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SPECTRUM OF LESIONS IN BONE MARROW ASPIRATION AND TREPHINE BIOPSY IN A TERTIARY CARE HOSPITAL IN EASTERN UTTAR PRADESH

Pathology

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ABSTRACT

Introduction Hematological disorders, including anaemia and malignancies, are prevalent worldwide and particularly burdensome in low income regions.Accurate diagnosis often requires bone marrow aspiration and trephine biopsy, especially when initial tests are inconclusive. The procedure offers valuable insights into marrow structure and pathology, enhancing detection of various blood disorders. **Methodology:**A total of 160 samples were evaluated in Department of Pathology , BRD Medical college. The samples were analyzed after obtaining informed and written consent. Preserved tissue samples in the department were also utilized for detailed examination.**Results:**This study examined bone marrow aspiration (BMA) and biopsy (BMB) findings at a tertiary care centre in Eastern Uttar Pradesh. Most patients were children and young adults, with a slight male predominance. Anemia was the most common indication and diagnosis, with megaloblastic anemia being the leading subtype. Leukemia was identified in 26.87% of cases, with acute lymphoblastic leukemia (ALL) as the most frequent malignancy. Hypercellular marrow was the most common cellularity pattern, while dimorphic PBS patterns suggested nutritional deficiencies. BMA demonstrated high sensitivity (95.89%) and accuracy (93.75%), making it an effective initial diagnostic tool. BMB proved more specific and useful in identifying neoplastic and infiltrative conditions. The study emphasizes the complementary value of BMA and BMB in diagnosing hematological disorders.**Conclusion:**Bone marrow aspiration and biopsy are complementary to each other and the superiority of one over other depends on disease under consideration.

KEYWORDS

Bone marrow aspiration , bone marrow biopsy , diagnostic accuracy

INTRODUCTION

Hematological disorders affect millions of people globally, mostly affecting blood and blood-producing organs and are common among all age groups and usually range from anaemias to malignancies.[1] One-fourth of the world's population suffers from anemia. Anemia increased by 420 million during the previous 30 years to 1.92 billion in 2021.[2] Thalassemia, another important hematological illness, affects 5% of the world's population, with India having the most children with serious cases.[3] Malignant hematological illnesses such as leukemia, lymphoma, and multiple myeloma have varying occurrences worldwide. Hematological illnesses need extensive clinical examination and laboratory tests, such as CBC, peripheral smear, and biochemical analysis for diagnoses. Undiagnosed anemia, storage disorders, parasite infections,leukemia lymphoma, and plasma cell dyscrasias sometimes need bone marrow assessment. Bone marrow aspiration and trephine biopsy are necessary when peripheral blood smear analysis is unclear.[4] Hematopoietic diseases may be diagnosed quickly and accurately with bone marrow aspiration. Cytogenetics and molecular methods have improved bone marrow aspirate diagnosis and prognosis. When aspirates fail or in situations like myelofibrosis, aplastic anemia, and infiltrative illnesses, trephine biopsy is necessary and may aid in diagnosis.[5,6]The discrepancy between bone marrow aspiration and trephine biopsy in certain hematologic disorders highlights the necessity for a combined diagnostic hematology strategy.[7]

Eastern Uttar Pradesh, a heavily populated area in India, has a significant frequency of anemia, infectious illnesses, and rising incidence of hematological malignancies.[8] Comprehending the range of bone marrow lesions in this group is crucial for enhancing diagnostic and treatment approaches. Nonetheless, there exists little evidence from this area about the frequency and distribution of bone marrow diseases.[9] This research seeks to examine the variety of lesions seen in bone marrow aspiration and trephine biopsy specimens, emphasizing their clinical importance and epidemiological patterns in this area.

METHODOLOGY

This was a prospective/observational study conducted at Department of Pathology, Baba Raghav Das(BRD) medical college, Gorakhpur, Uttar Pradesh, India over a period of one year (Dec-2023 to Nov 2024).The bone marrow aspiration and biopsies of clinically suspected patients for evaluation of hematological disorders in the department of Pathology over a period for 1 year. After taking informed and written consent, bone marrow of the patient received in the department, was analysed. Tissues preserved inpathology department; B.R.D. Medical College were utilized for the study. The inclusion criteria was clinically indicated patient willingly giving consent.

