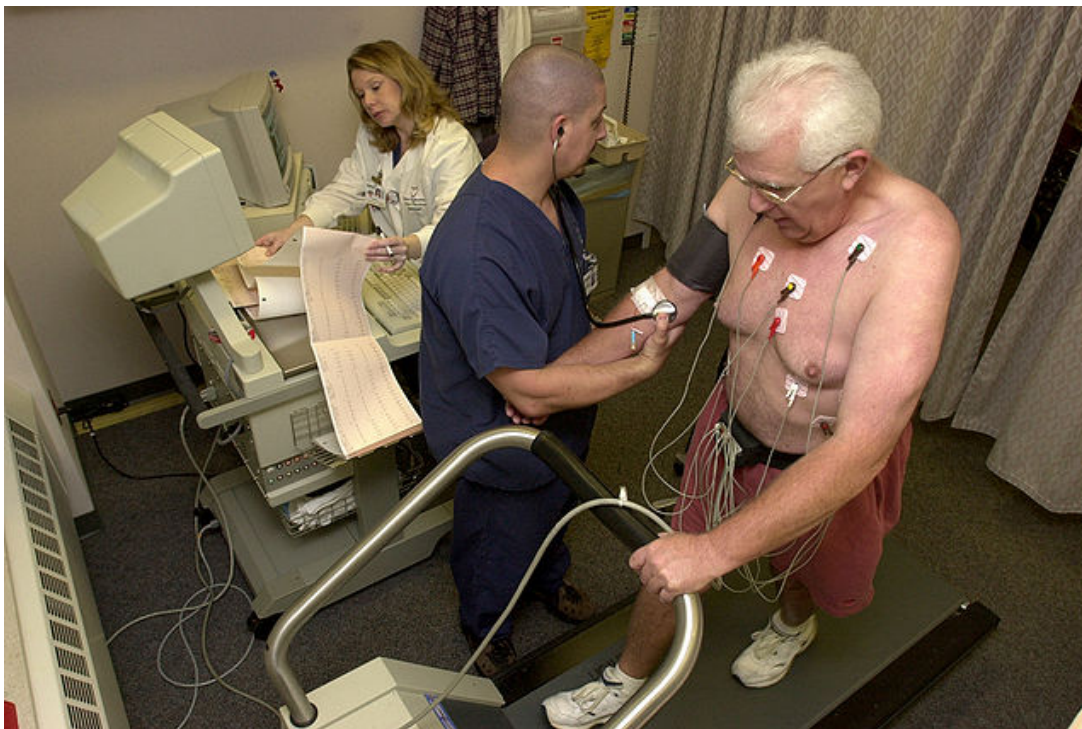


Diagnostic Tests in the Cardiovascular System and Blood Vessels

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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 Julu. License: Public Domain

According to the Joint National Commission report 7, **systolic pressure** (which represents the pressure during the contraction of the heart) of **less than 120 mmHg** and **diastolic pressure** (which represents the pressure during the relaxation of the heart) of less than **80 mmHg** is considered as **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 blood pressure during the systole greater than 140 mmHg and blood pressure during the diastole greater than 90 mm Hg with the same evaluation condition. In between normal and hypertensive patient is an entity known as **prehypertension**, which possesses a significant risk factor for progressing into hypertension in the future (systolic blood pressure between 120-139 and diastolic between 80-89).

In order to **measure blood pressure**, the basic instrument, which is absolutely essential, is a **sphygmomanometer**. It is economical and offers the further advantage of portability and is reliable in diagnosing and guiding the 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 the prediction of the risk factor of disease of cardiovascular system in patients greater than 60 years of age, and the diastolic blood pressure is important in patients less than 50 years of age. The most common types of Sphygmomanometer are **Mercury** and **Aneroid**. Automated oscillometric BP measuring devices are used in increasing amounts nowadays and gaining popularity.

Before measuring the blood pressure of the patient using a sphygmomanometer, a set of **precautions** need to be followed for the effective interpretation of the results. The patient needs to be properly seated and the appropriate cuff size in reference to the arm size of the patient is to be taken. Care should be taken to make sure that the sphygmomanometer used is appropriately calibrated. The proper sitting position comprises supporting the arms of the patient in which blood pressure is to be taken, with the patient comfortably in the sitting position without crossing of the legs. For the proper positioning of the bladder of the cuff which is used for measuring the blood pressure, it is recommended to keep it over the brachial artery.

There are three acceptable measurements of blood pressure.

Office-Based Blood Pressure Measurement

First is the blood pressure measured in the **physician cabin** known as an office-based blood pressure measurement.

