CT Acquisition and Reconstruction Techniques for Transcatheter Aortic Valve Procedure Planning Utilizing Canon Medical Systems

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WARNING: *Any reference to X–ray exposure, intravenous contrast dosage, and other medication is intended as a reference guideline only. The guidelines in this document do not substitute for the judgment of a health care provider. Each scan requires medical judgment by the health care 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.*

NOTE: *lgorithms/protocols included in this paper are for educational reference only. The authors do not endorse or support any one specific algorithm/protocol. It is up to each individual clinician and institution to select the treatment that is most appropriate.*

Philipp Blanke, MD is a paid consultant for Edwards Lifesciences

Introduction

Transcatheter aortic valve procedures have proven to be an effective alternative in the treatment of severe symptomatic aortic stenosis. Contrast-enhanced computed tomography (CT) is 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 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 that 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

- Position the patient, typically supine, on the scanner table to closely resemble catheterization table positioning. This is important for the prediction of C–arm angulation from the CT dataset.
- Place ECG–electrodes and IV access in accordance with institutional policies.
- Provide time for the patient to practice the breath hold prior to scan acquisition, as it may significantly improve patient compliance and thereby scan quality.
- Plan additional scanning and instruction time as needed, due to the advanced age and frailty of this patient population.

CT Scan – Scan Length and Scan Strategy

In general, three different approaches are used 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) *Systems without variable helical pitch (vHP).* Cardiac ECG–assisted data acquisition of the heart and aortic root (usually beginning 2 cm 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 to aid in limiting the contrast dose. Furthermore, limiting the ECG-assisted acquisition range also limits the radiation dose intensive component of the examination, although the cardiac scan range is covered twice. *The proposed protocols for the Aquilion ONE Vision/Genesis/PRISM, the Aquilion PRIME SP, Aquilion PRIME and Aquilion 64/VeloCT 128 Families without variable helical pitch (vHP) use this approach.*

2) *Systems utilizing 2 phase variable helical pitch (vHP 2).* ECG–assisted data acquisition of the thorax transitions to a non–ECG assisted CTA of the abdomen and pelvis. With this method, the thorax is ECG-assisted. Limit the ECG-assisted range to the necessary anatomy to reduce breath hold time for the patient and likelihood of breathing artifact. *The proposed protocols for the Aquilion ONE Vision/Genesis/PRISM, the Aquilion PRIME SP, Aquilion PRIME and Aquilion 64/VeloCT 128 Families utilizing 2 phase variable helical pitch (vHP 2) use this approach.*

3) *Systems utilizing 3 phase variable helical pitch (vHP 3).* Non-ECG-assisted CTA of the upper thorax to 2 cm below the carina, transitioning to ECG–assisted cardiac CTA, transitioning to a non–ECG assisted CTA of the abdomen and pelvis. With this method, limit the ECG-assisted range for the fastest acquisition time. Furthermore, limiting the ECG-assisted acquisition range also limits the radiation dose intensive component of the examination. *The proposed protocols for the Aquilion ONE Vision/Genesis/PRISM, the Aquilion PRIME SP, and Aquilion PRIME utilizing 3 phase variable helical pitch (vHP 3) use this approach.*

Canon Medical Systems – Aquilion ONE 640/Aquilion ONE ViSION / GENESIS / PRISM without variable helical pitch (vHP)

1. Scanogram

General

- AP/LAT Scanogram covering the thorax, abdomen, and pelvis including the proximal femoral to the lesser trochanter

Data acquisition

- AP Scanogram – 120 kVp/50 mA
- LAT Scanogram – 120 kVp/100 mA

2. Non–enhanced scan (optional) – Calcium Score

General

- Can be used for quantification of annular calcification
- Can be used for planning of subsequent contrast – enhanced data acquisition
- Volume data can be acquired as a single–beat/one rotation scan

Data acquisition

- Acquisition mode – Ca Score Volume Mode
- Tube voltage – 120 kVp
- Tube current – SUREExposure
- R–R Scanning Window – HR<71 bpm (75%); HR>71 bpm (40%) (determined by scanner)
- Slice/Collimation – 0.5/240 (120 mm)
- Rotation time – Aquilion ONE 640 / GENESIS 640 – 350 msec
  Aquilion ONE ViSION / GENESIS / PRISM – 275 msec

