Noninvasive Coronary Arteriography

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Abstract

The program addresses the fundamental concerns associated with conventional angiography, which requires the injection of a contrast agent directly into the coronary arteries by the means of arterial catheterization. The potential risks of patient mortality and morbidity, the discomfort and the frequent hospitalizations required (Rogers LF 1998, The heart of the matter: non-invasive coronary artery imaging Am. J. Roentgenol. 841,107) prevent its use for routine screening or research. A novel less invasive method is presented based on Computed tomography and Magnetic Resonance Imaging.

1. Motivation

In western countries disordered eating behavior and lacking exercise cause major civilisatory illnesses like high blood pressure and diabetes. As a consequence coronary blood vessels degenerate due to soft and hard plaques followed by more severe pathological degeneration. Chest pain is regarded as a first indication of a beginning heart disease which, if untreated, might result in a heart attack.

The aim of the method is to detect a heart disease at an early stage. Since invasive conventional methods allow for the detection of vessel degeneration only one aims to measure myocardial perfusion as a function of time. Recent developments have shown that minor vessel disorders don't affect cardiac function. These disorders can thus be treated with dietetic or medicinal measures alone provided the myocardial perfusion is sufficient and screened regularly. Clearly this cannot be measured with conventional means without putting the patient to an unacceptable risk. Even if patients had to undergo classical interventions (dilatation, stent) the method can be used to screen the course of disease non-invasively and ambulatory.

2. Instrumentation

We aim to use Computed Tomography Scanners (CT) **or** Magnetic Resonance Imaging devices (MRI) to assess heart disease in an ambulatory and non invasive manner. This is attractive since the devices are multipurpose devices that are well established in clinical routine.

3. Procedure

3.1. Computed Tomography Scanners (CT)

Modern 64-row CT scanners are able to simultaneously record multiple slices of the human heart which can be stacked in a volumetric data set. This method allows for the detection of 3D morphological vessel disorders which surpasses classical catheterization depicted in figure 1. The method can be enhanced.

Figure 1: Conventional 2D view of coronary arteries taken by standard catheterizations using a second volumetric data set where the patient has been given a bolus of Iodine-bases contrast agent. If both volumetric data sets are digitally subtracted using a suitable image processing algorithm the myocardial perfusion can be visualized as a function of time (4D).

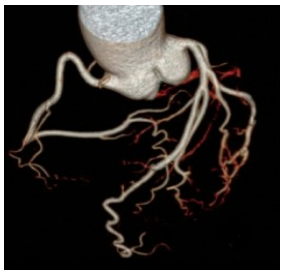
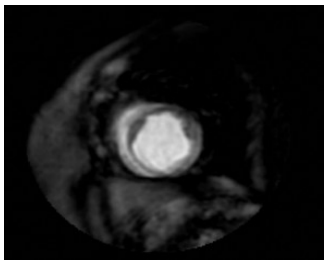


Figure 2: 3D view of coronary vessels taken by a 64-row CT scanner. Note that the method yields the vessel morphology as a side effect.



3.2. Magnetic Resonance Imaging devices (MRI)

Since CT scanners expose the patient to a radiation dose one can think about magnetic resonance imaging methods to visualize myocardial perfusion using special contrast agents based on Gadolinium. Modern MRI devices have a very good spatial resolution which makes this method attractive when the use of X-rays is prohibitive. Note that due to physical limitations this method yields 2D slices animated in time. This restriction is relaxed using the latest MRI devices. However temporal resolution is still a limiting factor.

Figure 3: 2D view of myocardial perfusion recorded by a MRI device. After intravenous injection of a contrast agent the heart's tissue is temporarily marked (bright semicircle left of image center).