

Canon

The ONE Guides

Aquilion ONE

Myocardial Perfusion Imaging

Table of Contents

Introduction.....3

Clinical Example4

Workflow6

Guidelines for Myocardial Perfusion Examinations.....8

Cardiac Reconstructions..... 15

Postprocessing: Vitrea™ fX..... 17

Myocardial Perfusion Measurements.....22

Guidelines for Use of Stress Agents
and Beta-Blockers in Cardiac CT Studies 24

Suggested Reading and References 26

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 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 radiation dose principle to balance factors such as the patient’s condition, size and age; region to be imaged; and diagnostic task.

This product may not be approved by the FDA for sale in the United States. Please consult your local Canon Medical sales representative.

Introduction

Analysis of the data obtained in the CoRE64 multicenter trial demonstrated that more than 25% of the patients examined by either CT angiography (CTA) or catheter angiography required further examination, usually a myocardial perfusion study (Miller et al. NEJM, 2008). For accurate treatment planning, it has been shown that patients with proven myocardial ischemia benefit most from revascularization (Hachamovitch et al. Circulation, 2003).

The unique ability of Aquilion ONE to acquire the entire heart in a single temporally uniform volume permits quantitative myocardial perfusion analysis to be performed with the same data used for coronary CTA. A similar acquisition during pharmacological stress permits the comprehensive evaluation of myocardial perfusion in ONE examination.

The CORE320 International multicenter trial has shown that the combination of CTA and CTP can detect flow limiting stenosis with good accuracy when compared to the combination of ICA and SPECT-MPI. The results also show that the addition of CTP to CTA adds to the diagnostic power of CTA alone (Lima J, ESC, 2012)

Comprehensive functional and morphological cardiac analysis with Aquilion ONE can reduce the need to perform multiple examinations in many patients, which saves time and money and minimizes the total exposure dose.

The scan protocol in this Guide closely follows the scan protocol used in CORE320 (George RT, et al, AJR, 2011)

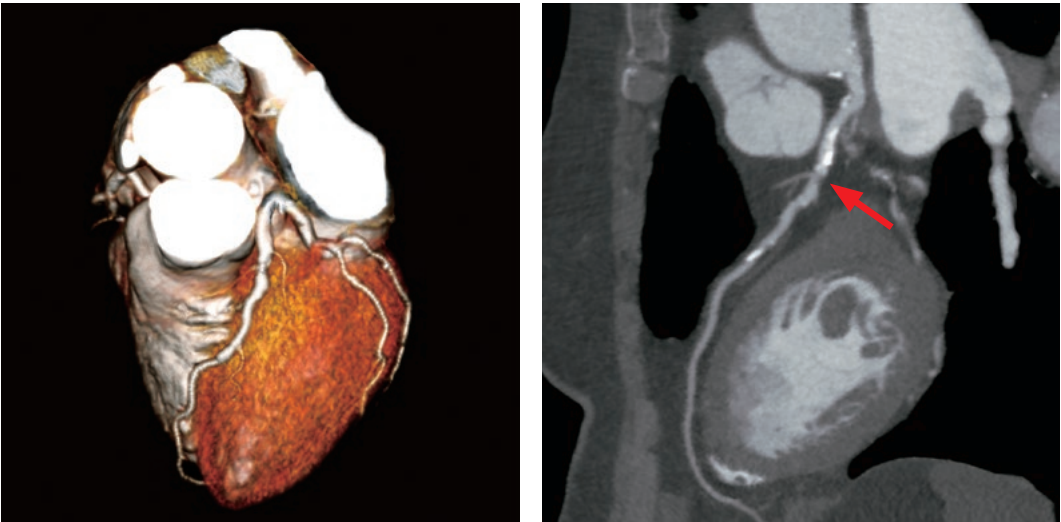


Clinical Example (Courtesy of Professor Kofoed, Rigshospitalet, Denmark)

This 80-year-old woman presented with unstable angina and shortness of breath. A CT scan was requested to rule out coronary artery disease.

CT Angiography

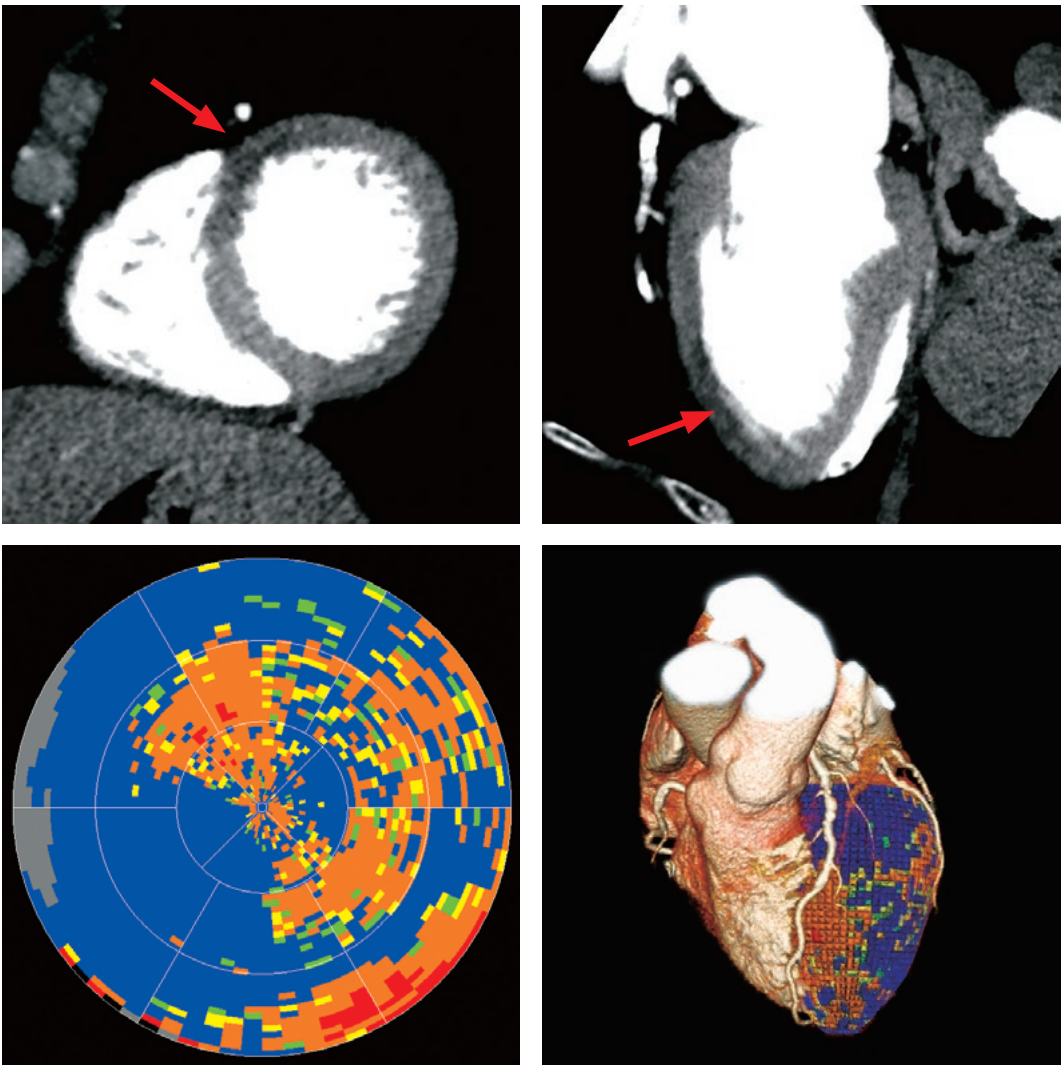
A mixed lesion is demonstrated in the proximal portion of the LAD, causing a stenosis that was determined to be greater than 70%.