The exclusion criteria were samples from patient denying consent; known case of haemorrhagic disorders such as congenital coagulation factor (eg. haemophillia) and disseminated intravascular coagulation and concomitant use of anticoagulants;any infection at the site of aspiration; disc prolapse, vertebral defects etc. which are not favourable for positioning of patient

RESULTS

Out of a total of 160 patients, 85 (53.13%) were male and 75 (46.88%) were female, indicating a slight male predominance in the study population. The highest proportion of cases was observed in the 11–20 years age group (26.88%), followed by the ≤10 years group (19.38%).

Table 1 : Gender-wise distribution of patients who underwent bone marrow aspiration and trephine biopsy

Gender	n	%
Male	85	53.13
Female	75	46.88

Table 2: Age-wise distribution of patients undergoing bone marrow aspiration and trephine biopsy

Age	n	%
≤10 years	31	19.38
11-20 years	43	26.88
21-30 years	23	14.38
31-40 years	11	6.88

41-50 years	22	13.75
51-60 years	16	10.00
>60 years	14	8.75

The most common indication was Anaemia Under Evaluation, followed by Pancytopenia and Suspected Acute Leukemia highlighting the fact that the majority of bone marrow examinations were conducted to investigate hematological abnormalities such as anaemia, cytopenias, and suspected leukemias.

Table 3 : Indications for which bone marrow aspiration and trephine biopsy were performed in the study population

Indication	n	%
Anaemia Under Evaluation	63	39.38
Pancytopenia	35	21.87
Suspected Acute Leukemia	31	19.37
Suspected Chronic Leukemia	12	7.50
Suspected Metastasis	2	1.25
Suspected Multiple Myeloma	10	6.25
Severe Thrombocytopenia	3	1.87
Suspected PV	1	0.62
Lymphoma	3	1.87

The majority of cases (48.12%) demonstrated hypercellular marrow, which is typically seen in conditions with increased hematopoietic activity, such as leukemias, megaloblastic anemia, or myeloproliferative disorders.Hypocellular marrow was observed in 30.62% of cases, which may indicate aplastic anemia, marrow suppression, or post-infectious states. Normocellular marrow was seen in 21.25% of patients, indicating a relatively normal hematopoietic reserve or early stages of disease.

Table 4 : Bone Marrow Cellularity

		n	%
Cellularity	Hypercellular	77	48.12
	Hypocellular	49	30.62
	Normocellular	34	21.25

The most common diagnosis was anaemia, accounting for 43.75% (n=70) of cases.Aplastic anaemia, a form of marrow failure, was diagnosed in 7.5% (n=12) of cases. Leukemia constituted a notable proportion of diagnoses: acute leukemia was identified in 8.75% (n=14), with acute lymphoblastic leukemia (ALL) and acute myeloid leukemia (AML) comprising 5.62% (n=9) and 3.75% (n=6), respectively. Chronic myeloid leukemia (CML) also appeared in 5.62% (n=9), and chronic lymphocytic leukemia (CLL) in 1.87% (n=3).Other hematological abnormalities included multiple myeloma (6.25%, n=10), immune thrombocytopenic purpura (ITP) (1.87%, n=3), lymphoproliferative disorder (LPD) (1.87%, n=3), and myeloid hyperplasia (1.87%, n=3). Rare hematological diagnoses such as myelodysplastic/myeloproliferative neoplasm (MDS/MPN), polycythemia vera (PV), and Gaucher's disease were identified in 0.62% (n=1) each.Non- hematological and infectious findings included metastasis to the bone marrow in 1.25% (n=2) and the presence of Leishmania (LD bodies) in 0.62% (n=1), reflecting the utility of biopsy in identifying systemic diseases and marrow infiltration.There was complete agreement between aspiration and biopsy in several diagnoses, demonstrating strong correlation andreliability of both procedures for certain conditions.Some discrepancies were observed in specific diagnoses, highlighting the complementary role of biopsy in confirming or refining diagnoses when aspiration is inconclusive or insufficient

Table 5 : Correlation between bone marrow aspiration (BMA) and bone marrow biopsy (BMB)