Home-Based Blood Pressure Measurement

Second is the measurement of blood pressure in the home (this is to **attenuate the white coat hypertension**). The final blood pressure, which is obtained, is an average of the blood pressure measured 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 mmHg.

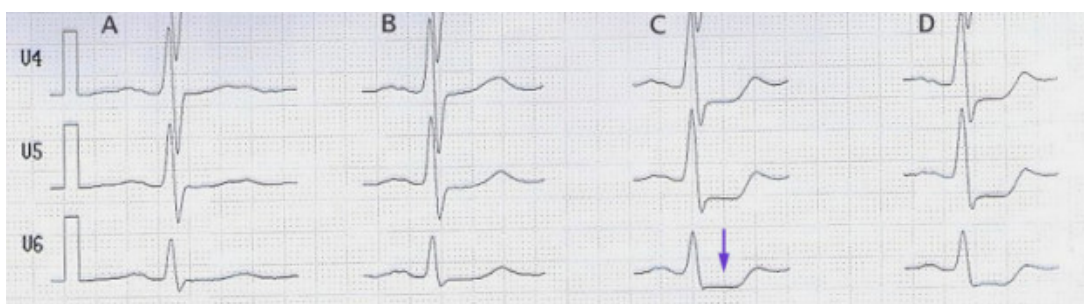
Ambulatory Blood Pressure Measurement

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 a 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 mmHg.

Cardiac Stress Testing

As the name suggests, after inducing stress, the **status of the functioning of the heart is evaluated**. The stress is generated by means of performing an exercise or by using the pharmacological agent (dobutamine or Dipyridamole). This is one of the well-validated tests for the evaluation of [coronary artery disease](#).



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

The test, which is performed after inducing the stress, can be **electrocardiogram, echocardiography or radionuclide imaging**. It is recommended to perform **pretest probability scoring** to evaluate the risk of disease-related to the cardiovascular system which is, in turn, based upon a lot of criteria like gender, age extra, and then to perform cardiac stress testing only in those individuals who fall under the intermediate pretest probability (pretest probability is a method of evaluating whether a stress test is required or not).

It should be kept in mind that serious complications can occur in 1 in 10,000 as a result of

stress tests like sudden **cardiac death** or [myocardial infarction](#).

Principle Behind the Test

The nourishment of a normal heart is supplied by the **myocardial oxygen supply**. When there is a block in a person, it won't be clinically symptomatic unless the level of blockage is significant. On performing the exercise, the symptoms will get precipitated as 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, presence of arrhythmia, heart failure, stenosis**, which is uncontrolled and **symptomatic, acute aortic dissection, acute myocardial infarction** within 2 days, **acute pulmonary embolism**.

Types of Exercise Testing

Motor-driven treadmill and the **stationary cycle Ergometer** are the two most common ways of doing exercise stress testing. The testing is usually shifted from a low workload to the higher workload, with the maximum timing of the test **lasting for about 10 minutes** for effective results. The endpoint is either a predetermined heart rate to be achieved or the showing of any symptoms by the patients in performing the test.

Bruce protocol is the common protocol, which is followed for exercise testing. It should be known that other protocols for testing of patients who are presenting after myocardial infarction like the Naughton protocol and for testing patients who are obese and having a sedentary lifestyle like modified Bruce protocols are also present.

Electrocardiogram

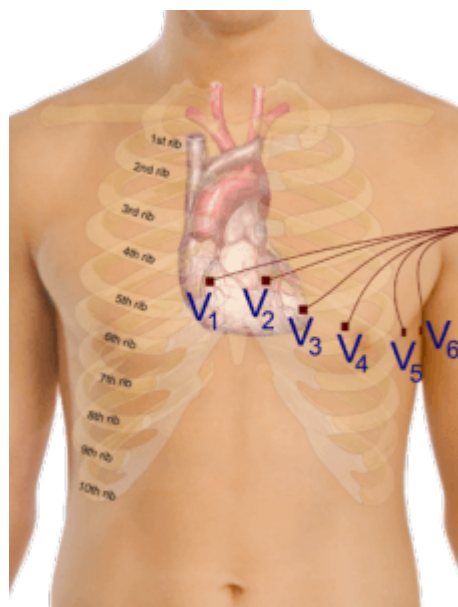


Image: "Placement of the Precordial Leads in Electrocardiography" by Mikael Häggström.
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The electrical activity in the [heart](#) starts from the sinoatrial node and progresses to the atrioventricular node. Finally, it enters the Purkinje fibers through the Bundle of His. This **electrical activity can be recorded as an electrocardiogram with the help of 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 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 in the heart because of the problems present 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 ventricular complex and intermittent skipped the ventricular beat. In addition, cardiac conditions, electrolyte abnormalities like hypokalemia and hyperkalemia, can also be diagnosed based on ECG.

