HeartFlow®

Acquisition and Reconstruction Techniques for Coronary CT Angiography

Philips Healthcare 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 analysed 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. Recommended Protocol: PHILIPS BRILLIANCE iCT and IQon SPECTRAL CT

1. Surview

General	Data Acquisition	Comments
Lateral and AP surview covering the heart and coronaries	• AP Surview: 120kVp/50mA • Lat Surview: 120kVp/100mA • Surview Angle: Dual • Surview Length (mm): 300 • Surview FOV: 500 • Surview Auto Voice: S Ins • Surview Breathing Lights: Yes	Position the patient for AP surview to acquire AP and lateral surview. Offset the patient to the right so the heart is at the center of the scan field. Place the patient's arms above their head with the ECG leads outside the scan range. Have the patient practice breath-holding before starting the examination. This should be a single "breathe in and hold" command.

2. CTA Acquisition

General	Data Acquisition	Data Reconstruction
Acquiring CT coronary Angiogram	**Helical CCTA Acquisition** • kV: 120 or 100 when appropriate • mAs: 800 (standard patients), 1000 (large patients) • Scan Type: Cardiac • DoseRight: Off • Cardiac DoseRight: On • Collimation: Auto • Pitch: 0.16 • Rotation Time: 0.27 • No of cycles/scan: N/A • Scan time 5.30 seconds • Resolution: STD • Auto Voice: s.insp. Stepandshoot,breath (longer instruction with longer delay at end) • Breathing Lights: Yes • Auto Pitch & RT based on HR: No • ECG Gating Phase: 78% • Handle irregularities On-line: Yes	**Coronary CTA (Acquisition)** • Field of View limited to the heart (220 mm) • Slice thickness 0.8mm • Increment 0.4mm • Acquisition Length (mm) 140.4 • Result Scan Length (mm): 140.4

2. CTA Acquisition (contd.)

General	Data Acquisition	Data Reconstruction
	Step & Shoot (Acquisition) • kV: 120 • mAs: 155 to 200 if phase tolerance = 0 phase tolerance = 5, system will recommend more mAs • Scan Type: Cardiac • Collimation: Auto • DoseRight: Off • Cardiac DoseRight: On • Pitch: N/A • No of cycles/scan: IQon 4, iCT 2 • Scan time: 4-9 seconds • Rotation Time: 0.27 • Resolution: STD • Auto Voice: s.insp. Stepandshoot,breath (longer instruction with longer delay at end) • Breathing Lights: Yes • Auto Pitch & RT based on HR: N/A • ECG Gating Phase: 78% • Handle irregularities On-line: Yes • ECG Gating Phase Tolerance: 5%	**Step & Shoot (Acquisition)** • Field of View limited to the heart (220 mm) • Slice thickness 0.8mm • Increment 0.4mm • Acquisition Length (mm) 144.5 • Result Scan Length (mm): 140.8

3. CTA Post-processing (Reconstructions)

General	Data Acquisition	Data Reconstruction
	Coronary CTA (Acquisition) • Reconstructions: Standard • iMR Level: None • iDose Level: 3 to 5 • Filter: XCB and XCC • Single Cycle Reconstruction: No • ECG Gating Recon Phase: 78% • Edge Correction: N/A **Step & Shoot (Acquisition)** • Reconstructions: Standard • iMR Level: None • iDose Level: 3 to 5 • Filter: XCB and XCC • Single Cycle Reconstruction: No • ECG Gating Recon Phase: 78% • Edge Correction: No	

4. Contrast Protocol

General	Parameter	Comments
The injection rate should be increased for shorter scan times and larger patients! CTA requires contrast medium with an iodine concentration of at least 350 mgI/mL. Place a 20- or 18-gauge IV cannula in the RIGHT arm.	**Coronary CTA & Large (Acquisition)** • Bolus Tracking: Yes • Trigger: 100 HU over blood base line • Post Threshold Delay: 5 Seconds **Step & Shoot (Acquisition)** • Bolus Tracking: Yes • Trigger: 100 HU over blood base line • Post Threshold Delay: 7 Seconds	

