Cardiac Enzyme tests

An enzyme test is a blood test that measures certain enzyme levels to assess how well the body's systems are functioning. They can also be used to determine whether there has been any tissue damage. Cardiac enzyme tests are performed to help diagnose a heart attack and to determine the extent of damage to the heart muscle. Less frequently, cardiac enzyme tests can be used to help diagnose a variety of other cardiovascular conditions, including coronary artery disease, heart failure and alcoholic cardiomyopathy. Similarly, liver enzyme tests are used to diagnose and monitor the extent of liver diseases or disorders.

There are three factors that could interfere with the enzyme test results: vigorous exercise, certain medications and (in some cases) eating before the test. Patients are strongly encouraged to follow their physician's orders in order to maximize the accuracy of their test results.

Although they can detect damage for any reason, cardiac enzyme tests are most commonly used to diagnose and monitor heart attacks. The enzyme test is a blood test that measures certain enzyme levels within the blood. By measuring enzymes that are specific to the heart, physicians are able to detect a heart attack, assess the damage and determine if there is an ongoing risk. As enzyme tests become more sensitive and widespread, they have become one of the most important tools in diagnosing a heart attack, along with the presence of other symptoms, such as chest pain and abnormal readings on an electrocardiogram.

If a very recent heart attack is suspected, a cardiac enzyme test might be conducted along with a *myoglobin test*. Studies have shown that it takes several hours (usually three to six) for cardiac enzyme levels to be elevated after a heart attack. In some people, levels are not elevated for 12 hours. The protein myoglobin, however, is rapidly

released during a heart attack, making it possible to more quickly and accurately diagnose the condition. In general, patients having an acute heart attack will have a diagnosis based on an immediate EKG, resulting in immediate treatment. Blood tests for cardiac enzymes will be performed, but it may take 6 to 12 hours for the test to be abnormal. These blood tests help diagnosis small heart attacks not detectable on the EKG or assess the magnitude of large heart attacks. In recent years, the science of cardiac enzyme testing has advanced and has developed more sensitive tests and better understands how cardiac enzymes react to stress or muscle damage. However, because of variations between laboratories, there is still some need for standardization among test results and cut-off points.

A cardiac enzyme test measures the blood levels of specific cardiac enzymes. Cardiac enzymes help natural chemical reactions that allow the heart to function normally. These tests have become extremely important to diagnosis of a heart attack because of predictable swings in enzyme levels after damage to the heart muscle. By measuring the levels of enzymes, physicians are able to tell when a heart attack occurred, how severe it was and if damage is ongoing.

The two most common cardiac enzyme tests performed are:

- Creatine kinase (CK)
- Cardiac troponin

In the past, another enzyme, lactate dehydrogenase (LDH or LD), was also commonly measured. However, recent studies have shown that the combination of troponin and specific CK levels is more specific to the heart. Accordingly, lactate dehydrogenase testing is no longer considered a diagnostic tool for heart attacks.

Alternatively, another enzyme, aspartate aminotransferase (AST), is sometimes measured to detect heart damage. However, AST is a liver enzyme and is more commonly measured as part of a standard liver

function test to diagnose and monitor liver disease. This test is rarely performed in connection with heart attack.

Enzyme testing may be done either as part of an initial diagnostic examination or to monitor the progress of treatment for an existing disorder. Some conditions require a series of regular enzyme tests over time.

Creatine kinase (CK)

Also known as creatine phosphokinase (CPK), creatine kinase (CK) is a cardiac enzyme that helps convert creatine to creatinine, a reaction that is necessary for metabolism and energy production. Creatine kinase is made up of three important isoenzymes.

- CK-BB (CK1). Exists primarily in the brain. CK-BB can be an important indicator of tissue damage in the brain from stroke, trauma or other causes.

