Case Reports

Percutaneous Aortic Valve Implantation Using Novel Imaging Guidance

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Thorough imaging of the aortic valve and related structures is highly important before and during percutaneous valve implantation. However, imaging modalities currently used in the catheterization room, namely, conventional aortography and transesophageal echocardiography are limited in guiding the precise valve placement during the implantation procedure. A novel real-time imaging modality capable of three-dimensional reconstruction of the ascending aorta has recently been introduced (CardioOp-THV, C-THV, Paieon Inc., Park Afek, Israel). We applied this system during a complex procedure of percutaneous aortic valve implantation in a patient with severe aortic tortuosity, large aortic-valve angulation, and asymmetric septal hypertrophy. We found the guidance system very helpful not only for accurate positioning of the valve but also for selecting the optimal projection for valve implantation, selecting the prosthetic valve size, and evaluating the results after deployment.

Key words: valvular heart disease (VALV); quantitative vascular angiography (QVA); (IMAG); imaging (CT/MR)

INTRODUCTION

On the basis of preliminary studies and accumulated practical experience, percutaneous aortic-valve implantation (PAVI) has become an alternative therapy for many patients with severe symptomatic aortic stenosis [1,2]. The transcatheter approach avoids the risks associated with surgery and cardiopulmonary bypass.

Thorough imaging of the aortic valve and related structures is highly important before and during percutaneous implantation [3,4]. However, imaging modalities currently used in the catheterization room, namely, conventional aortography and transesophageal echocardiography (TEE) are limited in guiding the operator for precise valve placement and positioning in relation to the native calcified valve during the procedure.

Our group and others have reported the development and validation of a system for three-dimensional reconstruction of coronary segments. In vivo tests yielded excellent precision, allowing better evaluation of the geometric anatomical features [5,6]. More recently, a novel imaging modality capable of three-dimensional reconstruction of the ascending aorta was introduced (CardioOp-THV, C-THV, Paieon Inc., Park Afek, Israel). The aim of this report was to describe our application of the C-THV system during PAVI in a patient with very challenging anatomic features that complicated valve deployment.

PATIENT DESCRIPTION

An 83-year-old man was examined in our department for deteriorating functional capacity (NYHA class IV). The medical history was positive for coronary artery bypass surgery 6 years previously. He also had many severe co-morbid diseases, including renal failure. Echocardiography revealed a severe aortic valve stenosis with measured valve gradients of 96/59 mm Hg and a calculated valve area of only 0.4 cm². The left

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Conflict of interest: Nothing to report.

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Received 20 October 2009; Revision accepted 21 October 2009

DOI 10.1002/ccd.22362
Published online 15 June 2010 in Wiley Online Library (wileyonlinelibrary.com).
ventricular (LV) ejection fraction was 60%. There was no significant aortic-valve regurgitation. The ascending aorta was slightly enlarged (38 mm), and there was also asymmetric septal hypertrophy of 16 mm. Thus, the diagnosis was severe symptomatic aortic-valve stenosis.

The patient was considered a very poor candidate for conventional aortic valve replacement surgery owing to his relatively old age, significant frailty, previous cardiac surgery, and other co-morbidities. The logistic EuroSCORE predicted a 17.1% risk of mortality; the logistic Parsonnet score was 31%. Therefore, we evaluated his suitability for PAVI. On TEE, the aortic valve annulus measured 22 mm. Angiography revealed patent bypass vessels. CT angiography of the thoracic aorta toward the femoral arteries revealed a severely tortuous thoracic aorta with a “question mark” appearance (Fig. 1A). The angulation of the aortic-valve horizontal plane was extreme (76°), with a “horizontal heart” morphology (Fig. 1B). The ascending aorta was enlarged (40 × 37 mm), and the peripheral vessels were larger than 8 mm, without significant tortuosity. We found the patient eligible for PAVI via the transfemoral approach, except for the significant thoracic aorta tortuosity and large aortic-valve angulation. Therefore, we decided to implant an Edwards-Sapien valve under the guidance of the C-THV system.

The patient underwent PAVI in July 2009. The procedure was performed under general anesthesia and continuous TEE monitoring.

**SELECTION OF OPTIMAL PROJECTION FOR VALVE IMPLANTATION**

The first projection was acquired empirically by the physician from the left anterior oblique (LAO) 33° and cranial (CRAN) 2°. The aortographic run images were transferred to the C-THV workstation, and the technician marked the aortic direction (Fig. 2A). The software then automatically calculated a recommendation for the second projection. Figure 2B shows the color-coded map display of the recommended angulation zones, from most recommended to restricted. The operator selected LAO 19° and caudal (CAUD) 30° projection from the blue zone for the second projection (Fig. 2B), at 35° from the previous one. Following aortography, the technician again marked the aortic direction (Fig. 2C), and the software calculated and displayed the aortic perpendicularity graph (Fig. 2D). The operator selected the ideal deployment angulation from the graph and evaluated the previously acquired run distance from that perpendicularity plane. In this case, the first marked run was 16° from the aortic perpendicular plane, and the second run, 13° away. For graft deployment, the software stipulated the LAO 20° CRAN 0° angulation, which was located exactly on the perpendicularity graph (Fig. 2E).

**SELECTION OF VALVE SIZE**

The valve annulus in our patient measured 23.0 mm by TEE, which is compatible with the Edwards-Sapien 26 mm valve (Fig. 2F). We decided to evaluate the aortic root as well, using the C-THV system. The technician measured the most prominent points on the aortic sinuses in real time in order to determine the required size of the prosthetic valve (Fig. 2G). When measurement of the first projection was completed, the technician measured the sinuses from another projection (Fig. 2H). The software automatically calculated and displayed the recommended prosthetic valve size. In this case, the sinus width measured 24.6 mm and the recommended valve size was 26 mm.

