



Cardiac CT  
Chapter 2

# CT IN CARDIOLOGY

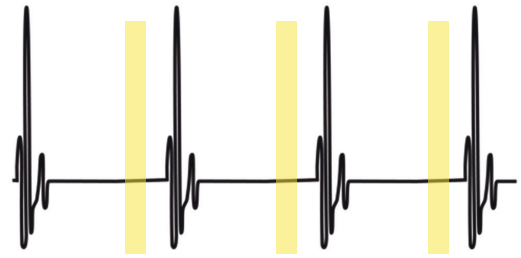
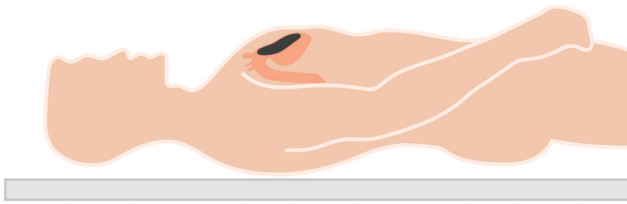


Ronak Rajani

## CT in cardiology

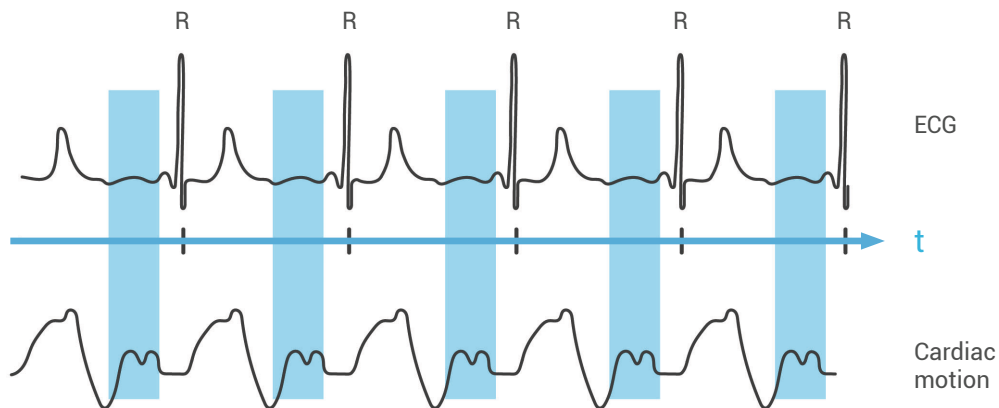
# SPECIALIZING IN CARDIAC CT

A coronary CT angiogram is a one-shot, high-speed, high-resolution, acquisition that occurs during the ECG-gated scanning of the chest, shortly after the injection of a rapidly infused bolus of contrast.



The aim is to image small and moving coronary arteries; therefore, we require optimal imaging conditions. To improve the visualization of the coronary arteries, it is recommended that sublingual

glyceryl trinitrate (GTN) be administered to patients. To counteract the temporal resolution limitations of coronary CT, it is also recommended that beta-blockers be given.



Beta-blockers are given to patients with heart rates < 65 bpm since cardiac motion in diastole is limited and there is ample time for modern CT scanners to image the coronary arteries. As the heart rate speeds up the diastasis decreases and more

motion artifact can appear in the scans. With higher heart rates, either scanning a greater proportion of the cardiac cycle, or end-systolic scanning, is required.

## CT in cardiology

# PERFORMING A CORONARY CT SCAN ANGIOGRAM (CCTA)

When performing a CT scan the key steps are detailed below:

Once you have prepared your patient and have done all of your safety checks, your patient can be placed on the scanner. Consider administering GTN (800 mcg sublingually) and controlling their heart rate with intravenous metoprolol, if the heart rate is above 65 bpm. Practice **breath hold instructions** and attach the patient to the ECG cables on the scanner.

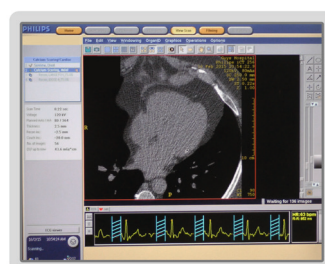
The next step is to acquire your scout images so the scan can be planned. Often this is followed by the prospective ECG-gated coronary calcium scan.

Now the ECG-gated coronary CT scan can be planned. This involves setting the **locator** for the **contrast bolus tracking**, planning the **scan range**, and selecting the CT **protocol** and **parameters**. The contrast can then be injected.

With **bolus tracking**, low dose dynamic scans will be taken by the CT scanner and when a certain threshold is reached, in terms of attenuation value within the region of interest, the scan will wait 8–10 seconds before acquiring the images.

