

Reimbursement Policy

Gamma-glutamyl Transferase Testing in Adults

[POLICY DESCRIPTION](#) | [INDICATIONS AND/OR LIMITATIONS OF COVERAGE](#) | [APPLICABLE STATE AND FEDERAL REGULATIONS](#) | [APPLICABLE CPT/HCPCS PROCEDURE CODES](#) | [EVIDENCE-BASED SCIENTIFIC REFERENCES](#) |

I. Policy Description

Gamma-glutamyl transferase (GGT), also known as gamma-glutamyl transpeptidase (GGTP) (Singh et al., 2006; Vroon & Israili, 1990), is an enzyme that has a half-life of between fourteen and twenty-six days and is present in the cell membrane of many different tissue types, including the heart, brain, seminal vesicles, kidneys, bile duct, spleen, and gallbladder (Dillon & Miller, 2016; Dixit & Singh, 2015). GGT is traditionally considered a predictive marker for liver dysfunction, bile duct ailments, and alcohol consumption (Koenig & Seneff, 2015). However, new research suggests that GGT may be useful as an early predictive marker for several other conditions including heart failure, arterial stiffness, arterial plaque, gestational diabetes, atherosclerosis, several infectious diseases, and numerous types of cancer (Koenig & Seneff, 2015). Terms such as male and female are used when necessary to refer to sex assigned at birth.

II. Indications and/or Limitations of Coverage

Application of coverage criteria is dependent upon an individual's benefit coverage at the time of the request. Specifications pertaining to Medicare and Medicaid can be found in the "Applicable State and Federal Regulations" section of this policy document.

This policy is specific to individuals 18 years of age or older. Criteria below do not apply to individuals less than 18 years of age.

- 1) For individuals with elevated alkaline phosphatase activity, serum GGT testing no more than once every two weeks **MEETS COVERAGE CRITERIA**.
- 2) To assess for liver injury, function, and/or disease, serum GGT testing no more than once every two weeks **MEETS COVERAGE CRITERIA** for individuals with at least one of the following conditions:
 - a) For individuals with chronic alcohol use.
 - b) For individuals on a long-term drug therapy known to have a potential for causing liver toxicity.
 - c) For individuals with exposure to hepatotoxins.
 - d) For individuals with viral hepatitis, amoebiasis, tuberculosis, psittacosis, or similar infections that may cause hepatic injury.
 - e) For individuals with primary or secondary malignant neoplasms.
 - f) For individuals with diabetes mellitus.
 - g) For individuals with malnutrition.

Reimbursement Policy

- h) For individuals with disorders of iron and mineral metabolism.
 - i) For individuals with sarcoidosis.
 - j) For individuals with amyloidosis.
 - k) For individuals with lupus.
 - l) For individuals with hypertension.
 - m) For individuals with gastrointestinal disease.
 - n) For individuals with pancreatic disease.
 - o) To assess liver function subsequent to liver transplantation.
- 3) For asymptomatic individuals, serum GGT testing during a wellness visit or a general exam without abnormal findings **DOES NOT MEET COVERAGE CRITERIA.**

III. Applicable State and Federal Regulations

DISCLAIMER: If there is a conflict between this Policy and any relevant, applicable government policy for a particular member [e.g., Local Coverage Determinations (LCDs) or National Coverage Determinations (NCDs) for Medicare and/or state coverage for Medicaid], then the government policy will be used to make the determination. For the most up-to-date Medicare policies and coverage, please visit the Medicare search website: <https://www.cms.gov/medicare-coverage-database/search.aspx>. For the most up-to-date Medicaid policies and coverage, visit the applicable state Medicaid website.

Food and Drug Administration (FDA)

Many labs have developed specific tests that they must validate and perform in house. These laboratory-developed tests (LDTs) are regulated by the Centers for Medicare and Medicaid (CMS) as high-complexity tests under the Clinical Laboratory Improvement Amendments of 1988 (CLIA '88). LDTs are not approved or cleared by the U. S. Food and Drug Administration; however, FDA clearance or approval is not currently required for clinical use.

IV. Applicable CPT/HCPCS Procedure Codes

CPT	Code Description
82977	Glutamyltransferase, gamma (GGT)

Current Procedural Terminology© American Medical Association. All Rights reserved.

Procedure codes appearing in Medical Policy documents are included only as a general reference tool for each policy. They may not be all-inclusive.

