

Bone Marrow Involvement By non-Hodgkin's Lymphom

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We retrospectively studied 156 patients with non-Hodgkin's lymphoma (NHL) in order to evaluate the incidence of bone marrow (BM) involvement at the time of diagnosis.

The incidence of marrow involvement in NHL was 35% (55 patients). The most common histologic type of lymphoma was diffuse large cell lymphoma with 30% of the cases having bone marrow involvement. The highest incidence of marrow involvement was seen in immunoblastic lymphoma & the lowest incidence in diffuse mixed cell lymphoma. Bone marrow lymphoma was present in 50% of low-, 34% of intermediate-, and 55% of high-grade lymphomas. B-cell vs T-cell lymphoma in cases of marrow involvement was 56% to 42%. The most frequent pattern of marrow involvement was interstitial & diffuse (56% & 31%). The paratrabeular pattern was rare (4%). Most lymphomas (42%) extensively involved marrow space greater than 76% of the total marrow space. Discordant histology between lymph node and BM was seen in 10 cases (18%). Biopsy was the best method compared to smear & clot section (sensitivity 82% vs 72% vs 69%).

In conclusion, our study revealed that the most common histologic type of marrow lymphoma was diffuse large cell type with frequent interstitial and diffuse pattern and extensive involvement of the marrow space. No predilection for a trabecular pattern was found. This result was in contrast to that in the Western literature.

Key Words : BM involvement, NHL.

INTRODUCTION

The examination of bone marrow is generally a valuable procedure in the diagnosis and management of patients with malignant lymphoproliferative disease. Marrow involvement in the presence of

nodal disease indicates stage IV disease (Juneka et al., 1990). Bone marrow involvement by diffuse large cell lymphoma has been associated with a higher incidence of central nervous system disease and a poor prognosis (Morra et al., 1989; Bunn et al., 1976). However, recent studies suggest that the bone marrow involvement may not contribute significantly to management decisions or be a useful prognostic indicator for some types of NHL (Yoon et al., 1993; Bartl et al., 1982). There have been numerous reports on the incidence of bone marrow

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involvement by lymphoma using various classifications. Reports have emphasized the dissimilar incidences and patterns of involvement by low- & intermediate- & high grade lymphoma (Ellis et al., 1989; McKenna and Hernandez, 1988; Brunning and McKenna, 1979; Jones et al., 1971). Recently, several studies have commented on the presence of a discordant histologic appearance in the lymph node and bone marrow biopsies and its clinical significance (Conlan et al., 1990; Kluin et al., 1990; Fisher et al., 1989; Bartl et al., 1988). We used the modified Working Formulation to study the incidence of BM involvement by NHL at the time of diagnosis, and to compare the patterns of disease in various histological subtypes, especially in comparison with the Western literature. We also determined if there was any morphologic discordance between the lymph node and the bone marrow.

MATERIALS AND METHODS

156 cases of marrow lymphomas in this study were selected from the pathologic files of three institutes: Kyunghee University Hospital dating from 1985 to 1992, Korea University Hospital from 1988 to 1992 and Chunbuk National University. Cases were included if both bone marrow & lymph node slides were available for histologic evaluation.

All pathologic material was reviewed by three of the authors; Lee, Lee, & Kim. Discordant lymphomas were defined as those in which two or more distinct areas of NHL of different histology occur in separate anatomic disease sites. All lymph node biopsies were processed under standardized conditions in the laboratory. Histologic diagnoses were made on the basis of hematoxylin and eosin stained paraffin sections. Histologic classification of malignant lymphoma was done according to the modified Working Formulation (1982). Immunophenotype was determined by the avidin biotin peroxidase complex method (Hsu et al., 1981) using touch imprints, frozen or B₅ or formalin fixed materials. The list of antibodies was LCA (CD45RB; Dako 1:50), L26 (CD20; Dako 1:50), UCHL-1 (CD45RO; Dako 1:50), MB2 (Biogenex 1:40), MT1 (CD43, Biogenex 1:40), CD43 (Dako 1:25), CD68 (Dako 1:50) and lysozyme (Dako 1:200). Bone marrow aspirates, clot sections and/or trephine biopsies were performed at the time of initial staging, and during the follow up. All biopsies and clot sections were paraffin embedded, and the majority were stained with

hematoxylin and eosin. All bone marrow biopsies and clot sections were also reviewed by us. Because of an inadequate amount of material, immuno-histochemistry could not be performed on most bone marrow biopsies.