During this **delay** the patient will be asked to hold their breath in.

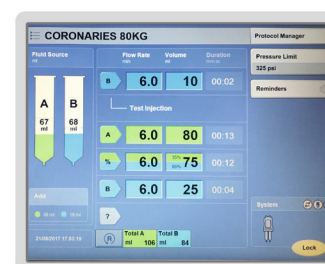
Once the scan is acquired be sure to **review the images** immediately for quality and artifacts.



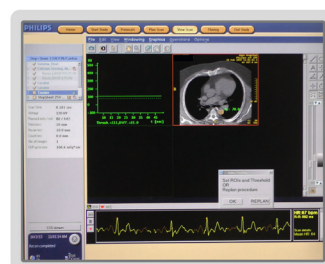
Perform coronary calcium scan



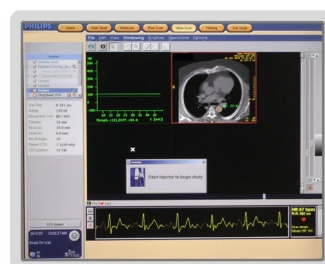
Select the protocol



Administer contrast



Track bolus



Start contrast



Acquire dynamic scans



Delay until threshold reached



Review images

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# ADMINISTERING CONTRAST IN CARDIAC CT

To obtain good contrast opacification in the coronary arteries it is important to ensure good patient preparation, with sublingual nitrates and beta-blockers. Both of these medications enable good contrast filling of the coronaries. It is equally important to ensure that adequate contrast flow

rates are used. These are typically > 5 mL / s. The total volume of contrast required for a coronary CT scan can be calculated by the following equation:

**Total contrast required =**  
 $\text{scan time} + \text{delay time} \times 5 \text{ mL} / \text{s}$



## CT in cardiology

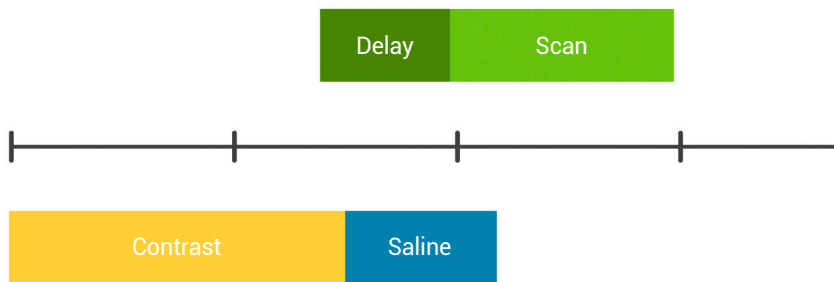
# CONTRAST PROTOCOLS

There are two main contrast protocols used in coronary CT. Each involves a contrast phase followed by a saline chaser. The saline chaser ensures a tighter bolus of contrast and better

contrast opacification of the coronary arteries. It also reduces streaking artifact of contrast as it enters the heart via the superior vena cava.

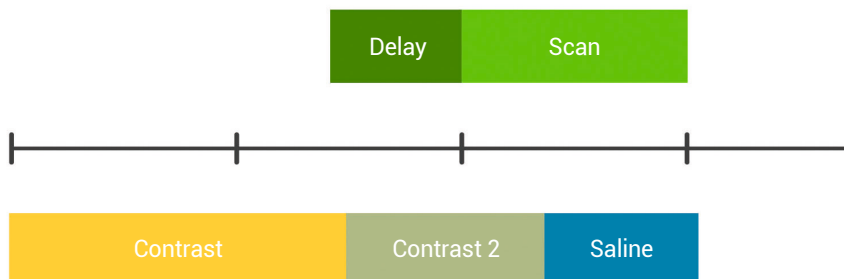
### *Biphasic protocol*

The biphasic protocol typically enables left-sided heart opacification.



### *Triphasic protocol*

The triphasic protocol enables left- and right-sided heart opacification.



## Timing of contrast

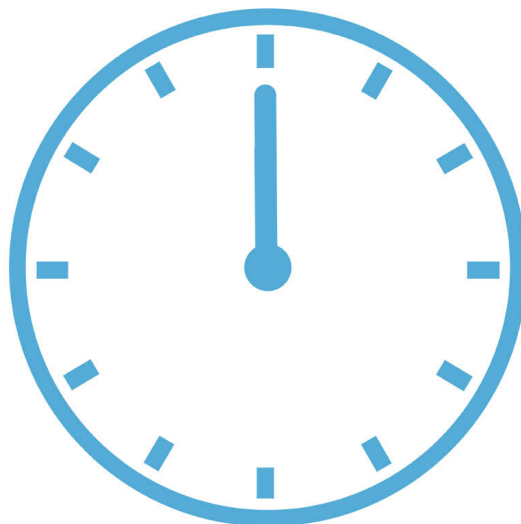
In coronary CT angiography, the objective is to acquire the scan when the contrast is greatest in the arterial component of the circulation (i.e., the coronary arteries). This can be achieved by two main methods.

