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Review

Multidetector Computer Tomography Angiography Protocol in the Context of Transcatheter Aortic Valve Implantation

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Abstract

Transcatheter aortic valve implantation is a procedure in the context of non-suitable for open surgery. Measurements of aortic root width, aortic valve surface area, and measurements of the aortic tree, coronary vessels, femoral, and subclavian arteries are of critical importance. In the TAVI procedure, the dimensions of the valve to be placed on the patient are determined by the computed tomography method. Appropriate protocols should be selected for coronary scoring and inclusion of coronary arteries in TAVI imaging and after the shooting, images of coronary arteries such as curved MPR and VRT should be processed, and these images should be prepared to guide the physician who will perform the procedure. The device to be used in imaging must be a tomography device with at least 64 MCDT sections. There are two methods for these shots using ECG triggering. These methods are as follows: Retrospective scan and prospective scan. Bolus tracking method for TAVI imaging is one of the most accurate contrast giving methods that can be used. Automatic dose calibration is used. With the success of the method day by day, the importance of "Computerized Tomography TAVI," which guides physicians during the method, has increase.

Keywords: Aortic root, Aortic valve diameter, Atherosclerotic plaque levels and degree of stenosis, Contrast injections, Coronary vessels, Diameter, Percutan aortic valve implantation, Sinus heights, Sinus valsalva, Transcatheter aortic implantation procedure width

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What is Multidetector Computed Tomography (MDCT)?

Multidetector computed tomography is a form of computed tomography (CT) technology for diagnostic imaging. It is also a transaxial cross-sectional technique into a true 3D imaging modality that allows for arbitrary cut planes as well as excellent 3D displays.

What is Transcathetery (Percutan Aortic Valve Implantation/Tavi) Aortic Valve Implantation?

Aortic stenosis is the most common valvular disease among older patients. Transcatheter aortic valve implantation is a procedure in the context of non-suitable for open surgery. As the succession of method increase day by day, pre-operative MDCT angiograph's role become more important.

What is the Importance of MDCT in Transcatheter Aortic Implantation Planning?

Measurements of aortic root width, aortic valve surface area and measurements of the aortic tree, coronary vessels, femoral, and subclavian arteries are of critical importance. Although there are different imaging modalities, TAVI performed with contrast material under CT guides physicians by giving these values. Before the transcatheter aortic im-

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plantation procedure, the artery to which the valve to be inserted into the patient will be passed must be identified and displayed in detail. Usually, the femoral artery is preferred. The "width, diameter, atherosclerotic plaque levels, and degree of stenosis" of the femoral arteries should be measured in detail and their suitability for the valve to be passed should be determined. If the femoral artery is not suitable, the subclavian artery, carotis artery, etc., where the extra valve can be passed viewing which is preferable. The FOV containing the extraction area should be prepared starting from the subclavian artery and including the femoral arteries. In this way, before the TAVI procedure, the artery where the valve will enter the body is determined by CT as preparation (Fig. 1).

In the TAVI procedure, the dimensions of the valve to be placed on the patient are determined by the CT method. In this way, valve selection with parameters suitable for the aortic valve can be performed.

Data that Have an Important Place During the Process are:

1. Diameter of femoral Arteries, plaque burden
2. Aortic root, the way the aorta exits the heart
3. Presence, degree, and extent of calcifications at the left ventricular outlet level
4. Annulus diameter, level
5. Diameter of the sinus valsalva
6. Coronary sinus heights
7. Coronary artery veins

It is shown in detail in axial, coronal, sagittal planes, and with VRT images. According to these data, appropriate valve sizes can be determined for the patients (Fig. 2).

What is the Importance of Including Coronary Angiography and Coronary Scoring in CT in Trascatheter Aortic Implantation Planning?

Appropriate protocols should be selected for coronary scoring and inclusion of coronary arteries in TAVI imaging and after the shooting, images of coronary arteries such as curved MPR and VRT should be processed, and these images should be prepared to guide the physician who will perform the procedure. It is important to measure the height of the ostia of the coronary arteries to the Annulus to select the appropriate valve before the procedure. This calculation is very important not to block the outlet of any coronary artery.

In the presence of any occlusive plaque or coronary artery disease in the coronary arteries, invasive procedures after TAVI are very difficult and undesirable, affecting the treatment. To prevent this, a more comfortable and faster planning can be made by changing the stent placement or the procedure priority during the TAVI procedure (Fig. 3).