V. Evidence-based Scientific References

AACC. (2024). *Gamma-Glutamyl Transferase (GGT)*.
<https://www.labtestsonline.org/tests/gamma-glutamyl-transferase-ggt>

Reimbursement Policy

- Andrade, R., Aithal, G., Björnsson, E., Kaplowitz, N., Kullak-Ublick, G., Larrey, D., & Karlsen, T. (2019). EASL Clinical Practice Guidelines: Drug-induced liver injury. *J Hepatol*, 70(6), 1222-1261. <https://doi.org/10.1016/j.jhep.2019.02.014>
- Andrews, S. J., Goate, A., & Anstey, K. J. (2020). Association between alcohol consumption and Alzheimer's disease: A Mendelian randomization study. *Alzheimers Dement*, 16(2), 345-353. <https://doi.org/10.1016/j.jalz.2019.09.086>
- Arasteh, S., Moohebati, M., Avan, A., Esmaeili, H., Ghazizadeh, H., Mahdizadeh, A., Rahmani, F., Mohamamdazade, E., Ferns, G. A., Parizadeh, M. R., & Ghayour-Mobarhan, M. (2018). Serum level of gamma-glutamyl transferase as a biomarker for predicting stenosis severity in patients with coronary artery disease. *Indian Heart J*, 70(6), 788-792. <https://doi.org/10.1016/j.ihj.2017.11.017>
- ASAM. (2020). The ASAM Clinical Practice Guideline on Alcohol Withdrawal Management. *J Addict Med*, 14(3S Suppl 1), 1-72. <https://doi.org/10.1097/adm.0000000000000668>
- Berzigotti, A., Tsochatzis, E., Boursier, J., Castera, L., Cazzagon, N., Friedrich-Rust, M., Petta, S., & Thiele, M. (2021). EASL Clinical Practice Guidelines on non-invasive tests for evaluation of liver disease severity and prognosis - 2021 update. *J Hepatol*, 75(3), 659-689. <https://doi.org/10.1016/j.jhep.2021.05.025>
- Castera, L., Chan, H., Arrese, M., Afdhal, N., Bedossa, P., Friedrich-Rust, M., & Han KH, P., M. (2015). EASL-ALEH Clinical Practice Guidelines: Non-invasive tests for evaluation of liver disease severity and prognosis. *J Hepatol*, 63(1), 237-264. <https://doi.org/10.1016/j.jhep.2015.04.006>
- Celik, O., Cakmak, H. A., Satilmis, S., Gungor, B., Akin, F., Ozturk, D., Yalcin, A. A., Ayca, B., Erturk, M., Atasoy, M. M., & Uslu, N. (2014). The relationship between gamma-glutamyl transferase levels and coronary plaque burdens and plaque structures in young adults with coronary atherosclerosis. *Clin Cardiol*, 37(9), 552-557. <https://doi.org/10.1002/clc.22307>
- Choe, Y. M., Lee, B. C., Choi, I. G., Suh, G. H., Lee, D. Y., & Kim, J. W. (2019). Combination of the CAGE and serum gamma-glutamyl transferase: an effective screening tool for alcohol use disorder and alcohol dependence. *Neuropsychiatr Dis Treat*, 15, 1507-1515. <https://doi.org/10.2147/ndt.s203855>
- Chung, H. S., Lee, J. S., Kim, J. A., Roh, E., Lee, Y. B., Hong, S. H., Yoo, H. J., Baik, S. H., Kim, N. H., Seo, J. A., Kim, S. G., Kim, N. H., & Choi, K. M. (2019). gamma-Glutamyltransferase Variability and the Risk of Mortality, Myocardial Infarction, and Stroke: A Nationwide Population-Based Cohort Study. *J Clin Med*, 8(6). <https://doi.org/10.3390/jcm8060832>
- CMS. (2023, 1/2023). *National Coverage Determination (NCD) for Gamma Glutamyl Transferase (190.32)*. Centers for Medicare & Medicaid Services. Retrieved 03/03/2020 from <https://www.cms.gov/Regulations-and-Guidance/Guidance/Transmittals/Downloads/R17NCD.pdf>
- Conigrave, K. M., Degenhardt, L. J., Whitfield, J. B., Saunders, J. B., Helander, A., & Tabakoff, B. (2002). CDT, GGT, and AST as markers of alcohol use: the WHO/ISBRA collaborative project. *Alcohol Clin Exp Res*, 26(3), 332-339. <https://doi.org/10.1111/j.1530-0277.2002.tb02542.x>