- CK-MB (CK2). The primary indicator used to diagnose a heart attack because it exists in the highest amount in the heart. If CK-MB makes up more than 5 percent of a total CK level, a heart attack is suspected. CK-MB rarely rises following chest pain caused by angina, pulmonary embolism or heart failure, making it a valuable tool for determining whether a heart attack is the cause of chest pain. CK-MB levels typically increase to above normal levels about six hours after a person has had a heart attack. Furthermore, if one part of CK-MB (CK-MB2) is greater than another part (CK-MB1) by a ratio of 1.5 or more, then this is another indication that a heart attack has occurred. CK-MB levels can also be used after balloon angioplasty and other catheter-based techniques. Studies have shown an increased risk of sudden cardiac death with higher CK-MB levels after these procedures. CK-MB can also be found in small intestine, uterus, prostate, diaphragm, and tongue.

- CK-MM (CK3). Exists primarily in skeletal muscle.

Creatine kinase tests may measure total CK levels or may break out the individual levels of CK-BB, CK-MB and CK-MM. Normal results are as follows:

- Total creatine kinase level (CK total). Normal levels are 25 to 130 micrograms per liter for men and 10 to 150 micrograms per liter for women. CK levels may be much higher in very muscular people, and infants up to 1 year may have levels up to four times the normal adult level. According to the American College of Cardiology (ACC), total CK levels should not be used in the diagnosis of heart attack. Instead, the College recommends that physicians rely on the more sensitive CK-MB levels, which are specific to the heart.
- CK-BB. Unless tissue damage in the brain has occurred, CK-BB levels will be undetectable.
- CK-MB. Normal range is from undetectable to 7 micrograms per liter.

CK-MM. Normal range is from 5 to 70 micrograms per liter.

Cardiac troponin

There are two types of cardiac troponin in cardiac muscle – Troponin T (cTNT) and Troponin I (cTNI). These proteins control the interactions of two other substances (*actin* and *myosin*) that cause the heart muscle to contract or squeeze. Normal levels of cardiac troponin in the blood are very low, but they rise sharply and quickly in response to a heart muscle injury, usually within two or three hours after the beginning of a heart attack. Unlike creatine kinase (CK), cardiac troponin will also rise in response to angina, which is one reason the two tests are often performed together.

Cardiac troponin is more sensitive to damage than CK and is therefore valuable at detecting mild heart attacks and early detection of other heart problems. Troponin T and I levels have also been used to help predict a patient's heart attack risk because of their sensitivity

and the fact that elevated levels are specific to a heart injury. Because troponin is filtered by the kidneys, it had been held that troponin level testing was not reliable in patients with renal disease. Recent studies have shown, however, that the test is sensitive enough even when the kidneys are not functioning normally. It is believed that the results of a troponin test could help identify people at a higher risk of a serious cardiovascular problem or death.

Normal cardiac troponin levels are listed below. However, it is important to note that because of variations between individual laboratories, these numbers might vary for individual patients:

- cTNT. Normal range is less than 0.1 nanograms per milliliter.
- cTNI. Normal range is less than 0.4 nanograms per milliliter.

Lactate dehydrogenase

Until recently, levels of lactate dehydrogenase (LDH) were used to measure cardiac damage. However, there were certain drawbacks with this approach. LDH is an enzyme that helps convert lactic acid to pyruvic acid. It is present in nearly all body tissues. Because troponin is specific to cardiac muscle, the LDH test has largely been replaced by the troponin test. Currently, the American College of Cardiology (ACC) does not recommend measuring LDH in the diagnosis of heart attack.

Aspartate aminotransferase

Formerly known as serum glutamic-oxaloacetic transaminase (SGOT), aspartate aminotransferase (AST) is one of two enzymes that convert amino acids to amino acid residues, which is vital to energy production.

Normal AST levels are 8 to 20 micrograms per liter, but infants up to 1 year may have levels up to four times the normal adult level.

Increases in AST levels are proportional to cell damage within the body, making it an important tool for monitoring the progression of damage and the healing process. The degree to which AST is elevated can also help pinpoint the type of cell damage that has occurred. For example:

- A maximum increase of 20 times normal usually indicates severe viral hepatitis, severe trauma or surgery.
- A high level of 10 to 20 times normal may indicate a heart attack or alcoholic cirrhosis of the liver.
- Moderate to high levels of five to 10 times normal could be caused by muscular dystrophy or chronic hepatitis.
- Low levels of two to five times normal may indicate a number of conditions, including pulmonary embolism, and disorders of the liver or pancreas.

