MAYO CLINIC LABORATORIES

Test Definition: MMAGP

Methylmalonic Aciduria Gene Panel, Varies

Overview

Useful For

Follow up for abnormal biochemical results suggestive of a methylmalonic acidemiaEstablishing a molecular diagnosis for patients with methylmalonic acidemiaIdentifying variants within genes known to be associated with methylmalonic acidemia, allowing for predictive testing of at-risk family members

Reflex Tests

Test Id	Reporting Name	Available Separately	Always Performed
CULFB	Fibroblast Culture for Genetic Test	Yes	No

Genetics Test Information

This test utilizes next-generation sequencing to detect single nucleotide and copy number variants in 25 genes associated with methylmalonic aciduria: ABCD4, ACSF3, ALDH6A1, AMN, CD320, CUBN, CBLIF, HCFC1, LMBRD1, MCEE, MMAA, MMAB, MMACHC, MMADHC, MTHFR, MTR, MTRR, MMUT, PRDX1, SUCLA2, SUCLG1, TCN1, TCN2, THAP11, ZNF143. For additional details see Method Description or Targeted Genes and Methodology Details for Methylmalonic Aciduria Gene Panel. Identification of a pathogenic variant may assist with diagnosis, prognosis, clinical management, familial screening, and genetic counseling for methylmalonic aciduria.

Testing Algorithm

For skin biopsy or cultured fibroblast specimens, fibroblast culture testing will be performed at an additional charge. If viable cells are not obtained, the client will be notified.

Special Instructions

- Molecular Genetics: Biochemical Disorders Patient Information
- Informed Consent for Genetic Testing
- Blood Spot Collection Card-Spanish Instructions
- Blood Spot Collection Card-Chinese Instructions
- Informed Consent for Genetic Testing (Spanish)
- Blood Spot Collection Instructions
- Targeted Genes and Methodology Details for Methylmalonic Aciduria Gene Panel

Method Name

Sequence Capture and Targeted Next-Generation Sequencing (NGS) followed by Polymerase Chain Reaction (PCR) and Sanger Sequencing

NY State Available

Yes

Specimen

Specimen Type

Varies

Ordering Guidance

The recommended first-tier tests to screen for methylmalonic aciduria include plasma acylcarnitine profile (ACRN / Acylcarnitines, Quantitative, Plasma), quantitative plasma amino acids (AAQP / Amino Acids, Quantitative, Plasma), urine organic acids (OAU / Organic Acids Screen, Random, Urine), and homocysteine (HCYSP / Homocysteine, Total, Plasma or HCYSS / Homocysteine, Total, Serum). Customization of this panel and single gene analysis for any gene present on this panel is available. For more information see CGPH / Custom Gene Panel, Hereditary, Next-Generation Sequencing, Varies.Targeted testing for familial variants (also called site-specific or known mutations testing) is available for the genes on this panel. See FMTT / Familial Variant, Targeted Testing, Varies. To obtain more information about this testing option, call 800-533-1710.

Shipping Instructions

Specimen preferred to arrive within 96 hours of collection.

