Bone Marrow

Protocol applies to acute leukemias, myelodysplastic syndromes, myeloproliferative disorders, chronic lymphoproliferative disorders, malignant lymphomas, plasma cell dyscrasias, histiocytic and dendritic cell neoplasms and mastocytosis.

Protocol revision date: January 2004
No AJCC/UICC staging system

Procedures

- **Blood Film**
- **Aspirate, Cell Block**
- **Trephine Biopsy, Touch Imprint**

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Surgical Pathology Cancer Case Summary (Checklist)

Protocol revision date: January 2004
Applies to hematopoietic and lymphoid disorders of the bone marrow only
No AJCC/UICC staging system

BONE MARROW: Blood Film, Aspirate, Cell Block, Trephine Biopsy, Touch Imprint

Patient name:
Hematopathology/Surgical pathology number:

Note: Check 1 response unless otherwise indicated.

MACROSCOPIC

Specimen Type
___ Aspirate
___ Biopsy
___ Both aspirate and biopsy
___ Blood film
___ Cell block (clot section)
___ Not specified

***Biopsy Site**
*___ Not applicable
*___ Right posterior iliac crest
*___ Left posterior iliac crest
*___ Other (specify): _____
*___ Not specified

***Aspirate Site**
*___ Not applicable
*___ Right posterior iliac crest
*___ Left posterior iliac crest
*___ Sternum
*___ Other (specify): _____
*___ Not specified

* Data elements ***with asterisks*** are ***not required*** for accreditation purposes for the Commission on Cancer. These elements may be clinically important, but are not yet validated or regularly used in patient management. Alternatively, the necessary data may not be available to the pathologist at the time of pathologic assessment of this specimen.

Adequacy of Specimen
___ Satisfactory
___ Limited
___ Unsatisfactory

Phenotyping
___ Performed, see separate report
___ Performed (specify method and results): _____
___ Not performed

Cytogenetics
___ Performed (see separate report)
___ Performed (specify results): _____
___ Not performed

WHO Classification (check all that apply)

Chronic Myeloproliferative Diseases
___ Chronic myelogenous leukemia
___ Chronic neutrophilic leukemia
___ Chronic eosinophilic leukemia/hypereosinophilic syndrome
___ Polycythemia vera
___ Chronic idiopathic myelofibrosis
___ Essential thrombocythemia
___ Myeloproliferative disease, unclassifiable

Myelodysplastic/Myeloproliferative Diseases
___ Chronic myelomonocytic leukemia
___ Atypical chronic myeloid leukemia
___ Juvenile myelomonocytic leukemia
___ Myelodysplastic/myeloproliferative disease, unclassifiable

Myelodysplastic Syndromes
___ Refractory anemia
___ Refractory anemia with ringed sideroblasts
___ Refractory cytopenia with multilineage dysplasia
___ Refractory cytopenia with multilineage dysplasia and ringed sideroblasts
___ Refractory anemia with excess blasts (RAEB)
    ___ RAEB-1
    ___ RAEB-2
___ Myelodysplastic syndrome, unclassifiable
___ Myelodysplastic syndrome associated with isolated del(5q)

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Acute Myeloid Leukemias (AMLs)

___ Acute myeloid leukemia with recurrent genetic abnormalities
- ___ AML with t(8;21)(q22;q22)
- ___ AML with abnormal bone marrow eosinophils inv(16) or t(16;16) or t(16;16)(p13;q22);CBFβ/MYH11)
- ___ Acute promyelocytic leukemia t(15;17)(q22;q12) and variants
- ___ AML with 11q23 (MLL) abnormality

___ Acute myeloid leukemia with multilineage dysplasia
- ___ Following a myelodysplastic syndrome or myelodysplastic syndrome/myeloproliferative disorder
- ___ Without antecedent myelodysplastic syndrome

___ Acute myeloid leukemia and myelodysplastic syndromes, therapy-related
- ___ Alkylating agent-related
- ___ Topoisomerase type II inhibitor-related (some may be lymphoid)
- ___ Other types (specify): _____