A stress perfusion scan was subsequently performed to evaluate the hemodynamic significance of the LAD stenosis.

CT Perfusion

In the stress short-axis and HLA images, a low-density area is clearly demonstrated in the anterior wall. The location of the deficit corresponds to the vascular territory supplied by the LAD and its branches. The TPR polar map confirms the presence of a deficit in the anterior wall. The fusion image shows that the anterior wall territory is supplied by the LAD.



Conclusion

The stenosis of the LAD was confirmed to be hemodynamically significant in the range of 80% by catheter angiography. The associated anterior wall defect was clearly shown in the rest and stress CT perfusion images, but the deficit was less extensive in the rest images, indicating partial reversibility. Based on the results of these studies, a stent was deployed to treat the lesion in the proximal LAD.

Workflow

In order to accurately evaluate myocardial perfusion, it is necessary to acquire images both at rest and during stress. The stress images demonstrate stress-induced perfusion defects, and the rest images are compared with the stress images to assess the reversibility of these defects. If a defect is seen in both rest and stress images, it is likely to be an infarct. In CT studies, stress imaging is achieved pharmacologically using either adenosine or dipyridamole because exercise stress is impractical.

The rest scan should be performed first to obtain the highest quality CT angiogram. This scan also provides the rest perfusion data.

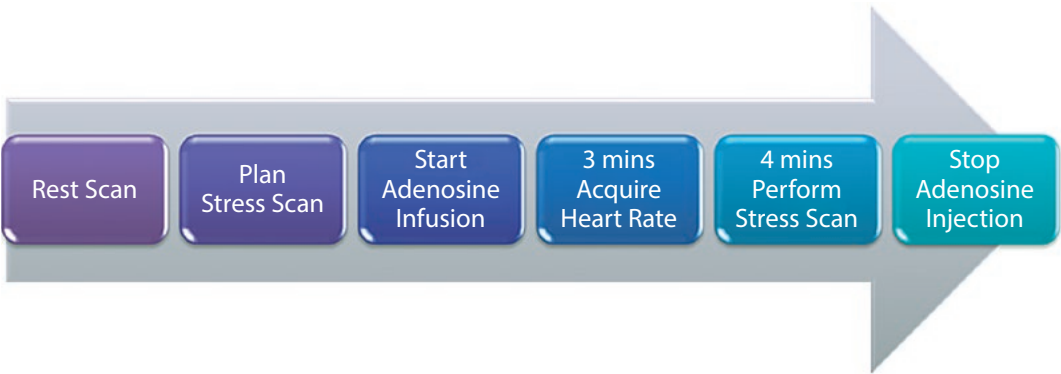
Following injection of the stress agent, the CT perfusion scan is performed.



The exact timing of the stress perfusion scan depends on the stress agent used. Two pharmacological stress agents are commonly employed, adenosine and dipyridamole.

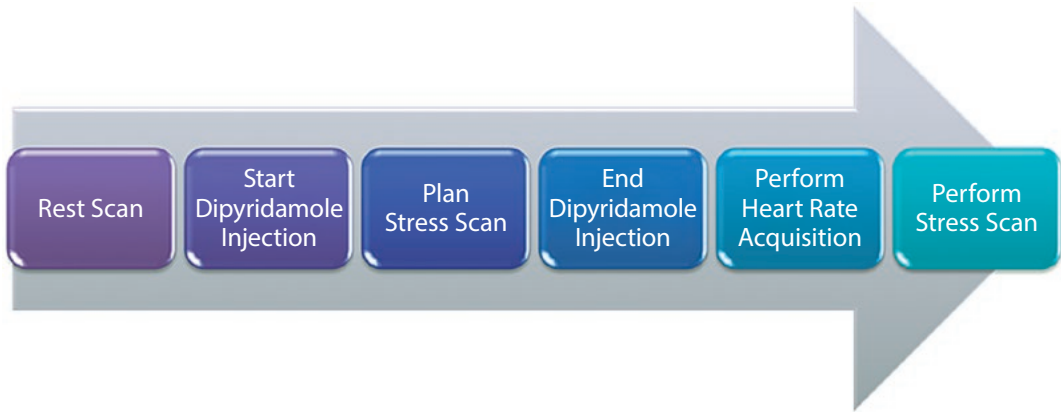
Adenosine

The effects of adenosine diminish very quickly after the injection is stopped. The stress scan must therefore be performed during adenosine injection. Generally, adenosine is injected over 5-6 minutes, and the scan must be completed before the injection is stopped.



Dipyridamole

The effects of dipyridamole are more prolonged than those of adenosine. The scan timing is therefore not as critical. The stress scan should be performed within 4 minutes after the end of the injection.



Nitroglycerine is usually not given when performing perfusion imaging due to the possible contraindications to pharmacological stress agents.

The patient's heart rate may increase by approximately 20 bpm following the injection of stress agents.

The scan and injection protocols outlined in this protocol guide have been optimized for myocardial perfusion analysis.

Guidelines for Myocardial Perfusion Examinations Rest CTA/CTP

1) Patient Preparation and Positioning

- 4-Hour fast. NO caffeine for 12 hours prior to the scan.
- Give the patient a full explanation of the procedure.
- Place a 20- or 18-gauge IV cannula in the RIGHT arm (for IV contrast).
- If adenosine is to be used, place a 22- or 20-gauge IV cannula in the left arm.
- Position the patient for an AP scanogram.
- Place the patient’s arms above their head with the ECG electrodes outside the scan range.

Confirm that a clean ECG signal is displayed before continuing!

2) ⓘ Station Breath-Hold Training

The patient should practice breath-holding before the examination is started.
The ⓘ Station should be set up to perform this directly from the CT gantry, so the recorded voice the patient hears during the scan is used for breath-hold training.
This should be a single “Breathe in and hold.” instruction.