Data reconstruction

- Field of View limited to the heart (220 mm)
- Thick Axial Reconstructions required
  Slice Thickness – 3 mm
  Slice Interval – 3 mm
- SUREIQ – Ca Score (FC 12)

3. S&V Scan and View

General

- Plan location of SUREStart on AP Scanogram view – center of volume
- Place region of interest (ROI) within the descending aorta

Data acquisition (manufacturers' default settings)

- Delay – 0 seconds
- Tube current – 50 mA
- Tube voltage – 100 kV
- Slice/Collimation – 0.5 mm x4
- Rotation Time – Aquilion ONE 640 / GENESIS 640 – 350 msec
  Aquilion ONE ViSION / GENESIS – 275 msec

4. Bolus tracking – SUREStart

General

- Same location as #3
- Threshold– 300 HU

Data acquisition (manufacturers' default settings)

- Delay – 10 seconds
- Tube current – 50 mA
- Tube voltage – 100 kVp
- Slice/Collimation – 0.5 mm x4
- Rotation Time – Aquilion ONE 640 / GENESIS 640 – 350 msec
  Aquilion ONE ViSION / GENESIS – 275 msec
- Cycle time/repetition – 2 second intermittent interval
- Voice timing – 18 seconds

Canon Medical Systems – Aquilion ONE 640/Aquilion ONE ViSION / GENESIS / PRISM without variable helical pitch (vHP) (continued)

5. ECG–assisted cardiac data acquisition – Contrast enhanced

General

- ECG–assisted data acquisition of the aortic root and heart as a single beat/one rotation scan
- Plan volume acquisition on scanogram view – Scan range beginning 1 cm below the carina to the apex of the heart
- Use unenhanced CaSc CT data for planning if available
- C-FOV must match helical CTA

Data acquisition

- No delay after bolus monitoring has reached threshold (system starts immediately with data acquisition)
- Breath hold command – Inspiration only (Breath command initiated with Voice HU threshold set in SUREStart at 18 seconds after beginning of contrast injection)
- Tube voltage – 100 kVp
- Tube current – SUREExposure (automatically selects the tube current based on the patient size)
- Target mode set to 50% and exposure window set to 1000 msec will ensure full R–R scan. The exposure time can be adjusted based upon HR. This is a single beat/one rotation scan
- Slice/Collimation – Configured based upon desired scan range (0.5x240/0.5x280/0.5x320)
- Rotation time – Aquilion ONE 640 / GENESIS 640 – 350 msec
  Aquilion ONE ViSION / GENESIS / PRISM – 275 msec

6. CTA of the thorax/abdomen/pelvis – Contrast enhanced

General

- Scan range – Upper thoracic aperture to the proximal femoral (lesser trochanter)
- C-FOV must match volume scan

Data acquisition

- Delay – 6.4 seconds (minimum delay needed to reposition scanner table and continue with non–gated acquisition)
- No additional automated breath hold command; alternatively manual instruction to slowly exhale
- Tube voltage – 100 kVp
- Tube current – SUREExposure (automatically selects the tube current based on the patient size)
- Slice/Collimation – 0.5 mm x 100
- Scan direction – Cranio–caudal
- Pitch – Standard
- Rotation time – Aquilion ONE 640 / Genesis 640 – 350 msec
  Aquilion ONE ViSION / GENESIS / PRISM – 275 msec

Data reconstruction

- Slice thickness – 1.0 mm
- Increment – 0.8 mm
- SUREIQ – CTA Body FC 08
- Iterative reconstruction – AIDR 3D

Canon Medical Systems – Aquilion ONE 640/Aquilion ONE ViSION / GENESIS / PRISM without variable helical pitch (vHP) (continued)

Contrast application protocol

General

- Single contrast administration for both the ECG–assisted as a single beat/one rotation scan of the aortic root/heart and the CTA of the thorax/abdomen/pelvis
- Placement of IV access per institutional protocol (an 18–guage IV typically provides the highest safety)
- Automated contrast injection using a dual–cylinder injector