___ Acute myeloid leukemia not otherwise categorized
- ___ AML minimally differentiated
- ___ AML without maturation
- ___ AML with maturation
- ___ Acute myelomonocytic leukemia
- ___ Acute monoblastic and monocytic leukemia
- ___ Acute erythroid leukemia
- ___ Acute megakaryoblastic leukemia
- ___ Acute basophilic leukemia
- ___ Acute panmyelosis with myelofibrosis
- ___ Myeloid sarcoma

___ Acute leukemia of ambiguous lineage
- ___ Undifferentiated acute leukemia
- ___ Bilineal acute leukemia
- ___ Biphenotypic acute leukemia

Precursor B-cell and T-cell Neoplasms

___ Precursor B lymphoblastic leukemia/lymphoblastic lymphoma

___ Precursor T lymphoblastic leukemia/lymphoblastic lymphoma

Mature B-cell Neoplasms
___ Chronic lymphocytic leukemia/small lymphocytic lymphoma
___ B-cell prolymphocytic leukemia
___ Lymphoplasmacytic lymphoma
___ Splenic marginal zone lymphoma
___ Hairy cell leukemia
___ Plasma cell myeloma
___ Monoclonal gammopathy of undetermined significance (MGUS)
___ Solitary plasmacytoma of bone
___ Extraosseus plasmacytoma
___ Primary amyloidosis
___ Heavy chain disease
___ Extranodal marginal zone B-cell lymphoma of mucosa-associated lymphoid tissue (MALT-lymphoma)
___ Nodal marginal zone B-cell lymphoma
___ Follicular lymphoma
    ___ Grade 1
    ___ Grade 2
    ___ Grade 3
___ Mantle cell lymphoma
___ Diffuse large B-cell lymphoma
___ Mediastinal (thymic) large B-cell lymphoma
___ Primary effusion lymphoma
___ Burkitt lymphoma / leukemia

B-cell Proliferations of Uncertain Malignant Potential
___ Lymphomatoid granulomatosis
___ Post-transplant lymphoproliferative disorder, polymorphic

* Data elements ***with asterisks*** are ***not required*** for accreditation purposes for the Commission on Cancer. These elements may be clinically important, but are not yet validated or regularly used in patient management. Alternatively, the necessary data may not be available to the pathologist at the time of pathologic assessment of this specimen.

Mature T-cell and NK-cell Neoplasms
Leukemic / Disseminated
___ T-cell prolymphocytic leukemia
___ T-cell large granular lymphocytic leukemia
___ Aggressive NK-cell leukemia
___ Adult T-cell leukemia/lymphoma
Cutaneous
___ Mycosis fungoides
___ Sézary syndrome
___ Primary cutaneous anaplastic large cell lymphoma
___ Lymphomatoid papulosis
Other Extranodal
___ Extranodal NK/T-cell lymphoma, nasal-type
___ Enteropathy-type T-cell lymphoma
___ Hepatosplenic T-cell lymphoma
___ Subcutaneous panniculitis-like T-cell lymphoma
Nodal
___ Angioimmunoblastic T-cell lymphoma
___ Peripheral T-cell lymphoma, unspecified
___ Anaplastic large cell lymphoma

Neoplasm of Uncertain Lineage and Stage of Differentiation
___ Blastic NK-cell lymphoma

Hodgkin Lymphoma
___ Nodular lymphocyte predominant Hodgkin lymphoma
___ Classical Hodgkin lymphoma
    ___ Nodular sclerosis classical Hodgkin lymphoma
    ___ Lymphocyte-rich classical Hodgkin lymphoma
    ___ Mixed cellularity classical Hodgkin lymphoma
    ___ Lymphocyte-depleted classical Hodgkin lymphoma

