HeartFlow®

Acquisition and Reconstruction Techniques for Coronary CT Angiography

Arineta Scanner Platforms

Edited and Approved by

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1. Overview

Coronary computed tomography angiography (CCTA) is a non-invasive diagnostic for detecting coronary artery disease (CAD). CCTA is increasingly utilized in clinical practice for evaluating coronary anatomy for obstructive disease and plaque.

It is, however, imperative that artifact free CCTA image data is obtained in order for it to be successfully analyzed for anatomic assessment and/or to act as adequate input for adjunct analyses such as physiologic simulations. Data acquisition strategies and scanning protocols may vary depending on scanner manufacturer, system, and institutional preferences. This document provides references for reliable image acquisition for CCTA.

2. Introduction

Image acquisition in computed tomography is governed ultimately by the principle of As Low As Reasonably Achievable (ALARA). In the first 10 years of CCTA, the focus was almost exclusively on the detection of anatomical stenosis in low to intermediate risk patients. With the evolution of technology, the clinical utility of CCTA has extended beyond stenosis assessment to atherosclerosis characterization, the evaluation of structural heart disease, and the functional and physiological assessment of coronary stenoses. Recently the SCCT acquisition guidelines were updated and provide an excellent reference for Cardiac CT imaging specialists to help optimize their scan protocols. That being said, given the growing information that is provided from cardiac CT, the imaging requirements have evolved and require tailoring to meet the clinical indication. The purpose of this white paper is to highlight the parameters and image acquisition protocols that are important to help optimize image quality, provide accurate representation of anatomy and thus enable quantitative CT.

Importance of Heart Rate Control

With the advancements in scanner technology, the necessary requirement for heart rate reduction has decreased over time. The demands for a low and steady heart rate to ensure diagnostic image quality may not be what they once were but best practice remains to optimize image quality through heart rate control. SCCT guidelines recommend performing CCTA with heart rates below 60 bpm.

In addition, CCTA no longer simply provides stenosis evaluation but needs to enable the interpreting physician to identify and characterize plaque and, following the identification of a stenosis, to perform functional or physiologic evaluation. As a result, while latest generation CT scanners may enable diagnostic image quality at higher heart rates, there remains meaningful image quality benefits from heart rate reduction. In addition, lower heart rates allow the use of lower dose scan acquisitions that are not possible at higher heart rates. Heart rate control strategies are well established and the appropriate strategy is dependent on a number of variables including available medications, setting of practice and site preference. For recommendations please refer to the recently updated SCCT acquisition guidelines.

Importance of Nitrates

Nitrates as smooth muscle dilators have direct effect on coronary vasodilation and result in tangible enlargement of coronary size. As such, similar to invasive coronary catheterization, nitroglycerine (glyceryl trinitrate) should be administered prior to CCTA to optimize image quality and enable the most accurate stenosis evaluation. A commonly used regimen is 400-800 μg of sublingual nitroglycerin administered as either sublingual tablets or a metered lingual spray (commonly 1-2 tablets or 1-2 sprays) prior to the CCTA. While the evidence is modest and there is no randomized data, both a higher dose and administration via spray are becoming increasingly preferred in clinical practice and have been shown to help optimize coronary evaluation.

Selection of Tube Current and Potential

The scan parameters used for any cardiac CT should be tailored to the individual patient but also the intended application. The image quality issues with the greatest impact on the interpretability of CT are misalignment and image noise. As such, care must be given to ensure that image noise properties are appropriate and adequate for accurate lumen segmentation. To do so, tube current and potential should be selected carefully, guided by chest wall circumference, the iodine concentration of the intravenous contrast medium, and whether iterative reconstruction is available or not.

Iterative reconstruction (IR) has the ability to reduce image noise in CT without compromising the diagnostic quality of the CT image dataset, which permits a significant reduction in effective radiation dose. In current clinical practice, IR has enabled a significant reduction in radiation dose by allowing for a reduction in tube current and is now increasingly available across all cardiac capable CT scanners. IR commonly takes the form of a blended reconstruction of IR and filtered back projection (FBP). While a very helpful tool, care should be given when using a very high percentage of IR for quantitative CT analysis due to the potential impact on vessel segmentation.

3. Reference Protocol: Arineta - SpotLight & SpotLight Duo

1. Scout

General	Data Acquisition	Comments
Volume scout covering the heart and coronaries	• Scan Range: 260 mm • Start: Superior 5 mm • End: Inferior 245 mm • Tube Current: 50 mA • Tube Voltage: 80 kV • ECG Trace: On • Scout Plane: Volume • Auto Voice: (Breath hold command)	Take note on the scouts to ensure that the patient is positioned within 2 cm of isocenter to allow for best image quality. Adjust table height and lateral table location to adjust isocenter location if more than 2 cm off.