RESULTS

Histologic Findings & Incidence of BM involvement

As classified according to the Working Formulation, there were 14 cases (9%) of low grade, 91 cases (59%) of intermediate grade, and 44 cases (28%) of high grade lymphomas (Table 1). The most common histologic subtype was diffuse large cell lymphoma at 35% with 30% of the cases having bone marrow involvement. Follicular small cleaved cell lymphoma was the rarest (3%) with only one case having marrow lymphoma. According to histological subtypes, the highest incidence of marrow involvement was seen in immunoblastic (80%, 4/5), followed by small lymphocytic (55%, 6/11) lymphomas. Cases of diffuse mixed lymphoma had the lowest incidence (11%, 3/27). The high grade lymphomas, especially of lymphoblastic lymphoma and small noncleaved lymphoma had a relatively high incidence of marrow involvement (52%

Table 1. Lymphoma Classification by Lymph Node Histology & Incidence of Bone Marrow Involvement

Lymph Node Histology	Number(%)	Bone Marrow Involvement(%)
Low	14(9)	7(50)
SL	11(7)	6(55)
FSC	3(3)	1(33)
Intermediate	91(58)	24(34)
FL	6(4)	3(50)
DSC	4(3)	2(50)
DM	27(17)	3(11)
DL	54(35)	16(30)
High	44(28)	24(55)
IBS	5(3)	4(80)
LB	31(20)	16(52)
SNC	8(5)	4(50)
Unclassified	7(4)	
Total	156	55(35)

SL: small lymphocytic. DL: diffuse large cell.
 FSC: follicular small-cleaved. IBS: immunoblastic.
 FL: follicular large cell. LB: lymphoblastic.
 DSC: diffuse small cleaved. SNC: small-noncleaved cell.
 DM: diffuse mixed, small & large cell.

and 50%). Bone marrow involvement was present in 50% (7/14) of low grade, 34% (24/91) of intermediate grade, and 55% (24/44) of high grade lymphomas. Overall fifty five cases (35%) had marrow involvement at diagnosis.

Clinical & Immunophenotypic findings in 55 patients with BM involvement in NHL

In 55 cases with marrow involvement of lymphoma, median age was 43 years with a range from 2 years to 78 years (Table 2). Age distribution

showed that small lymphocytic, diffuse small cleaved and follicular lymphomas occurred in old aged patients (range 57-66). However, the median age of diffuse large cell lymphoma & immunoblastic lymphoma was 43 years (14-71) and 38 years (26-53), respectively. Lymphoblastic lymphoma and small noncleaved lymphoma characteristically occurred in young adults (median age, 23 years & 28 years). The sex ratio was 4.5 : 1 with a male predominance in marrow lymphomas. Nodal lymphomas were 37 cases and extranodal, 13. The

Table 2. Clinical Findings of in 55 Patients with Bone Marrow Involvement by Lymphoma

Histologic Type	Number	Sex M/F	Median Age (range)	Location (nodal/extranodal/ #)
Low grade	7			
SL	6	5 : 1	66(53-78)	5 : 1
FSC	1	1 : 0	62	1 : 0
Intermediate grade	24			
FL	3	3 : 0	65(6-78)	3 : 0
DSC	2	2 : 0	57(51-63)	1 : 1
DM	3	2 : 1	65(61-69)	3 : 0
DL	16	14 : 2	43(14-71)	9 : 5 : 2
High grade	24			
IBS	4	3 : 1	38(26-53)	2 : 2
LB	16	12 : 4	23(2-52)	12 : 3 : 1
SNC	4	3 : 1	28(4-60)	1 : 1 : 2
Total	55	45 : 10	43(2-78)	37 : 13 : 5

SL : small lymphocytic. DM : diffuse mixed. LB : lymphoblastic.
 FSC : follicular small-cleaved. DL : diffuse large. SNC : small-noncleaved.
 FL : follicular large cell. IBS : immunoblastic. # : unknown.
 DSC : diffuse small cleaved.

