Test Definition: LCMS

Leukemia/Lymphoma Immunophenotyping, Flow Cytometry, Varies

Overview

Useful For

Evaluating lymphocytoses of undetermined etiology

Identifying B- and T-cell lymphoproliferative disorders involving blood and bone marrow

Distinguishing acute lymphoblastic leukemia (ALL) from acute myeloid leukemia (AML)

Immunologic subtyping of acute leukemias

Distinguishing reactive lymphocytes and lymphoid hyperplasia from malignant lymphoma

Distinguishing between malignant lymphoma and acute leukemia

Phenotypic subclassification of B- and T-cell chronic lymphoproliferative disorders, including chronic lymphocytic leukemia, mantle cell lymphoma, and hairy cell leukemia

Recognizing AML with minimal morphologic or cytochemical evidence of differentiation

Recognizing monoclonal plasma cells

This test is **not intended for** detection of minimal residual disease below 5% blasts.

This test is **not appropriate** for and cannot support diagnosis of sarcoidosis, hypersensitivity pneumonitis, interstitial lung diseases, or differentiating between pulmonary tuberculosis and sarcoidosis.

Reflex Tests

Test Id	Reporting Name	Available Separately	Always Performed
FCINT	Flow Cytometry Interp, 2-8 Markers	No, (Bill Only)	No
FCIMS	Flow Cytometry Interp, 9-15 Markers	No, (Bill Only)	No
FCINS	Flow Cytometry Interp,16 or greater	No, (Bill Only)	No
AMLMB	Probe, Each Additional (AMLMF)	No, (Bill Only)	No
AMLMF	AML, Specified FISH	Yes	No
AMLBA	Probe, Each Additional (AMLFA)	No, (Bill Only)	No
AMLFA	Adult-AML panel, FISH	Yes	No

Additional Tests

Test Id	Reporting Name	Available Separately	Always Performed
FIRST	Flow Cytometry, Cell Surface, First	No, (Bill Only)	Yes
ADD1	Flow Cytometry, Cell Surface, Addl	No, (Bill Only)	Yes

Testing Algorithm

The testing process begins with a screening panel. The screening panel will be charged based on the number of markers tested (FIRST for first marker, ADD1 for each additional marker). The interpretation will be based on markers tested in increments of 2 to 8, 9 to 15, or 16 and greater. In addition, reflex testing may occur to fully characterize a disease state or clarify any abnormalities from the screening test. Reflex tests will be performed at an additional charge for each marker tested (FIRST if applicable, ADD1 if applicable).

In addition to reflexing flow cytometric panels, acute myeloid leukemia (AML) fluorescence in situ hybridization (FISH) testing for *PML::RARA* translocation t(15;17) may be added by the Mayo Clinic pathologist to exclude acute promyelocytic leukemia if there is morphologic suspicion or if blasts and promyelocytes are CD34-negative and HLA-DR-negative.

The triage panel is initially performed to evaluate for monotypic B cells by kappa and lambda immunoglobulin light chain expression, increased numbers of blast cells by CD34 and CD45 expression along with side scatter gating, and increased plasma cells by CD45 expression and side scatter gating. The triage panel also includes antibodies to assess the number of CD3-positive T cells and CD16-positive/CD3-negative natural killer (NK) cells present. This triage panel also determines if there is an increase in the number of T cells that aberrantly coexpress CD16, an immunophenotypic feature of T-cell granular lymphocytic leukemia.

This panel, together with the provided clinical history and morphologic review, is used to determine what, if any, additional testing is needed for disease diagnosis or classification. If additional testing is required, it will be added per the algorithm to fully characterize a disease state with a charge per unique antibody tested.

If no abnormalities are detected by the initial triage panel, no further flow cytometric assessment will be performed unless otherwise indicated by specific features of the clinical presentation or prior laboratory results.

In addition to reflexing flow cytometric panels, FISH, molecular testing or cytochemical stains may be recommended by the Mayo Clinic pathologist to facilitate diagnosis. They will contact the referring provider or pathologist to confirm the addition of these tests.