Specimen Required

Patient Preparation: A previous bone marrow transplant from an allogenic donor will interfere with testing. For instructions for testing patients who have received a bone marrow transplant, call 800-533-1710. Submit only 1 of the following specimens: Specimen Type: Whole bloodContainer/Tube: Lavender top (EDTA) or yellow top (ACD)Specimen Volume: 3 mLCollection Instructions:1. Invert several times to mix blood.2. Send whole blood specimen in original tube. Do not aliquot.Specimen Stability Information: Ambient (preferred) 4 days/Refrigerated 14 days Specimen Type: Skin biopsySupplies: Fibroblast Biopsy Transport Media (T115)Container/Tube: Sterile container with any standard cell culture media (eg, minimal essential media, RPMI 1640). The solution should be supplemented with 1% penicillin and streptomycin.Specimen Volume: 4-mm punchSpecimen Stability Information: Refrigerated (preferred)/AmbientAdditional Information: A separate culture charge will be assessed under CULFB / Fibroblast Culture for Biochemical or Molecular Testing. An additional 3 to 4 weeks is required to culture fibroblasts before genetic testing can occur. Specimen Type: Cultured fibroblastContainer/Tube: T-25 flaskSpecimen Volume: 2 FlasksCollection Instructions: Submit confluent cultured fibroblast cells from a skin biopsy from another laboratory. Cultured cells from a prenatal specimen will not be accepted.Specimen Stability Information: Ambient (preferred)/Refrigerated (<24 hours)Additional Information: A separate culture charge will be assessed under CULFB / Fibroblast Culture for Biochemical or Molecular Testing. An additional 3 to 4 weeks is required to culture fibroblasts before genetic testing can occur. Specimen Type: Blood spotSupplies: Card-Blood Spot Collection (Filter Paper) (T493)Container/Tube:Preferred: Collection card (Whatman Protein Saver 903 Paper)Acceptable: PerkinElmer 226 (formerly Ahlstrom 226) filter paper or blood spot collection cardSpecimen Volume: 5 Blood spotsCollection Instructions:1. An alternative blood collection option for a patient older than 1 year is a fingerstick. For detailed instructions, see How to Collect Dried Blood Spot Samples.2. Let blood dry on the filter paper at ambient temperature in a horizontal position for a minimum of 3 hours.3. Do not expose specimen to heat or direct sunlight.4. Do not stack wet specimens.5. Keep specimen dry.Specimen Stability Information: Ambient (preferred)/RefrigeratedAdditional Information:1. Due to lower concentration of DNA yielded from blood spot, it is possible that additional specimen may be required to complete testing.2. For collection instructions, see Blood Spot Collection Instructions 3. For collection instructions in Spanish, see Blood Spot Collection Card-Spanish Instructions (T777)4. For collection instructions in Chinese, see Blood Spot Collection Card-Chinese Instructions (T800) Specimen Type: SalivaPatient Preparation: Patient should not eat, drink, smoke, or chew gum 30 minutes prior to collection.Supplies: Saliva Swab Collection Kit (T786)Specimen Volume: 1 SwabCollection Instructions:

Collect and send specimen per kit instructions.Specimen Stability Information: Ambient 30 daysAdditional Information: Due to lower concentration of DNA yielded from saliva, it is possible that additional specimen may be required to complete testing.

Forms

1. New York Clients-Informed consent is required. Document on the request form or electronic order that a copy is on file. The following documents are available:-Informed Consent for Genetic Testing (T576)-Informed Consent for Genetic Testing (Spanish) (T826)2. Molecular Genetics: Biochemical Disorders Patient Information (T527)3. If not ordering electronically, complete, print, and send a Biochemical Genetics Test Request (T798) with the specimen.

Specimen Minimum Volume

See Specimen Required

Reject Due To

All specimens will be evaluated at Mayo Clinic Laboratories for test suitability.

Specimen Stability Information

Specimen Type	Temperature	Time	Special Container
Varies	Varies		

Clinical & Interpretive

Clinical Information

Elevated levels of methylmalonic acid (MMA) result from inherited defects of enzymes involved in MMA metabolism. MMA is a specific diagnostic marker for the group of disorders collectively called methylmalonic acidemia, which include at least 7 different complementation groups. Two of them (mut0 and mut-) reflect deficiencies of the apoenzyme portion of the enzyme methylmalonyl-CoA mutase caused by pathogenic variants in the mutase gene (MUT). Two other disorders (CblA and CblB) are associated with abnormalities of the adenosylcobalamin (Cbl) synthesis pathway. CblC, CblD, and CblF deficiencies lead to impaired synthesis of both adenosyl- and methylcobalamin.Since the first reports of this disorder in 1967, hundreds of cases have been diagnosed worldwide. Newborn screening identifies approximately 1 in 30,000 live births with methylmalonic acidemia. The most frequent clinical manifestations are neonatal or infantile metabolic ketoacidosis, failure to thrive, and developmental delay. Excessive protein intake may cause life-threatening episodes of metabolic decompensation and remains a life-long risk unless treatment is closely monitored, including plasma and urine MMA levels (MMAP / Methylmalonic Acid, Quantitative, Plasma and MMAU / Methylmalonic Acid, Quantitative, Urine).Plasma acylcarnitine profile (ACRN / Acylcarnitines, Quantitative, Plasma), quantitative plasma amino acids (AAQP / Amino Acids, Quantitative, Plasma), urine organic acids (OAU / Organic Acids Screen, Random, Urine), and homocysteine (HCYSP / Homocysteine, Total, Plasma or HCYSS / Homocysteine, Total, Serum) are recommended first-tier biochemical tests to screen patients for methylmalonic acidemia.A comprehensive gene panel is a helpful tool to establish a targeted diagnosis for patients with suggestive clinical and biochemical features of methylmalonic acidemia.Treatment is most effective when tailored to the specific type of methylmalonic acidemia. For example, intramuscular injections of hydroxocobalamin are critical in the treatment of CblC, whereas oral cyanocobalamin is effective for methylmalonic acidemia mutase subtypes as well as other cobalamin subtypes. Acute treatment for methylmalonic acidemia consists of dialysis and administration of nitrogen scavenger drugs to reduce ammonia concentration. Chronic management typically involves restriction of dietary protein with essential amino acid