Table 3. Histologic-Immunophenotypes in Patients with Bone Marrow Involvement of Lymphoma

Histologic Type	No. of Case	B	T	Undefined	Not Done
SL	6	4	2		
FSC	1	1			
FL	3	3			
DSC	2	2			
DM	3		2		1
DL	16	6	2	1	7
IBS	4	3	1		
LB	16	2	12		2
SNC	4	4			
Total	55	25	19	1	10

SL : small lymphocytic. DSC : diffuse small cleaved. IBS : immunoblastic.
 FSC : follicular small-cleaved. DM : diffuse mixed. LB : lymphoblastic.
 FL : follicular large cell. DL : diffuse large. SNC : small-noncleaved.

Table 4. Pattern of Bone Marrow Involvement by Lymphoma

Histologic Grade	diffuse	Interstitial	Focal	Nodule	Para-	Mixed Trabecular	Inter-
Low	2(33)	2(33)	2(34)			1(17)	5(83)
Intermediate	(25)	13(54)	3(13)	2(8)	2(8)	1(4)	21(83)
High	9(38)	15(62)					24(100)
Total(%)	17(31)	30(56)	5(9)	2(4)	2(4)	2(4)	50(92)

One case of low grade lymphoma could not be evaluated.

Table 5. Extent of Bone Marrow Involvement by Lymphoma

Histologic Grade	I <25%	II 26-50%	III 51-75%	IV >76%	Total
Low	2(33)		2(33)	2(34)	6
Intermediate	6(25)	5(21)	6(25)	7(29)	24
High	2 (9)	2(9)	6(26)	13(57)	23
Total(%)	10(19)	7(13)	14(26)	22(42)	53*

* : each cases of low and high grade lymphoma could not be evaluated.

primary site in 5 cases could not be determined. The ratio of nodal & extranodal lymphoma was roughly 3 : 1. Histologic-immunophenotypes in patients having marrow lymphomas, are summarized in Table 3. 25 cases showed B cell lineage and 19 cases, T cell lineage.

Pattern and extent of BM involvement in NHL

The pattern of marrow involvement by lymphoma is summarized in Table 4. The diffuse pattern was found in 17 (31%) patients, interstitial pattern in 30 (56%), and focal in 5 (9%) patients. The intermediate & high grade lymphomas showed the interstitial pattern. The lymphomatous infiltrates were paratrabeular in location in 2 patients (4%) and intertrabeular in 50 patients (92%). Mixed paratrabeular & intertrabeular infiltrates were found in 2 patients (4%)(Table 4). The paratrabeular pattern was very rare. Table 5 shows the extent of bone marrow involvement by lymphoma. Less than 25% of bone marrow was replaced by lymphoma in 10 patient (19%), 26% to 50% in 7 patients (13%), 51% to 75% in 14 patients (26%), and greater than 75% in 22 patients(42%). Fifty seven percent of high grade lymphomas extensively involved marrow space greater than 75%. The extent of marrow involvement shows a similar distribution in low and intermediate grade lymphomas. Most marrow lymphomas were extensive and advanced.

Morphologic discordance

In 10 of 55 cases (18%), morphologic differences between the lymph node and the bone marrow were found(Table 6). Of 23 large cell and immunoblastic lymphomas in lymph node, 6 cases showed small cleaved cells in their marrow. In one case, the marrow lesion was large cells, whereas the lymph node showed small lymphocytic lymphoma. With 7 cases that were totally discordant, there was small cell at one site and large cell at the other site. With

Table 6. Comparison of Lymph Node & Bone Marrow Histology

Lymph Node Histology	SL	Bone Marrow Histology	SC	DM	DL	IBS
SL	5			1		
SC			3			
DM				2	1	
FL			3			
DL			3	1	12	
IBS					1	3

SL : small lymphocytic.
 SC : small cleaved.
 DM : diffuse mixed, small & large cell.
 FL : follicular large cell.
 DL : diffuse large cell.
 IBS : immunoblastic.
 Exclude lymphoblastic lymphoma(N=16) & small noncleaved cell lymphoma(n=4).

the remaining 3 cases of the same grade they showed a difference in histology.