Specific

- Recommended contrast media application – 50–90 cc iodinated contrast medium at 4 cc/sec
- Contrast bolus monitoring and timing of data acquisition by means of bolus tracking at the level of the descending aorta with an ROI placed within the descending aorta; threshold set at 250 HU

Recommendations for a Low-Contrast Protocol

- Use lower range of total amount of contrast (50 cc)
- Place ROI for bolus tracking (^{SURE}Start) in descending aorta
- A threshold of 250 HU ensures a contrast attenuation of at least 250 HU in the aortic root, however with 50 cc of contrast, attenuation of the non–gated scan may be variable

Canon Medical Systems – Aquilion ONE 640/Aquilion ONE ViSION / GENESIS /PRISM, Aquilion Prime SP and Prime with 2-Phase Variable Helical Pitch (vHP 2 Optional)

1. Scanogram

General

- AP/LAT Scanogram covering the thorax, abdomen, and pelvis including the proximal femoral to the lesser trochanter

Data acquisition

- AP Scanogram – 120 kVp/50 mA
- LAT Scanogram – 120 kVp/100 mA

2. Non–enhanced scan (optional) – Calcium Score

General

- Can be used for quantification of annular calcification
- Can be used for planning of subsequent contrast–enhanced

Data acquisition

- Wide–Volume Scan mode
- Tube voltage – 120 kVp
- Tube current – ^{SURE}Exposure
- R–R Scanning Window – HR<71 bpm (75%) – HR>71 bpm (40%)
- Slice/Collimation – (0.5 x 80)
- Rotation time – 350 msec

Data reconstruction

- Field of View limited to the heart (220 mm)
- Thick Axial Reconstructions required
  Slice Thickness – 3 mm
  Slice Interval – 3 mm
- ^{SURE}IQ – Ca Score (FC 12)

3. S&V Scan and View

General

- Plan location of ^{SURE}Start on AP Scanogram view – 1 cm below carina
- Place region of interest (ROI) within the descending aorta

Data acquisition (manufacturers' default settings)

- Delay – 0 seconds
- Tube current – 50 mA
- Tube voltage – 100 kV
- Slice – 0.5 mm x 4
- Rotation Time – 350 msec

Canon Medical Systems – Aquilion ONE 640/Aquilion ONE ViSION / GENESIS /PRISM, Aquilion Prime SP and Prime with 2-Phase Variable Helical Pitch (vHP 2 Optional) (continued)

4. Bolus tracking – ^{SURE}Start

General

- Same location as #3
- Threshold – 180 HU

Data acquisition (manufacturers' default settings)

- Delay – 10 seconds
- Tube current – 50 mA
- Tube voltage – 100 kVp
- Slice/Collimation – 0.5 mm x 4
- Rotation Time – 350 msec
- Intermittent cycle – 2 second interval

5. ECG–gated thoracic data acquisition and non–gated data acquisition of the abdomen and pelvis – Contrast enhanced

General

- Utilize vHP (optional scan mode on Aquilion ONE and PRIME family of CT scanners)
- Allows for one helical scan/ one breath hold combining gated thoracic and non–gated abdominal/pelvic data acquisition
- Plan helical scan from above apices of the lung to the femoral lesser trochanter
- The retrospectively ECG–gated helical range can be set in the scan details. ECG-gated should start above lung apices and transition to Non-ECG assisted acquisition at the apex of the heart

Thoracic Data acquisition

- Delay after monitoring has reached threshold – 4 seconds
- Breath hold command – Inspiration only
- Tube voltage – 100 kVp
- Tube current and anatomical dose modulation – ^{SURE}Exposure XYZ Modulation
- Helical retrospectively ECG gated mode using vHP
- Slice/Collimation – 0.5 mm x 80
- Rotation time – 350 msec
- Pitch– Cardiac (automatically set by ^{SURE}Cardio)

Abdominal/Pelvic Data acquisition

- Tube voltage– 100 kVp
- Tube current and anatomical dose modulation – ^{SURE}Exposure XYZ Modulation
- Slice/Collimation – 0.5 mm x 80
- Scan direction – Cranio–caudal
- Pitch – Standard
- Rotation time – 350 msec