Histiocytic and Dendritic-cell Neoplasms
___ Histiocytic sarcoma
___ Langerhans cell histiocytosis
___ Langerhans cell sarcoma
___ Interdigitating dendritic cell sarcoma / tumor
___ Follicular dendritic cell sarcoma / tumor
___ Dendritic cell sarcoma, not otherwise specified

Mastocytosis
___ Indolent systemic mastocytosis
___ Systemic mastocytosis with associated clonal, hematologic non-mast-cell lineage disease
___ Aggressive systemic mastocytosis
___ Mast cell leukemia
___ Mast cell sarcoma

Other
___ Malignant neoplasm, type cannot be determined

***Additional Pathologic Findings**
*Specify: _____

***Comment(s)**

* Data elements ***with asterisks*** are ***not required*** for accreditation purposes for the Commission on Cancer. These elements may be clinically important, but are not yet validated or regularly used in patient management. Alternatively, the necessary data may not be available to the pathologist at the time of pathologic assessment of this specimen.

Background Documentation

Protocol revision date: January 2004

I. Blood Film, Aspirate, Cell Block, Trephine Biopsy, Touch Imprint

A. Clinical Information

1. Patient identification
   a. Name
   b. Identification number
   c. Age (birth date)
   d. Sex
2. Responsible physician(s)
3. Date of procedure
4. Other clinical information
   a. Relevant history and physical findings (eg, prior diagnosis; prior therapy, including transplantation; physical findings; symptoms; indication for biopsy)
   b. Relevant laboratory and radiological data (eg, peripheral blood studies, serum protein analyses, radiographic data, imaging studies)
   c. Procedure (eg, aspirate, trephine biopsy)
   d. Anatomic site(s) of specimen(s) (eg, left and/or right posterior iliac crest)

B. Macroscopic Examination

1. Specimen(s) (Note A)
   a. Blood
      (1) fluid specimen (anticoagulated)
      (2) slides
         i. number
         ii. unstained/stained (specify stain)
   b. Aspirate
      (1) fluid specimen volume
      (2) slides
         i. number
         ii. unstained/stained (specify stain)
   c. Touch preparations
      (1) number
      (2) unstained/stained (specify stain)
   d. Trephine biopsy
      (1) unfixed/fixed (specify fixative)
      (2) size (eg, number of pieces, aggregate length)
   e. Other (eg, cell block of particle concentrate)
2. Special studies (eg, flow cytometry immunophenotyping, cytogenetic analysis, molecular genetic analysis)

C. Microscopic Examination

1. Blood
   a. Quantitative cellular data
      (1) differential counts (Note **B**)
   b. Morphologic cellular data (details of description will depend on morphologic findings and indication for biopsy)
      (1) normal cells
         i. red blood cells
         ii. leukocytes
         iii. platelets

(2) abnormal findings, if present
i. morphologic abnormalities (eg, oval macrocytes, schistocytes, pseudo-Pelger Hüet neutrophils, giant platelets)
ii. abnormal cell types (eg, blasts, micromegakaryocytes)
iii. other (eg, microorganisms)

2. Bone marrow aspirate smear(s) and/or touch preparation(s)
   a. Adequacy of specimen (if unsatisfactory for evaluation, specify reason, eg, absence of bone marrow elements)
   b. Quantitative cellular data
      (1) differential counts (Note **B**) (see reference for ranges[1])
      (2) megakaryocytes (Note **C**)
   c. Morphologic cellular data (details of description will depend on morphologic findings and indication for biopsy)
      (1) normal cells
         i. erythroid precursors
         ii. myeloid cells
         iii. megakaryocytes
         iv. lymphocytes
         v. others
      (2) abnormal findings, if present
         i. morphologic abnormalities (eg, megaloblastic hematopoiesis, dysplasia)
         ii. abnormal or malignant cells (eg, blasts, lymphoma cells, myeloma cells, tumor cells)
         iii. other (eg, fungal organisms)
3. Trephine biopsy and/or cell block
   a. Adequacy of specimen (if unsatisfactory for evaluation, specify reason)
   b. Quantitative cellular data
      (1) cellularity and cell composition
      (2) megakaryocyte numbers
   c. Morphologic cellular data (details of description will depend on morphologic findings and indication for biopsy)
      (1) normal cells
         i. erythroid precursors
         ii. myeloid cells
         iii. lymphocytes
         iv. megakaryocytes
         v. others
      (2) abnormal findings, if present (it is often important to quantify the abnormalities, eg, percent involvement by lymphoma)
         i. morphologic abnormalities (eg, dysplastic megakaryocytes)
         ii. abnormal or malignant cells (eg, foci of blasts, lymphoma, myeloma, metastatic tumor)
         iii. other (eg, fibrosis, necrosis, granulomata, bony abnormalities)
4. Assessment of iron stores and sideroblastic iron, if performed
5. Results of cytochemical stains, if performed (Note **D**)
6. Results of histochemical stains, if performed (eg, reticulin stain, stains for organisms)
7. Results of immunohistochemical reactions, if performed (Note **E**)