Reimbursement Policy

- De Silva, N. M. G., Borges, M. C., Hingorani, A. D., Engmann, J., Shah, T., Zhang, X., Luan, J., Langenberg, C., Wong, A., Kuh, D., Chambers, J. C., Zhang, W., Jarvelin, M. R., Sebert, S., Auvinen, J., Gaunt, T. R., & Lawlor, D. A. (2019). Liver Function and Risk of Type 2 Diabetes: Bidirectional Mendelian Randomization Study. *Diabetes*, 68(8), 1681-1691. <https://doi.org/10.2337/db18-1048>
- Dillon, J. F., & Miller, M. H. (2016). Gamma glutamyl transferase 'To be or not to be' a liver function test? *Ann Clin Biochem*, 53(6), 629-631. <https://doi.org/10.1177/0004563216659887>
- Dixit, S., & Singh, P. (2015). Usefulness of Gamma Glutamyl Transferase as Reliable Biological Marker in Objective Corroboration of Relapse in Alcohol Dependent Patients. *J Clin Diagn Res*, 9(12), Vc01-vc04. <https://doi.org/10.7860/jcdr/2015/14752.6895>
- Engelken, F. J., Bettschart, V., Rahman, M. Q., Parks, R. W., & Garden, O. J. (2003). Prognostic factors in the palliation of pancreatic cancer. *Eur J Surg Oncol*, 29(4), 368-373. <https://doi.org/10.1053/ejso.2002.1405>
- Friedman, L. (2024, April 8). *Approach to the patient with abnormal liver biochemical and function tests*. <https://www.uptodate.com/contents/approach-to-the-patient-with-abnormal-liver-biochemical-and-function-tests>
- Gori, E., Pierini, A., Lippi, I., Boffa, N., Perondi, F., & Marchetti, V. (2019). Urinalysis and Urinary GGT-to-Urinary Creatinine Ratio in Dogs with Acute Pancreatitis. *Vet Sci*, 6(1). <https://doi.org/10.3390/vetsci6010027>
- Gowda, S., Desai, P. B., Hull, V. V., Math, A. A., Vernekar, S. N., & Kulkarni, S. S. (2009). A review on laboratory liver function tests. *Pan Afr Med J*, 3, 17. <https://www.ncbi.nlm.nih.gov/pubmed/21532726>
- Grundy, S. M. (2007). Gamma-glutamyl transferase: another biomarker for metabolic syndrome and cardiovascular risk. *Arterioscler Thromb Vasc Biol*, 27(1), 4-7. <https://doi.org/10.1161/01.atv.0000253905.13219.4b>
- Hong, S. H., Han, K., Park, S., Kim, S. M., Kim, N. H., Choi, K. M., Baik, S. H., Park, Y. G., & Yoo, H. J. (2020). Gamma-Glutamyl Transferase Variability and Risk of Dementia in Diabetes Mellitus: A Nationwide Population-Based Study. *J Clin Endocrinol Metab*, 105(3). <https://doi.org/10.1210/clinem/dgaa019>
- Huang, C. F., Yeh, M. L., Tsai, P. C., Hsieh, M. H., Yang, H. L., Hsieh, M. Y., Yang, J. F., Lin, Z. Y., Chen, S. C., Wang, L. Y., Dai, C. Y., Huang, J. F., Chuang, W. L., & Yu, M. L. (2014). Baseline gamma-glutamyl transferase levels strongly correlate with hepatocellular carcinoma development in non-cirrhotic patients with successful hepatitis C virus eradication. *J Hepatol*, 61(1), 67-74. <https://doi.org/10.1016/j.jhep.2014.02.022>
- Jousilahti, P., Rastenyte, D., & Tuomilehto, J. (2000). Serum gamma-glutamyl transferase, self-reported alcohol drinking, and the risk of stroke. *Stroke*, 31(8), 1851-1855. <https://doi.org/10.1161/01.str.31.8.1851>
- Kaneko, K., Yatsuya, H., Li, Y., Uemura, M., Chiang, C., Hirakawa, Y., Ota, A., Tamakoshi, K., & Aoyama, A. (2019). Association of gamma-glutamyl transferase and alanine aminotransferase with type 2 diabetes mellitus incidence in middle-aged Japanese men: 12-year follow up. *J Diabetes Investig*, 10(3), 837-845. <https://doi.org/10.1111/jdi.12930>

