Cardiovascular Diagnostic Tests

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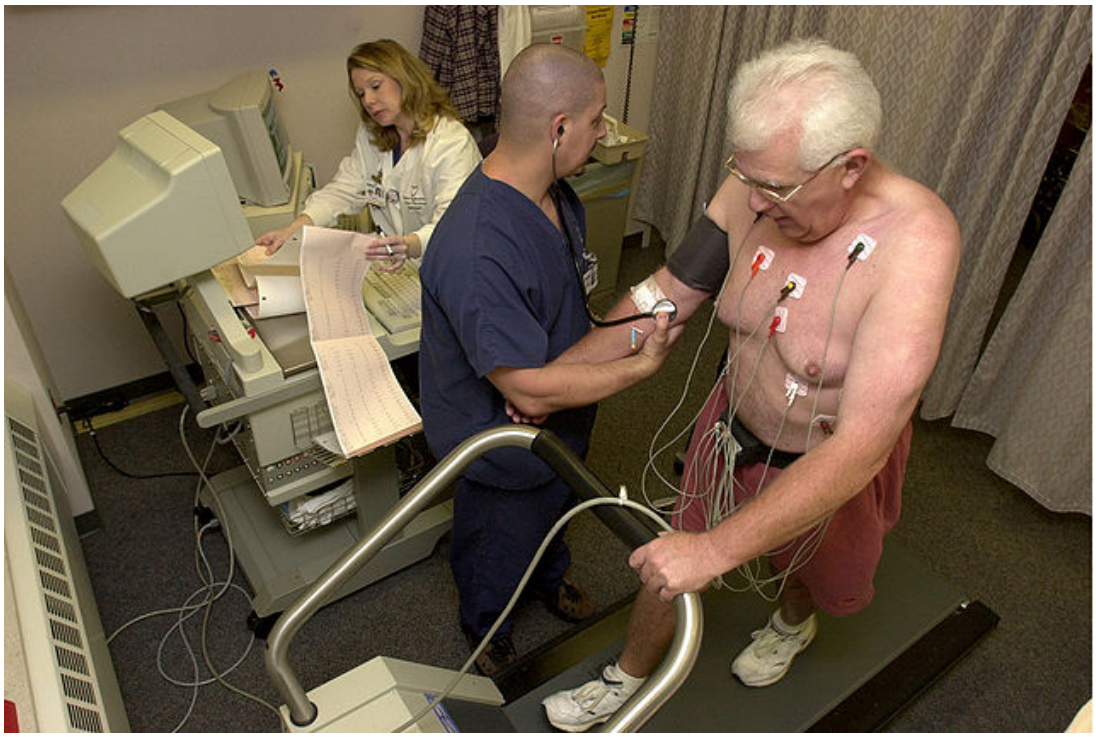
Cardiovascular diseases can be diagnosed and investigated using different tests and methods, such as the measurement of blood pressure using a sphygmomanometer, the cardiac stress test, electrocardiogram, echocardiogram and more. This article provides an overview.



Measurement of Blood Pressure Using a Sphygmomanometer

Image: "Blood Pressure 126/70 mmHg – Result of Measurement" by Julo. License: Public Domain

According to the Joint Commission Report 7, **systolic pressure** (which represents the pressure during heart contraction) of **less than 120 mm Hg** and **diastolic pressure** (which means the pressure during the relaxation of the heart) of less than **80 mm Hg** is considered **normal** blood pressure.

An important condition is that the evaluation is an average of two or more measurements and at two or more different office visits. **Hypertension** is defined as systolic blood pressure greater than 140 mm Hg and diastolic blood pressure greater than 90 mm Hg under the same evaluation conditions. **Prehypertension** is a state between normal blood pressure levels and hypertension, which has a significant risk of progressing into hypertension in the future (systolic blood pressure between 120–139 and diastolic between 80–89).

The basic instrument for measuring blood pressure is called a **sphygmomanometer**. It is economical, portable, and reliable for diagnosing and guiding treatment with a further assessment of the prognosis.

According to the famous Framingham heart study, in between systolic, diastolic, and pulse pressure, **systolic blood pressure initially followed by pulse pressure,** is the most important prognostic marker for predicting risk factors of cardiovascular disease in patients over 60, and diastolic blood pressure is important in patients under 50. The most common types of sphygmomanometers are **Mercury** and **Aneroid,** and automated oscillometric BP measuring devices are used most frequently.