Diagnosis	**Aspiration**		**Biopsy**	
	n	**%**	**n**	**%**
Megaloblastic Marrow	25	15.62	25	15.62
Micronormoblastic Maturation	15	9.37	15	9.37
Combined Nutritional Deficiency	20	12.5	20	12.5
Erythroid Hyperplasia With Normoblastic Maturation	10	6.25	10	6.25
Aplastic Anaemia	10	6.25	12	7.5
Acute Leukemia	12	7.5	14	8.75
Acute Lymphoblastic Leukemia	11	6.87	9	5.62
Acute Myeloid Leukemia	6	3.75	6	3.75
Chronic Myeloid Leukemia	8	5	9	5.62
Chronic Lymphocytic Leukemia	3	1.87	3	1.87
Myeloid Hyperplasia	3	1.87	3	1.87
Metastasis	2	1.25	2	1.25
ITP	2	1.25	3	1.87
Lympho Prolife Rative Disorder	3	1.87	3	1.87
Leishmania (LD BODY)	1	0.62	1	0.62
MDS/MPN	1	0.62	1	0.62
Polycythemia Vera	1	0.62	1	0.62
Gauchers Disease	1	0.62	1	0.62
Multiple Myeloma	8	5.00	10	6.25
Dry Tap	6	3.75	4	2.5
Inadequate	10	6.25	10	6.25

The sensitivity of BMA was found to be 95.89%, indicating its high ability to correctly detect cases . The specificity was 71.42%, reflecting its capacity to correctly rule out pathology when absent. The positive predictive value (PPV) of 97.22% suggests that most patients diagnosed on aspiration trulyhad the disease, while the negative predictive value (NPV) of 80.65% indicates a good probability that a negative BMA result correlates with the absence of disease. The overall accuracy of 93.75% demonstrates that bone marrow aspiration considering bone marrow biopsy as gold standard is a reliable and efficient initial diagnostic tool, though biopsy remains essential for definitive confirmation in ambiguous or borderline cases.

DISCUSSION:

The present study has been conducted in the department of Pathology, BRD Medical College, Gorakhpur on the patients admitted and referred from wards of Medicine, Pediatrics and Obstetrics and Gynaecology Department, Nehru Chikitsalaya , Gorakhpur during a period of one year.

Table D1 : Comparative Study Of Age Groups Of Different Study

STUDIES	AGE GROOP
Our study	11-20 yrs
Jawed et al (2024)[103]	2-20 yrs
Thakur et al (2023)[97]	11-20 yrs
Piplani et al (2022) [94]	50-59 yrs
Dharani et al(2024) [104]	31-60 yrs

Our study observed that the highest proportion of cases involving bone marrow pathology was seen in the 11–20 years age group (26.88%), followed by the ≤10 years group (19.38%). This trend indicates a significant burden of hematological disorders among children and young adults. This pattern suggests either a higher susceptibility of this demographic to hematological disorders or a greater likelihood of clinical evaluation in this age group due to symptomatic presentations, such as anemia or pancytopenia. Jawed et al. (2024) and Thakur et al. (2023), on the other hand, found results that were more like ours. The findings of our study contrasts with the study by Piplani et al. (2022), where the most common age group was 50–59 years, with a mean age of 50.22 years, reflecting a shift toward older populations. Dharani et al. (2024) also found a majority of cases in the 31–60 years range. Our study's findings, therefore, support the notion that in Eastern Uttar Pradesh, younger age groups are disproportionately affected by marrow disorders, which may warrant further public health attention.

Table D2 : Comparative Study Of Clinical Indications

STUDY	MOST COMMON INDICATION
Our study	Anaemia under evaluation
Rajan et al (2015)[109]	Anaemia under evaluation
Piplani et al (2022)[94]	Anaemia under evaluation
Dharani et al (202)[104]	Pancytopenia
Bela et al (2024)[114]	Anaemia under evaluation