8. Results/status of special studies, if performed
    a. Immunophenotyping by flow cytometry (Note **E**)
    b. Cytogenetic analysis (Note **F**)
    c. Molecular analysis (Note **G**)
9. Diagnostic assessment
    a. Diagnosis and classification of disease process with integration of results from blood, aspirate, and trephine biopsy specimens, as well as special studies (Note **H**)
10. Comments
    a. Correlation with previous bone marrow biopsies (Note **I**)
    b. Correlation with other specimens, as appropriate
    c. Correlation with clinical information, as appropriate
    d. Ancillary studies referred to reference laboratory (Note **J**)

Explanatory Notes

A. Macroscopic Examination of Specimen

Not all specimen components will be present in an individual case.

B. Quantitative Cellular Data

Differential counts, including the number of cells counted, that are utilized in the evaluation of the specimen should be documented in the report. If estimates are used, these should be documented in the report.

C. Bone Marrow Aspirate

Since the trephine biopsy usually provides a more accurate assessment of megakaryocyte numbers than the aspirate alone, both should be used, if possible, to quantify megakaryocytes.

D. Cytochemical Stains

The most frequently utilized cytochemical stains for the evaluation of acute leukemias include myeloperoxidase, Sudan black B, non-specific esterase, and periodic acid-Schiff (PAS). Cytochemical stains for acid phosphatase with and without tartrate (TRAP) are often performed to aid in the diagnosis of hairy cell leukemia.

E. Immunophenotyping (Including Immunohistochemistry and/or Flow Cytometry)

Immunophenotypic analysis is essential to precisely diagnose and classify many of the hematologic malignancies.[2] For example, immunophenotyping is used in the diagnosis of acute leukemias to determine lineage, especially in acute lymphoblastic leukemias and in acute myeloid leukemias (AMLs) that are negative by cytochemical stains for myeloperoxidase (eg, AML minimally differentiated). Evaluation of additional markers in acute leukemia aids in further subclassification (B versus T lineage in acute lymphoblastic leukemias, megakaryocyte lineage of blasts in AML, etc).

Immunophenotyping is also integral to the diagnosis of the chronic lymphoproliferative disorders, such as chronic lymphocytic leukemia, to determine B- or T-cell lineage, test for presence of monotypic immunoglobulin light-chain restriction, and to evaluate for other markers, such as CD5, CD23, and CD103, to aid in categorization of the various disorders. Similarly, work-up of the bone marrow for lymphoma and plasma cell malignancies is aided by immunophenotyping. Immunophenotypic studies are not only

useful for initial diagnosis, but may also be utilized as an adjunct to morphology in determining the presence and extent of bone marrow involvement at the time of staging of lymphomas or following therapy for both leukemias and lymphomas, especially if the phenotype has been previously determined. Immunophenotyping may also be necessary to document antigen expression when immunotherapy, such as anti-CD20, anti-CD33, or anti-CD53, is being considered.

