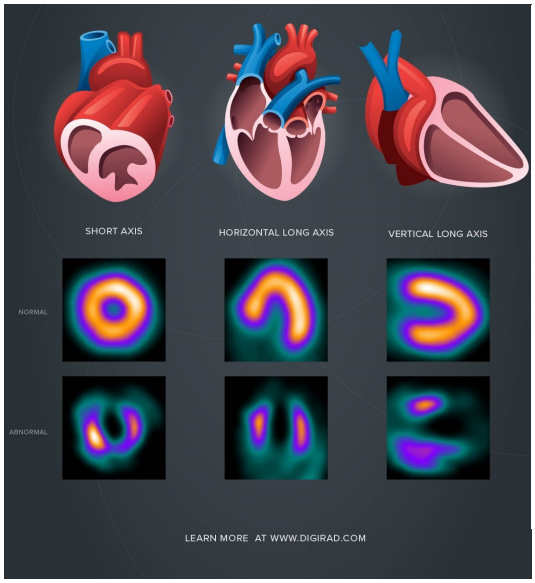
Thallium Persantine Cardiac Stress Test

Alexander Claydon 23/4



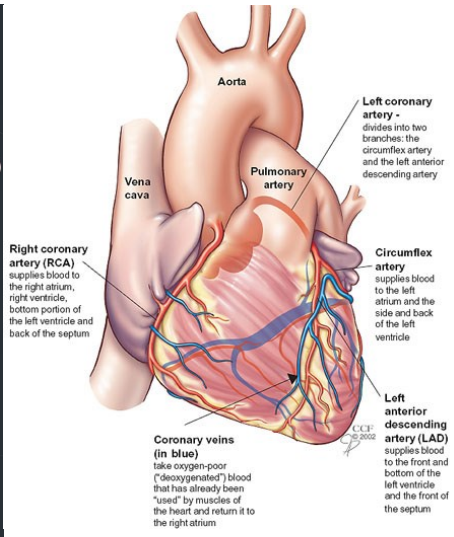


Fig.1 (left) Thallium Persantine Scan images corresponding to cross sections of the heart. Fig. 2 diagram of arteries of the heart.

Isotopes are forms of the same element that contain the same number of protons but different numbers of neutrons. An isotope is radioactive when it's nucleus is unstable, by having an unstable ratio of protons to neutrons (in a nucleus with a small number of protons a "stable ratio is 1:1" (CK-12 foundation). A radioactive atom will attempt to reach a stable state by ejecting protons or neutrons, as well as other particles, or by releasing radiation energy in other ways/forms. This process changes the element. The radiation that emanates from the nuclei of unstable isotopes is generally alpha, beta or gamma radiation. Alpha radiation is the emission of two neutrons and two protons from the nucleus. Beta particles are electrons or positrons (similar to a proton) emitted by an atom undergoing beta decay. "A gamma ray is a packet of electromagnetic energy (photon) emitted by the nucleus of some radionuclides following radioactive decay" (ARPANSA).

A Thallium persantine scan is a test of the heart muscle cells directly. The thallium-persantine stress test uses the radioisotope Thallium-201 *to detect the effect of blockages or narrowings in the coronary arteries* and show exactly where the heart muscles are getting adequate or inadequate *blood flow* with accuracy unattainable by other tests.

The heart muscles work by generating a positive charge in order to trigger a contraction. Muscle works by using oxygen and energy glucose to power the membrane pumps which pump potassium cations(+ve charges ions) directly into the heart muscle cells. Thallium 201 is of a similar size and charge to potassium so the heart cannot detect the difference. The oxygen and energy is delivered via the coronary arteries. The more activity the heart does, the more energy and potassium is needed. When not undergoing increased activity, narrowings in the coronary arteries may make little difference and are hard to notice as less resources are needed. However, when the heart is placed under an increased work load there is an an increase in the oxygen and energy needed which may not be able to be delivered due to the narrow coronary artery.

In order for an accurate scan to be produced the heart is required to be under stress. The drug "Persantine® mimics the effects of treadmill exercise" (Montreal Heart Institute) and increases heart activity. Prior to this, Thallium-201 is injected into a vein in the arm and given time to fully circulate and then the Persantine® is given to the patient. The Thallium "radionuclides that are used" "emit a single gamma ray photon" (ScienceDirect) which is "detected by the rotation of a gamma camera around the body" from which "the position and concentration of the radionuclide distribution can be determined". Thallium also emits Mercury 201 but this cannot be detected by the gamma camera.

This test is used before cardiac and vascular operations to tell If the heart is strong enough to undergo the operation. In addition to this, it can be used to see if a patient's moderate narrowing of one or more of their coronary arteries is significant. This test is typically used over others as it is a non-invasive procedure and provides a detailed 3d imaging. This technique has provided scientists and medical professionals with an increased understanding of the passage of blood around the heart and effects of coronary artery disease and narrowing of coronary arteries; mapping in detail the areas of muscle effected.

The Thallium Persantine scan has revolutionized the way in which medical professionals view and analyse the heart and the way in which it works. The Thallium Persantine scan is a relatively cheap method of non-invasively testing the bloodflow to the heart muscles, a gamma camera typically costing around $4,000 which pales in comparison to similar medical testing equipment. This allows for **some** poorer countries to utilize this technology, allowing for better medical treatment than people in those country would normally have access to. This test is also affordable for most people to have done, provides highly detailed results and does not require an operation or invasive techniques, making it ideal for the elderly. Despite it's relatively low cost, many poorer countries cannot yet use this technology to it's full potential as they lack the number medical staff to complete these tests at large.

Unfortunately, thallium is only available in low quantities in the Earth's Crust, and it is not deemed as a very profitable resource to be mined. Many would say that due to this, Thallium Persantine scanning is an unsustainable practice. However, Thallium is chiefly obtained through zinc and lead processing and due to it's short half-life of 73 hours thallium often goes to waste. Additionally Thallium Persantine scanning only requires a small amount of thallium to attain detailed imaging. As such, Thallium Persantine scanning is currently sustainable, an efficient use of resources and affordable.

References:

Science Direct 2019, *Radioisotope - an overview | ScienceDirect Topics,* viewed 24 April 2020, <https://www.sciencedirect.com/topics/medicine-and-dentistry/radioisotope>. ScienceDirect 2019, *Thallium-201 - an overview | ScienceDirect Topics,* viewed 24 April 2020, <https://www.sciencedirect.com/topics/chemistry/thallium-201>. ARPANSA 2019, *What is ionising radiation? | ARPANSA,* viewed 24 April 2020, <https://www.arpansa.gov.au/understanding-radiation/what-is-radiation/ionising-radiation>. CK-12 2019, *Radioisotopes (read) | Chemistry | CK-12 Foundation,* viewed 24 April 2020, <https://www.ck12.org/c/physical-science/radioisotopes/lesson/Radioisotopes-MS-PS/>.