The patient should be instructed to hold their breath at about 75% of maximum lung capacity (“Take a comfortable breath in.”) and to take the same size breath each time they are told.

This important step has two purposes:

- To ensure that the patient is familiar with the instructions given during scanning.
- To monitor the patient’s heart rate during breath-holding. Make sure that a steady heart rate is displayed with a clean ECG signal.

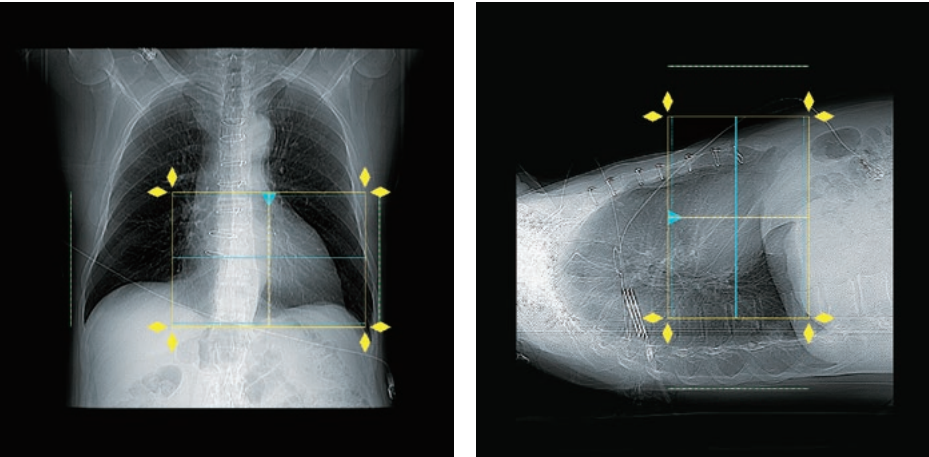
* The patient’s heart rate should not fluctuate by more than ±10% during breath-hold training.

- Beta-blockers can be administered if necessary.
See the Guidelines for Beta-Blocker Administration on page 25 for further information.

3) Planning the Rest Scan

Select the Prospective CTA scan protocol.

- Acquire AP and lateral scanograms.
- Position the volume scan to cover the entire heart.
 - Visually set a plan to cover the range from the bifurcation of the trachea to below the apex of the heart.
- Reduce the display FOV to about 200-220 mm.
 - A smaller FOV provides a higher in-plane spatial resolution.
- Place the ^{SURE}Start S&V slice at the center of the volume scan.



4) Selecting the Exposure Dose

- ^{SURE}Exposure Cardiac is used to automatically select the mA based on patient size.
- The following settings are recommended for ^{SURE}Exposure.

Cardiac	SD	^{SURE} IQ	Max mA	Min mA
CTA	33	Cardiac CTA	580	40

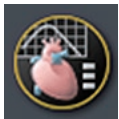
Note: The analysis algorithms have been optimized for 120 kV and 100 kV only.

Guidelines for Myocardial Perfusion Examinations Rest CTA/CTP

5) SURECardio Breathing Exercise

The SURECardio automated breathing exercise feature is used to automatically select all of the other scan parameters according to the patient’s heart rate in order to ensure that high-quality images are obtained.

- Open the SURECardio menu by clicking the heart icon in scan plan.
- Click the “Breath Ex.” icon to start the automated breath-hold practice routine.
- SURECardio monitors the patient’s heart rate during breath-hold training.
- The patient’s recorded heart rate range is displayed, and the scan parameters to ensure the optimal temporal resolution and the appropriate phase window are automatically set.



Tip: Scan Delay After Breathing Instruction

The patient’s heart rate is often unstable for the first 2 seconds after the start of breath-holding.

Be sure to provide a 2 second delay time between the breath-hold instruction and the start of scanning. A 2 second delay time can be set as a system default for all ECG-gated scans. This option is in the Set-up utility menu. The system default is set to 2 seconds

6) Guidelines for the Contrast Protocol

As a general rule:

- The injection rate and contrast volume should be increased for larger patients.
- CT perfusion requires the use of contrast medium with an iodine concentration of at least 350 mgI/mL.

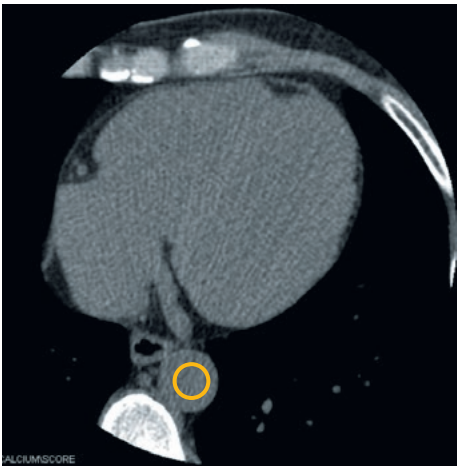
The following contrast injection protocol has been optimized for CT perfusion:

Weight (kilograms)	Weight (pounds)	Contrast	Saline	Injection Rate
<59 kg	<130 lb	50 mL	50 mL	4 mL/s
60-80 kg	131-176 lb	60 mL	50 mL	4.5 mL/s
81-100 kg	177-220 lb	60 mL	50 mL	5 mL/s
>100 kg	>220 lb	70 mL	50 mL	6 mL/s

* For larger patients, the injection rate and contrast volume should be increased to ensure adequate iodine flux, and as a result, good arterial enhancement. For smaller patients, the injection rate and volume can be reduced. In both cases, to ensure consistent results, the duration of injection should be maintained.

7) SUREStart Setup

- Acquire the SUREStart planning image.
- Confirm that the descending aorta can be clearly identified.



- The S&V slice should be locked to the center of the volume (‘lock position’ should be ON).
- The voice delay should be 14 seconds.
- Set the SUREStart trigger to 300 HU.
- Place the SUREStart ROI within the descending aorta as shown above.

The 300 HU trigger threshold has been carefully determined after extensive analysis of data. This ensures the volumetric cardiac scan is acquired at or just before peak contrast enhancement which is optimal for myocardial perfusion analysis.

8) Acquiring the Rest CT scan

Final checks:

- Reassure the patient that it is normal to experience a sensation of warmth following contrast administration.
- Confirm that the patient’s heart rate is steady.
- It is a good idea to have someone monitor the first few seconds of contrast administration to minimize the risk of extravasation.

OK to go.

- Contrast injection and scanning are started simultaneously.

Occasionally, the HU density in the descending aorta does not reach 300 HU. In this case, manually trigger the volume scan when the SUREStart contrast curve plateaus by clicking the ‘Next Scan’ button.

Guidelines for Myocardial Perfusion Examinations Stress CT Perfusion

9) Planning the Stress Scan

Select the Myocardial Stress scan protocol.
This examination uses the same scanogram as the rest scan. The magnification factor used for the rest scan is automatically applied to this protocol.

