**Material adicional**

# La imagen de la raíz aórtica en la era del implante valvular aórtico percutáneo/remplazo valvular aórtico percutáneo

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## Imaging of the aortic root in the era of TAVI /TAVR

Degenerative aortic stenosis (AS) has a high prevalence in persons over 75 years[1]. Surgical valve replacement is the standard therapy for symptomatic patients with severe AS[2]. Until a few years ago, imaging of the aortic root in the context of aortic valve surgery was well standardized: Transthoracic and/or trans esophageal echocardiography was used to defined severity of stenosis (based on gradients, planimetry of AVA, etc.), details of aortic valve anatomy (including leaflet calcification, etc.), size of the root and ascending aorta, and left ventricular ejection fraction (LVEF). If details of aortic valve and root anatomy remained unclear, computed tomography (CT) and magnetic resonance imaging (MRI) occasionally provided additional information. Together with clinical information, pre-operative imaging data allowed to determinate the indication of surgery and plan its details. Importantly, at the time of surgery, direct visualization provided the opportunity to verify the imaging results. Specifically, the aortic annulus was measured with dilators to determine the correct valve size

While surgical aortic valve replacement has very good outcome, there is a significant percentage of patients with severe AS, who are not candidates for surgery because of comorbidities and anticipated increase surgical mortality. For these patients, less invasive technique and specifically percutaneous aortic valve replacement (TAVR, for Transcatheter aortic valve replacement or TAVI for Transcatheter aortic valve implantation) were developed. This novel therapeutic approach has been used in more than 50,000 patients worldwide, demonstrating its effectiveness for up to five years of follow up[4]. A characteristic feature of this procedure is the limited direct visualization of the surgical field. Therefore the procedure requires more detailed pre-operative information. Multidetector computed tomography (MDCT) provides information that is relevant for: 1) the proper selection of candidates, 2) choosing the correct valve type and size for the patient, and 3) identifying anatomical factors associated with complications[5].

## Measurement of the Aortic Annulus

One of the most important aspects prior to placement of percutaneous aortic valve is the accurate determination of the aortic annulus (AA) diameter. The AA is the base of the aortic root and represents the transition zone between the left ventricular outflow tract and the tubular aorta, it is also the scaffold for the aortic valve. Because its configuration is in most cases elliptical, two-dimensional imaging techniques such as echocardiography or angiography often underestimate the true diameter as it is measured only in one plane. In this regard, it has been shown that the MDCT and MRI provide greater accuracy in evaluating the three-dimensional anatomy of the AA due to the possibility to evaluate the major and minor diameter, the area of the ring and the area derivated diameter. AA measurements by these two methods have a low inter and intra-observer variability, and may allow more precise selection of the prosthesis size to be implanted[6,7] (Figure 1).

**Analysis of the Aortic Root.**

Pre-procedural MDCT allows to evaluate aortic root anatomy in a detailed manner. It is important to describe the distance of the valve plane to the origin of the coronary ostia, the dimensions of the aortic root, the presence, severity and extent of valvular calcification[8]. These data define inclusion and exclusion criteria for individual valve types and sizes, identify patients with increase risk of complications (rupture of the annulus, conduction abnormalities, acute coronary events secondary to embolization of calcified plaques near the origin of the coronary arteries).[9] In addition, 3-dimensional reconstruction of CT data can determinate the angulation of the valvular plane that correlates with angiographic projections used during valve implantation, which can reduce the time and radiation during the procedure.

**Access Site**

Vascular injury at the access site has been a frequent complications in the early experience with TAVR / TAVI.[10] MDCT allows superior 3-dimensional visualization of vascular and cardiac structures to decide the best access site for valve implantation. The diameter and degree of calcification of the iliac and femoral arteries, and its path and tortuosity can be identified. Small, calcified, and tortuous arteries, increase the risk of dissection and vascular perforation, and are frequent contraindications for peripheral access. Evaluation of the diameter and calcification of the ascending aorta, as well as axillary and subclavian arteries is performed. These vessels are potential alternative access sites when the femoral access cannot be used. In addition, characteristics of the left ventricular apex, including presence of apical thrombus, and its distance from the chest wall are evaluated and allow planning a transapical approach[11].

Disadvantages and limitations: One of the limitations of MDCT is exposure to radiation, but this is less relevant in the older patient population currently evaluated for TAVR / TAVI. A clinically more relevant limitation is the need for iodine contrast agent, with its risk of worsening glomerular filtration. Protocols with reduced contrast administration (e.g. intra-arterial injection for pelvic vessels) and non-contrast studies provides potential alternative in selected patients.

Perspectives: A topic of current interest is the evaluation of patients with severe aortic stenosis with low gradient and preserved left ventricular function, in which the MDCT can make a precise determination of valve area, as well as a correlation of valvular calcification with stenosis severity, especially in those cases where the severity of the stenosis is in doubt. (Figure 2).

**Conclusions**

The development of percutaneous valve replacement has had a profound impact on imaging. Peri-procedural MDCT provides relevant information for decision-making before, during, and probably after the procedure. It has been established as a tool for routine use in the TAVR/TAVI reference centers around the world.  Importantly, along with the evolution of this novel treatment modality, the imaging techniques for its evaluation are expected to evolve as well.