For more information, the following algorithms are available:
-Bone Marrow Staging for Known or Suspected Malignant Lymphoma Algorithm
-Acute Myeloid Leukemia: Testing Algorithm
-Acute Myeloid Leukemia: Relapsed with Previous Remission Testing Algorithm

-Acute Promyelocytic Leukemia: Guideline to Diagnosis and Follow-up
-Mast Cell Disorder: Diagnostic Algorithm, Bone Marrow
-Acute Leukemias of Ambiguous Lineage Testing Algorithm

Special Instructions

- Hematopathology Patient Information
- Bone Marrow Staging for Known or Suspected Malignant Lymphoma Algorithm
- Acute Promyelocytic Leukemia: Guideline to Diagnosis and Follow-up
- Acute Leukemias of Ambiguous Lineage Testing Algorithm
- Acute Myeloid Leukemia: Testing Algorithm
- Acute Myeloid Leukemia: Relapsed with Previous Remission Algorithm
- Mast Cell Disorder: Diagnostic Algorithm, Bone Marrow

Method Name

Immunophenotyping

NY State Available

Yes

Specimen

Specimen Type

Varies

Ordering Guidance

For B-cell acute lymphoblastic leukemia minimal residual disease testing in either blood or bone marrow, order BALLM / B-Cell Lymphoblastic Leukemia Monitoring, Measurable/Minimal Residual Disease Detection, Flow Cytometry, Varies.

This test is appropriate for hematopoietic specimens only. For solid tissue specimens, order LLPT / Leukemia/Lymphoma Immunophenotyping, Flow Cytometry, Tissue.

For bone marrow specimens being evaluated for possible involvement by a myelodysplastic syndrome (MDS) or a myelodysplastic/myeloproliferative neoplasm (MDS/MPN) including chronic myelomonocytic leukemia (CMML), order MYEFL / Myelodysplastic Syndrome, Flow Cytometry, Bone Marrow.

Bronchoalveolar lavage specimens submitted for evaluation for leukemia or lymphoma are appropriate to send for this test.

This test is **not appropriate for** and cannot support diagnosis of sarcoidosis, hypersensitivity pneumonitis, interstitial lung diseases, or differentiating between pulmonary tuberculosis and sarcoidosis (requests for CD4/CD8 ratios); **specimens sent for these purposes will be rejected.**

This test is **not intended** for product of conception (POC) specimens. For POC specimens see CMAPC / Chromosomal Microarray, Autopsy, Products of Conception, or Stillbirth.

Additional Testing Requirements

For bone marrow testing, if cytogenetic tests are desired along with this test request, an additional specimen should be submitted. It is important that the specimen be obtained, processed, and transported according to instructions for the other test.

Shipping Instructions

Specimen must arrive within 4 days of collection.

Necessary Information

The following information is required:

1. Pertinent clinical history including reason for testing or clinical indication/morphologic suspicion.
2. Specimen source
3. **For spinal fluid specimens: spinal fluid cell and differential counts are required**

Specimen Required

Submit only 1 of the following specimens:

Specimen Type: Whole blood
Container/Tube:
Preferred: Yellow top (ACD solution A or B)
Acceptable: Lavender top (EDTA) or green top (sodium heparin)
Specimen Volume: 6 mL
Collection Instructions:
1. Send whole blood specimen in original tube. **Do not aliquot**.
2. Label specimen as blood.
3. Include 1 to 2 unstained blood smears labeled with 2 unique identifiers.
Specimen Stability Information: Ambient 4 days/Refrigerated 4 days

Specimen Type: Bone marrow
Container/Tube:
Preferred: Yellow top (ACD solution A or B)
Acceptable: Lavender top (EDTA) or green top (sodium heparin)
Specimen Volume: 1 to 5 mL
Collection Instructions:
1. Submission of bilateral specimens is not required.
2. Send bone marrow specimen in original tube. **Do not aliquot.**
3. Label specimen as bone marrow.
4. Include 1 to 2 unstained bone marrow smears labeled with 2 unique identifiers.
Specimen Stability Information: Ambient 4 days/Refrigerated 4 days
Note: A fresh (less than 4 days post-collection), unfixed, nonembedded bone marrow core biopsy, bone or bone lesion is acceptable as an equivalent source for bone marrow aspirate for this test **only in the event of a dry tap** during the bone marrow harvesting procedure. Indicate "dry tap" in performing lab notes or paperwork when submitting this specimen

type.