F. Cytogenetic Analysis

Cytogenetic analysis is an integral part of the work up and classification of many hematologic malignancies.[3] For example, the World Health Organization (WHO) classification for hematologic malignancies (Table 1) incorporates several specific cytogenetic abnormalities into the classification scheme for AMLs.[4] The t(15;17) is diagnostic of acute promyelocytic leukemia. Cytogenetic analysis not only aids in the diagnosis and classification of the acute leukemias, but also gives important prognostic information. For example, AMLs associated with some specific translocations, such as t(8;21) and inv(16), occur primarily in younger individuals and are usually accompanied by a good response to therapy and a favorable prognosis. In contrast, AML with multilineage dysplasia is often associated with chromosomal deletions; for example, -7/del(7q), -5/del(5q), occurs more frequently in older individuals and is associated with an unfavorable response to therapy. Among the myeloproliferative disorders, identification of the t(9;22) is essential to confirm a morphologic diagnosis of chronic myelogenous leukemia and separate it from other myeloproliferative disorders.

Detection of cytogenetic alterations in the myelodysplastic syndromes, usually loss of chromosomal material, may also aid the diagnosis and give prognostic information. In addition, cytogenetic studies are used increasingly in the chronic lymphoid leukemias and non-Hodgkin lymphomas primarily to aid in classification but also to obtain prognostic information. Cytogenetic analysis is not only useful at diagnosis but also has utility in evaluating bone marrow after therapy for residual disease. If these results are not available at the time of the bone marrow report, an addendum could be issued when they become available.

G. Molecular Analysis

Molecular analyses are being performed increasingly to evaluate for the presence of genetic abnormalities in all types of hematologic malignancies.[5] As with cytogenetic analysis, the detection of several specific genetic alterations gives both diagnostic and prognostic information and can also be used to aid in the detection of minimal residual disease. The most common molecular techniques available at the present time include Southern blot hybridization, polymerase chain reaction (PCR) and fluorescent in situ hybridization (FISH). Currently, molecular analysis is most helpful in assessing for clonality and detecting chromosomal translocations, but its role will undoubtedly increase in the future. If these results are not available at the time of the bone marrow report, an addendum could be issued when they become available.

H. Disease Classification

The Protocol recommends the World Health Organization (WHO) classification of tumors of hematopoietic and lymphoid tissues (Table 1).[4] Variants and subtypes of lesions most applicable to bone marrow biopsies are shown in Tables 2 through 6.

I. Previous Biopsy

When bone marrow biopsies are performed following an initial diagnostic biopsy, comparison of the current biopsy with the prior biopsy findings, if possible and relevant, should be reported.

J. Referred Ancillary Studies

If ancillary studies are referred to another laboratory, it is suggested that the date of the referral and the name of the reference laboratory be included in the report. If the results are not included in the initial bone marrow report, the status and location of referral laboratory results should be given.

Table 1. World Health Organization (WHO) Classification of Tumors of Hematopoietic and Lymphoid Tissues

- Chronic myeloproliferative diseases
  - Chronic myelogenous leukemia, (Philadelphia chromosome t(9;22)(q34;q11), BCR/ABL positive)
  - Chronic neutrophilic leukemia
  - Chronic eosinophilic leukemia (and the hypereosinophilic syndrome)
  - Polycythemia vera
  - Chronic idiopathic myelofibrosis (with extramedullary hematopoiesis)
  - Essential thrombocythemia
  - Myeloproliferative disease, unclassifiable
- Myelodysplastic/myeloproliferative diseases
  - Chronic myelomonocytic leukemia
  - Atypical chronic myeloid leukemia
  - Juvenile myelomonocytic leukemia
  - Myelodysplastic/myeloproliferative disease, unclassifiable
- Myelodysplastic syndromes
  - Refractory anemia
  - Refractory anemia with ringed sideroblasts
  - Refractory cytopenia with multilineage dysplasia
  - Refractory cytopenia with multilineage dysplasia and ringed sideroblasts
  - Refractory anemia with excess blasts (RAEB)
    - RAEB-1
    - RAEB-2
  - Myelodysplastic syndrome, unclassifiable
  - Myelodysplastic syndrome associated with isolated del(5q) chromosome abnormality
- Acute myeloid leukemias (AML)
  - Acute myeloid leukemia with recurrent genetic abnormalities
    - AML with t(8;21)(q22;q22); (AML1/ETO)
    - AML with abnormal bone marrow eosinophils (inv(16)(p13q22) or t(16;16)(p13;q22);CBFβ/MYH11)
    - Acute promyelocytic leukemia (AML) with t(15;17)(q22;q11-12) PML/RARα) and variants
    - AML with 11q23 (MLL) abnormalities