supplementation. More recently, liver transplantation has been successful in treating some patients.

Reference Values

An interpretive report will be provided.

Interpretation

All detected alterations are evaluated according to American College of Medical Genetics and Genomics recommendations.(1) Variants are classified based on known, predicted, or possible pathogenicity and reported with interpretive comments detailing their potential or known significance.

Cautions

Clinical Correlations:Test results should be interpreted in the context of clinical findings, family history, and other laboratory data. Misinterpretation of results may occur if the information provided is inaccurate or incomplete. If testing was performed because of a clinically significant family history, it is often useful to first test an affected family member. Detection of at least one reportable variant in an affected family member would allow for more informative testing of at-risk individuals. To discuss the availability of additional testing options or for assistance in the interpretation of these results, contact the Mayo Clinic Laboratories genetic counselors at 800-533-1710. Technical Limitations:Next-generation sequencing may not detect all types of genomic variants. In rare cases, false-negative or false-positive results may occur. The depth of coverage may be variable for some target regions; assay performance below the minimum acceptable criteria or for failed regions will be noted. Given these limitations, negative results do not rule out the diagnosis of a genetic disorder. If a specific clinical disorder is suspected, evaluation by alternative methods can be considered. There may be regions of genes that cannot be effectively evaluated by sequencing or deletion and duplication analysis as a result of technical limitations of the assay, including regions of homology, high guanine-cytosine (GC) content, and repetitive sequences. Confirmation of select reportable variants will be performed by alternate methodologies based on internal laboratory criteria. This test is validated to detect 95% of deletions up to 75 base pairs (bp) and insertions up to 47 bp. Deletions-insertions (delins) of 40 or more bp, including mobile element insertions, may be less reliably detected than smaller delins. Deletion/Duplication Analysis:This analysis targets single and multi-exon deletions/duplications; however, in some instances single exon resolution cannot be achieved due to isolated reduction in sequence coverage or inherent genomic complexity. Balanced structural rearrangements (such as translocations and inversions) may not be detected. This test is not designed to detect low levels of mosaicism or to differentiate between somatic and germline variants. If there is a possibility that any detected variant is somatic, additional testing may be necessary to clarify the significance of results. Genes may be added or removed based on updated clinical relevance. For detailed information regarding gene-specific performance and technical limitations, see Method Description or contact a laboratory genetic counselor. If the patient has had an allogeneic hematopoietic stem cell transplant or a recent heterologous blood transfusion, results may be inaccurate due to the presence of donor DNA. Call Mayo Clinic Laboratories for instructions for testing patients who have received a bone marrow transplant. Reclassification of Variants:Currently, it is not standard practice for the laboratory to systematically review previously classified variants on a regular basis. The laboratory encourages healthcare providers to contact the laboratory at any time to learn how the classification of a particular variant may have changed over time. Due to broadening genetic knowledge, it is possible that the laboratory may discover new information of relevance to the patient. Should that occur, the laboratory may issue an amended report. Variant Evaluation:Evaluation and categorization of variants are performed using published American College of Medical Genetics and Genomics and the Association for Molecular Pathology recommendations as a guideline.(1) Other gene-specific guidelines may also be considered. Variants are classified based on known, predicted, or possible pathogenicity and reported with interpretive comments detailing their potential or known significance. Variants classified as benign or likely benign are not reported. Multiple in silico evaluation tools may be used to assist in the interpretation of these results. The accuracy of predictions made by in silico evaluation tools is highly dependent upon