Before measuring the patient's blood pressure using a sphygmomanometer, take appropriate **precautions** for accurate results. The patient needs to be properly seated and use the appropriate cuff size for the arm size. The proper sitting position comprises supporting the patient's arms in which blood pressure is to be taken, with the patient comfortably in the sitting position without crossing the legs. The sphygmomanometer must be calibrated appropriately. Keep the bladder of the cuff over the brachial artery.

There are three acceptable measurements of blood pressure.

Office-Based Blood Pressure Measurement

This term refers to measuring the patient's blood pressure in the **physician's office**.

Home-Based Blood Pressure Measurement

This term refers to measuring the patient's blood pressure at home (to **attenuate white coat hypertension**). The final blood pressure, which is obtained, is an average of the blood pressure measurements during one week with at least 7 to 14 data points (the data points should contain a mix of both morning and evening blood pressure). According to the home-based assessment, hypertension is defined as blood pressure greater than, or equal to, 135/85 mm Hg.

Ambulatory Blood Pressure Measurement

Ambulatory blood pressure measurement is the **measurement of the blood pressure on the continuous movement of the patient**. In this method, the blood pressure is an average of the data collected during a particular time interval (usually 24 to 48 hours).

Within the specified time interval, the repetition of measurement varies between daytime and night-time (usually every 15 minutes in the daytime and 30 to 60 minutes during sleep.) According to the ambulatory blood pressure measurement, hypertension is defined as blood pressure (final average) greater than 130/80 mm Hg.

Cardiac Stress Testing

As the name suggests, this test is used to **evaluate heart function** after inducing stress. Stress is generated by having the patient perform an exercise or by using a pharmacological agent (dobutamine or dipyridamole). This is a well-validated test for evaluating coronary artery disease.

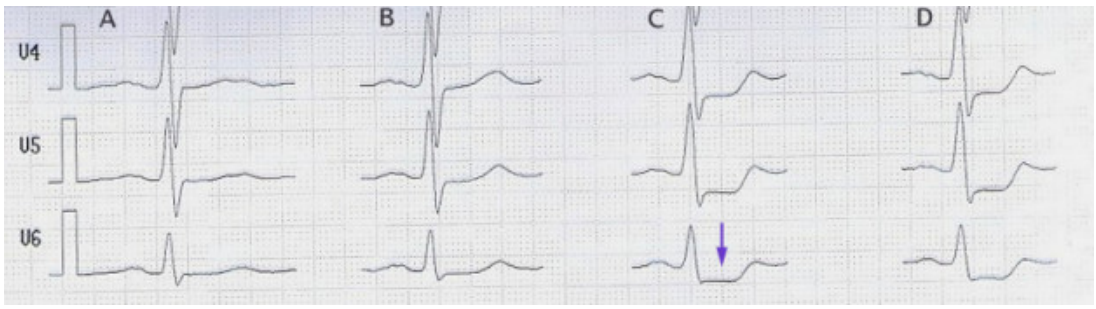


Image: "Stress-ECG with ST-segment-depression (arrow) beginning at 100 W (column C)" by J. Heuser. License: Public Domain CC BY-SA 3.0

The test, which is performed after inducing the stress, can be an **electrocardiogram**, **echocardiography, or radionuclide imaging**. **Pretest probability scoring** will help evaluate cardiovascular disease risk, which is based upon criteria such as gender and age. Perform cardiac stress testing only on those individuals who fall under the intermediate pretest probability (pretest probability is a method of evaluating whether a stress test is required).

It should be kept in mind that stress tests can cause serious complications, like sudden **cardiac death** or myocardial infarction, in 1 in 10,000 patients.

Principle Behind the Test

A healthy heart is nourished by the **myocardial oxygen supply**. A blockage will not be clinically symptomatic unless the level of blockage is significant. The symptoms will get

precipitated on performing the exercise since the demand will be increased during the exercise. This presentation of symptoms can be diagnosed by the ECG changes.

Contraindications To Look Out For

There are some absolute contraindications for conducting stress tests like **unstable angina pectoris, arrhythmia, heart failure, stenosis**, which is uncontrolled and **symptomatic, acute aortic dissection**, **acute myocardial infarction** within 2 days, and **acute pulmonary embolism**.

Types of Exercise Testing

The **motor-driven treadmill** and the **stationary cycle ergometer** are the two most common means of exercise stress testing. The testing usually shifts from a low workload to a higher workload. For effective results, the test should last no longer than **10 minutes**. The endpoint is either a predetermined heart rate to be achieved or the patient's development of any symptoms while performing the test.

The **Bruce protocol** is the most common for exercise testing. Other protocols for testing patients after myocardial infarction include the Naughton protocol. The modified Bruce protocol can be used to test patients who are obese and have a sedentary lifestyle.