- Acute myeloid leukemia with multilineage dysplasia
  - Following a myelodysplastic syndrome or myelodysplastic syndrome/myeloproliferative disorder
  - Without antecedent myelodysplastic syndrome
- Acute myeloid leukemia and myelodysplastic syndromes, therapy related
  - Alkylating agent-related
  - Topoisomerase type II inhibitor-related (some may be lymphoid)
  - Other types
- Acute myeloid leukemia not otherwise categorized
  - AML, minimally differentiated
  - AML without maturation
  - AML with maturation
  - Acute myelomonocytic leukemia
  - Acute monoblastic and monocytic leukemia
  - Acute erythroid leukemia
  - Acute megakaryoblastic leukemia
  - Acute basophilic leukemia
  - Acute panmyelosis with myelofibrosis
  - Myeloid sarcoma
- Acute leukemia of ambiguous lineage
  - Undifferentiated acute leukemia
  - Bilineal acute leukemia
  - Biphenotypic acute leukemia

Precursor B-cell and T-cell neoplasms

- Precursor B lymphoblastic leukemia/lymphoblastic lymphoma (precursor B-cell acute lymphoblastic leukemia)
- Precursor T lymphoblastic leukemia/lymphoblastic lymphoma (precursor T-cell acute lymphoblastic leukemia)

Mature B-cell neoplasms

- Chronic lymphocytic leukemia/small lymphocytic lymphoma
- B-cell prolymphocytic leukemia
- Lymphoplasmacytic lymphoma
- Splenic marginal zone lymphoma
- Hairy cell leukemia
- Plasma cell myeloma
- Monoclonal gammopathy of undetermined significance (MGUS)
- Solitary plasmacytoma of bone
- Extraosseus plasmacytoma
- Primary amyloidosis
- Heavy chain diseases
- Extranodal marginal zone B-cell lymphoma of mucosa-associated lymphoid tissue (MALT lymphoma)
- Nodal marginal zone B-cell lymphoma
- Follicular lymphoma
  - Grade 1
  - Grade 2
  - Grade 3
- Mantle cell lymphoma
- Diffuse large B-cell lymphoma
- Mediastinal (thymic) large B-cell lymphoma

- Primary effusion lymphoma
- Burkitt lymphoma / leukemia

B-cell proliferations of uncertain malignant potential

- Lymphomatoid granulomatosis
- Post-transplant lymphoproliferative disorder, polymorphic

Mature T-cell and natural killer (NK)-cell neoplasms

- Leukemic / disseminated
  - T-cell prolymphocytic leukemia
  - T-cell large granular lymphocytic leukemia
  - Aggressive NK-cell leukemia
  - Adult T-cell leukemia/lymphoma
- Cutaneous
  - Mycosis fungoides
  - Sézary syndrome
  - Primary cutaneous anaplastic large cell lymphoma
  - Lymphomatoid papulosis
- Other extranodal
  - Extranodal NK/T-cell lymphoma, nasal-type
  - Enteropathy-type T-cell lymphoma
  - Hepatosplenic T-cell lymphoma
  - Subcutaneous panniculitis-like T-cell lymphoma
- Nodal
  - Angioimmunoblastic T-cell lymphoma
  - Peripheral T-cell lymphoma, unspecified
  - Anaplastic large cell lymphoma