- Set the same scan start and end positions as for the rest scan.
- Place the ^{SURE}Start S&V slice at the center of the volume scan.

Scan Sequence Time Sequence						
No.	Start	Start Time	Wait	Start Pos.	End Pos.	Scan Mode
1	P	***	0.0	64.0	64.0	S&V
2	P	***	5.0	***	***	SureStart
3	A		0.0	0.0	128.0	Volume

10) Selecting the Exposure Dose

- ^{SURE}Exposure Cardiac is used to automatically select the mA based on patient size.
- The following settings are recommended for ^{SURE}Exposure.

Cardiac	SD	^{SURE} IQ	Max mA	Min mA
CTA	33	Cardiac CTA	580	40

Note: The analysis algorithms have been optimized for 120 kV and 100 kV only.

11) Stress Injection

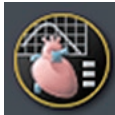
Begin injection of the pharmacological stress agent.
The patient will experience a flushing sensation.
Be sure to follow your institution's standard of care for the use of pharmacological stress agents (e.g., heart rate and blood pressure monitoring etc.).

See the Guidelines for Stress Agent Administration on page 24 for further information concerning stress agents.

12) ^{SURE}Cardio Heart Rate Acquisition

^{SURE}Cardio heart rate acquisition is used to automatically select all of the other scan parameters according to the patient's heart rate in order to ensure that high-quality images are obtained.

- Open the ^{SURE}Cardio menu by clicking the heart icon in scan plan.
- Click the "Heart Rate Acq." icon to start automated heart rate acquisition.
- The patient's recorded heart rate range is displayed, and the scan parameters to ensure the optimal temporal resolution and the appropriate phase window are automatically set.
- Confirm that the myocardial perfusion exposure window (75% to 95%) is selected.
- In this case, Breath Exercise is not used because it has been shown that during administration of pharmacological stress agents, the patient's heart rate may become unstable after the breath-hold.



13) Guidelines for the Contrast Protocol

The following contrast injection protocol has been optimized for perfusion imaging:

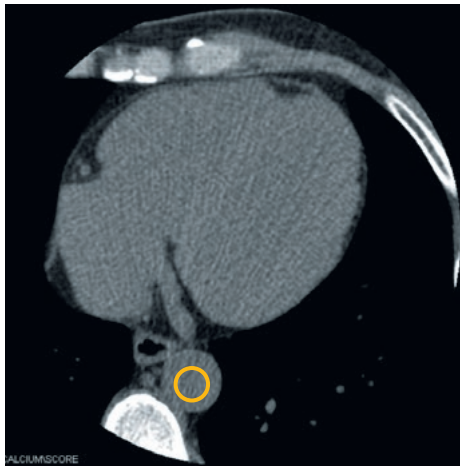
Weight (kilograms)	Weight (pounds)	Contrast	Saline	Injection Rate
<59 kg	<130 lb	50 mL	50 mL	4 mL/s
60-80 kg	131-176 lb	60 mL	50 mL	4.5 mL/s
81-100 kg	177-220 lb	60 mL	50 mL	5 mL/s
>100 kg	>220 lb	70 mL	50 mL	6 mL/s

* For larger patients, the injection rate and contrast volume should be increased to ensure adequate iodine flux, and as a result, good arterial enhancement. For smaller patients, the injection rate and volume can be reduced. In both cases, to ensure consistent results, the duration of injection should be maintained.

Guidelines for Myocardial Perfusion Examinations Stress CT Perfusion

14) SUREStart Setup

- Acquire the SUREStart planning image.
- Confirm that the descending aorta can be clearly identified.



- The S&V slice should be locked to the center of the volume ('lock position' should be ON).
- The voice delay should be 14 seconds.
- Set the SUREStart trigger to 300 HU.
- Place the SUREStart ROI within the descending aorta as shown above.

The 300 HU trigger threshold has been carefully determined after extensive analysis of data. This ensures the volumetric cardiac scan is acquired at or just before peak contrast enhancement which is optimal for myocardial perfusion analysis.

15) Acquiring the Stress CT scan

Final checks:

- Reassure the patient that it is normal to experience a sensation of warmth following contrast administration.
- Confirm that the patient's heart rate is steady.
- It is a good idea to have someone monitor the first few seconds of contrast administration to minimize the risk of extravasation.

OK to go.

- Contrast injection and scanning are started simultaneously.

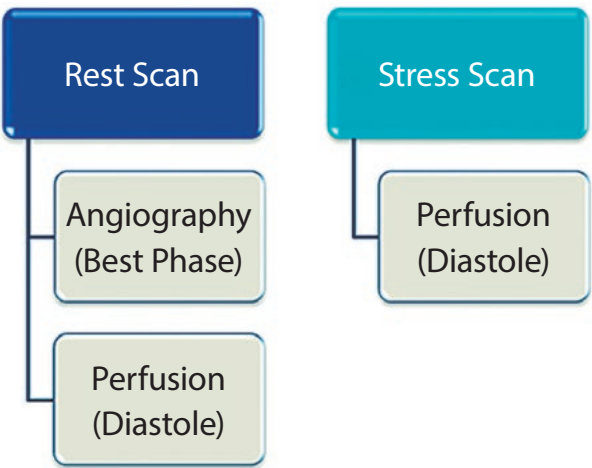
Occasionally, the HU density in the descending aorta does not reach 300 HU. In this case, manually trigger the volume scan when the SUREStart contrast curve plateaus by clicking the 'Next Scan' button.

Cardiac Reconstructions

Coronary CTA and Perfusion

The rest scan is reconstructed for both coronary CTA and rest perfusion analysis. It is necessary to ensure that the rest CTP is reconstructed in diastole to permit comparison with the stress scan.

Since phaseXact is fine-tuned for coronary CTA, it may be useful in some cases to reconstruct multiple phases in order to determine the best diastolic phase of the left ventricle for both rest and stress perfusion.



Note: The correct reconstruction algorithms should be used for the SUREStart, CTA, and CTP volumes.

Cardiac	FC	AIDR* 3D	OSR
CTA	3	Standard	Cardiac
Stent	5	Standard	Cardiac
Low Dose	2	Standard	Cardiac
Myoperfusion	3	Standard	Cardiac

Our Applications Specialists can assist in entering these optimized reconstruction parameters for perfusion imaging directly into the scan protocol.



* Adaptive Iterative Dose Reduction

Cardiac Reconstructions

phaseXact - Fully automated phase selection software

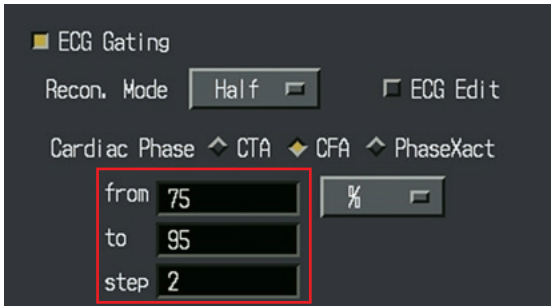
The phaseXact software automatically determines the optimal cardiac phase for motion-free imaging. Phase selection is performed in the raw data domain and requires no operator intervention.

