CT Acquisition and Reconstruction Techniques for Transcatheter Aortic Valve Procedure Planning Utilizing Philips Hardware

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INTRODUCTION

Transcatheter aortic valve procedures have proven to be an effective alternative in the treatment of aortic stenosis in high-risk and inoperable patients. Contrast-enhanced computed tomography (CT) has become an integral part of transcatheter aortic valve procedure planning by allowing for anatomical assessment of the aortic root and the aorto-iliofemoral vasculature within a single examination. It is critical that artifact free image data is obtained to allow for reliable anatomical measurements. Data acquisition strategies and scanning protocols may vary depending on scanner manufacturer, system, and institutional preferences. This document provides some recommendations for reliable CT image acquisition for transcatheter aortic valve procedures.

WORK-FLOW RATIONALE

The key component of all approaches is an ECG-assisted data acquisition which covers at least the aortic root, while the remainder of the data acquisition may be performed without ECG assistance. If employed properly, ECG assistance allows for artifact-free depiction of the aortic root. The sequence of patient preparation and the relevant principles of CT data acquisition will be explained in brief below.

PATIENT PREPARATION

- Positioning of the patient on the scanner table, typically supine, should closely resemble positioning on the cath lab table.
    - This is important for the prediction of c-arm angulation from the CT dataset.
    - Placement of ECG-electrodes and IV access should follow institutional policies.
- Patient instruction on breath-holding prior to scanning may improve compliance with the breath-holding instructions during the scan.
    - Due to the advanced age and frailty of this patient population, additional time may be needed for patient instruction.

Providing time for the patient to practice the breath hold prior to scan acquisition may drastically improve patient compliance and thereby scan quality.

CT SCAN – SCAN LENGTH AND SCAN STRATEGY

In general, there are two different approaches on how to combine the ECG-assisted data acquisition of the aortic root structures and the non-ECG assisted computed tomography angiography (CTA) of the aorto/ilio/femoral vasculature for evaluation of the transfemoral access route:

1) Cardiac ECG-assisted data acquisition of the heart and aortic root (usually beginning 2cm below the carina) followed by a non-ECG assisted CTA of the thorax, abdomen and pelvis. Although this approach results in repeat data acquisition of the aortic root and cardiac structures, the time-intensive ECG-assisted data acquisition is kept to a minimum which aids in limiting the contrast dose. Furthermore, limiting the ECG-assisted data acquisition also limits the radiation dose intensive component of the examination; although the cardiac scan range is covered twice. *The proposed protocols below all use this approach.*

2) ECG-assisted data acquisition of the thorax followed by a non-ECG assisted CTA of the abdomen and pelvis. The disadvantage of this approach is the relatively long acquisition time required for the entire thorax (may exceed 15 seconds), which increases the risk of breathing artifacts at the level of the cardiac structures.

NOTE: *The following protocols are fully editable by the user (in particular tube current and tube voltage settings may be changed). Customized protocols can be saved as alternate protocols.*

PHILIPS BRILLIANCE iCT (ELITE/SP), IQon SPECTRAL, INGENUITY (ELITE/CORE), BRILLIANCE 64

NOTE: ***iCT Elite****, 256-slice, 128 × 0.625-mm detector row system with 80mm z-axis coverage;*
iCT SP, IQon *and* ***Ingenuity Elite****, 128-slice, 64 x 0.625mm detector row system with 40mm z-axis coverage;*
Brilliance 64 *and* ***Ingenuity Core****, 64-slice, 64 x 0.625-mm detector row systems with 40 mm coverage*

1. Surview (Topogram/Scout)		
General • AP topogram/scout covering the thorax, abdomen and pelvis including the proximal femoral to the lesser trochanter	**Data acquisition (manufacturers' default settings)** • Length: 750 mm • Tube voltage: 120 kV • Tube current: 30 mA • Field of View: 500 mm	
2. Non-enhanced scan (optional)		
General • Can be used for quantification of annular calcification • Can be used for planning of subsequent contrast-enhanced data acquisition	**Data acquisition** • Acquisition mode: Prospective ECG-triggered, axial (a.k.a. Step & Shoot) • Pulsing window: 75% of RR-interval • Tube voltage: 120 kV • Tube current: 55 mAs • Anatomical dose modulation: No • Slice/Collimation: AUTO • Scan direction cranio-caudal • Rotation time: 0.4 sec	**Data reconstruction** • Axial reconstruction within the pulsing window: 75% phase • Field of View limited to the heart: 220 mm • Slice thickness: 2.5 mm • Increment: 2.5 mm • Filter: CB
3. Locator		
General • Plan location of Locator on Surview: 2 cm below carina • Place region of interest (ROI) within the ascending aorta	**Data acquisition (manufacturers' default settings)** • Delay: None • Tube current: Automatically populated and is set to 30 mAs • Tube voltage: Automatically populated and is set to 120 kVp • Slice/Collimation: Automatically populated and is set to 16 x 0.625 mm	
4. Bolus Tracking		
General • Same location as #3 • Threshold: change/difference of 110 HU in the ROI within the ascending aorta to trigger cardiac contrast enhanced data acquisition (#5)	**Data acquisition (manufacturers' default settings)** • Delay: Variable (use minimum delay possible) • Tube current: Automatically populated and is set to 30 mAs • Tube voltage: Automatically populated and is set to 120 kVp • Slice/Collimation: Automatically populated and is set to 16 x 0.625 mm	