Comparison of the specimen type

A comparison of the specimen type for adequate evaluation is seen in Table 7. The trephine biopsy was positive for lymphoma in 40 patients. The clot section was positive in 34 patients, and the smear, in 39 patients. The sensitivity for a trephine biopsy was 82% (40 of 49), for clot section, 69% (34/49) and for aspirate smear, 71% (39/55). The clot section & aspirate smear were good for cell morphology in detail. However, the extent & pattern of marrow lymphomas were best seen in a trephine biopsy.

Table 7. Comparison of the specimen Type for Adequate Evaluation in 55 cases of Marrow Involvement by Lymphoma.

	Biopsy	Clot	Smear
Positive for Lymphoma	40	34	39
Negative for Lymphoma	4	15	15
Inadequate	5	—	1
Not done	6	6	—

DISCUSSION

The incidence of marrow involvement in NHL varies with the different histologic subtypes. Using the Working Formulation, the incidence in aggregate for all types at time of diagnosis was 35% in our study. In other Korean reports, Seo and Chi(1994) reported that 166 cases with NHL showed marrow involvement in 50 cases (30.1%), and Yoon et al.(1993) reported 28.5% (128/497). This incidence was lower than in Western studies; Juneka et al.(1990) reported 38% using the Working Formulation, Dick et al.(1974) & Bennett et al.(1986) using the Rappaport classification reported 35% & 59%, respectively, Foucar et al.(1982) reported 53% using the Lukes Collin's classification. This is explained by the decreasing incidence of low grade lymphoma with frequent marrow involvement in Korea (Seo and Chi, 1994). However the incidence of marrow involvement was much higher, at 70% in studies using the Kiel classification(Lennert et al., 1983; Bartl et al., 1982). This is explained by increasing chronic lymphocytic leukemia & hairy cell leukemia in the Kiel

classification. We found a similar frequency of marrow involvement by NHL for both low and high grade lymphomas (50% and 55%, respectively). Marrow involvement was least common in the intermediate grade lymphomas (34%). In contrast to our study, marrow involvement was more common in the low-grade lymphomas than in most of the high grade-lymphomas in the Western literature (Juneka et al., 1990; McKenna and Hernandez, 1988; Park et al., 1984).

About 60% to 70% of small cleaved cell lymphomas had marrow involvement, compared to 33% of T-immunoblastic and 25% for B-immunoblastic (Foucar et al., 1982). Small lymphocytic lymphoma in our study had a relatively high incidence (55%) of marrow involvement. Interestingly enough, there were few cases of follicular small cleaved cell lymphomas in our study. The incidence of follicular small cleaved cell lymphoma was 3%. Although 33% (1/3) of follicular small cleaved cell lymphoma had marrow involvement, the cases were too small in number to be significant. Juneka et al.(1990) reported that the incidence of marrow involvement by NHL was 83% in small lymphocytic lymphoma & 19% in diffuse large cell lymphoma. In our study, the incidence was 55% in small lymphocytic & 30% in diffuse large cell lymphoma. The relatively low incidence of marrow involvement in small lymphocytic lymphoma could be explained by two two reasons in our study. one possibility is that extranodal lymphoma of small lymphocytic type, was included. The other one is that most cases of chronic lymphocytic leukemia (CLL) were excluded because they did not obtain lymph node slides for histologic evaluation in this study. The incidence of marrow involvement in diffuse large cell lymphoma was higher than Juneka's (1990). In other Korean reports (Seo and Chi., 1994; Yoon et al., 1993), the most common histologic cell type of the marrow lymphomas was diffuse large cell lymphoma same as our study.

Foucar et al.(1982) reported that 51 per cent of B cell and 65 per cent of T-cell lymphomas showed marrow involvement. Conlan et al.(1990) reported that bone marrow involvement was equally common in B-cell and T-cell NHL (31% vs 31%). However we did not find the incidence of marrow involvement differed according to immunophenotype. Just 56% of 45 cases having marrow lymphoma showed B cell lineage & 42% showed T-cell lineage.