Pre-Operative Determination of Coronary Artery Origin And Course Anomalies

The patient, whose images are below, was referred to the CT Unit, as the catheter could not be advanced during interventional angiography. As a result of the images taken, a vessel containing collaterals reaching the short areas of the aorta root and interatrial septum, was observed in the

Figure 1. Femoral artery and abdominal VRT procedure extracted from TAVI.

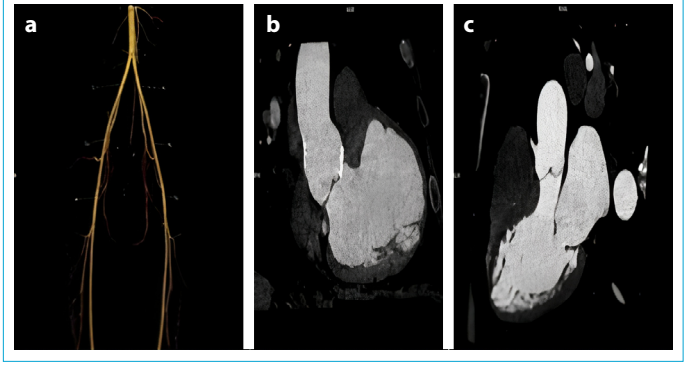

Figure 2. (a) Thoracic-abdominal VRT, **(b)** annulus calcification, and **(c)** annulus height

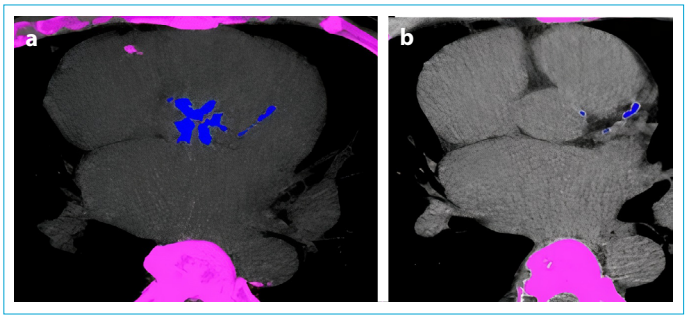

Figure 3. Blue painted areas in the scoring patient. It shows calcifications in the aorta **(a)**, patient with LAD plaques, and axial plane scoring image **(b)**.

patient's right sinus valvalsa, at the same level as the right coronary artery origin or slightly medial to it (Fig. 4).

Tavi CT Shooting Protocol and Techniques

Patient Preparation

- Patient consent form must be obtained.
- The creatinine value should be checked.
- Before the procedure, there should be 4–5 h of fasting.
- Consumption of foods containing caffeine should be stopped 3–4 days before the procedure.
- Patients should take their routine heart medications as usual. For a stable heart rate, the drugs recommended by the physician should be used regularly. If necessary, extra pulse-reducing drugs can be given to the patient in the presence of a cardiologist and radiologist.
- To receive electrocardiogram signals from the patient, at least four electrodes that can change from device to device should be placed at the level of the 5th rib, in line with the sternoclavicular joint and anterior axillary line and the signal should be received.
- The patient should be placed on the table in a supine position in a head-first position and an vascular access should be established through the right median cubital vein with a green cannula for contrast injection. Both arms of the patient should be placed above his head to avoid artifacts.
- Temperature, nausea, etc., that may occur during contrast injection to the patient. Information about complications should be given. In this way, the patient does not panic during the injection and can more easily adapt to the breathing commands given by the technician.

Figure 4. Br46 BestDiast 71% in Axial Plane

Shooting Protocol

The device to be used in imaging must be a tomography device with at least 64 MCDT sections. There are two methods for these shots using ECG triggering. These methods are as follows: Retrospective scan and prospective scan.

Prospective ECG Trigger[1] (Fig. 5)

It is also called the "Step and Shoot" method. It provides a reduction in radiation dose. It can be preferred in arrhythmic patients, especially when undergoing coronary angiography.

Retrospective ECG Coating[2] (Fig. 6)

To reach healthy data in subsequent reconstructions for TAVI protocol, retrospective images should be viewed. Retrospective imaging captures all data throughout the

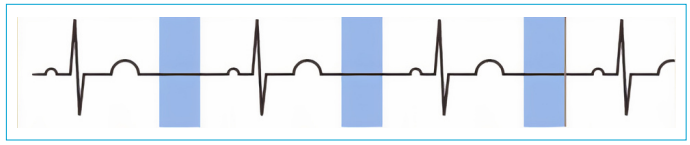

Figure 5. Prospective ECG trigger.