5. Retrospectively ECG-gated cardiac data acquisition - Contrast enhanced		
General • ECG-assisted data acquisition of the aortic root and heart • Plan data acquisition on Surview: Scan range beginning 2 cm below the carina to the base of the heart • Use unenhanced CaSc CT data for planning if available	**Data acquisition** • Acquisition mode: Retrospective ECG-gated helical • Delay after monitoring has reached threshold: 5 sec • Breath hold command: Inspiration only • Tube voltage: 120 kV • Reference tube current: 800 mAs • Anatomical dose modulation: NO • Dose modulation throughout the cardiac cycle: full exposure throughout is preferred, alternatively dose modulation with peak dose in systole • Slice/Collimation: AUTO • Scan direction cranio-caudal • Pitch: AUTO • Rotation time: Brilliance 64: 0.4 sec Ingenuity Core/Elite: 0.33 sec iCT Elite/SP, IQon: 0.27 sec	**Data reconstruction** • Axial multiphasic reconstruction covering the entire cardiac cycle , 5% or 10% intervals in sinus rhythm • Use ECG editing if necessary • Field of View limited to the heart: 220 mm • Slice thickness: 0.9 mm • Increment: 0.45 mm • Filter: XCB • Iterative reconstruction: iDose[4] or IMR

6. CTA of the thorax/abdomen/pelvis - Contrast enhanced		
General • Scan range: Upper thoracic aperture to the proximal femoral (lesser trochanter)	**Data acquisition** • Delay: Variable (use minimum delay possible) • No additional automated breath hold command; alternatively manual instruction to slowly exhale • Tube voltage: 120 kV • Reference tube current: 251 mAs • Anatomical dose modulation: Z-Modulation; 3-D Modulation • Slice/Collimation: AUTO • Scan direction: cranio-caudal • DoseRight: YES • DoseRight Index: 26 • Pitch: MAX per DRI • Rotation time: MIN per DRI • FOV: 350 mm	**Data reconstruction** • Axial reconstructions • Slice thickness thin: 3 mm • Increment: 3 mm • Filter: B for ST Recon, YB for Lung Recon • Iterative reconstruction: iDose[4] or IMR

Contrast application protocol	
General • Single contrast application for both the retrospectively ECG-gated CTA of the aortic root/heart and the CTA of the thorax/abdomen/pelvis • Placement of IV access per hospital protocol (an 18-guage IV typically provides the highest safety) • Automated contrast injection using a dual-cylinder injector	**Specific** • Recommended contrast media application: Site specific and scan protocol driven • Contrast bolus monitoring and timing of data acquisition by means of bolus tracking at the level of the ascending aorta with a region of interest placed within the ascending aorta; threshold set at 110 HU above baseline, delay to start of data acquisition after reaching threshold 5 sec

LOW-CONTRAST DOSE PROTOCOL – RATIONAL FOR ALL SCANNER TYPES

- Reduce scan length of the retrospectively ECG-gated CTA to a minimum to cover only the aortic root as opposed to the entire heart, as this is the time-intensive part in regard to data acquisition
- Injection rate and total amount of contrast may be lowered
- Threshold to trigger initiation of the retrospective ECG-gated spiral data acquisition can be lowered to 80 HU
- Reduce tube voltage to increase contrast attenuation

These alterations should allow for a sufficiently contrast enhanced CT dataset of the aortic root. Contrast attenuation of the iliofemoral acquisition may be variable.

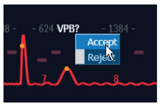
RECONSTRUCTION OF MULTIPHASIC DATA SET

The image data of the aortic root and heart should be reconstructed as multiphasic data set throughout the entire cardiac cycle in 5% or 10% intervals, allowing for cine review of the anatomy.

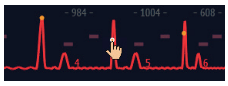
REVIEW OF DATA RECONSTRUCTION AND ECG-EDITING

- Image reconstructions of the aortic root and heart should be reviewed immediately after the scan when raw data is still available
- The ECG-gating should be reviewed to ensure that the automated algorithms correctly identified the R-peaks
- If any R points were not correctly identified, manual correction should be performed. This can enhance the quality of cardiac images in the presence of heart rate irregularities
- To activate the editing tools, click the pencil icon. If the icon is grayed out, editing has been disabled

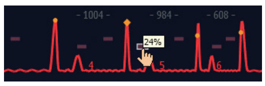
- Right-click on an arrhythmia to Accept or Reject



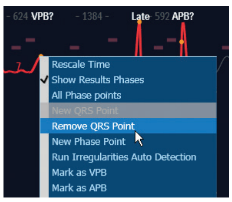
- Double-click on the wave to add a new R point
- Move an existing R point by drag and drop
- Double click on a R point to delete it



- Move phase points by drag and drop



- Additional options are available in the right-click menu



- The undo option functions with the editing tools. Click this to delete your edit

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