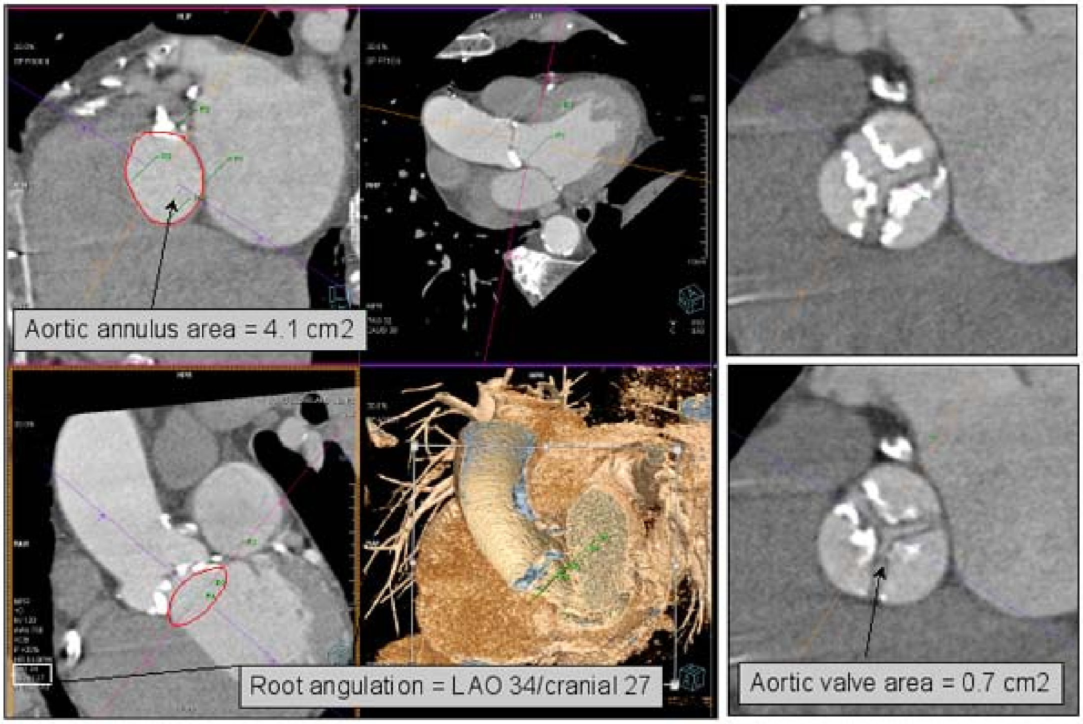


**Figure 1.** This figure demonstrates the important measurements at the aortic annulus and aortic valve. The left upper image is reformatted at the level of the aortic annulus. Annulus diameter and area are measured. On the reformatted images, modern workstations display the angiographic angulation, corresponding to the displayed image (left lower panel). This information is used for intra-operative guidance. The right-sided panels show extent and severity of valve calcification and the severely restricted aortic valve area.

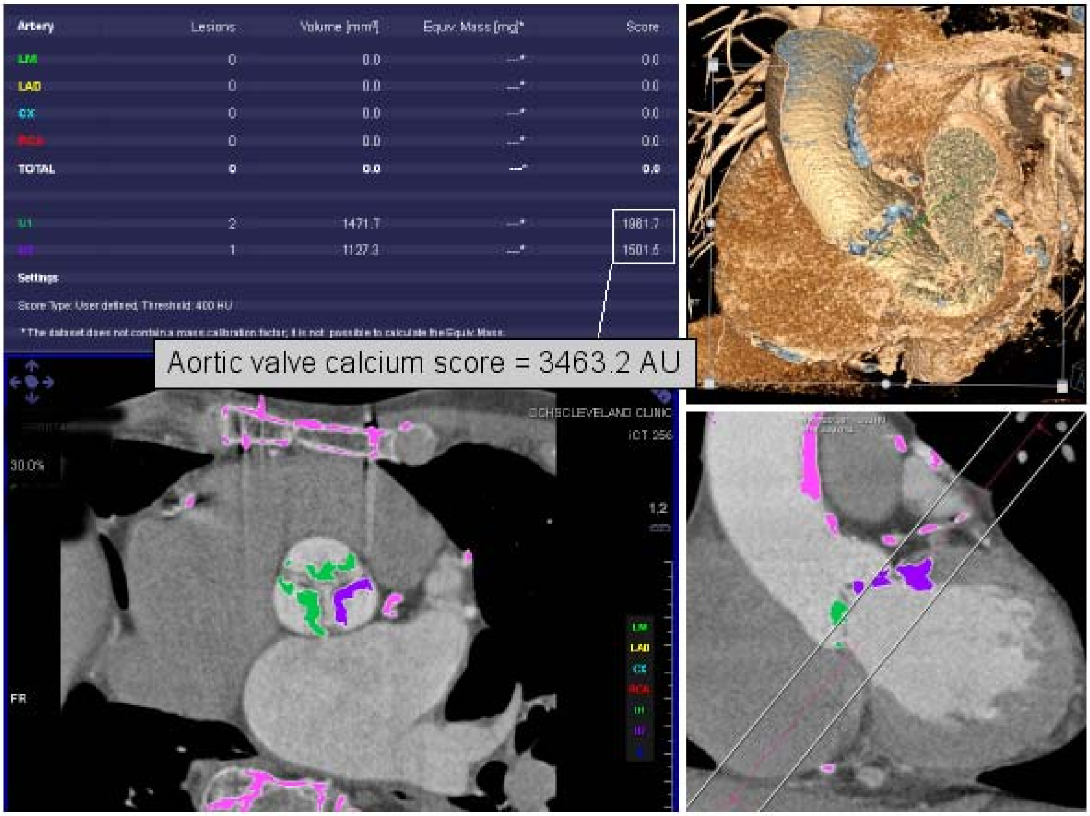


**Figure 2.** This figure shows images of the calcified aortic valve, processed in a calcium-scoring software. Quantification of calcification (score of 3463 units) allows correlation with stenosis severity.

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