Considerable diversity has been noted in the ex-

tent & pattern of bone marrow involvement by lymphoma. The most common pattern of marrow involvement in our study was interstitial (56%) & diffuse (31%). Paratrabeular pattern was very rare (4%). The rareness of paratrabeular pattern in our study could be explained by the few cases of follicular small cleaved lymphomas. Conlan et al.(1990) reported that the most common pattern of marrow involvement was focal pattern(63%) and mixed paratrabeular & intertrabeular pattern (45.7%). Seo and Chi (1994) reported that focal nodular pattern (48%) was the most common, followed by interstitial pattern. However, diffuse pattern (41.5%) was the most common in Yoon's study (1993). Most B-cell follicular center cell lymphoma, predominantly of small cleaved cell type have been reported to have focal paratrabeular pattern and replace less than 30% of bone marrow (Park et al., 1984 ; Bartl et al., 1982). The extent of marrow varies and in less than half of our cases was greater than 76%. The pattern & extent of marrow involvement in our study was in contrast to those in the Western literature(McKenna and Hernandez, 1988 ; Foucar et al., 1979). In general, most lymphomas in our study were advanced and extensively involved the marrow space with no predilection for a paratrabeular location.

The cytologic findings of the lymphomas in the marrow sections usually parallel those in the lymph node. This is particularly true for the T-cell lymphoma & the B-non follicular center cell types. In 24-52% of follicular center cell lymphoma, discordant or divergent histology between in the lymph node and the bone marrow was seen (Conlan et al., 1990 ; Kluin et al., 1990 ; Fisher et al., 1989 ; Bartl et al., 1988 ; Mead et al., 1983). In our study, the discordance rate was 18%. Eight cases were totally discordant between histologic grades of NHL. Three cases were discordant in different compositions of the cellular infiltrates. The marrow lesion consists predominantly of small cleaved cells whereas the lymph node shows mixed cell or large cell. The reverse occurs in only 2 cases. In one case of small lymphocytic lymphoma, the marrow showed a mixed small & large cell suggesting foci of transformation. In cases of immunoblastic lymphomas, the marrow showed mixed large cells & immunoblasts. There is still a debate about what percentage of immunoblasts is necessary for the lymphoma to be classified as immunoblastic. Mead et al.(1983) reported a much lower incidence of discordance

e : 9.3% overall and 4.8% when comparing "favorable" to "unfavorable" histology.

In cases with divergent histology in lymph node and bone marrow, the question immediately arises as to the biological significance. Fisher et al.(1982) reported that patients with large cell lymphoma who have a simultaneous bone marrow biopsy positive for low grade lymphoma, have a survival rate which is no different from that of patients with negative marrow. When there are large cell lymphomas in the bone marrow, Conlan et al.(1990) predicted a short survival. Kluin et al.(1990) reported that most differences between BM and lymph node cytology was caused by tumor heterogeneity. Unfortunately we could not find any prognostic significance of discordant lymphomas because of the lack of follow up in most patients.

Therefore morphologic evaluation of BM and lymph node may be helpful in the treatment of individual patients with a low grade lymphoma or transformation into a high grade lymphoma. As emphasized by other investigators(Seo and Chi, 1994 ; Yoon et al., 1993 ; Ellis et al., 1989), we found the trephine biopsy produced a higher positivity yield than either clot section or aspirate smear. Thus, bone marrow biopsy remains a useful tool for the diagnosis and staging of malignant lymphoma, and providing adequate clinical & laboratory information for the management of patients.

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REFERENCES

- Bartl R, Frish B, Burkhardt R . *Assessment of bone marrow histology in the management lymphomas ; Correlation with clinical factors for diagnosis, prognosis, classification, and staging. Br J Haematol 1982 ; 51 : 511-30.*
- Bartl R, Hansmann BR, Frish B, Burkhardt R . *Comparative histology of malignant lymphoma in lymph node and bone marrow. Br J Haematol 1988 ; 69 : 229-37.*
- Bennett JM, Cain KC, Glick JH, Johnson GJ . *The significance of bone marrow involvement in non-Hodgkin's lymphoma ; The eastern cooperative oncology group experience. J Clin Oncol 1986 ; 4 : 1462-9.*
- Brunning RD, McKenna RW . *Bone marrow manifestations*