Data reconstruction

- Axial multiphasic reconstruction covering the entire cardiac cycle in 5% or 10% intervals
- Use ECG editing if necessary
- Field of View limited to the heart (220 mm)
- Slice thickness – 0.5 mm
- Increment – 0.3 mm
- ^{SURE}IQ – Cardiac CTA (FC 03)
- Iterative reconstruction – AIDR 3D

Data reconstruction

- Slice thickness – 1.0 mm
- Increment – 0.8 mm
- ^{SURE}IQ – CTA Body FC 08
- Iterative reconstruction – AIDR 3D
- CTA 75% Phase

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 institutional protocol (an 18–gauge IV typically provides the highest safety)
- Automated contrast injection using a dual–cylinder injector

Specific

- Recommended contrast media application – 90 cc iodinated contrast medium at 4 cc/sec
- Contrast bolus monitoring and timing of data acquisition by means of bolus tracking at the level of the descending aorta with an ROI placed within the descending aorta; threshold set at 180 HU

Canon Medical Systems – Aquilion ONE 640/Aquilion ONE ViSION / GENESIS /PRISM, Aquilion Prime SP and Prime with 3-Phase Variable Helical Pitch (vHP 3 Optional)

1. Scanogram

General

- AP/LAT Scanogram covering the thorax, abdomen, and pelvis including the proximal femoral to the lesser trochanter

Data acquisition

- AP Scanogram – 120 kVp/50 mA
- LAT Scanogram – 120 kVp/100 mA

2. Non–enhanced scan (optional) – Calcium Score

General

- Can be used for quantification of annular calcification
- Can be used for planning of subsequent contrast–enhanced

Data acquisition

- Wide–Volume Scan mode
- Tube voltage – 120 kVp
- Tube current – SUREExposure
- R–R Scanning Window – HR<71 bpm (75%) – HR>71 bpm (40%)
- Slice/Collimation – (0.5 x 80)
- Rotation time – 350 msec

Data reconstruction

- Field of View limited to the heart (220 mm)
- Thick Axial Reconstructions required
  Slice Thickness – 3 mm
  Slice Interval – 3 mm
- SUREIQ – Ca Score (FC 12)

3. S&V Scan and View

General

- Plan location of SURE Start on AP Scanogram view – 1 cm below carina
- Place region of interest (ROI) within the descending aorta

Data acquisition (manufacturers' default settings)

- Delay – 0 seconds
- Tube current – 50 mA
- Tube voltage – 100 kV
- Slice/Collimation – 0.5 mm x 4
- Rotation Time – 350 msec

4. Bolus tracking – SURE Start

General

- Same location as #3
- Threshold – 180 HU

Data acquisition (manufacturers' default settings)

- Delay – 10 seconds
- Tube current – 50 mA
- Tube voltage – 100 kVp
- Slice/Collimation – 0.5 mm x 4
- Rotation Time – 350 msec
- Intermittent cycle – 2 second interval

Canon Medical Systems – Aquilion ONE 640/Aquilion ONE ViSION / GENESIS /PRISM, Aquilion Prime SP and Prime with 3-Phase Variable Helical Pitch (vHP 3 Optional) (continued)

5. ECG–gated thoracic data acquisition and non–gated data acquisition of the abdomen and pelvis – Contrast enhanced

General

- Utilize vHP (optional scan mode on Aquilion ONE and PRIME family of CT scanners)
- Allows for one helical scan/one breath hold combining non-gated upper thoracic, gated cardiac and non–gated abdominal/pelvic data acquisition
- Plan helical scan from above apices of the lung to the femoral lesser trochanter
- Set a non-ECG-assisted range from the apices of the lungs to 1cm below the carina, transitioning there to a retrospectively ECG–gated cardiac. ECG-gated range can be set to transition at the apex of the heart to a non-ECG assisted acquisition of the abdomen and pelvis

Thoracic Data acquisition

- Delay after monitoring has reached threshold – 4 seconds
- Breath hold command – Inspiration only
- Tube voltage – 100 kVp
- Tube current and anatomical dose modulation – SUREExposure XYZ Modulation
- Helical retrospectively ECG gated mode using vHP
- Slice/Collimation – 0.5 mm x 80
- Rotation time – 350 msec
- Pitch– Cardiac (automatically set by SURECardio)