Specimen Type: Body fluid
Sources: Serous effusions, pleural fluid, pericardial fluid, abdominal (peritoneal) fluid, bronchoalveolar lavage (BAL)
Container/Tube: Body fluid container
Specimen Volume: 20 mL
Collection Instructions:
1. If possible, body fluids other than spinal fluid should be anticoagulated with heparin (1 U/mL of fluid).
2. Label specimen with body fluid type.
Specimen Stability Information: Refrigerated 4 days/Ambient 4 days
Additional Information: The volume of serous effusions necessary to phenotype lymphocytes or blasts depends upon the cell count in the specimen. Usually, 20 mL of pleural or peritoneal fluid is sufficient. Smaller volumes can be used if there is a high cell count.

Specimen Type: Spinal fluid
Container/Tube: Sterile vial
Specimen Volume: 1 to 1.5 mL
Collection Instructions:
1. An original cytospin preparation (preferably unstained) should be included with the spinal fluid specimen so correlative morphologic evaluation can occur.
2. Label specimen as spinal fluid.
Specimen Stability Information: Refrigerated 4 days/Ambient 4 days
Additional Information: The volume of spinal fluid necessary to phenotype lymphocytes or blasts depends upon the cell count in the specimen. A cell count should be determined and submitted with the specimen. Usually, 1 to 1.5 mL of spinal fluid is sufficient. Smaller volumes can be used if there is a high cell count. If cell count is less than 10 cells/mcL, a larger volume of spinal fluid may be required. When cell counts drop below 5 cells/mcL, the immunophenotypic analysis may not be successful.

Forms

1. Hematopathology Patient Information (T676)
2. If not ordering electronically, complete, print, and send 1 of the following forms with the specimen:
-Hematopathology/Cytogenetics Test Request (T726)
-Benign Hematology Test Request (T755)

Specimen Minimum Volume

Blood: 3 mL; Bone marrow: 0.5mL; Spinal fluid: 1 mL; Fluid from serous effusions: 5 mL

Reject Due To

Whole blood: Gross hemolysis	Reject
Whole blood: Fully clotted	Reject

Specimen Stability Information

Specimen Type	Temperature	Time	Special Container
Varies	Varies		

Clinical & Interpretive

Clinical Information

Diagnostic hematopathology has become an increasingly complex subspecialty, particularly with neoplastic disorders of blood and bone marrow. While morphologic assessments of blood smears, bone marrow smears, and tissue sections remain the cornerstone of lymphoma and leukemia diagnosis and classification, immunophenotyping is a very valuable and important complementary tool.

Immunophenotyping hematopoietic specimens can help resolve many differential diagnostic problems posed by the patient's clinical or morphologic features.

This test is appropriate for only hematopoietic specimens.

Reference Values

An interpretive report will be provided.

Interpretation

This test will be processed as a laboratory consultation. An interpretation of the immunophenotypic findings and correlation with the morphologic features will be provided by a hematopathologist for every case.

The report will include a morphologic description, a summary of the procedure, the percent positivity of selected antigens, and an interpretive conclusion based on the correlation of the patient's clinical history with morphologic features and immunophenotypic results.

Cautions

Specimens will be initially triaged to determine which, if any, of the immunophenotyping panels should be performed.

Clinical Reference

1. Jevremovic D, Dronca RS, Morice WG, et al. CD5+ B-cell lymphoproliferative disorders: Beyond chronic lymphocytic leukemia and mantle cell lymphoma. Leuk Res. 2010;34(9):1235-1238. doi:10.1016/j.leukres.2010.03.020
2. Hanson CA. Acute leukemias and myelodysplastic syndromes. In: McClatchey KD, ed. Clinical Laboratory Medicine. Williams and Wilkins; 1994:939-969
3. Jevremovic D, Olteanu H. Flow cytometry applications in the diagnosis of T/NK-Cell lymphoproliferative disorders. Cytometry B Clin Cytom. 2019;96(2):99-115. doi:10.1002/cyto.b.21768
4. Rosado FG, Morice WG, He R, Howard MT, Timm M, McPhail ED. Immunophenotypic features by multiparameter flow cytometry can help distinguish low grade B-cell lymphomas with plasmacytic differentiation from plasma cell proliferative disorders with an unrelated clonal B-cell process. Br J Haematol. 2015;169(3):368-376. doi:10.1111/bjh.13303
5. Shi M, Ternus JA, Ketterling RP, et al. Immunophenotypic and laboratory features of t(11;14)(q13;q32)-positive plasma