- phaseXact is set ON in the eXam Plan.
- Select "Best Phase".

After the eXam Plan is completed, phaseXact finds and reconstructs the best motion-free cardiac phase.

Myocardial Perfusion Reconstructions

To determine the best motion-free phase of the myocardium, reconstruct volumes at every 2% of the available phase range for both the rest and stress acquisitions.

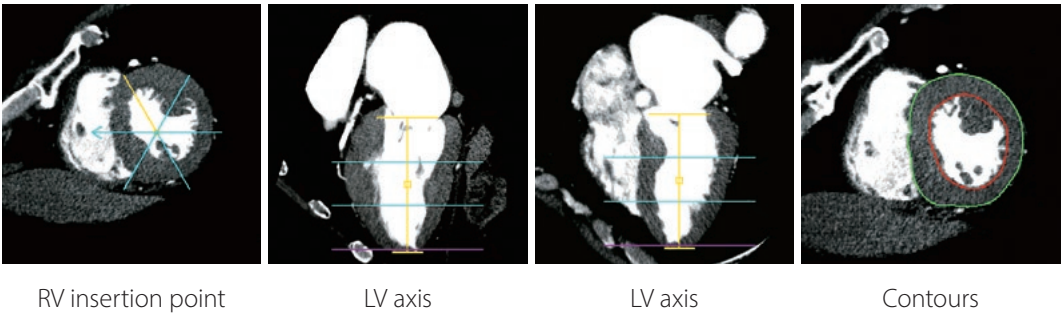


Postprocessing: Vitrea fX

This section describes the functions of the Vitrea fX.

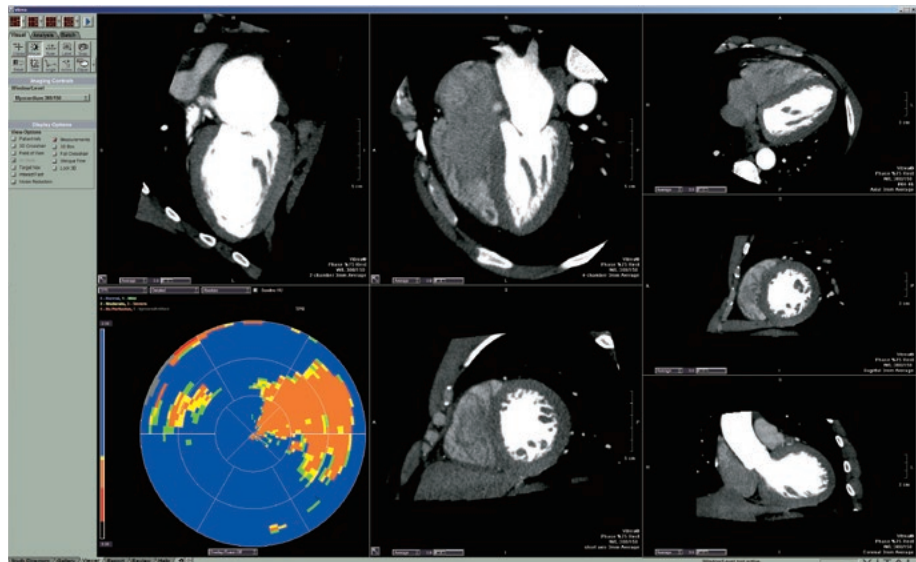
We recommend our Myocardial Perfusion Interpretation Guide for a complete description of the interpretation of myocardial perfusion images.

- Load the optimal phases selected above for rest and stress into the Vitrea myocardial perfusion analysis software. Select the Cardiac: Myocardial CT, Myocardial Perfusion protocol.
 - Align the anterior right ventricular insertion point.
 - Set the left ventricular axis using the LV Axis tool. At the base, include all slices in which the myocardium covers more than 50% of the circumference in the short axis.
 - Check the contour detection accuracy. The accuracy of any quantitative metrics is dependent on accurate subendocardial and subepicardial borders.
 - Edit the contours using the Edit tool to ensure that they are accurately fitted to the myocardium and do not include lung tissue or ventricular contrast.

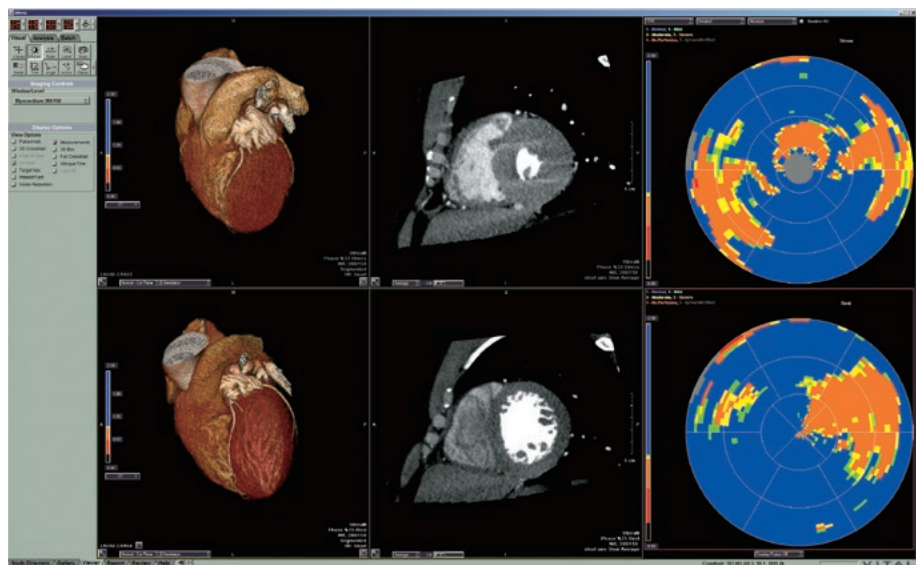


Postprocessing: Vitrea fX

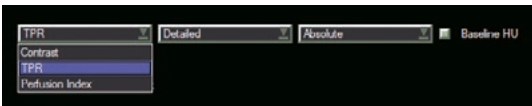
- This is the default layout. The rest data is displayed. Use the Next and Previous keys to switch between volumes.