Neoplasm of uncertain lineage and stage of differentiation

- Blastic NK-cell lymphoma

Hodgkin lymphoma

- Nodular lymphocyte predominant Hodgkin lymphoma
- Classical Hodgkin lymphoma
  - Nodular sclerosis classical Hodgkin lymphoma
  - Lymphocyte-rich classical Hodgkin lymphoma,
  - Mixed cellularity classical Hodgkin lymphoma
  - Lymphocyte-depleted classical Hodgkin lymphoma

Histiocytic and dendritic-cell neoplasms

- Histiocytic sarcoma
- Langerhans cell histiocytosis
- Langerhans cell sarcoma
- Interdigitating dendritic cell sarcoma / tumor
- Follicular dendritic cell sarcoma / tumor
- Dendritic cell sarcoma, not otherwise specified

Mastocytosis

- Cutaneous mastocytosis
- Indolent systemic mastocytosis
- Systemic mastocytosis with associated clonal, hematologic nonmast-cell lineage disease
- Aggressive systemic mastocytosis
- Mast cell leukemia
- Mast cell sarcoma
- Extracutaneous mastocytoma

Table 2. Genetic Subgroups of Precursor B-Lymphoblastic Leukemia/Lymphoblastic Lymphoma

Genetic Abnormalities	Prognosis
t(9;22)(q34;q11.2); BCR/ABL	Unfavorable
t(4;11)(q21;23); AF4/MLL	Unfavorable
t(1;19)(q23;p13.3) PBX/E2A	Unfavorable but varies with therapeutic regimen
t(12;21)(p12;q22) TEL/AML1	Favorable
Hyperdiploid > 50	Favorable
Hypodiploidy	Unfavorable

Table 3. Diffuse Large B-Cell Lymphoma, Morphologic Variants and Subtypes

- Morphologic variants
  - Centroblastic
  - Immunoblastic
  - T-cell/histiocyte-rich
  - Anaplastic
- Other variants / subtypes
  - Plasmablastic
  - Diffuse large B-cell lymphoma with expression of full-length ALK

Table 4. Burkitt Lymphoma, Morphologic Variants and Subtypes

- Burkitt lymphoma, morphologic variants
  - Classical
  - Variants
    - Burkitt lymphoma with plasmacytoid differentiation
    - Atypical Burkitt/Burkitt-like
- Burkitt lymphoma, subtypes (clinical and genetic)
  - Endemic
  - Sporadic
  - Immunodeficiency-associated

Table 5. Plasma Cell Neoplasms: Subtypes and Variants

- Plasma cell myeloma variants
  - Non-secretory myeloma
  - Indolent myeloma
  - Smoldering myeloma
  - Plasma cell leukemia
- Plasmacytoma
  - Solitary plasmacytoma of bone
  - Extramedullary plasmacytoma
- Immunoglobulin deposition diseases
  - Primary amyloidosis
  - Systemic light and heavy chain deposition diseases
- Osteosclerotic myeloma (POEMS) syndrome
- Heavy chain diseases (HCD)
  - Gamma HCD
  - Mu HCD
  - Alpha HCD

Table 6. Categories of Post-Transplant Lymphoproliferative Diseases (PTLD)

- Early lesions
  - Reactive plasmacytic hyperplasia
  - Infectious mononucleosis-like
- Polymorphic PTLD
- Monomorphic (classify according to lymphoma classification)
  - B-cell neoplasms
  - Diffuse large B-cell lymphoma (immunoblastic, centroblastic, anaplastic)
    - Burkitt/Burkitt-like lymphoma
    - Plasma cell myeloma
    - Plasmacytoma-like lesions
  - T-cell lymphomas
    - Peripheral T-cell lymphoma, not otherwise specified
    - Other types
  - Hodgkin lymphoma and Hodgkin lymphoma-like PTLD Hodgkin lymphoma

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1. Bain BJ. The bone marrow aspirate of healthy subjects. *Br J Haematol.* 1996;94:206-209.
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