Electrocardiogram

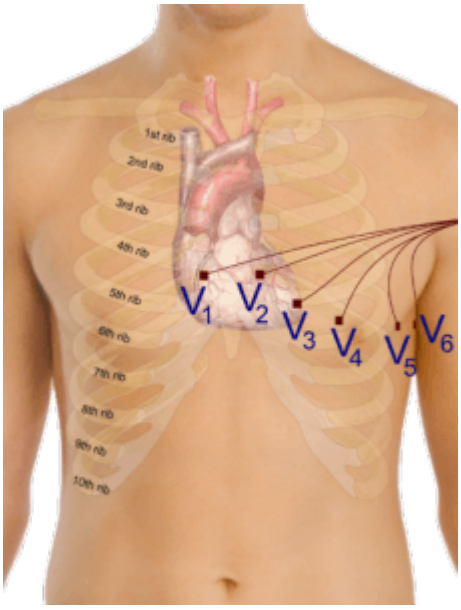


Image: "Placement of the Precordial Leads in Electrocardiography" by Mikael Häggström. License: Public Domain

Electrical activity in the heart starts from the sinoatrial node and progresses to the atrioventricular node. Finally, it enters the Purkinje fibers through the Bundle of His. This **electrical activity can be recorded with 12 electrodes** placed over the skin on the chest at particular scientifically predefined regions.

There are many conditions that can be characteristic leads on the echocardiogram pattern like **ST elevation** and **depression** in the case of myocardial infarction, QT prolongation in the case of torsades de pointes. Premature ventricular contraction (time

interval between R peak is a multiple of R-R interval) and ventricular tachycardia (wide ventricular complexes) can be diagnosed based on the ECG pattern.

Conduction defects occur because of problems in the conduction pathway. The various degrees of heart block, like the first, second, and third-degree, can be diagnosed based on a characteristic ECG pattern like a P-wave precedes the ventricular complex and intermittently skipped the ventricular beat. Also, cardiac conditions and electrolyte abnormalities, like hypokalemia and hyperkalemia, can be diagnosed with an ECG.

Electrocardiogram has advantages; it is economical, and a primary care physician can determine the status of the cardiovascular system based on the ECG.

Echocardiogram (Heart Ultrasound)

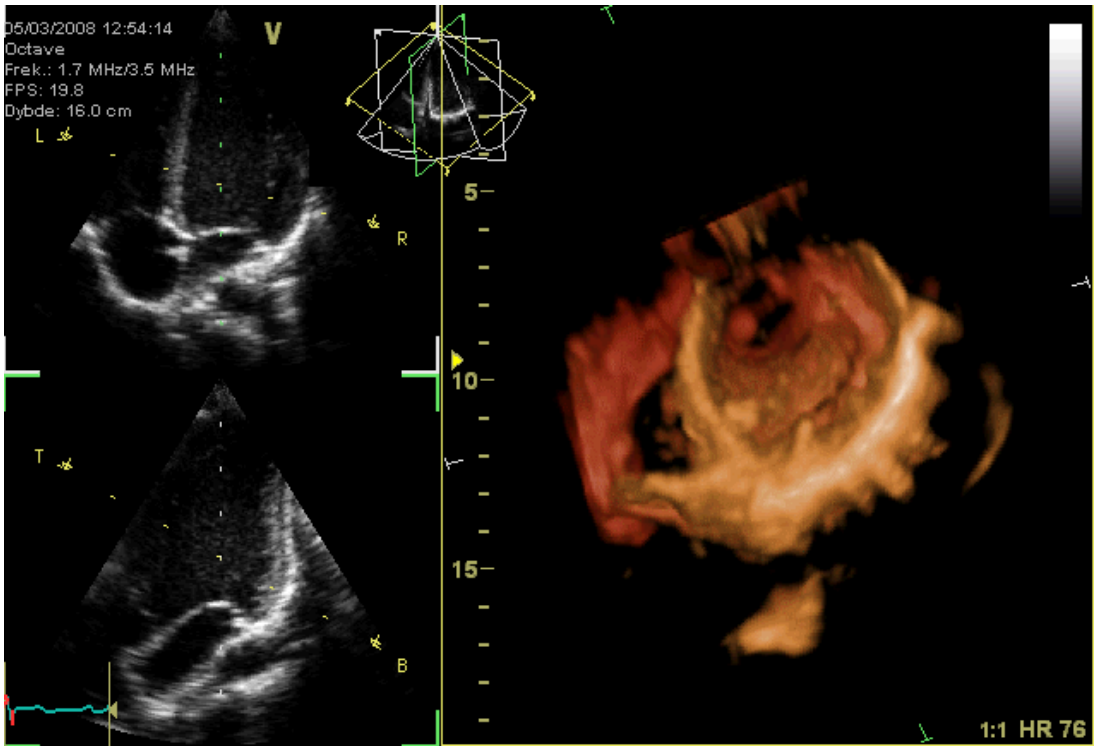


Image: “GIF-animation showing a moving echocardiogram; a 3D-loop of a heart viewed from the apex, with the apical part of the ventricles removed and the mitral valve clearly visible. Due to missing data, the leaflet of the tricuspid and aortic valve is not clearly visible, but the openings are. To the left are two standard two-dimensional views taken from the 3D dataset.” by Kjetil Lenes. License: CC BY-SA 3.0