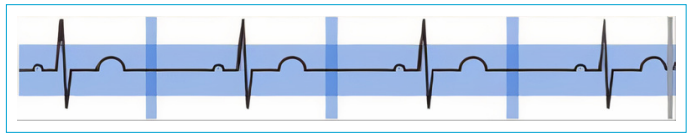

Figure 6. Retrospective ECG coating.

cardiac cycle. Next images at certain intervals are reconstructed. Reconstructed images in specific phases are positioned in the RR interval defined as a percentage. For example, 30% systolic phase for valve area measurements and 70% for 3D reformats.[3] The images taken in this format, functional and morphological evaluations can be made by reconstructing the valve and coronary artery images in the systolic and diastolic phases.[4] "Coronary Scoring" phase must be taken before contrast. There are different acquisition initiation techniques in existing protocols (Test Bolus, Time Bolus, etc.). Bolus tracking method for TAVI imaging is one of the most accurate contrast giving methods that can be used.

What is Bolus Tracking?

It is an injection method that the flow of the contrast material is observed and when the contrast material reaches sufficient maturity in the desired area the images taken.[5] A preliminary image (pre-monitoring) should be taken to include the four chambers of the patient's heart. ROI can be placed in the descending aorta or right atrium. Contrast injection and bolus tracking must be started immediately (Fig. 7).

Examples Reconstruction Parameters

Automatic dose calibration is used. However, as sample dose parameters are as follows: mAs/Rot.188, kV: 120, CTDIvol: 28 mGy, Maxtrix Size: 512, Pitch: 0.17, Scan Time: 20 s, Rotation Time: 0.28 s, Delay: 4 s, Detector Collimation: 128*0.6 mm, and Slice: 1.00 mm, Tilt: 0.

- Kernel: Body Regular 32 (Br32) Window: Cardiac, iterative beam hardening correction (*IBHC): Lodine, Slice: 1.0 mm, *Increment: 0.75 mm, Safire Strength: 4, BestDiastol (The use of Br32 increases the resolution in 3D Myocardial image.)
- Kernel: Br46, Window: Cardiac, Slice: 1.0 mm, Increment: 0.75, Safire Strength: 4 BestDiastol (Curved multiplanar curvature of coronary arteries with its increase in Br46 HU scale) provides efficiency in reformat reconstructions.)
- Kernel: Br38, Window: Cardiac, Slice: 1.0 mm, Increment: 0.75, Safire Strength: 4, (Reduces Blooming artifact opens.)

*Increment: Reducing 0.75 reduces the "STIR (Ladder) Artifact" in 3D reconstructions.

*IBHC: Traditional segmentation algorithms, iodine, and bone cannot make a clear distinction between IBCH Lodine parameter by increasing the HU scale in the coronary arteries, which provides increased resolution. In this way, the beam hardening greatly reduces artifacts (Figs. 8 and 9).

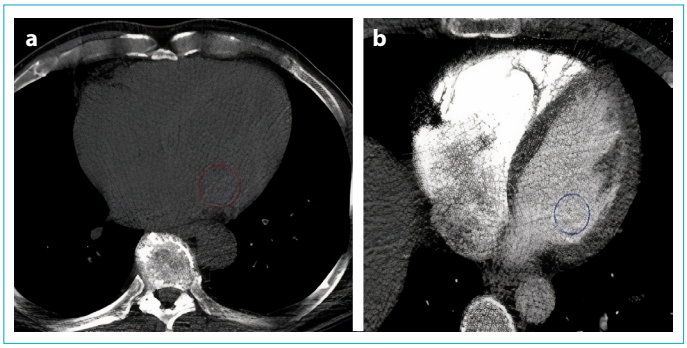

Figure 7. Front view **(a)** and bolus tracking **(b)**.

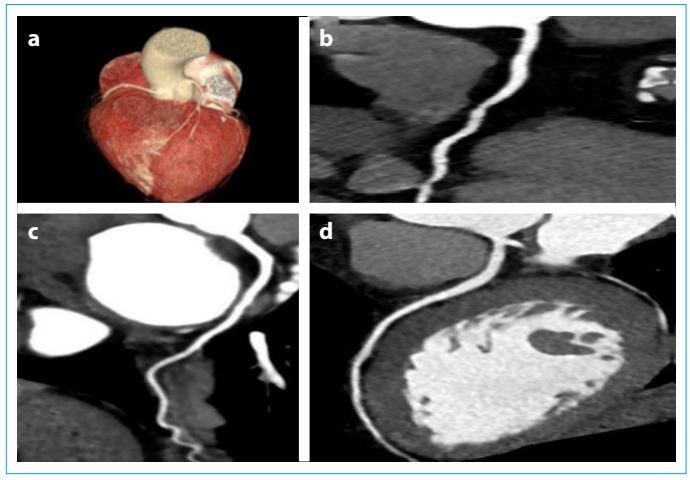

Figure 8. Myocardial VRT **(a)**, circumflex artery (cx) curved MPR **(b)**, left anterior descending artery (LAD) curved MPR **(c)**, and right coronary artery (RCA) curved MPR **(d).**