Electrocardiogram has advantages like being economical and it is affordable to be kept even at the level of a Primary Health Centre. It also has an advantage that a basic medical doctor, without any super specialty, can make an interpretation of the status of the cardiovascular system based on the ECG.

Echocardiogram

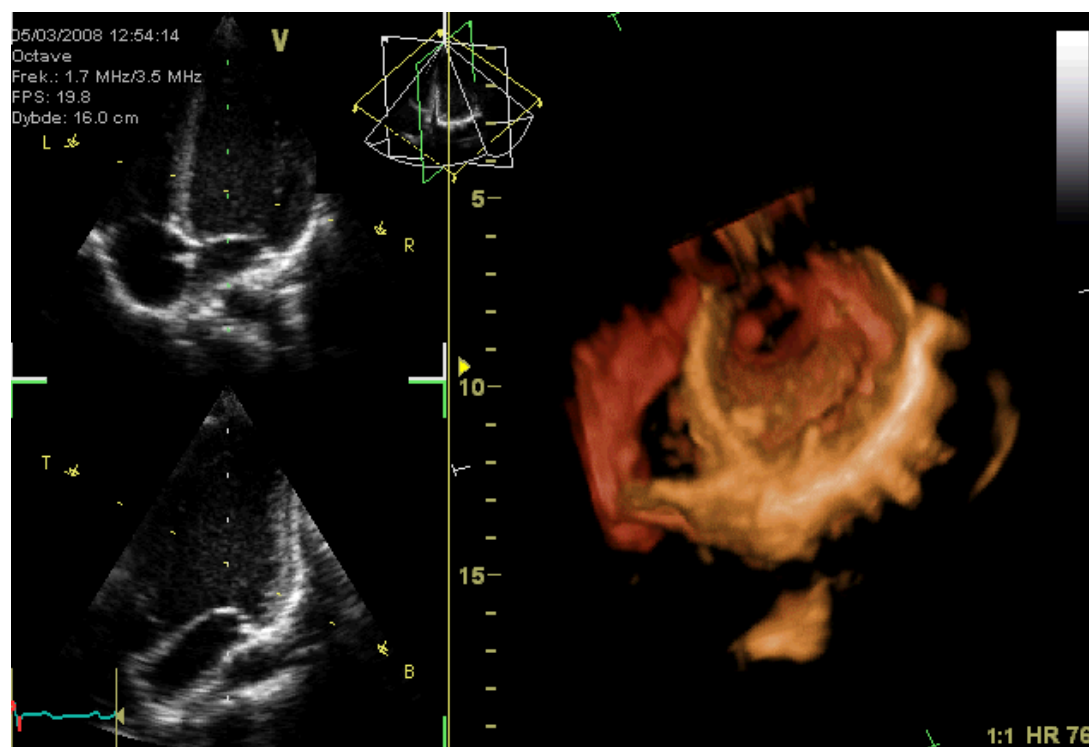


Image: "GIF-animation showing a moving echocardiogram; a 3D-loop of a heart viewed from the apex, with the apical part of the ventricles removed and the mitral valve clearly visible. Due to missing data the leaflet of the tricuspid and aortic valve is not clearly visible, but the openings are. To the 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 with the **visualization of the chambers of the heart**, along with the status of the valves of the heart.

Doppler Echocardiography

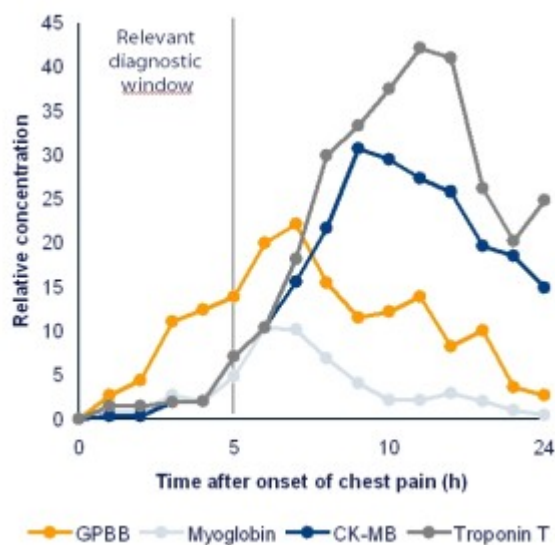
Doppler echocardiography is **based on the Doppler Effect**. When a transmitted wave is reflected back, based on the pattern of the reflected waves, particularly its frequency, the velocity and direction of the flow of obstacle can be determined.