**VALVE POSITIONING**

A 26 mm Edwards-Sapien balloon-expandable aortic valve (Edwards Inc., Irvine, CA) was delivered through...
a 24-Fr introducer sheath using a Retroflex I delivery system. The operator delivered the prosthetic valve into the diseased annulus under fluoroscopic guidance according to the angulation selected by the software (LAO 20° CRAN 0°) (Fig. 3A). The technician marked the annulus target line on the program and circled an

Fig. 2. Assessment of the optimal projection for valve implantation. A: First empirical aortography from LAO 33° CRAN 2°. B: Map with recommendation for the second aortography projection. Recommended angulation zones are indicated by color: green, most recommended; blue, less recommended; black, restricted. C: Second aortography from LAO 19° CAUD 30°, selected according to the map. D: Software calculation and display of the aortic perpendicularity graph. E: Final aortography projection from the LAO 20° CRAN 0° angulation, which is located exactly on the perpendicularity graph. Choosing the valve size. F: Transesophageal echocardiographic annulus measurement of 23.0 mm, compatible with an Edwards-Sapien 26 mm valve. G, H: Aortic root measurements using the C-THV system from two different projections. The sinus width measures 24.6 mm and the recommended valve size is 26 mm. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]
opaque object that was moving synchronically with the annulus (Fig. 3B). The operator then entered the procedural parameters: approach (transfemoral), valve size (26 mm), and aorta/LV ratio of the prosthetic valve location before implantation (35%/65%). C–E: The operator carefully moves the prosthetic valve as the software tracks and displays its position in real time on fluoroscopic images. Under the system’s guidance, the operator localizes the valve exactly at the desired position, indicated by the software as a yellow target line between the green lines. Post-deployment analysis. F: Aortography after valve implantation. The prosthetic valve is deployed exactly at the desired location. G, H: Valve diameters: outer, 26.7 mm; middle, 25.3 mm; inner, 25.6 mm. These results confirm the choice of the 26-mm valve and indicate that the valve is fully opened. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

**POST-DEPLOYMENT ANALYSIS**

After the implantation procedure, aortography and TEE evaluation revealed that the prosthetic valve was deployed exactly at the desired location (Fig. 3F). The balloon-valve complex was then inflated under rapid ventricular pacing (220 Hz), and the prosthetic valve was successfully implanted.
technician measured the valve diameters in three different locations by marking two points on the valve edges. The software displayed the results as follows: outer diameter, 26.7 mm; middle diameter, 25.3 mm; inner diameter, 25.6 mm (Fig. 3G). These values confirmed that the choice of the 26 mm valve was correct and that the valve was fully opened (Fig. 3H). Only trivial paravalvular leak was demonstrated by aortography and TEE.

POST-PROCEDURAL FOLLOW-UP

The vascular access was closed surgically. The patient was transferred to the intensive care unit, and extubation was performed 2 hr later. Echocardiography showed a decrease in the aortic valve gradients (from 96/59 to 11/6 mm Hg) and an increase in the valve area (from 0.4 to 1.7 cm²). One day after the procedure, the patient commenced ambulation. There was no evidence of significant vascular or hemorrhagic complications, arrhythmias, or conduction disturbances. The patient was discharged from hospital 7 days after the procedure in excellent condition, with early evidence of significant clinical improvement. The improvement was sustained on clinical and echocardiographic follow-up 3 months later.

DISCUSSION

Optimal positioning of the prosthetic valve during PAVI is crucial in order to avoid valve embolization, coronary ostial obstruction, and perivalvular regurgitation [7,8]. Valve deployment is performed under rapid pacing with the expectation of rapid patient hemodynamic deterioration; therefore, it needs to be done as quickly and safely as possible. Valve positioning is even more complex in the presence of an extremely irregular anatomy. In these cases, PAVI using current systems carries a significant risk.

Other unresolved issues in PAVI are sizing of the prosthesis, which is crucial to avoiding patient–prosthesis mismatch complications, and selection of the best projection for deployment. Conventional two-dimensional angiography is limited for vessel evaluation [9,10]; measurements of root diameter vary markedly among echocardiography, contrast aortography, multislice computed tomography, or magnetic resonance imaging. The gold standard imaging modality for use before transcatheter valvular implantation is still controversial, and studies are lacking. Therefore, to make the procedure safe and efficient, an improved imaging technique should be used.

We describe herein the deployment of an Edwards-Sapien valve under the guidance of the novel C-THV system in a potential candidate for PAVI with severe aortic tortuosity, large aortic-valve angulation, and asymmetric septal hypertrophy. We found the system of great asset in properly positioning the valve in this very hostile anatomy. It helped us to choose the optimal projection for valve implantation, and to elect a prosthetic valve of correct size. Finally, the C-THV system confirmed that the valve struts were fully open and that there was no need for post-deployment balloon inflation. Applying the system in the catheterization laboratory did not interfere with the procedural flow, and almost all phases were performed by a technician. It should be noted that in this case, we used a Retroflex 1 delivery system. Novel delivery systems, such as, the Retroflex 3, hold promise for improving the safety of valve implantation, especially in patients with anatomic limitations for standard percutaneous procedures.

In summary, we found the C-THV system valuable in guiding transfemoral implantation of an Edwards-Sapien aortic valve in a patient with a hostile anatomy. Using the system, we were able not only to accurately position the valve but also to choose the optimal projection for valve implantation, select the proper prosthetic valve size, and evaluate the results after valve deployment.

REFERENCES