Abdominal/Pelvic Data acquisition

- Tube voltage– 100 kVp
- Tube current and anatomical dose modulation – SUREExposure XYZ Modulation
- Slice/Collimation – 0.5 mm x 80
- Scan direction – Cranio–caudal
- Pitch – Standard
- Rotation time – 350 msec

Data reconstruction

- Axial multiphasic reconstruction covering the entire cardiac cycle in 5% or 10% intervals
- Use ECG editing if necessary
- Field of View limited to the heart (220 mm)
- Slice thickness – 0.5 mm
- Increment – 0.3 mm
- SUREIQ – Cardiac CTA (FC 03)
- Iterative reconstruction – AIDR 3D

Data reconstruction

- Slice thickness – 1.0 mm
- Increment – 0.8 mm
- SUREIQ – CTA Body FC 08
- Iterative reconstruction – AIDR 3D
- CTA 75% Phase

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 institutional protocol (an 18–gauge IV typically provides the highest safety)
- Automated contrast injection using a dual–cylinder injector

Specific

- Recommended contrast media application – 90 cc iodinated contrast medium at 4 cc/sec
- Contrast bolus monitoring and timing of data acquisition by means of bolus tracking at the level of the descending aorta with an ROI placed within the descending aorta; threshold set at 180 HU

Canon Medical Systems – Aquilion Prime without variable Helical Pitch (vHP)

1. Scanogram

General
- AP/LAT Scanogram covering the thorax, abdomen, and pelvis including the proximal femoral to the lesser trochanter

Data acquisition
- AP Scanogram – 120 kVp/50 mA
- LAT Scanogram – 100 kVp/20 mA

2. Non–enhanced scan (optional) – Calcium Score

General
- Can be used for quantification of annular calcification
- Can be used for planning of subsequent contrast–enhanced data acquisition

Data acquisition
- Acquisition mode – Wide – Volume Scan Mode
- Tube voltage – 120 kVp
- Tube current – SUREExposure
- R–R Scanning Window– HR<71 bpm (75%); HR>71 bpm (40%)
- Slice/Collimation – (0.5 x 80)
- Rotation time– 350 msec

Data reconstruction
- Field of View limited to the heart (220 mm)
- Thick Axial Reconstructions required.
  Slice Thickness – 3.0 mm
  Slice Interval – 3.0 mm
- SUREIQ – Ca Score (FC12)

3. S&V Scan and View

General
- Plan location of SUREStart on AP Scanogram view – 1 cm below carina
- Place ROI within the descending aorta

Data acquisition (manufacturers' default settings)
- Delay – 0 seconds
- Tube current – 50 mA
- Tube voltage – 100 kV
- Slice/Collimation – 0.5 mm x 4
- Rotation Time – 350 msec

4. Bolus tracking – SUREStart

General
- Same location as #3
- Threshold – 180 HU

Data acquisition (manufacturers' default settings)
- Delay– 10 seconds
- Tube current – 50 mA
- Tube voltage – 100 kVp
- Slice/Collimation – 0.5 mm x 4
- Rotation Time – 350 msec
- Cycle time/repetition – 2 second intermittent interval

Canon Medical Systems – Aquilion Prime without variable Helical Pitch (vHP) (continued)

5. ECG–gated data acquisition of the aortic root/heart

General
- Retrospectively ECG–gated helical acquisition of the aortic root and heart.

ECG–gated Data acquisition of the aortic root and heart
- Delay after monitoring has reached threshold – 4 seconds
- Breath hold command – Inspiration only
- Tube voltage – 100 kVp
- Tube current and anatomical dose modulation – SUREExposure XYZ Modulation
- Helical retrospective ECG Gated
- mode
- Slice/Collimation – 0.5 mm x 80
- Rotation time – 350 msec
- Pitch – Cardiac (set by SURECardio)

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 – 0.5 mm
- Increment – 0.3 mm
- SUREIQ – Cardiac CTA (FC 03)
- Iterative reconstruction – AIDR 3D

6. CTA of the thorax/abdomen/pelvis – Contrast enhanced

General
- Non–gated data acquisition of the thorax, abdomen, and pelvis immediately following the prior data acquisition