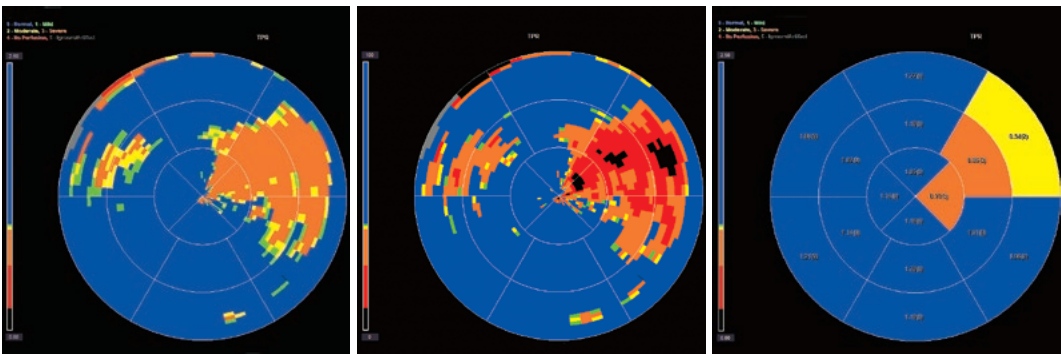
- This is the comparison layout.



- Select the analysis method:
 - Transmural Perfusion Ratio (TPR)
 - Perfusion Index
 - Contrast map



- The polar maps are displayed as absolute value, relative value, and 17 segments.



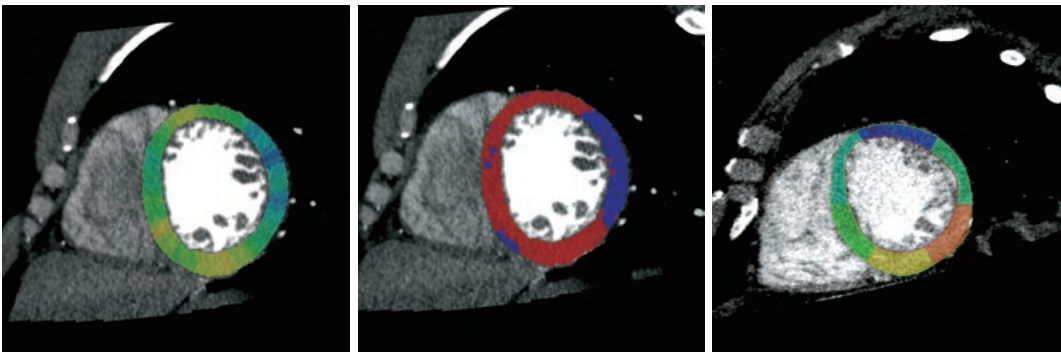
Detailed Absolute

Detailed Relative

17 Segment

Detailed = TPR value for every 2 × 2 mm voxel.
If the Normalize HU box is unchecked, the base HU value is not included in the TPR calculations.

- Maps can be overlaid onto the SA, VLA, and HLA images.



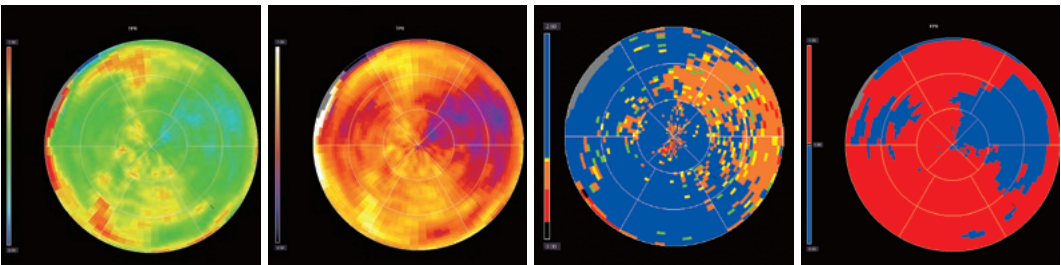
Detailed

Voxel

17 Segment

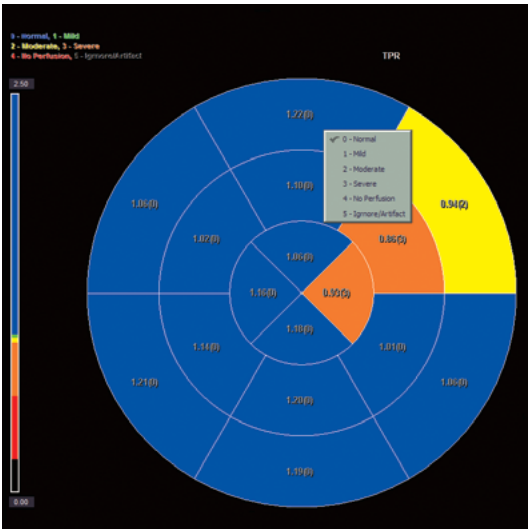
Postprocessing: Vitrea fX

- The color scale can be changed by clicking on the scale:
 - Rainbow
 - Heated
 - 5 color threshold
 - 2 color threshold

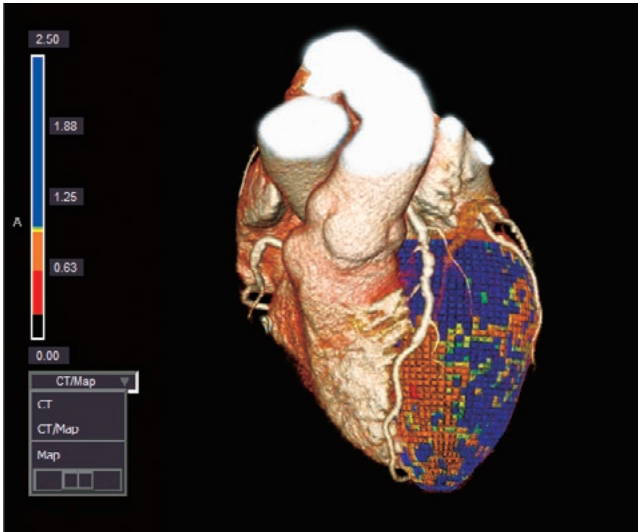


The threshold between the two colors can be changed on the scale.
The thresholds for the 5 color scale are fixed. The values for TPR are described in the Myocardial Perfusion Measurements section.

- Each segment can be labeled for severity of defect. These labels are automatically included in the Myocardial Report.



- The stress or rest perfusion map can be fused onto the 3D CT image. The amount of fusion can be adjusted.



- Note:
- The default Base HU value is 50 HU. This represents the baseline HU of the myocardium before the arrival of contrast.
 - This can be calculated manually by placing a ROI in the myocardium in a noncontrast image (calcium score scan or S&V slice).

Myocardial Perfusion Measurements

Myocardial perfusion results are displayed as polar plot maps with the left ventricle divided into 17 segments. This is the same as functional analysis polar maps. The color polar maps display colors for a 72-segment model of the left ventricle. It is very important to review the short-axis images for artifacts. Motion and beam hardening can cause artifacts that mimic low-density perfusion defects.

