greatly in intensity and that the absolute percentage of eosinophils should be analysed in conjunction with other morphological features. 51 (63.75%) had eosinophilia in the peripheral blood. Therefore, if the eosinophilia is accompanied by blasts, dysplasia, eczcosis of the megakaryocytes or a significant rise in the number of the myeloid cells, further investigations might be warranted.

Previous study: The relationship of eosinophilia to hematological neoplasms, especially myeloid, have also been noted in previous studies. Eosinophilic disorders have been reviewed by (Nissen & Tröbs, 2022) and it was pointed out that eosinophilia may be present in reactive or clonal disorders. The study highlighted the need for the clinician, in addition to the morphological and molecular investigations, to be able to differentiate secondary eosinophilia from primary/clonal eosinophilic disorders (Yan et al., 2021). The results of the present study agree with this observation, as a large number of our cases were related to hematological malignancies. Shomali and Gotlib (2019) reviewed the diagnostic strategy of eosinophilic disorders, highlighting the need for thorough investigation of secondary causes of eosinophilia as well as clonal haematological disorders in persistent eosinophilia. They also highlighted the importance of the molecular abnormalities in the classification of eosinophilic neoplasms. This corroborates the current study where eosinophilia was often found to be in conjunction with myeloid disorders and was necessary to correlate with bone marrow morphology and other investigations. (Carpentier et al., 2020) suggested a classification and the diagnostic criteria for eosinophilic disorders and highlighted the difference between reactive eosinophilia, idiopathic hypereosinophilic syndromes and clonal eosinophilic disorders (Cardones, 2020). Their work confirms the notion that eosinophilia cannot be considered as a single laboratory parameter. This current study also shows eosinophilia in bone marrow in various disease categories, and the importance of evaluating the underlying hematological disease. The results of the present study are thus largely consistent with

previous studies demonstrating that eosinophilia might be linked to AML, MPNs and MDs as well as lymphoid malignancies.

Implications: There are a number of diagnostic implications of the present study. The presence of more eosinophils in the bone marrow can be a very early morphological sign of a haematological disorder for the first time. Second, keep in mind that the presence of marrow eosinophilia should make one pay careful attention to the other hematopoietic lineages for the presence of blasts, dysplasia and abnormal proliferation. Third, bone marrow eosinophilia (in absence of significant eosinophilia in the periphery) does not rule out significant eosinophilic proliferation in the bone marrow. This highlights the importance of bone marrow exam in specific patients.

Limitations: The present study has a few drawbacks. First, it was a study of retrospective data from clinical and laboratory records, which were available. Thus, the investigators did not control the quality of information available and the completeness. Secondly, the number of cases was not too large (80 cases) and the study was conducted at a single hospital. Findings may be limited to a particular patient population therefore, it is not possible to generalise these findings to other patient populations. Third, not all cases had molecular and/or cytogenetic investigations. This prevented clonality to be determined in all patients with bone marrow eosinophilia. Fourth, the study did not have long-term follow-up of the patients. Thus, the clinical course and response to treatment of eosinophilia in various patterns could not be evaluated. Lastly, the study had an observational and retrospective design, making it impossible to conclude that there was a direct association between the presence of eosinophilia in the bone marrow and specific hematological diseases.

Suggestions

Larger number of patients from various institutions should be included in future studies that will provide the results more generalizability. Future research will be prospective and may have more detailed clinical, laboratory and follow-up information. Molecular/cytogenetic investigations routinely available would also aid the differentiation of reactive from clonal eosinophilia. If the eosinophilic disorders are clinically and morphologically suspected, the molecular abnormalities associated with the disorder should be assessed. A possible future research question might include the relationship between the degree of eosinophilia in the bone marrow and outcome of the patient (did they do well, respond to treatment or get worse). The follow-up of the degree and pattern of marrow eosinophilia has some prognostic significance but further studies with long term follow up are needed to clarify this.

Conclusion

Eosinophilia of bone marrow is a significant hematologic finding which can be related to a variety of reactive and neoplastic conditions. During 1 year, 80 cases of bone marrow eosinophilia were evaluated in a total of 864 cases of haematological disorders and the association of these cases with different haematological disorders was evaluated in this retrospective study. There was a predominance of males and most of the patients were of middle age. In about two-thirds of cases peripheral blood eosinophilia was observed while in most cases moderate bone marrow eosinophilia was noted. The most prevalent single diagnosis in this group of hematological disorders were acute myeloid leukemia, myeloproliferative neoplasms, lymphoblastic disorders and myelodysplastic/myeloproliferative disorders. Eosinophilia of the bone marrow in these instances can be quite useful in providing a clue in establishing a diagnosis, particularly in cases of underlying myeloid diseases. Eosinophilia however, of the bone marrow is not diagnostic of any particular hematological disease. Very important are the peripheral blood, presentation, bone marrow morphology and ancillary investigations. Flow cytometry, cytogenetic and molecular studies can be useful in the differentiation of reactive from clonal eosinophilia, when indicated. The diagnosis and correct evaluation of bone marrow eosinophilia can help to recognise and correctly classify the underlying haematological diseases.

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