- of malignant lymphoma and lymphoma like conditions. *Path Annu* 1979; 14 : 1-59.
- Bunn PA Jr, Schein PS, Banks PM, deVita VT Jr. Central nervous system complications in patients with diffuse histiocytic and undifferentiated lymphoma; Leukemia revisited. *Blood* 1976; 47 : 3-10.
- Conlan MG, Bast M, Armitage JO, Weisenburger DD. Bone marrow involvement by non-Hodgkin's lymphoma; The critical significance of morphologic discordance between the lymph node and bone marrow. *J Clin Oncol* 1990; 8 : 1163-72.
- Dick F, Bloomfield CD, Brunning RD. Incidence, cytology, and histopathology of non-Hodgkin's lymphomas in the bone marrow. *Cancer* 1974; 33 : 1382-98.
- Ellis ME, Diehl LF, Granger E, Elson E. Trephine needle bone marrow biopsy in the initial staging of Hodgkin's disease; Sensitivity and specificity of the Ann Arbor staging procedure criteria. *Am J Haematol* 1989; 30 : 115-20.
- Fisher DE, Jacobson JO, Ault KA, Harris NL. Diffuse large cell lymphoma with discordant bone marrow histology clinical features and biological implications. *Cancer* 1989; 64 : 1879-87.
- Foucar K, McKenna RW, Frizzera G, Brunning RD. Bone marrow and blood involvement by lymphoma in relationship to the Lukes-Collins classification. *Cancer* 1982; 49 : 888-97.
- Foucar K, McKenna RW, Frizzera G, Brunning RD. Incidence & Patterns of bone marrow and blood involvement by lymphoma in relationship to the Lukes-Collins classification. *Blood* 1979; 54 : 1417-22.
- Hsu SM, Raine L, Fanger H. The use of avidin biotin peroxidase complex(ABC) in immunoperoxidase technique; a comparison between ABC and unlabeled antibody(PAP) procedures. *J Histochem Cytochem* 1981; 29 : 577-80.
- Jones SE, Rosenberg SA, Kaplan HS. non-Hodgkin's lymphomas 1) Bone marrow involvement. *Cancer* 1971; 29 : 954-60.
- Juneka SK, Wolf MM, Cooper IA. Value of bilateral bone marrow biopsyspecimen in non-Hodgkin's lymphoma. *J Clin Pathol* 1990; 43 : 630-2.
- Kluin PM, van Krieken JH, Kleiverda K, Kluin-Nelemans HC. Discordant morphologic characteristics of b cell lymphomas in bone and lymph node biopsy. *Am J Clin Path* 1990; 94 : 59-66.
- Lennert K, Mohri N, Stein H, kaiserling E. The histopathology of malignant lymphoma. *Br J Haematol* 1975; 31(suppl) : 193-203.
- Lukes RJ, Collins RD. Immunologic characterization of human malignant lymphoma. *Cancer* 1974; 34 : 1488-503.
- McKenna RW, Hernandez JA. Bone marrow in malignant lymphoma. *Haemato Oncol Clin of North Am* 1988; 2 : 617-35.
- Mead GM, Kushlan P, O'Neil M, Burke JS, Rosenberg SA. Clinical aspects of non-Hodgkin's lymphomas presenting with discordant histologic subtypes. *Cancer* 1983; 52 : 1496-501.
- Morra E, Laxxarino M, Castello A. Bone marrow and blood involvement by non-Hodgkin's lymphoma. A study of clinidopathologic correlations and prognostic significance in relationship to the Working Formulation. *Eur J Haematol* 1989; 3 : 105-19.
- National Cancer Institute-sponsored study of classifications of non-Hodgkin's : lymphomas. Summary description of a working formulation for clinical uauage. *Cancer* 1982; 49 : 2112-35.
- Park CJ, Cho HI, Kim SI. A study on the Bone marrow involvement of malignant lymphoma. *The Seoul J of Med* 1984; 25 : 375-86.
- Seo EJ, Chi HS. Bone marrow involvement by non-Hodgkin's lymphoma : Incidence, histopathology, and diagnostic efficacies. *Korean J Clin Pathol* 1994; 14 : 20-9.
- Yoon JH, Park HS, Kim CW, Cho HI. Bone marrow involvement of malignant lymphoma. *The Korean J Haematol* 1993; 28 : 373-87.