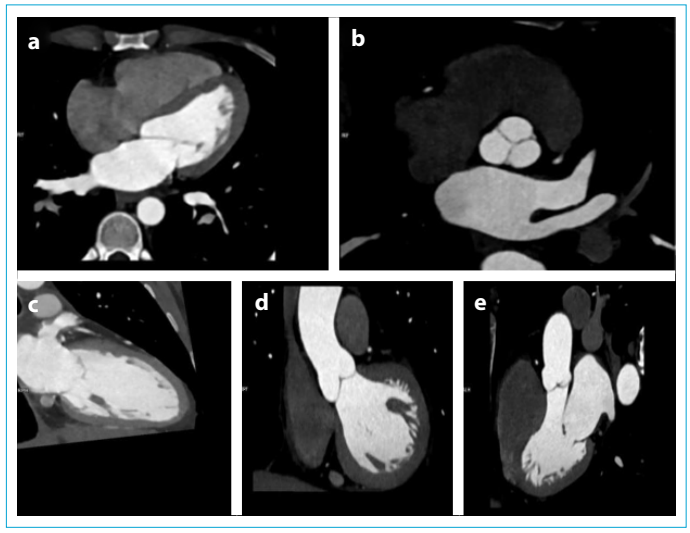

Figure 9. Apical four chamber axial image **(a)**, axial image for aortic valve **(b)**, sagittal images aortic valve, ascending aorta **(c)**, sinus heights to the annulus **(d)**, and vertical long axis LV 2-chamber mitral valve leaflets, posterior, papillary muscle and associated chordae tendinea **(e).**

Conclusion

CCTA is quick, precise and relatively painless method comparing invasive catheter angiography. It is also have results enough for doctors to make decisions that are almost 98% accurate in patients without severe disease.[6] It is able to reliably rule out coronary artery disease in patients with atypical symptoms and low-to-medium risk of disease. MDCT is a safe effective method that needs no time to recover (Fig. 10).

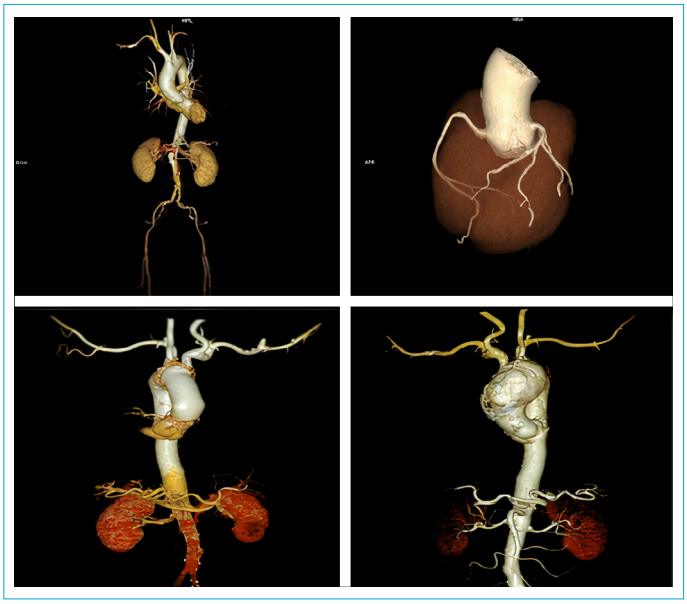

Figure 10. The patient who was operated for dissection. When the extraction requirements are calculated, the protocols to the patient most suitable TAVI protocol was selected. Pre-operative and post-operative VRT images of the patient.

All computed tomography images were taken at VRT, Curved MPR, Seyrantepe Hamidiye Etfal Training and Research Hospital, Radiology Clinic, Tomography-1 and Tomography-2 Departments, Siemens Somatom Deifinition Edge (2019), Germany, Collimation 128 × 1.0 mm device. Processed with Siemens Syngo Via30 and CT Vascular, Coronary, Ca Skoring, programs.

Disclosures

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