Reimbursement Policy

- Koenig, G., & Seneff, S. (2015). Gamma-Glutamyltransferase: A Predictive Biomarker of Cellular Antioxidant Inadequacy and Disease Risk. *Dis Markers*, 2015, 818570. <https://doi.org/10.1155/2015/818570>
- Korantzopoulos, P., Tzimas, P., Kalantzi, K., Kostapanos, M., Vemmos, K., Goudevenos, J., Elisaf, M., & Milionis, H. (2009). Association between serum gamma-glutamyltransferase and acute ischemic nonembolic stroke in elderly subjects. *Arch Med Res*, 40(7), 582-589. <https://doi.org/10.1016/j.arcmed.2009.07.012>
- Kunutsor, S. K., Abbasi, A., & Adler, A. I. (2014). Gamma-glutamyl transferase and risk of type II diabetes: an updated systematic review and dose-response meta-analysis. *Ann Epidemiol*, 24(11), 809-816. <https://doi.org/10.1016/j.annepidem.2014.09.001>
- Kwo, P. Y., Cohen, S. M., & Lim, J. K. (2017). ACG Clinical Guideline: Evaluation of Abnormal Liver Chemistries. *Am J Gastroenterol*, 112(1), 18-35. <https://doi.org/10.1038/ajg.2016.517>
- LabCorp. (2021). *γ-Glutamyl Transferase (GGT)*. <https://www.labcorp.com/tests/001958/glutamyl-transferase-ggt>
- Lee, D. Y., Han, K., Yu, J. H., Park, S., Seo, J. A., Kim, N. H., Yoo, H. J., Kim, S. G., Kim, S. M., Choi, K. M., Baik, S. H., Park, Y. G., & Kim, N. H. (2020). Prognostic value of long-term gamma-glutamyl transferase variability in individuals with diabetes: a nationwide population-based study. *Scientific Reports*, 10(1), 15375. <https://doi.org/10.1038/s41598-020-72318-7>
- Lee, J., Kim, M. Y., Kang, S. H., Kim, J., Uh, Y., Yoon, K. J., & Kim, H. S. (2018). The gamma-glutamyl transferase to platelet ratio and the FIB-4 score are noninvasive markers to determine the severity of liver fibrosis in chronic hepatitis B infection. *Br J Biomed Sci*, 75(3), 128-132. <https://doi.org/10.1080/09674845.2018.1459147>
- Lee, M. Y., Hyon, D. S., Huh, J. H., Kim, H. K., Han, S. K., Kim, J. Y., & Koh, S. B. (2019). Association between Serum Gamma-Glutamyltransferase and Prevalence of Metabolic Syndrome Using Data from the Korean Genome and Epidemiology Study. *Endocrinol Metab (Seoul)*, 34(4), 390-397. <https://doi.org/10.3803/enm.2019.34.4.390>
- Li, S., Liao, X., Pan, Y., Xiang, X., & Zhang, Y. (2022). Gamma-glutamyl transferase levels are associated with the occurrence of post-stroke cognitive impairment: a multicenter cohort study. *BMC Neurology*, 22(1), 65. <https://doi.org/10.1186/s12883-022-02587-4>
- Lippi, I., Perondi, F., Meucci, V., Bruno, B., Gazzano, V., & Guidi, G. (2018). Clinical utility of urine kidney injury molecule-1 (KIM-1) and gamma-glutamyl transferase (GGT) in the diagnosis of canine acute kidney injury. *Vet Res Commun*, 42(2), 95-100. <https://doi.org/10.1007/s11259-018-9711-7>
- Liu, C. F., Zhou, W. N., Lu, Z., Wang, X. T., & Qiu, Z. H. (2018). The associations between liver enzymes and the risk of metabolic syndrome in the elderly. *Exp Gerontol*, 106, 132-136. <https://doi.org/10.1016/j.exger.2018.02.026>
- Lothar, T. (2022). Enzymes In *Clinical Laboratory Diagnostics* <https://www.clinical-laboratory-diagnostics.com/k01.html>
- Minuk, G. Y. (1998). Canadian Association of Gastroenterology Practice Guidelines: evaluation of abnormal liver enzyme tests. *Can J Gastroenterol*, 12(6), 417-421. <https://doi.org/10.1155/1998/943498>