This works on the **principle of ultrasound,** and it helps **visualize the chambers of the heart and** the status of heart valves.

Doppler Echocardiography

Doppler echocardiography is **based on the Doppler Effect**. When a transmitted wave is reflected back, based on the pattern of the reflected waves, mainly its frequency, the velocity and direction of the flow of obstacle can be determined.

There are three main types of Doppler evaluations: continuous, color flow, and pulsed evaluation. In a **constant Doppler**, there is a constant transmission and continuous reception in the transducer. This causes the problem of overlapping. In the **pulsed evaluation**, there is a constant transmission, but the region of the reception by the transducer is defined as a particular space. This helps in determining low-velocity blood

flow with more accuracy.

The Doppler is used for diagnosing conditions of the heart and in diagnosing pathologies related to the blood vessels like deep vein thrombosis. It is very helpful for diagnosing varicose veins, which occur because of the incompetence of the valves communicating between the superficial and deep venous systems. One of the most powerful attributes of the Doppler echocardiography is its effectiveness in measuring the pressure difference across the stenotic valve and between the various chambers.

Biomarker **of the Heart**

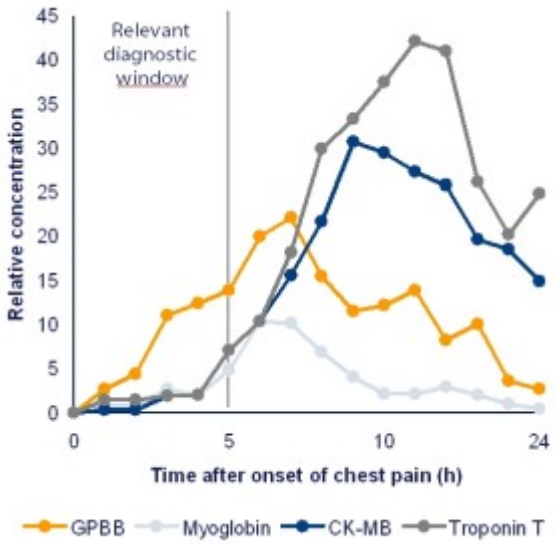


Image: “Comparison of the Cardiac Marker” by Peetz et al.
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Whenever there is an injury to the cardiac cells, there occurs a disruption of the cell membrane. The constituent of the cell gets leaked like **troponin, lactate dehydrogenase, myoglobin,** etc. These can act as effective biomarkers in determining the extent and prognosis of cardiac injury, which occurs in the case of myocardial infarction and many other conditions.

The normal physiological functions of troponin are to mediate the calcium-mediated interactions with actin and myosin, which are the contractile elements present in the cardiac cell. There are two types of troponin, namely troponin I and troponin T. In employing the troponin test, it should be performed at the time of admission, followed by a second assay after 3 to 6 hours. The second assay should demonstrate at least a 20% increase than what was determined during the time of admission.

Some of the recent recommendations propose troponin I and troponin T when compared to creatine kinase MB. Cardiac troponin is also said to be better and more predictable when compared to lactate dehydrogenase, myoglobin, and other biomarkers that were used in the past.