Thorax/Abdominal/Pelvic Data acquisition
- Delay prior to scan scans – 7 seconds (minimum delay needed to reposition scanner and continue with non–gated acquisition)
- No additional automated breath hold command; alternatively manual instruction to slowly exhale
- Tube voltage – 100 kVp
- Tube current and Anatomical dose modulation – SUREExposure XYZ Modulation
- Slice/Collimation – 0.5 mm x 80
- Scan direction – Cranio–caudal
- Pitch – Standard
- Rotation time – 350 msec

Data reconstruction
- Slice thickness – 1.0mm
- Increment – 0.8 mm
- SUREIQ – CTA Body (FC 08)
- Iterative reconstruction – AIDR 3D

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 institutional protocol (an 18–guage IV typically provides the highest safety)
- Automated contrast injection using a dual–cylinder injector

Specific
- Recommended contrast media application – 80 – 100 cc iodinated contrast medium at 4 cc/sec
- Contrast bolus monitoring and timing of data acquisition by means of bolus tracking at the level of the descending aorta with an ROI placed within the descending aorta; threshold set at 180 HU

Canon Medical Systems – Aquilion 64 and Aquilion VeloCT 128 with vHP

1. Scanogram

General
- AP/LAT Scanogram covering the thorax, abdomen, and pelvis including the proximal femoral to the lesser trochanter

Data acquisition
- AP Scanogram – 120 kVp/50 mA
- LAT Scanogram – 120 kVp/100 mA

2. Non–enhanced scan (optional) – Calcium Score

General
- Can be used for quantification of annular calcification
- Can be used for planning of subsequent contrast–enhanced data acquisition

Data acquisition
- Acquisition mode – Scan & Scan (sequential mode)
- Tube voltage – 120 kVp
- Tube current – 300 mA (Aquilion 64), SUREExposure (VeloCT 128)
- R–R Scanning Window – HR<71 bpm (75%); HR>71 bpm (40%)
- Slice/Collimation – 3.0 mm x 4
- Rotation time – 400 msec, 350 msec (optional)

Data reconstruction
- Field of View limited to the heart (220mm)
- Thick Axial Reconstructions required.
  Slice Thickness – 3.0 mm
  Slice Interval – 3.0 mm
- SUREIQ – Ca Score (FC12)

3. S&V Scan and View

General
- Plan location of SURE Start on AP Scanogram view – 1 cm below carina
- Place region of interest (ROI) within the descending aorta

Data acquisition (manufacturers' default settings)
- Delay – 0 seconds
- Tube current – 50 mA
- Tube voltage – 100 kV
- Slice/Collimation – 0.5 mm x 4
- Rotation time – 400 msec (350 msec optional)

4. Bolus tracking – SURE Start

General
- Same location as #3
- Threshold – 180 HU

Data acquisition (manufacturers' default settings)
- Delay – 10 seconds
- Tube current– 50 mA
- Tube voltage – 100 kVp
- Slice/Collimation – 0.5 mm x 4
- Rotation time – 400 msec (350 msec optional)
- Cycle time/repetition – 2 second intermittent interval

Canon Medical Systems – Aquilion 64 and Aquilion VeloCT 128 with vHP (continued)

5. ECG–gated thoracic data acquisition and non–gated data acquisition of the abdomen and pelvis – Contrast enhanced

General
- Utilize Variable Helical Pitch (vHP) vHP is an optional scan mode on Aquillion 64 and Aquilion VeloCT 128 CT scanners.
- Allows for one helical scan/one breath hold combining gated/ non–gated data acquisition.
- Plan helical scan from above apices to below ischium. The retrospectively ECG–gated helical acquisition should be set to start above lung apices to below apex of the heart

Thoracic Data acquisition
- Delay after monitoring has reached threshold – 4 seconds.
- Breath hold command – Inspiration only
- Tube voltage – 100 kVp
- Tube current – fixed tube current adjusted to BMI, e.g 400 mA (Aquilion 64), SUREExposure XYZ Modulation (VeloCT 128)
- Helical retrospective ECG Gated mode using vHP
- Slice/Collimation – 0.5 x 64
- Rotation time – 400 msec, 350 msec (optional)
- Pitch – Cardiac (Set by SURECardio)