There are three main types of Doppler evaluations: continuous, color flow and pulsed evaluation. In the case of **continuous Doppler**, there is a continuous transmission and continuous reception in the transducer. This causes the problem of overlapping. Whereas, in the case of **pulsed evaluation**, though there is a continuous transmission, 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 not only used in diagnosing conditions of the heart, but also in diagnosing pathologies related to the blood vessels like deep vein thrombosis. In the case of varicose veins, which occur because of the incompetence of the valves communicating between the superficial and deep venous system, this is very helpful in diagnosis.

In the case of the heart, it is able to determine the pressure difference across the stenotic valve and between the various chambers, and this remains one of the most powerful attributes of the Doppler echocardiography in the cast.

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 and, in turn, the constituent of the cell gets leaked like **troponin, lactate dehydrogenase, myoglobin**, etc. These can act as effective biomarkers in the determination of the extent and prognosis of cardiac injury which occurs in 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 which

should be followed by a second assay after 3 to 6 hours. A second assay should demonstrate at least a 20% increase than what was determined during the time of admission.

Some of the recent recommendations propose the use of 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

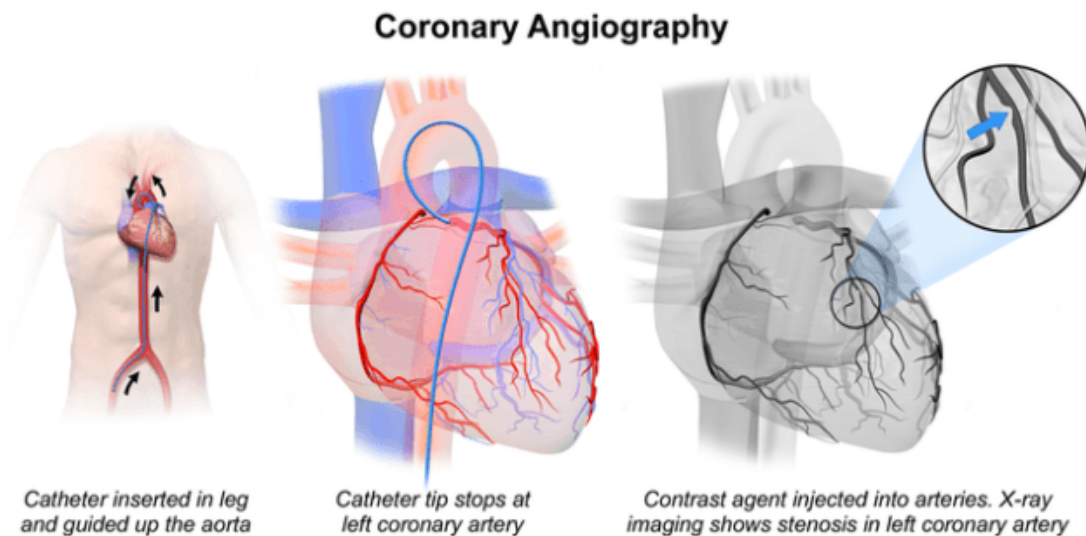


Image: "Coronary Angiography" by BruceBlaus. License: Public Domain [CC BY-SA 4.0](https://creativecommons.org/licenses/by-sa/4.0/)

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 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 heart like right atrium and right ventricle classically. In addition to this, electrodes are also kept in a position like coronary sinus, 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 the tools for research, but nowadays its use in clinical practice is steadily in an uprise.

Rules for Ordering Tests

1. Never order a test where the results will not affect patient care decisions.
2. Do not order two tests that give the same result. A patient with suspected angina does not need an exercise nuclear test and a dobutamine echo test.
3. Always order the simplest of two forms of an imaging test first. If you can get the information you need for an exercise ECG test, do not order an expensive nuclear stress test as well, unless additional information is needed, for example, the ECG test gave equivocal results.
4. Before ordering, a stress test, review the findings from the history, physical exam, and ECG. Then decide if you really need the test. The patient with a recent invasive coronary angiogram does not need a CT coronary angiogram.
5. Always think before you order a test: What questions are you asking? What information do you want from the test? If you are ordering a CT angio to rule out coronary arterial atherosclerosis, do you really need the CT angiogram if a recent nuclear stress test was completely normal?
6. A 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 a number of leads. His echo shows normal LV wall motion. This patient has not had an MI of considerable size, for example, a STEMI. However, you have not completely ruled out unstable angina or a small NSTEMI.
7. Which is the best stress test to diagnose ischemic heart disease? An 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 the imaging (echo and nuclear) stress tests have fewer false negatives and false positives compared with the ECG alone 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, and the 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 (not high and not 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 some degree on the expertise and experience of the person doing and interpreting the test. This will vary from hospital to hospital and should be explored at your hospital.

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