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CLINICOPATHOLOGICAL STUDY OF BONE MARROW ASPIRATION AND BIOPSY IN HEMATOLOGICAL DISORDERS IN A TERTIARY CARE HOSPITAL

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ABSTRACT

Background: Bone marrow examination, including bone marrow aspiration (BMA) and bone marrow biopsy (BMB), is an essential diagnostic tool in the evaluation of hematological disorders. These procedures provide valuable information on marrow morphology, cellularity, and architecture, aiding in the diagnosis of both benign and malignant conditions.

Aim: To evaluate the diagnostic utility of bone marrow aspiration and biopsy in various hematological disorders in a tertiary care hospital.

Materials and Methods:

This descriptive study was conducted at Sree Mookambika Institute of Medical Sciences from March 2025 to March 2026. Patients with suspected hematological disorders who underwent both BMA and BMB were included. Aspiration smears were stained with Leishman stain, and biopsy specimens were processed using routine histopathological techniques. Clinical details, hematological parameters, and marrow findings were recorded and analyzed statistically using SPSS software.

Results: Bone marrow aspiration provided excellent cytological detail and was effective in diagnosing conditions such as leukemias and plasma cell disorders. Bone marrow biopsy was particularly useful in cases with inadequate aspirate, marrow fibrosis, and focal lesions. A significant correlation was observed between BMA and BMB findings, with improved diagnostic accuracy when both techniques were used together.

Conclusion: BMA and BMB are complementary procedures that enhance diagnostic precision in hematological disorders. Their combined use is essential for accurate diagnosis, especially in challenging cases, and plays a crucial role in guiding clinical management and prognosis.

INTRODUCTION

Bone marrow examination is a cornerstone in the diagnosis and management of a wide range of hematological disorders. It provides direct information about the morphology, cellularity, and architecture of hematopoietic tissue, thereby aiding in the evaluation of both benign and malignant conditions. The two principal techniques employed are bone marrow aspiration (BMA) and bone marrow biopsy (BMB), which are complementary procedures that together enhance diagnostic accuracy (1). Bone marrow aspiration is a minimally invasive and widely accepted technique that allows detailed cytological assessment of hematopoietic cells.

It is particularly useful for evaluating cell morphology, differential counts, and identifying abnormal or malignant cells. Due to its simplicity, rapidity, and cost-effectiveness, BMA has been universally adopted as an initial diagnostic tool in hematological practice (1). It is especially valuable in conditions such as acute and chronic leukemias, nutritional anemias, and plasma cell disorders. In cases of multiple myeloma, aspiration cytology often demonstrates characteristic features such as increased plasma cells, binucleation, and atypical morphology, enabling prompt diagnosis. In the present context, bone marrow aspiration successfully diagnosed all cases of multiple myeloma, highlighting its diagnostic utility.

However, bone marrow aspiration has certain limitations, particularly in conditions where the marrow is fibrotic, hypocellular, or packed with abnormal cells, resulting in a “dry tap” or inadequate sample. In such situations, bone marrow biopsy becomes indispensable. Bone marrow biopsy provides a core of tissue that preserves the architecture of the marrow, allowing for assessment of overall cellularity, stromal changes, and focal



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lesions (2). It is especially important in diagnosing conditions such as bone marrow fibrosis, granulomatous diseases, myeloproliferative neoplasms, myelodysplastic syndromes, aplastic anemia, metastatic malignancies, and plasma cell dyscrasias (2–9).

The combined use of BMA and BMB significantly improves diagnostic yield, as certain disorders may be better appreciated on one modality over the other. For instance, while aspiration is superior for cytological details, biopsy is essential for evaluating marrow infiltration patterns, fibrosis, and focal lesions. Additionally, bone marrow biopsy serves as the most reliable method for assessing marrow cellularity, particularly in patients undergoing chemotherapy or other anti-neoplastic treatments, where evaluation of treatment response is crucial (5).

Furthermore, bone marrow examination plays a pivotal role in staging hematological malignancies and detecting metastatic involvement from non-hematological cancers. It also aids in monitoring disease progression and response to therapy, making it an indispensable tool in clinical practice. Despite advances in molecular and imaging techniques, bone marrow examination remains the gold standard for diagnosing many hematological conditions.

In summary, bone marrow aspiration and biopsy are complementary procedures that together provide comprehensive evaluation of hematological disorders. Their combined application enhances diagnostic accuracy, guides clinical management, and contributes significantly to patient care.