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
- Slice thickness – 0.5 mm
- Increment – 0.25 mm SUREIQ-Cardiac
  CTA FC 03 (VeloCT 128), FC 43 (Aquilion 64)
- Quantum De–noising Software (QDS +) (Aquilion 64)
- Boost 3D (Aquilion 64)
- Iterative reconstruction – AIDR 3D (VeloCT 128)

6. Contrast enhanced ECG–assisted cardiac data acquisition

General
- Non–gated data acquisition of the thorax, abdomen, and pelvis

Abdominal/Pelvic Data acquisition
- Tube voltage – 100 kVp
- Tube current and Anatomical dose modulation – SUREExposure XYZ Modulation
- Slice/Collimation – 0.5x64
- Scan direction – Cranio–caudal
- Pitch – Standard
- Rotation time – 350 msec

Data reconstruction
- Slice thickness thin – 1.0 mm
- Increment – 0.8 mm
- SUREIQ – CTA Body FC 08
- Quantum De–noising Software (QDS +) (Aquilion 64)
- Boost 3D (Aquilion 64)
- Iterative reconstruction – AIDR 3D (VeloCT 128)
- 75% phase

Canon Medical Systems – Aquilion 64 AND Aquilion VeloCT 128 without vHP

1. Scanogram

General
- AP/LAT Scanogram covering the thorax, abdomen, and pelvis including the proximal femoral to the lesser trochanter

Data acquisition
- AP Scanogram – 120 kVp/50 mA
- LAT Scanogram – 120 kVp/100 mA

Canon Medical Systems – Aquilion 64 AND Aquilion VeloCT 128 without vHP

1. Scanogram

General
- AP/LAT Scanogram covering the thorax, abdomen, and pelvis including the proximal femoral to the lesser trochanter

Data acquisition
- AP Scanogram – 120 kVp/50 mA
- LAT Scanogram – 120 kVp/100 mA

2. Non–enhanced scan (optional) – Calcium Score

General
- Can be used for quantification of annular calcification
- Can be used for planning of subsequent contrast–enhanced data acquisition

Data acquisition
- Acquisition mode – Scan & Scan (sequential mode)
- Tube voltage – 120 kVp
- Tube current – 300 mA Aquilion 64), SUREExposure (VeloCT 128)
- R–R Scanning Window – HR<71 bpm (75%); HR>71 bpm (40%)
- Slice/Collimation – 3.0 mm x 4
- Rotation time – 400 msec (350 msec optional)

Data reconstruction
- Field of View limited to the heart (220 mm)
- Thick Axial Reconstructions required.
  Slice Thickness – 3.0 mm
  Slice Interval – 3.0 mm
- SUREIQ – Ca Score (FC 12)

3. S&V Scan and View

General
- Plan location of SURE Start on AP Scanogram view – 1 cm below carina
- Place ROI within the descending aorta

Data acquisition (manufacturers' default settings)
- Delay – 0 seconds
- Tube current – 50 mA
- Tube voltage – 100 kV
- Slice/Collimation – 0.5 mm x 4
- Rotation time – 400 msec (350 msec optional)

4. Bolus tracking – SURE Start

General
- Same location as #3
- Threshold – 180 HU

Data acquisition (manufacturers' default settings)
- Delay – 0 seconds
- Tube current – 50 mA
- Tube voltage – 100 kV
- Slice/Collimation – 0.5 mm x 4
- Rotation time – 400 msec (350 msec optional)

Canon Medical Systems – Aquilion 64 AND Aquilion VeloCT 128 without vHP (continued)

5. ECG–gated data acquisition of the aortic root/heart – Contrast enhanced

General
- Retrospectively ECG–gated helical acquisition of the aortic root and hear

Thoracic Data acquisition
- Delay after monitoring has reached threshold – 0 seconds
- Breath hold command – Inspiration only
- Tube voltage 100 kVp
- Tube current – fixed tube current adjusted to BMI, e.g. 400mA (Aquilion 64), SUREExposure XYZ Modulation (VeloCT 128)
- Helical retrospective ECG-gated mode
- Slice/Collimation – 0.5 mm x 64
- Rotation time – 400 msec (350 msec optional)
- Pitch – Cardiac (set by SURECardio)