Invasive Coronary Angiography

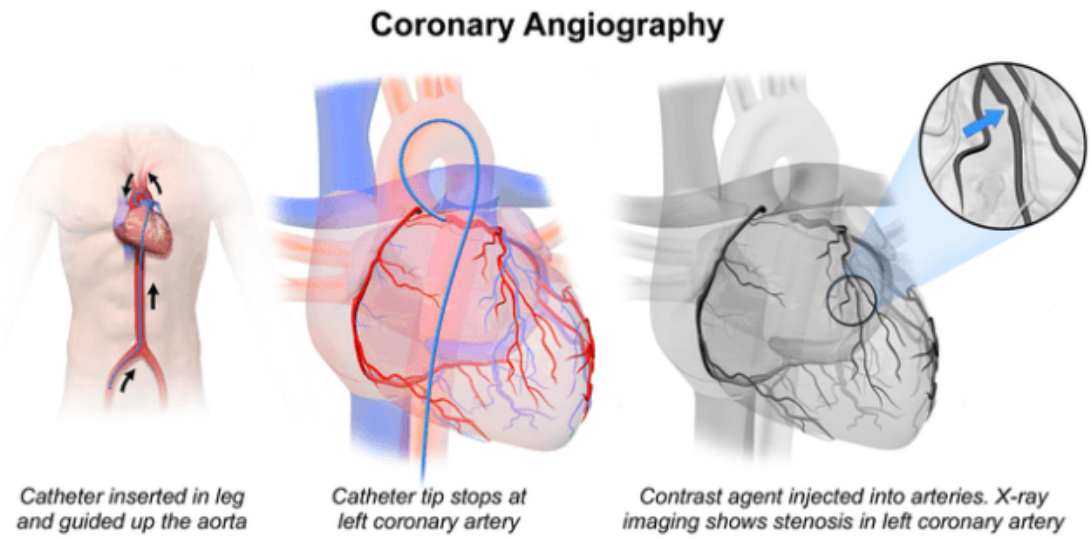

Image: “Coronary Angiography” by BruceBlaus. License: Public Domain CC BY-SA 4.0

In the cardiovascular system, the best and the **gold standard test** for the visualization of the status of the heart vessel in coronary artery disease is invasive coronary angiography. Though it has advantages over other tests, it has demerits like being an invasive procedure with the high cost incurred in carrying out the test. It does not give an insight into the functional status of the heart and the blocks present in the microcirculation.

Electrophysiology Study

For the **diagnosis and evaluation of the rhythm disorder of the heart,** electrophysiology tests are used. This testing is highly invasive in nature with multipolar electrodes placed in varying positions of the heart like the right atrium and right ventricle classically. In addition to this, electrodes are also kept in a position like the coronary sinus, a bundle of His.

Advanced Radiological Techniques

Computed Tomography Coronary Angiography (CTCA)

It is employed with the principles of coronary angiography, combined with the power of computed tomography for visualization.

Multi-Detector Cardiac Computed Tomography (MDCT) and Magnetic Resonance (MR)

This imaging offers advantages of being non-invasive; these were mainly used as tools for research, but nowadays, its use in clinical practice is steadily in an uprise.

Rules for Ordering Tests

1. Avoid ordering tests if the results will not affect patient care decisions.
2. Avoid ordering two tests that provide the same result. A patient with suspected

angina does not need a nuclear exercise test and a dobutamine echo test.

3. Order the simplest forms of an imaging test first. If an exercise ECG test provides the necessary information, then an expensive nuclear stress test is unnecessary unless additional information is needed, for example, if the ECG test results are equivocal.
4. Determine the need for a stress test based on findings from the patient's history, physical exam, and ECG. The patient with a recent invasive coronary angiogram does not need a CT coronary angiogram.
5. Ensure the test results will provide the necessary information. If a CT angiogram will rule out coronary arterial atherosclerosis, is it necessary if a recent nuclear stress test was normal?
6. Transthoracic echo study can help rule out a STEMI or a large NSTEMI in a patient with an abnormal ECG. For example, a 40-year-old diabetic male comes to the ER complaining of chest discomfort. His ECG shows atypical ST elevations in several leads. His echo shows normal LV wall motion. This patient has not had an MI of considerable size, for example, a STEMI. However, it is necessary to rule out unstable angina or a small NSTEMI.
7. Which is the best stress test to diagnose ischemic heart disease? Exercise stress ECG test, an exercise nuclear stress test, a pharmacological nuclear stress test (dipyridamole, adenosine), an exercise echo stress test, or a pharmacological echo stress test (dobutamine)? The answer is that the imaging (echo and nuclear) stress tests have fewer false negatives and false positives than the ECG test. The CT angiogram is most helpful if it is normal. However, the CT, echo, and nuclear tests are more expensive.
8. The test you pick depends on the patient´s age and gender, baseline ECG, patient's ability to exercise, the presenting history, and the best test in your location.
9. How useful is a CT coronary artery calcium imaging test? This test has a good, but not perfect, predictive value for diagnosing CAD. It is most useful in patients with an intermediate (neither high nor low) risk for CAD. It is not useful in patients with a known diagnosis of CAD and not useful in the elderly.
10. A positive test result does not always establish a diagnosis. Test results can be erroneous, although they are usually accurate. Always interpret the test result in light of the clinical situation.
11. Which test to order depends on the expertise and experience of the person conducting the test and interpreting the results.

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Notes