### 1. Bolus tracking

A small region of interest is drawn within the left ventricle, ascending aorta, or proximal descending aorta. As the contrast is injected, a series of low dose dynamic scans are acquired, which monitor the attenuation within the region of interest. Once a threshold is achieved, there is a slight delay, and the scan is acquired. This is an automated technique.

### 2. Timed bolus

A small test bolus of contrast is administered to the patient, to time the arrival of the contrast to point of interest, in the left side of the heart. With this information being inputted into the scan parameters, once this time has been measured, the formal coronary CT scan can be acquired.



## CT in cardiology

# IDENTIFYING ARTIFACTS IN CARDIAC CT

It is important to be able to identify artifacts in your CT scan datasets since this can influence image interpretation.

### *Respiratory motion artifact*

These may be identified by seeing small breaks in the outer boundary of the heart, on the coronal or sagittal planes. When you suspect respiratory motion

artifact, look at the lung windows, and if the patient has taken a breath during the scan, the lungs will appear blurred.

### *Coronary motion artifact*

This is identified by seeing blurred coronary arteries, which are surrounded by a black halo.

### *Hard beam artifact*

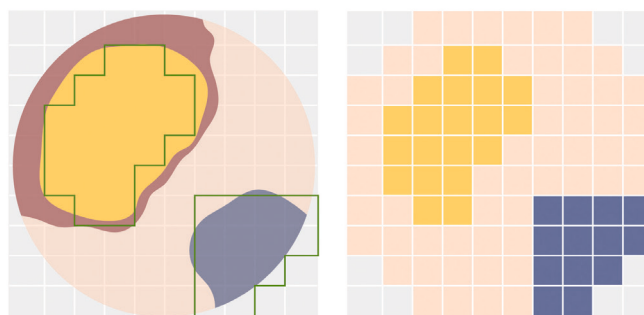
This usually occurs in the context of high attenuating matter within the scan range, such as: pacing wires, mechanical heart valves, and stents. Hard beam

artifact can be identified by areas of black in the vicinity of the high-attenuating matter.

### *Calcium blooming artifact*

Calcium blooming artifact is caused by a phenomenon called partial voluming. If we consider the image below, the yellow represents non-calcified plaque and the purple, calcium. The left-hand image represents the true size of the plaque and the right-hand image, the reconstructed image from the attenuation values. We know that when looking at CT data each pixel represents the average value of Hounsfield units intensity

of that voxel. If calcified plaque enters the space of an adjacent voxel the average attenuation will increase, and on the reconstructed image the plaque will appear larger than its true size. The converse occurs with non-calcified plaque. Since the non-calcified plaque has a lower attenuation than the contrast, the size of the plaque on the reconstructed image appears smaller.



## Windowing artifact

The windowing artifact is an artifact caused by incorrect workstation settings. It is important to set the window width and level appropriately. Remember, the window width represents the range of Hounsfield unit values displayed and the window level / center, the mid-point of these values. To analyze structures appropriately, contrast-

filled structures should have a slightly off-white appearance (a matt white finish versus a glossy white finish) and the soft tissue structures around the contrast should be an easily visible grey. As you get used to reviewing cardiac CT datasets, you will adjust these settings automatically.

## Phase misalignment

Phase misalignment is a variation in the R-R interval when trying to acquire prospective ECG-gated images. Horizontal lines are seen across the

dataset, which represent where the blocks of data have tried to be laid alongside one another.

## Streak artifacts

Streak artifacts are seen as rays of artifact spanning out from a metal object in the scan range. The presence of metal objects in the scan field leads to severe streaking artifacts, the density of the metal is beyond the normal range that can be

handled by the computer, resulting in incomplete attenuation profiles. Additional artifacts due to beam hardening, partial volume, and aliasing are likely to compound the problem when scanning very dense objects.



# READING LIST

Halliburton, S, Arbab-Zadeh, A, Dey, D, et al. 2012. State-of-the-art in CT hardware and scan modes for cardiovascular CT. *J Cardiovasc Comput Tomogr.* **6**: 154–163.

The Royal College of Physicians, the British Society of Cardiovascular Imaging and The Royal College of Radiologists. *Standards of practice of computed tomography coronary angiography (CTCA) in adult patients*. London: The Royal College of Radiologists, 2014. [Ref No. BFCR(14)16]