4. Recommended Protocol: PHILIPS BRILLIANCE iCT SP

1. Surview

General	Data Acquisition	Comments
Lateral and AP surview covering the heart and coronaries	• AP Surview: 120kVp/50mA • Lat Surview: 120kVp/100mA • Surview Angle: Dual • Surview Length (mm): 300 • Surview FOV: 500 • Surview Auto Voice: S Ins • Surview Breathing Lights: Yes	Position the patient for AP surview to acquire AP and lateral surview. Offset the patient to the right so the heart is at the center of the scan field. Place the patient's arms above their head with the ECG leads outside the scan range. Have the patient practice breath-holding before starting the examination. This should be a single "breathe in and hold" command.

2. CTA Acquisition

General	Data Acquisition	Data Reconstruction
Acquiring CT coronary Angiogram	**Helical CCTA Acquisition** • kV: 120 • mAs: 800 (standard patients), 1000 (large patients) • Scan Type: Cardiac • DoseRight: Off • Cardiac DoseRight: On • Collimation: Auto • Pitch: 0.16 • Rotation Time: 0.27 • No of cycles/scan: N/A • Scan time 8.20 seconds • Resolution: STD • Auto Voice: s.insp. Stepandshoot,breath (longer instruction with longer delay at end) • Breathing Lights: Yes • Auto Pitch & RT based on HR: No • ECG Gating Phase: 78% • Handle irregularities On-line: Yes	**Helical CCTA Acquisition** • Field of View limited to the heart (220 mm) • Slice thickness 0.8mm • Increment 0.4mm • Acquisition Length (mm) 140.4 • Result Scan Length (mm): 140.4

2. CTA Acquisition (contd.)

General	Data Acquisition	Data Reconstruction
	Step & Shoot CCTA Acquisition • kV: 120 • mAs: 155 • Scan Type: Cardiac • Collimation: Auto • DoseRight: Off • Cardiac DoseRight: On • Pitch: N/A • No of cycles/scan: 4 • Scan time: 9.17 seconds • Rotation Time: 0.27 • Resolution: STD • Auto Voice: s.insp. Stepandshoot,breath (longer instruction with longer delay at end) • Breathing Lights: Yes • Auto Pitch & RT based on HR: N/A • ECG Gating Phase: 78% irregularities On-line: Yes • ECG Gating Phase Tolerance: 5%	**Step & Shoot CCTA Acquisition** • Field of View limited to the heart (220 mm) • Slice thickness 0.8mm • Increment 0.4mm • Acquisition Length (mm) 144.5 • Result Scan Length (mm): 134.8

3. CTA Post-processing (Reconstructions)

General	Data Acquisition	Data Reconstruction
Acquiring CT coronary Angiogram	**Coronary CTA (Acquisition)** • Reconstructions: Standard • iMR Level: None • iDose Level: 3 to 5 • Filter: XCB and XCC • Single Cycle Reconstruction: No • ECG Gating Recon Phase: 78% • Edge Correction: N/A **Step & Shoot (Acquisition)** • Reconstructions: Standard • iMR Level: None • iDose Level: 3 to 5 • Filter: XCB and XCC • Single Cycle Reconstruction: No • ECG Gating Recon Phase: 78% • Edge Correction: No	

4. Contrast Protocol

General	Parameter	Comments
The injection rate should be increased for shorter scan times and larger patients! CTA requires contrast medium with an iodine concentration of at least 350 mgI/mL. Place a 20- or 18-gauge IV cannula in the RIGHT arm.	**Coronary CTA & Large (Acquisition)** • Bolus Tracking: Yes • Trigger: 100 HU over blood base line • Post Threshold Delay: 5 Seconds **Step & Shoot (Acquisition)** • Bolus Tracking: Yes • Trigger: 100 HU over blood base line • Post Threshold Delay: 7 Seconds	

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