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
- Slice thickness – 0.5 mm
- Increment – 0.5 mm
  SUREIQ – Cardiac CTA FC 43 (Aquilion 64), FC 03 (VeloCT 128)
- Quantum De–Noising Software

6. Contrast enhanced ECG–assisted cardiac data acquisition

General
- Non–gated data acquisition of the thorax, abdomen, and pelvis

Abdominal/Pelvic Data acquisition
- Delay between scans – As short as possible
- Tube voltage – 100 kVp
- Tube current and Anatomical dose modulation – SUREExposure XYZ Modulation
- Slice/Collimation – 0.5 mm x 64
- Scan direction – Cranio–caudal
- Pitch– Standard
- Rotation time – 400 msec (350 msec optional)

Data reconstruction
- Slice thickness – 1.0 mm
- Increment – 0.8 mm
- SUREIQ – CTA Body FC 08
- Quantum De–Noising Software (QDS +)
- Boost 3D
- Iterative reconstruction – AIDR 3D (VeloCT 128)

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 institutional protocol (an 18–guage IV typically provides the highest safety)
- Automated contrast injection using a dual–cylinder injector

Specific
- Recommended contrast media application – 80–100 cc iodinated contrast medium at 4 cc/sec
- Contrast bolus monitoring and timing of data acquisition by means of bolus tracking at the level of the descending aorta with an ROI placed within the descending aorta; threshold set at 180 HU

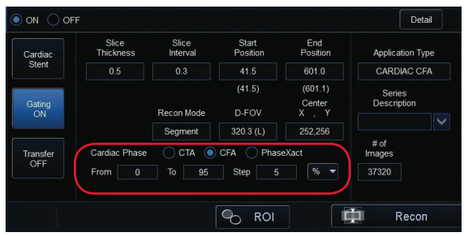
Recommendations for a Low–Contrast Protocol

- Use reduced amount of contrast material (e.g. 50 – 60 cc)
- Place ROI for bolus tracking (SUREStart) in ascending aorta as this decreases the delay between contrast administration/arrival to the start of the data acquisition
- Reduce threshold for bolus tracking to 160 HU
- Limit the Z – axis coverage of the ECG–gated data acquisition to the aortic root, as this is the time–intensive part of the examination (due to the low pitch value for ECG–gated data acquisition)
- This approach should allow for sufficient contrast attenuation of the aortic root, however contrast attenuation of the non–gated scan may be variable

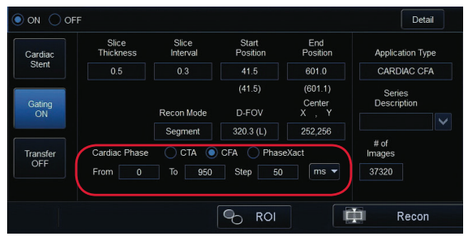
Reconstruction of Multiphasic Data Set

Multiphasic ('dynamic', 'cine') data sets can be reconstructed using a relative approach (percentage intervals [% between two R–peaks) or an absolute approach (fixed distance of the reconstruction window form the R–peak, reported as [msec]).

For retrospectively ECG–gated CT data, the relative approach (e.g. 5% or 10% intervals) performs well in regular sinus rhythm. In case of increased heart rate variability, atrial fibrillation, or ectopic beats, absolute reconstruction should be employed in combination with ECG – editing if necessary.



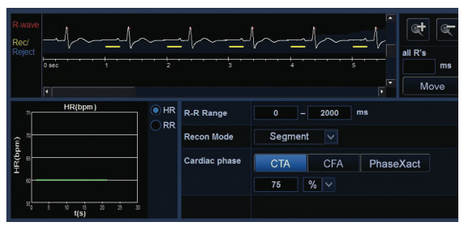
Relative Reconstruction settings in 5% intervals



Absolute Reconstruction settings in 50 ms intervals

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 R–peaks were not correctly identified, manual correction should be performed (e.g. add an R–peak if an R–peak was not identified, or delete an R– peak if an R–peak was placed on anything other than the R–peak; alternatively R–peaks can be shifted manually)
- In case of ectopic contractions, absolute reconstruction should be used and the R–peak of the ectopic beat should be deleted



ECG–editing screen showing correctly identified R–peaks.

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