The most frequent clinical indication for bone marrow examination in our study was anemia under evaluation (39.38%) followed by pancytopenia(21.87%). Suspected cases of acute leukemia accounted for 19.37%. These results show how important it is to check the bone marrow when someone has a hematological cytopenia or is suspected of having a cancer. Piplani et al.(2022), Rajan et al.((2015) and Sharda Bela et al. (2023) also said that anemia was a common reason for bone marrow studies, which shows how important they are in the clinical diagnostic process. Dharani et al. (2024), listed pancytopenia as the most common indication (43.3%) followed by anemia under assessment (18.8%). The clinical profile in our study also included indications like thrombocytopenia, multiple myeloma, and metastasis, albeit less frequently. These patterns show that bone marrow studies

are very useful for finding a lot of different diseases, especially when peripheral smear and other non-invasive tests don't give clear results. The relatively high frequency of anaemia and pancytopenia as an indicator in our study may mean that more people in Eastern Uttar Pradesh are aware of and researching this condition. This is because nutritional and infectious causes are common in this demographic area.

Table : D3 Comparative Study Of Cellularity Of Bone Marrow Aspirate

Study	Total Cases	NARMO	HYPO	HYPER
Our study	160	21.25%	30.62%	48.12%
Javed et al.(2024)[103]	200	31%	16.5%	52.5%
Rajan et al (2015)[109]	153	30%	20%	40%

Hypercellular marrow was the most common finding in our study (48.12%), which means that there was increased hematopoietic activity. This is often seen in conditions like megaloblastic anemia and hematologic cancers. Hypocellular marrow was seen in 30.62% of cases, suggesting marrow failure syndromes like aplastic anemia or post-infectious suppression. Normocellular marrow was reported in 21.25% of patients. These findings align well with those of Jawed et al. (2024), who found hypercellularity in 52.5% of cases and hypocellularity in 16.5%.[103] Rajan et al(2015) found 40% hypercellular, 30% normocellular and 20% hypocellular cases.[109] These patterns of cellularity help to make correct diagnoses by telling the difference between marrow hyperactivity and suppression and directing more research into the causes. The importance of assessing marrow aellulauli, is also highlighted in studies by Sharda Bela et al. (2023) and Thakur et al. (2023), where it served as a vital clue to the final diagnosis, especially in challenging or ambiguous cases. Our study reported the highest incidence of megaloblastic anemia (15.62%), which aligns with findings from Bela et al. (14%) and Thakur et al. (21.9%).[97,114] micronormoblastic and combined nutritional deficiencies were also frequently observed, reflecting widespread nutritional insufficiencies in the studied populations. Aplastic anemia was reported in 7.5% of our cases, comparable to other studies, emphasizing its significant though less common role in bone marrow failure syndromesteukem ia was the second most common broad category, with our study showing 26.87% combined leukemic cases. Acute leukemia, particularly AML and ALL had a varied prevalence: Thakur al. reported the highest frequencies (AML 26%, ALL 25.6%), while our study observed slightly lower figures (AML 3.75%, ALL 6.87%). This variance may reflect regional diagnostic trends or population differences.Chronic leukemias like CML and CLL were less frequent but showed consistent presence across studies. Our findings of CML (5.62%) and CLL (1.87%) were similar to those in Jawed et al. and Piplani et al., suggesting a stable occurrence pattern...Amon& plasma disorders multiple myeloma (MM)was diagnosed in 6.25% of our cell patients, aligning with Jawed et al. (6%) but higher than Piplani et al. (0.6%) and Dharani et at (3.5%).[103,104] These differences may reflect varying diagnostic access or referral patterns_ Rare conditions like Gaucher's disease_polycythemia Vera (PV), MIDS/MPN, and Leishmaniasis (LD body) were infrequent but reported across several studies, highlighting the diverse range of marrow pathology that may present in clinical practice.OveralL the data show that nutritional anemias and hematologic malignancies total the diagnostic bulk in bone marrow evaluations, with trends broadly aligning across regions, albeit with slight variations due to demographic and environmental differences.