Reimbursement Policy

- Mujawar, S. J., Suchitra, G., Kosandal, K. A., Choudhari, S., Inamdar, N. A., & Ahmed, K. B. (2020). Evaluation of salivary gamma-glutamyl transpeptidase as a biomarker in oral squamous cell carcinoma and precancerous lesions. *Journal of oral and maxillofacial pathology : JOMFP*, 24(3), 584-584. https://doi.org/10.4103/jomfp.JOMFP_73_20
- Nano, J., Muka, T., Ligthart, S., Hofman, A., Darwish Murad, S., Janssen, H. L. A., Franco, O. H., & Dehghan, A. (2017). Gamma-glutamyltransferase levels, prediabetes and type 2 diabetes: a Mendelian randomization study. *Int J Epidemiol*, 46(5), 1400-1409. <https://doi.org/10.1093/ije/dyx006>
- Ndrepepa, G., Colleran, R., & Kastrati, A. (2018). Gamma-glutamyl transferase and the risk of atherosclerosis and coronary heart disease. *Clin Chim Acta*, 476, 130-138. <https://doi.org/10.1016/j.cca.2017.11.026>
- Ndrepepa, G., Holdenrieder, S., Cassese, S., Fusaro, M., Xhepa, E., Laugwitz, K. L., Schunkert, H., & Kastrati, A. (2018). A comparison of gamma-glutamyl transferase and alkaline phosphatase as prognostic markers in patients with coronary heart disease. *Nutr Metab Cardiovasc Dis*, 28(1), 64-70. <https://doi.org/10.1016/j.numecd.2017.09.005>
- Ndrepepa, G., & Kastrati, A. (2016). Gamma-glutamyl transferase and cardiovascular disease. *Ann Transl Med*, 4(24), 481. <https://doi.org/10.21037/atm.2016.12.27>
- Newsome, P. N., Cramb, R., Davison, S. M., Dillon, J. F., Foulerton, M., Godfrey, E. M., Hall, R., Harrower, U., Hudson, M., Langford, A., Mackie, A., Mitchell-Thain, R., Sennett, K., Sheron, N. C., Verne, J., Walmsley, M., & Yeoman, A. (2018). Guidelines on the management of abnormal liver blood tests. *Gut*, 67(1), 6-19. <https://doi.org/10.1136/gutjnl-2017-314924>
- Nivukoski, U., Bloigu, A., Bloigu, R., Aalto, M., Laatikainen, T., & Niemela, O. (2019). Liver enzymes in alcohol consumers with or without binge drinking. *Alcohol*, 78, 13-19. <https://doi.org/10.1016/j.alcohol.2019.03.001>
- Noborisaka, Y., Ishizaki, M., Yamazaki, M., Honda, R., & Yamada, Y. (2013). Elevated Serum Gamma-Glutamyltransferase (GGT) Activity and the Development of Chronic Kidney Disease (CKD) in Cigarette Smokers. *Nephrourol Mon*, 5(5), 967-973. <https://doi.org/10.5812/numonthly.13652>
- Rosoff, D. B., Charlet, K., Jung, J., Lee, J., Muench, C., Luo, A., Longley, M., Mauro, K. L., & Lohoff, F. W. (2019). Association of High-Intensity Binge Drinking With Lipid and Liver Function Enzyme Levels. *JAMA Netw Open*, 2(6), e195844. <https://doi.org/10.1001/jamanetworkopen.2019.5844>
- Sette, L. H., & Almeida Lopes, E. P. (2014). Liver enzymes serum levels in patients with chronic kidney disease on hemodialysis: a comprehensive review. *Clinics (Sao Paulo)*, 69(4), 271-278. [https://doi.org/10.6061/clinics/2014\(04\)09](https://doi.org/10.6061/clinics/2014(04)09)
- Shibabaw, T., Dessie, G., Molla, M. D., Zerihun, M. F., & Ayelign, B. (2019). Assessment of liver marker enzymes and its association with type 2 diabetes mellitus in Northwest Ethiopia. *BMC Res Notes*, 12(1), 707. <https://doi.org/10.1186/s13104-019-4742-x>
- Singh, M., Tiwary, S., Patil, D., Sharma, D., & Shukla, V. (2006). Gamma-Glutamyl Transpeptidase (GGT) As A Marker In Obstructive Jaundice. *The Internet Journal of Surgery*, 9. <http://ispub.com/IJS/9/2/7169>