Though AST is sometimes used to track heart attack patients, it is not used as commonly for this purpose as CK or LDH. AST is more commonly used to track liver disease as a component of liver enzyme testing.

Heart damage and cardiac enzymes

When heart damage occurs the heart releases enzymes at a predictable pace. Troponin levels begin to rise two to four hours after a heart attack and peak within 10 to 24 hours. Elevated levels can still be detected a week or more after the onset of chest pain. CK-MB levels begin to rise four to six hours after a heart attack and may remain elevated for up to 48 hours after the heart attack. The degree the CK-MB level rises depends on the severity of the heart attack. When these enzyme levels begin to decline, it is a sign that the heart attack stopped several hours earlier. Heart muscle cannot heal itself, hence the importance of rapid diagnosis and treatment.

Based on this information, physicians can determine from cardiac enzyme tests that:

- Cardiac enzymes will demonstrate increased levels following heart damage.
- If subsequent tests show that enzyme activity is decreasing, the heart attack stopped several hours ago and the heart tissue may be healing.
- If enzyme activity continues to increase, it is likely that the heart attack was larger than initially thought.
- If enzyme activity plateaus, begins to decline, then rises again, it is likely a second, follow-up heart attack is occurring.
- The extent of the heart attack based on the magnitude of rise of the enzymes.

Enzyme testing may be done as part of making an initial diagnosis or to monitor the progress of treatment for a disorder. Some conditions will require a series of regular enzyme tests over time.

Understanding cardiac enzyme test results

Higher-than-normal enzyme levels indicate tissue damage in one or more areas of the body. Conditions that may have caused the damage include but are not limited to the following:

- Heart attack. An event that results in permanent heart damage or death. It is also known as a myocardial infarction, because part of the heart muscle (myocardium) may literally die (infarction). It is caused by a lengthy or severe episode in which the heart is not getting enough oxygen-rich blood. Over time, the accumulated effects of tissue damage from a heart attack can lead to heart failure.

- Cardiac ischemia. A temporary episode in which part of the heart is not getting enough oxygen–rich blood. Whether or not cardiac enzyme testing is valuable as a screening and diagnosis tool for non-acute heart disease is actually a controversial issue among physicians. Some physicians believe that particularly troponin testing can help diagnose ischemic heart disease, while controlled studies of subjects in stress testing has not consistently shown elevations in enzymes due to ischemia. In addition, troponins may be elevated in response to a wide variety of diseases. However, because troponins are generally only elevated in response to a disease somewhere in the body, any elevation of troponins should be taking seriously.

- Stroke. An event in which the brain does not receive enough oxygen-rich blood, as a result of either an obstructing blood clot in a major artery (e.g., one of the carotid arteries) or excessive bleeding into the brain (cerebral hemorrhage).

- Pericarditis. An inflammation of the pericardium – a thin, fluid-filled sac surrounding the heart.

- Alcoholic cardiomyopathy. An enlargement, stiffening or thickening of the heart muscle due to excessive consumption of alcohol. As a result, the heart muscle's ability to pump blood is often weakened.

- Low blood pressure (*hypotension*).

- Heart failure. A serious condition in which the heart is not pumping well enough to meet the body's demand for oxygen. It gets its name because the heart is *failing* to pump efficiently, which often results in *congestion* in the lungs.

- Coronary artery disease. A chronic disease in which there is a "hardening" (atherosclerosis) of the arteries on the surface of the heart. The term "hardening" refers to a condition that causes the arteries to become so narrowed and stiff that they block the free flow of blood. Many patients have symptoms

such as chest pain, pressure or discomfort angina, but other patients have no warning signs before a total blockage occurs, which can lead to heart attacks.

- Platelet disorders. Platelets are components in blood necessary to the formation of blood clots.
- *Muscular dystrophy*. A progressive, often inherited disease characterized by the deterioration of muscle.
- Hypothyroidism. An underactive thyroid gland that leads to a deficiency of thyroid hormone in the body.
- *Hypokalemia*. A deficiency of potassium in the blood.
- Carbon monoxide poisoning.
- Seizures or convulsions.
- Pulmonary infarction (lung tissue death).
- Leukemia, lymphoma or brain cancer.
- *Hemolytic anemia*. A type of anemia (red blood cell deficiency) caused by the premature destruction of red blood cells.
- Liver, kidney or pancreas disorders.
- Trauma from accident, injury or electric shock.