Table D4 : Comparative Study Of Final Diagnoses

Diagnosis	Our Study (%)	Jawed et al [103]	Bela et al [114]	The Kur et al [114]	Piplani et al [94]	Dharani et al [104]
Megaloblastic Marrow	15.62%	20%	14%	21.9 %	10.3%	8%
Micronormoblastic Marrow	9.37%	-	15.04 %	-	14%	7.5%
Combined Nutritional Deficiency	12.5%	-	-	-	7.5%	8.75%
Erythroid Hyperplasia	6.25%	20%	-	-	-	2%
Aplastic Anemia	7.5%	4%	-	-	4%	4%
Leukemias and Lymphoid Malignancies						
Acute Leukemia	8.75%	20%	21.9%	14%	9.5%	9.4%
AML	3.75%	8%	2.8%	26%	6.4%	6%
ALL	6.87%	4%	4%	25.6 %	4%	5%
CML	5.62%	2%	1.5%	4%	4%	4%
CLL	1.87%	1%	1%	-	1%	1%
Myeloid Hyperplasia	1.87%	-	-	-	-	1%
ITP	1.87%	1%	-	1%	1%	1%
Lymphoproliferative Disorder	1.87%	-	-	-	1%	1%
MDS/MPN	0.62%	-	-	-	-	1%
Polycythemia Vera	0.62%	-	-	-	-	0.5%
Gaucher's Disease	0.62%	-	-	-	-	0.5%
LD Body	0.62%	-	1%	-	0.5%	0.5%

The concordance between bone marrow aspiration (BMA) and biopsy (BMB) in our study was high for several key diagnoses. Majority of the cases showed complete agreement between BMA and BMB. However, minor discrepancies were noted-acute leukemia was diagnosed in 1

Table D5 Comparative Study Of Sensitivity Specificity And Diagnostic Accuracy

Studies	Sensitivity	Specificity
Our study	95.89%	71.2%
Bela et al [114]	81.11%	100%
S. Chauhan et al [115]	84%	90%

Studies	Diagnostic efficacy
Our study	93.75%
Piplani et al(2022) [94]	92.0 %
Bela et al(2023)[114]	82.69%
Chandra and Chandra et al [79]	77.5%
Das et al [101]	77.18%

In our study, bone marrow aspiration had an overall diagnostic accuracy of 93.75%, with a sensitivity of 95.89%, specificity of 71.42%, positive predictive value (PPV) of 97.22% and negative predictive value (NPV) of 62.5%. These metrics show that BMA is a very good way to diagnose several conditions. However, BMB is still needed when the results are unclear or borderline In contrast. Bela et al. reported perfect specificity (100%) but a lower sensitivity (81.11%-i, suggesting their findings were highly accurate when positive, but may have missed some true disease cases_ Similarly, S. Chauhan et al. observed a balance between the two parameters, with 84% sensitivity and 909 specificity, reflecting a relatively strong diagnostic accuracy overa111114.115] garsjiugcljagnostc. efficacy. which reflects the overall accuracy in identifying disease correctly, our study reported a high diagnostic accuracy of 93.75% surpassing previous studies. Piplani et al. (2022) also reported a comparable efficacy of 92.0%, reinforcing the utility of bone marrow aspiration as a primary diagnostic tool. Sharda et al. (2023) Chandra and Chandra and Das et al. showed slightly lower diagnostic accuracies (81.69%, 77.5%. and 77.18% respectively), but still within acceptable diagnostic ranges479,94,101,114] These comparisons suggest that while bone marrow aspiration is generally reliable. its diagnostic yield can vary based on clinical context, examiner experience, and disease profile. emphasizing the complementary role of biopsy in certain cases. Our results support the idea that BMA and BMB, with a diagnostic accuracy of 93.75% when used together, are a reliable way to diagnose hematologic conditions, with BMB being an important confirmatory tool when aspiration isn't clear or doesn't give a diagnosis.

CONCLUSION

This study underscores the complementary roles of BMA and BMB in the evaluation of hematological disorders. While BMA is very sensitive and can be used as an initial diagnostic tool, BMB is much more specific and accurate, making it necessary for confirming neoplastic pathology and evaluating marrow architecture.Our study had certain limitations. The sample size was relatively small, which may limit the generalizability of the findings. Additionally, conducting the study at a single tertiary care center may introduce selection bias.

Inadequate bone marrow aspirates in 6.25% of cases reduced diagnostic yield, highlighting procedural challenges. The lack of advanced immunophenotyping or molecular studies limited the ability to characterize ambiguous or atypical cases. Furthermore, the studydid not include long-term follow-up, preventing the assessment of disease progression or treatment outcomes. Future multicentric studies with larger cohorts and advanced diagnostic techniques are recommended.

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