

Non-Invasive and Invasive Cardiac Imaging

Introduction:

Coronary artery disease is the most common cause of patient hospitalization and mortality in many industrialized countries. The current standard of assessment is coronary angiography (CA) in conjunction with interventional therapeutic procedures. While CA and other invasive cardiac imaging procedures have become relatively safe, the inconvenience to the patient is extensive. This has caused a popularization throughout the past decades of potential, non-invasive cardiac imaging devices. Different devices such as magnetic resonance and electron beam computed tomography have been explored. In this monograph various imaging technologies are discussed.

The Problem:

The current cardiac imaging devices provide an inconvenience to the patient in many forms including hospitalization and higher economic burden. Various technologies have been developed to ease patient burden in the form of non-invasive cardiac imaging devices. However, these new technologies are not without their unique challenges. Such challenges as cardiac motion and calcium deposits often render scans inadequate. The characterization of atherosclerotic plaque is another major challenge for non-invasive imaging as the rupture of such plaques can cause acute vessel occlusion. There is a need to find a suitable procedure that minimizes or eliminates rupturing the plaque. In addition, conventional imaging techniques expose the patient to ionizing radiation. These are some of the various challenges surrounding the design of a non-invasive device.

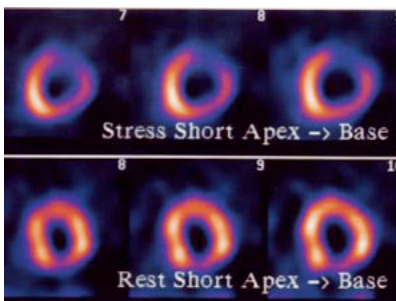
Invasive Imaging

Modern IVUS systems have presented some difficulties that necessitate further exploration. One such difficulty with IVUS is total obstruction when a transducer is brought in close proximity to a severely stenosed vessel. Volcano Corporation recently launched the VH™ IVUS system. This is the first technology to enable real-time compositional assessment of atherosclerotic plaque in coronary arteries. It provides automated measurement tools to simplify image interpretation. It also uses a color key to better display plaque composition. This technology allows for colorized VH images of four plaque component types. This is the first IVUS system capable of providing information about plaque composition.

Optical Coherence Tomography (OCT) is another popular technology used for cardiac imaging. This non-contact, light-based imaging modality provides in situ tissue images at near histological resolution. This technique allows for the identification of mural as well as luminal morphologies. When compared to IVUS, studies showed that OCT provides additional morphologic information which is helpful in the characterization of plaque. Optical frequency domain imaging (OFDI) is a new technology in this area of imaging. OFDI is used in the diagnosis and management of coronary artery disease. It uses infrared light delivered to the imaging site through a single optical fiber incorporated within a catheter. Advanced algorithms are used to remove the reflected signals from the infrared light. This provides the clinician with real-time cross sectional and 3-dimensional images.

Non-invasive Imaging:

Nuclear cardiac imaging is a popular non-invasive imaging method which uses technetium Tc 99m sestamibi (MIBI), a radionuclide, in its process. MIBI is a technetium imaging agent that is used to reveal blood-starved tissue, usually during a heart attack. It has been used for more than a decade as an imaging agent. MIBI concentrates in tissues in proportion to desmoplastic and metabolic activity and blood flow. This technique has been considered a reliable method of assessing myocardial salvage in patients with acute myocardial infarction in addition to evaluating and diagnosing a heart attack.



(Nuclear cardiac illustration from <http://images.google.com> Google Images)

Cardiovascular Magnetic Resonance (CMR) is another technique used for non-invasive imaging. This device was developed to quantify calcium deposits and coronary morphology and flow. It is based upon the magnetic characteristics of tissues and molecules within a magnetic field. CMR is superior to other methods for use on those patients with complex congenital heart disease. CMR provides excellent visualization of extracardiac venous structures and intracardiac baffles as well. However, it is not feasible for use on patients with pacemakers or other metallic implants or on those who suffer from claustrophobia.

Most recently, the technique of spiral balanced steady-state free precession cardiac imaging (SSFP) has been brought to the forefront of CMR. These sequences are useful in cardiac imaging because they have the ability to achieve high signal efficiency and blood-myocardium contrast. This procedure enables efficient acquisition with reduced blood flow and motion artifacts. SSFP has been combined with spiral imaging allowing for real-time interactive cardiac CMR. In contrast to conventional echo imaging, this method yields an intrinsic blood-myocardium contrast independent of inflow and has become extremely useful in cardiac imaging.

Computed Tomography (CT) is another well-known device that is being used for non-invasive cardiac imaging. Like CMR, electron beam computed tomography (EBCT) was designed with the goal of measuring calcium deposits and coronary artery morphology and flow. CT of the heart throughout the last decade has been the exclusive realm of EBCT. The most popular use for this technology has been assessment of myocardial perfusion and function as well visualization of the coronary arteries.

In recent years, multidetector-row computed tomography (MDCT) has become available. This technology has become the preferred method because it rectifies some of the limitations of the EBCT such as low spatial resolution and pronounced noise. The ability of the MDCT scanners to acquire multiple slices has considerably improved cardiac imaging. The image quality produced by MDCT favorably compares to that of coronary angiography. In addition, it provides assessment of coronary calcium and plaque characterization while also producing a high image quality.

Non-invasive echocardiography is an optional ultrasonic method of cardiac imaging. Recently, live three dimensional echocardiography (L3DE) has broken through into the field of medical ultrasound. This non-invasive system is easy to operate and images rapidly and clearly. In L3DE ultrasonic beams are generated in a phased array manner which gives the clinician the ability to evaluate the cardiac structures from every direction. The ability of the operator to improve temporal and spatial resolution of the image during acquisition is one benefit of this procedure.

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