Lower-than-normal enzyme levels may indicate:

- Malnutrition. Inadequate nutrition that may be caused by either an unbalanced diet or malabsorption – a condition in which the body has difficulty digesting or absorbing nutrients from food.
- Congenital enzyme disorder. Metabolic disorders present from birth that produce a deficiency in one or more enzymes.

Liver enzyme tests

Liver enzymes are enzymes that help perform chemical reactions in the body necessary to normal liver functions. The liver enzyme tests most commonly performed are:

- Aspartate aminotransferase (AST). Although AST is not specific to liver disease, levels are a vital component of liver enzyme testing because it is the best enzyme to use in tracking both the tissue damage and the healing process. As noted earlier, normal levels are 8 to 20 micrograms per liter, but infants up to 1 year may have levels up to four times the adult normal.
    - A maximum increase of 20 times normal usually indicates severe viral hepatitis, severe trauma or surgery.
    - A high level of 10 to 20 times normal may indicate a heart attack or alcoholic cirrhosis.
    - Moderate to high levels of five to 10 times normal could be caused by muscular dystrophy or chronic hepatitis.
    - Low levels of two to five times normal may indicate a number of conditions, including pulmonary embolism, and disorders of the liver or pancreas.
- Alanine aminotransferase (ALT), formerly known as serum glutamate pyruvate transaminase (SGPT). ALT is one of two enzymes that convert amino acids to amino acid residues, which is vital to energy production.
    - Normal levels are 8 to 20 micrograms per liter.
    - Low levels occur during a heart attack.
    - Moderate levels indicate cirrhosis.

    - Moderate to high levels indicate chronic hepatitis for severe liver congestion due to heart failure.
    - Very high ALT levels, up to 50 times greater than normal, are an indication of severe hepatitis (inflammation of the liver) caused by infection or medications.
- Alkaline phosphatase (ALP). An enzyme found primarily in the liver, bones, kidneys and intestinal lining that influences bone growth and the transport of fats (*lipids*) through the bloodstream. ALP increases may be caused by blood disorders or liver disease and, in combination with other enzyme tests, ALP levels can be used to differentiate between the two.
    - Normal levels are 90 to 239 micrograms per liter for males, 76 to 196 micrograms per liter for females under age 45 and 87 to 250 micrograms per liter for females over age 45. Children have higher levels than adults because their bones are still growing.
    - Moderate increases in ALP are usually caused by bile obstructions or liver infections, but can also be an indicator of rickets from vitamin D deficiency.
    - Higher levels may indicate liver diseases causing obstructions or skeletal diseases that cause rapid bone growth.
- Gamma glutamyl transferase (GGT), also called gamma glutamyl transpeptidase. An enzyme found primarily in the kidneys that is involved in the transfer of amino acids across cell membranes. Recent studies suggest that elevated levels of GGT may indicate an increased risk of death from cardiovascular disease.
    - Normal GGT levels are 8 to 37 micrograms per liter in males and 5 to 24 micrograms per liter in females under age 45 and 6 to 37 micrograms per liter for females over

age 45. In combination with an elevated ALP, a normal GGT level indicates that the ALP elevation is being caused by a bone disorder, not liver dysfunction.

- An elevated GGT level five to 10 days following a heart attack is either a sign of the healing process or that the weakened heart is affecting liver functions.

A variety of factors can influence liver enzyme levels including drugs, tumors, infections, toxins or trauma. When liver damage occurs, the enzymes are released in stages, similar to the cardiac enzymes. When all of these enzyme levels begin to decline, it is a sign that the damaged liver is beginning to heal. Measuring a single enzyme level will not diagnose a condition, but a combination can provide valuable information to help in the diagnosis and management of various conditions.

Enzyme testing may be done either as part of making an initial diagnosis or to monitor the progress of treatment for an existing disorder. Some conditions will require a series of regular enzyme tests over time.