cell neoplasms. Leuk Lymphoma. 2018;59(8):1913-1919. doi:10.1080/10428194.2017.1410885
6. Morice WG, Kimlinger T, Katzmann JA, et al. Flow cytometric assessment of TCR-Vbeta expression in the evaluation of peripheral blood involvement by T-cell lymphoproliferative disorders: a comparison with conventional T-cell immunophenotyping and molecular genetic techniques. Am J Clin Pathol. 2004;121(3):373-383. doi:10.1309/3A32-DTVM-H640-M2QA
7. Shi M, Jevremovic D, Otteson GE, Timm MM, Olteanu H, Horna P. Single antibody detection of T-Cell receptor alpha beta clonality by flow cytometry rapidly identifies mature T-Cell neoplasms and monotypic small CD8-positive subsets of uncertain significance. Cytometry B Clin Cytom. 2020;98(1):99-107. doi:10.1002/cyto.b.21782

Performance

Method Description

Flow cytometric immunophenotyping of peripheral blood, bone marrow, and body fluids is performed using the following antibodies:

Triage Panel: CD3, CD10, CD16, CD19, CD34, CD45 and kappa and lambda immunoglobulin light chains
Possible Additional Panels: Performed per algorithmic approach
-B-cell Panel: CD5, CD11c, CD19, CD20, CD22, CD23, CD38, CD45, CD103, CD200 and kappa and lambda immunoglobulin light chains
-T-cell Panel: CD2, CD3, CD4, CD5, CD7, CD8, CD45, TRBC1, and gamma/delta
-Sezary Panel: CD2, CD3, CD4, CD5, CD7, CD8, CD26, CD45, and TRBC1.-Killer-cell Immunoglobulin-like Receptor Panel: CD3, CD8, CD16, CD56, CD57, CD94, CD158a, CD158b, CD158e (p70), and NKG2a
-Acute Panel: CD2, CD7, CD13, CD15, CD16, CD33, CD34, CD36, CD38, CD45, CD56, CD64, CD117, and HLA-DR
-B-cell ALL: CD10, CD19, CD20, CD22, CD24, CD34, CD38, CD45, CD58, and CD66c
-Myeloperoxidase (MPO)/terminal deoxynucleotidyl transferase (TdT) (MPO/TdT) Panel: cytoplasmic CD3, CD13, cytoplasmic CD22, CD34, CD45, cytoplasmic CD79a, nuclear TdT, and cytoplasmic MPO
-Plasma Cell Panel: CD19, CD38, CD45, CD138, and cytoplasmic kappa and lambda immunoglobulin light chains
-Mast Cell Panel (bone marrow only): CD2, CD25, CD69, CD117.
(Keren D, McCoy JP, Carey J. Flow Cytometry in Clinical Diagnosis. 4th ed. American Society for Clinical Pathology; 2007; Betters DM: Use of flow cytometry in clinical practice. J Adv Pract Oncol. 2015;6[5]:435-440. doi:10.6004/jadpro.2015.6.5.4)

PDF Report

No

Day(s) Performed

Monday through Saturday

Report Available

1 to 4 days

Specimen Retention Time

Whole blood/Bone marrow:14 days; Fluids: 7 days

Performing Laboratory Location

Mayo Clinic Laboratories - Rochester Main Campus

Fees & Codes

Fees

- Authorized users can sign in to Test Prices for detailed fee information.
- Clients without access to Test Prices can contact Customer Service 24 hours a day, seven days a week.
- Prospective clients should contact their account representative. For assistance, contact Customer Service.

Test Classification

This test was developed using an analyte specific reagent. Its performance characteristics were determined by Mayo Clinic in a manner consistent with CLIA requirements. This test has not been cleared or approved by the US Food and Drug Administration.

CPT Code Information

88184-Flow cytometry; first cell surface, cytoplasmic or nuclear marker x 1
88185-Flow cytometry; additional cell surface, cytoplasmic or nuclear marker (each)
88187-Flow Cytometry Interpretation, 2 to 8 Markers (if appropriate)
88188-Flow Cytometry Interpretation, 9 to 15 Markers (if appropriate)
88189-Flow Cytometry Interpretation, 16 or More Markers (if appropriate)

LOINC® Information

Test ID	Test Order Name	Order LOINC® Value
LCMS	Leukemia/Lymphoma, Phenotype	101119-6

Result ID	Test Result Name	Result LOINC® Value
18253	Microscopic Description	22635-7
18254	Special Studies:	30954-2
18255	Final Diagnosis:	34574-4
CK155	LCMS Result	No LOINC Needed
CKR1	Reason for Referral	42349-1
CKS1	Specimen Source	31208-2