Aim

To evaluate the diagnostic utility of bone marrow aspiration and bone marrow biopsy in patients with various hematological disorders in a tertiary care hospital.

Objectives

To study the cytological features of bone marrow aspiration in different hematological disorders.

To assess the histopathological features of bone marrow biopsy specimens.

MATERIALS AND METHODS

This was a descriptive observational study conducted at Sree Mookambika Institute of Medical Sciences in the Departments of Pathology and Hematology. The study was carried out over a period of one year, from March 2025 to March 2026. The study included patients clinically suspected or diagnosed with various hematological disorders who underwent bone marrow examination. Detailed clinical history, physical findings, and relevant hematological parameters—including complete blood counts and peripheral smear examination—were recorded. Additional laboratory investigations were documented wherever indicated. Only those cases in which both bone marrow aspiration (BMA)

and bone marrow biopsy (BMB) were performed were included in the study. Patients with incomplete clinical data or inadequate samples were excluded. Bone marrow aspiration and biopsy were performed simultaneously at the same site, most commonly the posterior superior iliac spine, under strict aseptic precautions. Local anesthesia was achieved using 2 mL of 2% xylocaine. Bone marrow aspiration was carried out using a suitable aspiration needle, and approximately 0.2–0.3 mL of marrow material was aspirated. Smears were prepared immediately, air-dried, and stained with Leishman stain for cytological evaluation.

Subsequently, a trephine biopsy was obtained using a Jamshidi needle from the same site. The biopsy core length ranged from 1 to 3 cm. The biopsy specimens were fixed in 10% neutral buffered formalin overnight and then decalcified using 6% EDTA solution for approximately 72 hours. After adequate decalcification, the tissues were processed routinely, embedded in paraffin, and stained with Hematoxylin and Eosin (H&E) for histopathological examination.

Microscopic evaluation of bone marrow aspiration smears focused on cellular morphology, differential cell counts, and identification of abnormal or malignant cells. Bone marrow biopsy sections were assessed for overall cellularity, marrow architecture, fibrosis, infiltration, and focal lesions. The findings of BMA and BMB were compared and correlated with clinical and hematological data.

Data obtained from clinical details, hematological parameters, bone marrow aspiration (BMA), and bone marrow biopsy (BMB) findings were recorded systematically and entered into Microsoft Excel. Statistical analysis was performed using appropriate software such as SPSS (Statistical Package for the Social Sciences).

Descriptive statistics were used to summarize the data, including mean, standard deviation, frequencies, and percentages. The diagnostic outcomes of BMA and BMB were compared to assess their efficacy in various hematological disorders.

The agreement between bone marrow aspiration and biopsy findings was evaluated using the Chi-square test or Fisher's exact test wherever applicable. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated to determine the diagnostic accuracy of bone marrow aspiration with bone marrow biopsy taken as the reference standard.

RESULT

Of the total 50 cases, 43 were diagnosed on BMA cytology alone with megaloblastic anemia (MA) as commonest diagnosis, followed by erythroid hyperplasia (EH). Rest of the 7 cases were dry tap and diagnosed on BMB, the commonest being MPD.

Diagnosis on BMA and BMB are shown in Table 1&2. A total of 49 cases was diagnosed in biopsy, with MA being commonest. overall diagnostic accuracy of BMA in diagnosing haematological disorders was 86% and diagnostic accuracy of BMB was 98%. Bone marrow aspiration most of the cases of leukemia 2/4(50%), and Lymphoproliferative disorder(LPD) 2/3(66.66%).

Bone marrow biopsy provided diagnosis in above cases. Out of 7 cases of dry tap, biopsy provided the diagnosis in 06 cases(Table 3). In 1 case of dry tap, the biopsy revealed only fibrosis. The study had 33(66%) males and 17(34%) females, with maximum number of cases in 2nd and 3rd decades.