the data available for a given gene, and periodic updates to these tools may cause predictions to change over time. Results from in silico evaluation tools should be interpreted with caution and professional clinical judgment. Rarely, incidental or secondary findings may implicate another predisposition or presence of active disease. These findings will be carefully reviewed to determine whether they will be reported.

Clinical Reference

1. Richards S, Aziz N, Bale S, et al. Standards and guidelines for the interpretation of sequence variants: a joint consensus recommendation of the American College of Medical Genetics and Genomics and the Association for Molecular Pathology. Genet Med. 2015;17(5):405-4242. Fenton WA, Gravel RA, Rosenblatt DS. Disorders of propionate and methylmalonate metabolism. In: Valle D, Antonarakis S, Ballabio A, Beaudet A, Mitchell GA, eds. The Online Metabolic and Molecular Bases of Inherited Disease. McGraw-Hill Education; 2019. Accessed March 8, 2024. Available at: http://ommbid.mhmedical.com/content.aspx?bookid=2709§ionid=225086103

Performance

Method Description

Next-generation sequencing (NGS) and/or Sanger sequencing are performed to test for the presence of variants in coding regions and intron/exon boundaries of the genes analyzed, as well as some other regions that have known disease-causing variants. The human genome reference GRCh37/hg19 build was used for sequence read alignment. At least 99% of the bases are covered at a read depth over 30X. Sensitivity is estimated to be over 99% for single nucleotide variants, over 94% for deletions-insertions (delins) less than 40 base pairs (bp), and over 95% for deletions up to 75 bp and insertions up to 47 bp. NGS and/or a polymerase chain reaction-based quantitative method is performed to test for the presence of deletions and duplications in the genes analyzed. There may be regions of genes that cannot be effectively evaluated by sequencing or deletion and duplication analysis as a result of technical limitations of the assay, including regions of homology, high guanine-cytosine (GC) content, and repetitive sequences. For details regarding the targeted genes analyzed and the specific gene regions not routinely covered, see Targeted Genes and Methodology Details for Methylmalonic Aciduria Gene Panel.(Unpublished Mayo method) Genes analyzed: ABCD4, ACSF3, ALDH6A1, AMN, CD320, CUBN, CBLIF, HCFC1, LMBRD1, MCEE, MMAA, MMAB, MMACHC, MMADHC, MTHFR, MTR, MTRR, MMUT, PRDX1, SUCLA2, SUCLG1, TCN1, TCN2, THAP11, and ZNF143

PDF Report

Supplemental

Day(s) Performed

Varies

Report Available

28 to 42 days

Specimen Retention Time

Whole blood: 2 weeks (if available); Extracted DNA: 3 months; Blood spots, saliva, cultured fibroblasts: 1 month

Performing Laboratory Location

Rochester

Fees & Codes

Test Classification

This test was developed and its performance characteristics determined by Mayo Clinic in a manner consistent with CLIA requirements. It has not been cleared or approved by the US Food and Drug Administration.

CPT Code Information

8144388233-Tissue culture, skin, solid tissue biopsy (if appropriate)88240-Cryopreservation (if appropriate)

LOINC® Information

Test ID	Test Order Name	Order LOINC® Value
MMAGP	Methylmalonic Aciduria Gene Panel	105347-9

Result ID	Test Result Name	Result LOINC® Value
608656	Test Description	62364-5
608657	Specimen	31208-2
608658	Source	31208-2
608659	Result Summary	50397-9
608660	Result	82939-0
608661	Interpretation	69047-9
608662	Resources	99622-3
608663	Additional Information	48767-8
608664	Method	85069-3
608665	Genes Analyzed	48018-6
608666	Disclaimer	62364-5
608667	Released By	18771-6