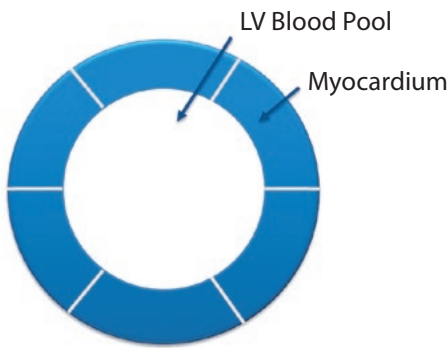
There are two perfusion analysis methods. Both are based on the ratios to the attenuation density of the myocardium. The attenuation density of the myocardium is calculated using the following equation.

ATTENUATION DENSITY = **MEAN MYOCARDIAL HU** - **BASELINE HU**

Perfusion Index
The perfusion index is calculated using the following equation. It is calculated for each segment. These results are shown in the numerical polar plot.

PERFUSION INDEX = $\frac{\text{MEAN MYOCARDIAL AD}}{\text{MEAN LV AD}}$

Where myocardial AD is the myocardial attenuation density (blue segment) and LV AD is the LV blood pool attenuation density.



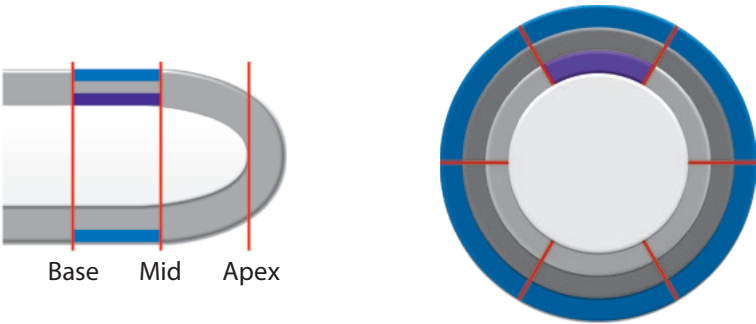
Contrast Map
A contrast map is also calculated using the following equation. It is calculated for each segment. This map shows the distribution of contrast in the myocardium and is the same as Attenuation Density.

CONTRAST MAP = **MEAN MYOCARDIAL HU** - **BASELINE HU**

TPR (Transmural Perfusion Ratio)
The TPR is calculated using the following equation. It is calculated for each segment. The myocardium is divided into subendocardial, middle, and subepicardial regions. The attenuation density in a single segment is divided by that of the total subepicardial ring for the layer (Base, Mid, Apex). Dividing the myocardium into three rings makes the early perfusion defects that occur in the subendocardial layer more obvious.

TPR = $\frac{\text{SUBENDOCARDIAL PI}}{\text{SUBEPICARDIAL PI}}$

Where TPR is the Transmural Perfusion Ratio, Subendocardial PI is the sector-specific subendocardial Perfusion Index (purple), and Subepicardial PI is the mean Perfusion Index for the entire subepicardial ring for the layer (blue).



By using the entire subepicardial layer, this algorithm attempts to limit the effect of artifacts on the results.

The TPR is considered mildly abnormal when the value is less than 0.99 (George et al., *Circulation: Cardiovascular Imaging*, 2009).

The 5 color polar map aids the reader in determining the severity of a defect by color-coding the voxels based on the TPR value. The following thresholds are used for each color:

- Normal (blue) – 2.5-0.99
- Mild (green) – 0.99-0.97
- Moderate (yellow) – 0.97-0.94
- Severe (orange) – 0.94-0.60
- No Perfusion/Infarct (red) – 0.60-0.20

These ratios have been shown to correspond closely with myocardial blood flow (MBF) (George et al. JACC, 2006) and therefore permit the semiquantitative analysis of perfusion defects.

Guidelines for Use of Stress Agents in Cardiac CT Studies

The following protocol is intended to serve as general guidelines for the use of pharmacological stress agents (specifically adenosine and dipyridamole) in cardiac CT studies. Each site should evaluate their policies and procedures regarding the use of pharmacological stress agents.

Pharmacological stress agents are administered for stress perfusion imaging.

[Note: Patients should be screened for any contraindications to the use of pharmacological stress agents.](#)

- 1) Adenosine: The amount of adenosine is based on the patient’s weight. Administer adenosine by continuous infusion via a peripheral IV line at a rate of 0.14 mg/kg/min over 5 minutes.
 - 2) Dipyridamole: The amount of dipyridamole is based on the patient’s weight. Administer dipyridamole by continuous infusion via a peripheral IV line at a rate of 0.142 mg/kg/min over 4 minutes. The maximum dose is 60 mg.
- Monitor the patient’s blood pressure and ECG during infusion.

Post-procedure guidelines

- 1) Patients who have received adenosine should remain in the department for 15 minutes after the study. The blood pressure and heart rate should be checked. Patients who are free of abnormal signs or symptoms may be released.
- 2) Patients who have received dipyridamole should remain in the department for 15 minutes after the study. The blood pressure and heart rate should be checked. Patients who are free of abnormal signs or symptoms may be released. Aminophylline can be administered to reverse the effects of dipyridamole. Administer 2 mg/kg, up to a maximum dose of 250 mg.

Guidelines for Use of Beta-Blockers in Cardiac CT Studies

The following protocol is intended to serve as general guidelines for the use of beta-blockers (specifically metoprolol) in cardiac CT studies. Each site should evaluate their policies and procedures regarding the use of beta-blockers.

Beta-blockers are administered if the patient is found to have an average resting heart rate of >70 bpm (regular rhythm) or >65 bpm (irregular rhythm).

[Note: Patients should be screened for any contraindications to the use of beta-blockers. Exclude patients with systolic blood pressure <100 mmHg.](#)

- 1) Administer 50 mg of metoprolol as a single oral dose. (Exclude patients who have received medicinal beta-blockers within the previous 4 hours.)
 - Monitor the patient every 15 minutes for 1 hour to check whether the heart rate has fallen to within the desired range of ≤70 bpm (regular rhythm) or ≤65 bpm (irregular rhythm).
- 2) If the patient’s heart rate has not fallen to within the desired range after 60 minutes, additional metoprolol can be administered intravenously.
 - Administer 2.5 mg of metoprolol by slow intravenous push over 1 minute while monitoring the patient’s heart rate and checking the blood pressure every 2 minutes.
 - If the patient’s heart rate remains high after 5 minutes and there is no evidence of hypotension, additional 2.5 mg doses of metoprolol may be administered up to a maximum of 15 mg.

Post-procedure guidelines

- 1) Patients who have received only oral metoprolol should remain in the department for 15 minutes after the study. The blood pressure and heart rate should be checked. Patients who are free of abnormal signs or symptoms may be released.
- 2) Patients who have received intravenous metoprolol should remain in the department for 30 minutes after the study. The blood pressure and heart rate should be checked. Patients who are free of abnormal signs or symptoms may be released.