Reimbursement Policy

- Thursz, M., Gual, A., Lackner, C., Mathurin, P., Moreno, C., Spahr, L., Sterneck, M., & Cortez-Pinto, H. (2018). EASL Clinical Practice Guidelines: Management of alcohol-related liver disease. *J Hepatol*, 69(1), 154-181. <https://doi.org/10.1016/j.jhep.2018.03.018>
- Vos, M. B., Abrams, S. H., Barlow, S. E., Caprio, S., Daniels, S. R., Kohli, R., Mouzaki, M., Sathya, P., Schwimmer, J. B., Sundaram, S. S., & Xanthakos, S. A. (2017). NASPGHAN Clinical Practice Guideline for the Diagnosis and Treatment of Nonalcoholic Fatty Liver Disease in Children: Recommendations from the Expert Committee on NAFLD (ECON) and the North American Society of Pediatric Gastroenterology, Hepatology and Nutrition (NASPGHAN). *J Pediatr Gastroenterol Nutr*, 64(2), 319-334. <https://doi.org/10.1097/mpg.0000000000001482>
- Vroon, D., & Israili, Z. (1990). *Clinical Methods: The History, Physical, and Laboratory Examinations*. 3rd edition. <https://www.ncbi.nlm.nih.gov/books/NBK203/>
- Wang, R. Q., Zhang, Q. S., Zhao, S. X., Niu, X. M., Du, J. H., Du, H. J., & Nan, Y. M. (2016). Gamma-glutamyl transpeptidase to platelet ratio index is a good noninvasive biomarker for predicting liver fibrosis in Chinese chronic hepatitis B patients. *J Int Med Res*, 44(6), 1302-1313. <https://doi.org/10.1177/0300060516664638>
- Wang, S., Zhang, J., Zhu, L., Song, L., Meng, Z., Jia, Q., Li, X., Liu, N., Hu, T., Zhou, P., Zhang, Q., Liu, L., Song, K., & Jia, Q. (2017). Association between liver function and metabolic syndrome in Chinese men and women. *Sci Rep*, 7, 44844. <https://doi.org/10.1038/srep44844>
- Wang, Z., Song, P., Xia, J., Inagaki, Y., Tang, W., & Kokudo, N. (2014). Can gamma-glutamyl transferase levels contribute to a better prognosis for patients with hepatocellular carcinoma? *Drug Discov Ther*, 8(3), 134-138. <https://doi.org/10.5582/ddt.2014.01025>
- Xing, M., Gao, M., Li, J., Han, P., Mei, L., & Zhao, L. (2022). Characteristics of peripheral blood Gamma-glutamyl transferase in different liver diseases. *Medicine*, 101(1), e28443-e28443. <https://doi.org/10.1097/md.00000000000028443>
- Xu, T., Wang, W., Zhai, L., Zhang, Y. F., Zhou, H. Z., Wu, X. M., Li, A. H., Xie, L. L., Ning, X. J., Ji, Y. T., Wang, H. M., & Ke, K. F. (2017). Serum Gamma-glutamyl Transferase Levels Predict Functional Outcomes after Aneurysmal Subarachnoid Hemorrhage. *Biomed Environ Sci*, 30(3), 170-176. <https://doi.org/10.3967/bes2017.024>
- Yamada, J., Tomiyama, H., Yambe, M., Koji, Y., Motobe, K., Shiina, K., Yamamoto, Y., & Yamashina, A. (2006). Elevated serum levels of alanine aminotransferase and gamma glutamyltransferase are markers of inflammation and oxidative stress independent of the metabolic syndrome. *Atherosclerosis*, 189(1), 198-205. <https://doi.org/10.1016/j.atherosclerosis.2005.11.036>
- Yang, W., Kang, D. W., & Lee, S. H. (2020). Effects of Gamma-Glutamyl Transferase on Stroke Occurrence Mediated by Atrial Fibrillation. *J Clin Neurol*, 16(1), 60-65. <https://doi.org/10.3988/jcn.2020.16.1.60>
- Yao, T., Li, J., Long, Q., Li, G., Ding, Y., Cui, Q., & Liu, Z. (2019). Association between Serum Gamma-glutamyl transferase and Intracranial Arterial Calcification in Acute Ischemic Stroke Subjects. *Sci Rep*, 9(1), 19998. <https://doi.org/10.1038/s41598-019-56569-7>

Reimbursement Policy

- Yavuz, B. B., Yavuz, B., Halil, M., Cankurtaran, M., Ulger, Z., Cankurtaran, E. S., Aytemir, K., & Ariogul, S. (2008). Serum elevated gamma glutamyltransferase levels may be a marker for oxidative stress in Alzheimer's disease. *Int Psychogeriatr*, 20(4), 815-823. <https://doi.org/10.1017/s1041610208006790>
- Yoo, D., Kim, R., Jung, Y. J., Han, K., Shin, C. M., & Lee, J. Y. (2020). Serum gamma-glutamyltransferase activity and Parkinson's disease risk in men and women. *Sci Rep*, 10(1), 1258. <https://doi.org/10.1038/s41598-020-58306-x>