2. ECG-gated Axial Data Acquisition of the Coronaries/Heart Smart Prep

General	Data Acquisition	Comments
• Bolus tracking to automatically trigger the diagnostic scan acquisition based on the HU reading in the ROI reaching the prescribed enhancement threshold • Slice location: approximately 2 cm below the carina • ROI location: Descending aorta	• Monitoring Delay: 8 sec • Monitoring Inter Scan Delay: 2 sec • Tube Voltage: 100 kV • Tube current: 70 mA • Diagnostic Delay: 8 sec • Threshold: 120 HU Enhancement • Auto Voice: (Breath hold command): “Breathe in and hold your breath”	The effective (‘diagnostic’) delay between reaching the threshold and the start of the subsequent data acquisition is the combined time comprising (breath hold commands) and the time needed for table movement NOTE: the kV and Rotation Time parameters in the diagnostic scan tasks have to be the same.

3. Scan Parameters

General	Settings	Comments
• ECG-gated axial data acquisition of the heart • Scan range beginning 2 cm below the carina to the base of the heart for routine CCTA without previous CABG procedure • mA set achieve best IQ	**Anatomy Selection:** • Start location: ~2cm below the carina • End location: base of heart • SFOV: 25 cm • DFOV: 25 cm **ECG & Gating** • HR Variation Allowance: 1 BPM • Arrhythmia Retriggering: On **kV and mA** • kV: 80-140 (see table on page 11) • mA: 400-600 (see table on page 11) • (Breath hold command): • Post voice Delay Time: 5 seconds (Together with Breath hold command and table movement, this results in a diagnostic delay 7.7 sec) **Scan Type:** • Scan Type: Cardiac • Hi-Res Mode: Off • Rotation Speed: 0.24 seconds (slower for very large patients with a low heart rate) **Coverage Speed:** • Table Positions: One • Detector Coverage: • Number of Passes: 1 **Primary Recon:** • Thickness: 0.5 mm • Recon Type: Stnd CV • DLIR-MBAF2-MED **Secondary Recon:** • Off line	Use the ECG trace information within the last test breath hold to determine target phases for reconstruction. For example, if the HR was steady at 65 beats per minute the acquisition window will be set to acquire a phase range of 70-80% of the R to R Recommendation: SnapShot Freeze is an optional feature that should be turned on if HR is >60 BPM. Reconstruct off line.

4. Contrast Protocol

General	Specific	
• Single contrast application for both the ECG-gated axial CTA of the aortic root/heart and the CTA of the thorax/abdomen/pelvis • Biphasic administration protocol with pure contrast followed by a saline chaser • Placement of IV access per hospital protocol (an 18-guage IV typically provides the highest safety) • Automated contrast injection using a dual-cylinder injector	• For normal weighted patients and an iodinated contrast agent with 350-370 mg/ml apply 70 ml contrast at 5 ml/sec, followed by 30 ml saline at 5 ml/sec; 350-370 mg/ml 5 ml/sec of 70 ml contrast 5 ml/sec of 50 ml saline	• For large patients and an iodinated contrast agent with 350-370 mg/ml apply 70 ml contrast at 6 ml/sec, followed by 50 ml saline at 6 ml/sec 350-370 mg/ml 6 ml/sec of 70 ml \contrast 6 ml/sec of 50 ml saline

5. Recommended mA and kV based on the patient's BMI:

BMI	kV	mA	Gantry Rotation	Recon
<21	100	350	0.24	DLIR & MBAF2-MED
21-23	100	400	0.24	DLIR & MBAF2-MED
23-25	100	450	0.24	DLIR & MBAF2-MED
25-28	100	500	0.24	DLIR & MBAF2-MED
29-34	120	600	0.24	DLIR & MBAF2-MED
>35*	120	600	0.33	DLIR & MBAF2-MED

*Heart rate >60 BPM for patients with high BMI may result in images with a high degree of coronary motion

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WARNING: Any references to x-ray exposure, intravenous contrast dosage, and other medication are intended as reference guidelines only. The guidelines in this document do not substitute for the judgment of a trained healthcare provider. Each scan requires medical judgment by the healthcare provider about exposing the patient to ionizing radiation. Use the As Low As Reasonably Achievable (ALARA) radiation dose principle to balance factors such as the patient’s condition, size and age; region to be imaged; and diagnostic task.

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