Journal of Cardiovascular Computed Tomography (2012) 6, 422–428

Journal of Cardiovascular Computed Tomography

Original Research Article

A method to determine suitable fluoroscopic projections for transcatheter aortic valve implantation by computed tomography

Martin Arnold, MD[a], Stephan Achenbach, MD, FSCCT[a,*], Ina Pfeiffer, MD[a], Stephan Ensminger, MD[b], Mohamed Marwan, MD[a], Friedrich Einhaus, MD[c], Tobias Pflederer, MD, FSCCT[a], Dieter Ropers, MD, FSCCT[a], Annika Schuhbaeck, MD[a], Katharina Anders, MD[d], Michael Lell, MD[d], Michael Uder, MD[d], Josef Ludwig, MD[a], Michael Weyand, MD[e], Werner G. Daniel, MD[a], Richard Feyrer, MD[e]

[a]Department of Cardiology, University of Erlangen-Nürnberg, Ulmenweg 18, 91054 Erlangen, Germany; [b]Department of Cardiovascular Surgery, Heart and Cardiovascular Centre Nordrhein-Westfalen, Bad Oeynhausen, Germany; [c]Department of Anesthesiology, University of Erlangen-Nürnberg, Erlangen, Germany; [d]Department of Radiology, University of Erlangen-Nürnberg, Erlangen, Germany and [e]Department of Cardiac Surgery, University of Erlangen-Nürnberg, Erlangen, Germany

KEYWORDS:
Computed tomography;
Transcatheter aortic valve implantation;
Transcatheter aortic valve replacement;
Angulation;
Angle;
Fluoroscopy;
Projection;
Contrast agent;
Aortogram;
Maximum intensity projection

BACKGROUND: In transcatheter aortic valve implantation (TAVI), optimal selection of fluoroscopic projections that permit orthogonal visualization of the aortic valve plane is important but may be difficult to achieve.

OBJECTIVE: We developed and validated a simple method to predict suitable fluoroscopic projections on the basis of cardiac CT datasets.

METHODS: In 75 consecutive patients that underwent TAVI, angulations in which a 35-mm thick maximum intensity projection would render all aortic valve calcium into 1 plane were determined by manual interaction with contrast-enhanced dual-source CT datasets. TAVI operators used the predicted angulation for the first aortic angiogram and performed additional aortic angiograms if no satisfactory view of the aortic valve plane was obtained. Predicted angulations were compared with the angulation used for valve implantation. Radiation exposure and contrast use was compared between patients with accurate prediction of fluoroscopic angulations by CT and patients in whom CT failed to predict a suitable view.

RESULTS: The mean difference between the predicted angulation according to CT and the angulation used for implantation was 3 ± 6 degrees. CT predicted a suitable angulation (<5-degree deviation) in 63 of 75 cases (84%). The mean number of aortic angiograms acquired in patients

Conflict of interest: The authors report no conflicts of interest.
The study was partly funded by "Forschungstiftung Medizin am Universitätsklinikum Erlangen," Erlangen, Germany.

* Corresponding author.
E-mail address: stephan.achenbach@uk-erlangen.de

Submitted August 20, 2012. Accepted for publication October 31, 2012.

http://dx.doi.org/10.1016/j.jcct.2012.10.008

with correct prediction (1.02 ± 0.1) was significantly lower than in patients with incorrect prediction of the implantation angle by CT (3.0 ± 1.7; $P < 0.001$). Contrast agent required for the entire TAVI procedure was lower in patients with correct prediction (72 ± 36 mL vs 106 ± 39 mL; $P = 0.001$).

CONCLUSION: CT permits prediction of suitable angulations for TAVI in most cases.

Introduction

Transcatheter aortic valve implantation (TAVI), also termed transcatheter aortic valve replacement gains increasing clinical importance.[1,2] Computed tomography (CT) imaging plays an important role in the screening of candidates for TAVI.[3] It is used to determine aortic and aortic root dimensions, distance of the coronary ostia from the aortic valve plane, as well as the suitability of the peripheral vessels for arterial access.[4–8]

For catheter-based implantation of the valve prosthesis, especially when the balloon-expandable Edwards-Sapien valve is used, it is important to achieve an exactly orthogonal fluoroscopic view onto the aortic valve plane. This is typically achieved through repeated aortograms during the implantation procedure, which can be time consuming and require repeated aortic contrast injections. Contrast volume can be problematic in the often multi-morbid candidates for TAVI, a relevant number of which have impaired renal function.

Because CT datasets before implantation are available in most patients undergoing TAVI, and CT offers fully 3-dimensional data, it should be possible to determine suitable projections that render an orthogonal view onto the aortic valve plane by evaluation of pre-procedure CT. However, the complex shape and the variable orientation of the aortic valve apparatus make this assessment potentially difficult. Several investigators have described CT-based approaches to identify suitable projections from the CT dataset.[9–11] In series of 20–40 patients, and using specific software for aortic root segmentation,[10,11] they report that CT allows one to determine angulations that provide an orthogonal view onto the aortic valve plane, that the accuracy depends on image quality,[11] and that CT-based prediction may enhance the implantation procedure because it provided projections rated more satisfactorily by the operators.[11] Because dedicated software to determine the angulation of the aortic valve apparatus is not widely available, and because the series reported so far were relatively small and mostly retrospective in nature,[9,10] we developed a straightforward method to interactively determine angulations that render an orthogonal view onto the aortic valve from contrast-enhanced CT datasets and determined the method's efficacy in clinical practice in a series of 75 consecutive patients.

Methods

Patients

Seventy-five consecutive patients were evaluated. All patients were scheduled for TAVI because of high-grade stenosis of a trileaflet aortic valve and had either comorbidities or an estimated operative risk that made catheter-based valve implantation preferable to conventional surgical valve replacement. All patients were scheduled for implantation of an Edwards-Sapien balloon-expandable valve. A transfemoral approach was attempted in 21 patients, and a transapical approach was planned in 54 patients. Forty patients were men and 35 were women. The patients' mean age was 82 ± 5 years (range, 59–90 years), and the mean logistic EuroScore was 33% ± 13% (range, 3%–66%).

Computed tomography

All patients underwent dual-source CT during the clinical evaluation before TAVI. CT was performed to assess the peripheral access vessels, the aorta and the aortic root, including determination of the diameters of the iliac and common femoral arteries, as well as measuring the distance of the coronary ostia from the aortic valve. No medication to lower the heart rate or for coronary vasodilation was given before CT. Dual-source CT was performed in prospectively electrocardiogram (ECG)–triggered high-pitch spiral acquisition mode with intravenous contrast enhancement according to a previously published protocol.[12] Contrast timing was achieved by a test bolus (10 mL of contrast agent at 4 mL/s followed by 50 mL of saline at 4 mL/s). For acquisition of the CT dataset, 40 mL of contrast (370 mg iodine/mL) was injected at a rate of 4 mL/s. The image acquisition window extended from above the aortic arch to below the hip. A second, "cardiac-specific" image acquisition volume was defined from the mid segment of the pulmonary arteries to just below the diaphragmatic border of the heart. Image acquisition was performed in a craniocaudal direction and was triggered to the ECG in a way so that imaging of the "cardiac-specific" window commenced at 60% of the R-peak to R-peak interval. Collimation was $2 \times 128 \times 0.6$ mm, pitch was 3.4, and gantry rotation time was 0.28 second. Tube voltage and current were