Suggested Reading

Ambrose MS, Valdiviezo C, Mehra V, Lardo AC, Lima JA, George RT. CT perfusion: ready for prime time. *Curr Cardiol Rep* 2011 Feb;13(1):57–66.

George RT, Arbab-Zadeh A, Miller JM, Kitagawa K, Chang HJ, Bluemke DA, Becker L, Yousuf O, Texter J, Lardo AC, Lima JA. Adenosine stress 64- and 256-row detector computed tomography angiography and perfusion imaging: a pilot study evaluating the transmural extent of perfusion abnormalities to predict atherosclerosis causing myocardial ischemia. *Circ Cardiovasc Imaging* 2009 May;2(3):174–182.

George RT, Jerosch-Herold M, Silva C, Kitagawa K, Bluemke DA, Lima JA, Lardo AC. Quantification of myocardial perfusion using dynamic 64-detector computed tomography. *Invest Radiol* 2007;42(12):815–822.

George RT, Silva C, Cordeiro MA, DiPaula A, Thompson DR, McCarthy WF, Ichihara T, Lima JA, Lardo AC. Multidetector computed tomography myocardial perfusion imaging during adenosine stress. *J Am Coll Cardiol* 2006;48(1):153–160.

Kitagawa K, George RT, Arbab-Zadeh A, Lima JA, Lardo AC. Characterization and correction of beam-hardening artifacts during dynamic volume CT assessment of myocardial perfusion. *Radiology* 2010 Jul;256(1):111–118.

Kitagawa K, Lardo AC, Lima JA, George RT. Prospective ECG-gated 320 row detector computed tomography: implications for CT angiography and perfusion imaging. *Int J Cardiovasc Imaging (formerly Cardiac Imaging)* 2009;25(S2):201–208.

Ko BS, Cameron JD, Meredith IT, Leung M, Antonis PR, Nasis A, Crossett M, Hope SA, Lehman SJ, Troupis J, DeFrance T, Seneviratne SK. Computed tomography stress myocardial perfusion imaging in patients considered for revascularization: a comparison with fractional flow reserve. *Eur Heart J* doi:10.1093/eurheartj/ehr268.

Ko BS, Cameron JD, Defrance T Seneviratne SK. CT stress myocardial perfusion imaging using multidetector CT — a review. *J Cardiovasc Comput Tomogr* 2011;5(6):345–356.

Kühl T, Linde J, Fuchs A, Kristensen T, Kelbaeck H, George R, Hove J, Kofoed K. Patterns of myocardial perfusions in humans evaluated with contrast enhanced 320 multidetector computed tomography. *Int J Cardiovasc Imaging, Jan* 2012.

Mehra VC, Ambrose M, Valdiviezo-Schlomp C, Schuleri KH, Lardo AC, Lima JA, George RT. CT-based myocardial perfusion imaging — practical considerations: acquisition, image analysis, interpretation, and challenges. *J Cardiovasc Transl Res* 2011;4(4):437–448.

Mehra VC, Valdiviezo C, Arbab-Zadeh A, Ko BS, Seneviratne SK, Cerci R, Lima JA, George RT. A stepwise approach to the visual interpretation of CT-based myocardial perfusion. *J Cardiovasc Comput Tomogr* 2011;5(6):357–369.

Nasis A, Seneviratne S, DeFrance T. Advances in contrast-enhanced cardiovascular CT for the evaluation of myocardial perfusion. *Curr Cardiovasc Imaging Rep* 2010;3:372–381.

Valdiviezo C, Ambrose M, Mehra V, Lardo AC, Lima JA, George RT. Quantitative and qualitative analysis and interpretation of CT perfusion imaging. *J Nucl Cardiol* 2010 Dec;17(6):1091–1100.

Williams MC, Reid JH, McKillop G, Weir NW, van Beek EJ, Uren NG, Newby DE. Cardiac and coronary CT comprehensive imaging approach in the assessment of coronary heart disease. *Heart* 2011;97:1198–1205.

References

Miller JM, Rochitte CE, Dewey M, Arbab-Zadeh A, Niinuma H, Gottlieb I, Paul N, Clouse ME, Shapiro EP, Hoe J, Lardo AC, Bush DE, de Roos A, Cox C, Brinker J, Lima JA. Diagnostic performance of coronary angiography by 64-row CT. *N Engl J Med* 2008 Nov 27;359(22):2324–2336.

Hachamovitch R, Hayes SW, Friedman JD, Cohen I, Berman DS. Comparison of the short-term survival benefit associated with revascularization compared with medical therapy in patients with no prior coronary artery disease undergoing stress myocardial perfusion single photon emission tomography. *Circulation* 2003 Jun 17;107(23):2900–2907.

Lima J, Diagnostic Performance of Combined Non-invasive Coronary Angiography and Myocardial Perfusion Imaging using 320 detector Row Computed Tomography: The CORE320 Multicenter Trial, European Society of Cardiology Congress, Aug 28, 2012.

George RT, Arbab-Zadeh A, Cerci RJ, Vavere AL, Kitagawa K, Dewey M, Rochitte CE, Arai AE, Paul N, Rybicki FJ, Lardo AC, Clouse ME, Lima JA. Diagnostic performance of combined noninvasive coronary angiography and myocardial perfusion imaging using 320-MDCT: the CT angiography and perfusion methods of the CORE320 multicenter multinational diagnostic study. *AJR Am J Roentgenol* 2011 Oct;197(4):829–837.

George RT, Silva C, Cordeiro MA, DiPaula A, Thompson DR, McCarthy WF, Ichihara T, Lima JA, Lardo AC. Multidetector computed tomography myocardial perfusion imaging during adenosine stress. *J Am Coll Cardiol* 2006 Jul 4;48(1):153–160.

George RT, Arbab-Zadeh A, Miller JM, Kitagawa K, Chang HJ, Bluemke DA, Becker L, Yousuf O, Texter J, Lardo AC, Lima JA. Adenosine stress 64- and 256-row detector computed tomography angiography and perfusion imaging: a pilot study evaluating the transmural extent of perfusion abnormalities to predict atherosclerosis causing myocardial ischemia. *Circ Cardiovasc Imaging* 2009 May;2(3):174–182.



CANON MEDICAL SYSTEMS CORPORATION

<https://global.medical.canon>

©Canon Medical Systems Corporation 2010-2020. All rights reserved.
Design and specifications are subject to change without notice.
MOICT0100EAC 2020-06 CMSC/D/Printed in Japan

Canon Medical Systems Corporation meets internationally recognized standards for Quality Management System ISO 9001, ISO 13485.
Canon Medical Systems Corporation meets the Environmental Management System standard ISO 14001.

Aquilion ONE, SUREStart, SUREExposure, SUREIQ, SURECardio and Made for Life are trademarks of Canon Medical Systems Corporation.
Vitrea is a trademark of Vital Images, Inc.

Made For life