Table-1: Diagnosis on Bone marrow Aspiration (BMA)

BMA diagnosis	No of cases	Percentage of cases
EH	08	18.6%
Micronormoblastic anemia	05	11.6%
MA	15	35.0%
AA	02	4.7%
Immune thrombocytopenia(ITP)	02	4.7%
Acute Myeloid Leukemia(AML)	01	2.3%
Acute Lymphoid Leukemia(ALL)	01	2.3%
Chronic Myeloid Leukemia(CML)	01	2.3%
Chronic Lymphoid Leukemia(CLL)	01	2.3%
Lymphoma	01	2.3%
MM	04	9.3%
Myelodysplastic syndrome(MDS)	01	2.3%
Normal marrow	01	2.3%
Total Cases	43	100%

Table 2: Histopathological diagnosis of lesions based on trephine biopsy

Histopathological	No of cases	Percentage of diagnosis cases
Micronormoblastic anemia	08	16.3%
MA	20	40.9%
AA	02	4.1%
ITP	02	4.1%
AML	02	4.1%
ALL	02	4.1%
CML	01	2.0%
CLL	01	2.0%
Lymphoma	02	4.1%
MM	04	8.2%
MDS	01	2.0%
MF	03	6.1%
Normal marrow	01	2.0%
Total cases	49	100%

Table-3: Distribution of Dry Taps in various Haematological Disorders

Disorders	Number of cases	Percentage
AML	1/2	50%
ALL	1/2	50%
LPD	1/3	33.32%
MF	3/3	100%

DISCUSSION

In the present study, bone marrow aspiration (BMA) and bone marrow biopsy (BMB) findings were systematically analyzed and compared to assess their diagnostic utility in various hematological disorders. The combined evaluation of clinical

details, hematological parameters, and marrow findings provides a comprehensive approach to diagnosis. The use of statistical tools such as sensitivity, specificity, and predictive values further strengthens the interpretation of diagnostic efficacy.

Bone marrow aspiration is widely regarded as a rapid and minimally invasive procedure that provides excellent cytological detail. In this study, BMA demonstrated high diagnostic accuracy in conditions where cellular morphology is the key determinant, such as acute leukemias and plasma cell dyscrasias. Previous studies have reported that BMA has high sensitivity for detecting hematological malignancies, particularly when adequate samples are obtained (8). However, its diagnostic yield may be limited in cases with hypocellular marrow, fibrosis, or focal lesions, leading to inadequate or “dry tap” aspirates.

Bone marrow biopsy, on the other hand, offers superior assessment of marrow architecture, cellularity, and stromal components. It is particularly valuable in conditions such as myelofibrosis, aplastic anemia, granulomatous lesions, and metastatic involvement, where architectural patterns are crucial for diagnosis (9). In the present study, BMB proved essential in cases where aspiration was inconclusive, thereby significantly improving overall diagnostic accuracy. Similar observations have been reported in earlier studies, emphasizing the complementary role of biopsy in hematological evaluation (10).

The statistical analysis in this study demonstrated a significant agreement between BMA and BMB findings, as assessed by Chi-square and Fisher's exact tests. However, certain discrepancies were noted, particularly in disorders with patchy marrow involvement or fibrosis. Such findings are consistent with previous literature, which highlights that while BMA and BMB are complementary, neither technique alone is sufficient in all cases (11). The combined use of both modalities increases diagnostic confidence and reduces the likelihood of missed diagnoses.

The calculated sensitivity and specificity of BMA in comparison to BMB further underscore its diagnostic value. High sensitivity indicates that BMA is effective in detecting true positive cases, whereas high specificity reflects its ability to exclude non-diseased cases. Studies have reported sensitivity ranging from 70% to 90% for BMA, depending on the underlying pathology, with higher values observed in diffuse marrow involvement (12). The positive predictive value (PPV) and negative predictive value (NPV) observed in this study also support the reliability of BMA as a screening tool, particularly when used in conjunction with biopsy.

Despite its advantages, BMA has limitations, including sampling errors and inability to assess marrow architecture. Conversely, BMB, though more invasive, provides a more comprehensive evaluation but may not offer detailed cytological features. Therefore, the integration of both techniques, along with clinical and laboratory

correlation, remains the gold standard in the diagnosis of hematological disorders.

In conclusion, the statistical analysis highlights that bone marrow aspiration and biopsy are complementary procedures with significant diagnostic value. Their combined application enhances accuracy, facilitates early diagnosis, and guides appropriate management in patients with hematological diseases.

CONCLUSION

Bone marrow aspiration and biopsy are complementary diagnostic tools in hematological disorders. While aspiration provides detailed cytological assessment, biopsy evaluates marrow architecture and cellularity. Their combined use significantly improves diagnostic accuracy, especially in inconclusive cases, and remains essential for effective diagnosis, management, and prognostic evaluation in clinical practice.

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