

CT based planning for transaxillary valve surgery

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Clinical vignette

A 74-year-old woman with a cardiovascular history of dyslipidemia, type 2 diabetes mellitus, chronic atrial fibrillation, and a previous STEMI in 2022 treated with percutaneous coronary intervention (PCI) with a drug-eluting stent (DES) to a diagonal branch was admitted to the cardiology department for diagnostic evaluation. She presented with a recent onset of dyspnea on exertion [New York Heart Association (NYHA) functional class II–III] and echocardiographic assessment revealed a multivalvular disease involving mitral, aortic, and tricuspid valves, with surgical indication. Preoperative transesophageal echocardiography (TEE) revealed a preserved left ventricular ejection fraction (LVEF 62%) associated with severe aortic regurgitation, moderate-to-severe mitral regurgitation secondary to A2–P2 segment prolapse, and severe tricuspid regurgitation due to septal leaflet prolapse. Both the mitral and aortic valves showed rheumatic involvement of the leaflets. Invasive coronary angiography demonstrated patent coronary arteries without new significant obstructive lesions. Additionally, an angio-computed tomography (CT) scan was performed. Here we describe how to carefully analyze the CT scan to assess the feasibility of a minimally invasive approach to address the multivalvular disease.

Choosing the right intercostal space

Beyond general preoperative CT considerations—such as screening for aorto-coronary lesions, anatomical anomalies, coronary origin and course, or extensive valvular calcifications—the coronal view allows for precise assessments tailored specifically to the transaxillary approach (1-4). To do so, scrolling through the slices, we focused on the target valves to treat, and started by analyzing the fourth intercostal space, tracing a line between it and the valves. We analyzed the CT scan by carefully looking at:

I. “Drop and scroll”

- We first investigated the position of the valve inside the chest, in relation to the sternum, to be able to predict it before entering the chest—just looking at the patient’s thorax. To do so, an easy technique we apply consists of dropping the pointer on the target valve on the CT-scan coronal view, and

then scrolling towards the anterior side until we see the sternal bone. That would be the valve projection on the patient's thorax, and it helps us determine the working line in the OR to confirm the chosen intercostal space.

II. Valvular plane orientation

- To determine if that space was adequate, the angle of the line—which represents the surgeon's direct line of sight as well as the 'operative' axis—should approximate perpendicularity relative to the valvular plane. In our case, all three target valves looked perpendicular to the line made from the fourth intercostal space.

III. Working distance

- The working distance must not be excessive. The measured distances for our target valves were between 12 and 16 cm. However, the strong traction applied through the pericardial stay sutures must be considered, as this maneuver effectively approximates the valvular plane toward the incision by several centimeters.
- We consider a physical distance greater than 15 cm on the scan not as a contraindication, but as a more technically demanding scenario to manage, particularly during the early phases of the learning curve.

IV. Aortic manipulation

- Furthermore, from the selected intercostal space, it was possible to simulate the aortic cross-clamping trajectory. This helps to visualize the amount of ascending aorta available for the placement of the aortic vent and cardioplegia lines, and to evaluate overall aortic management, especially when treating aortic valve pathologies. For this case, since aortic valve surgery was planned, we gently dissected the ascending aorta from the surrounding tissues, to reach a higher safe clamping site.

V. Right superior pulmonary vein position

- The ideal line of sight should intersect the right superior pulmonary vein. This landmark is critical because its central position in the operative field serves as a reliable indicator of correct access placement, while also facilitating the straightforward insertion of a left ventricular vent as needed in our patient.

VI. Intercostal space width

- Finally, the width of the intercostal space can be evaluated. In case of ambiguity between two adjacent spaces, this assessment favors selecting the wider one, although space width is rarely a limitation due to the lateral nature of the incision, which allows the surgeon to exploit the maximum compliance and plasticity of the intercostal space.

In addition, when analyzing the aortic valve position, our projected line of sight intersected the tip of the right atrial appendage, which usually physically overlies and covers the aortic root. Anticipating this on the CT scan made us plan for a gentle traction suture on the appendage, ensuring an unhindered view of the aortic root and valve structures.

After we carefully analyzed every mentioned point, we confirmed the fourth intercostal space as our thoracic access.

Assessing peripheral vessel viability

Whether using a peripheral percutaneous or surgical cannulation, the femoral vessels must be rigorously investigated to evaluate their dimensions, the presence of calcifications, and severe tortuosity (3,4). Both the advancement of the guidewire during the Seldinger technique and, more critically, the initiation of retrograde perfusion during cardiopulmonary bypass (CPB), mandate a meticulous inspection of the entire aortoiliac axis. This is crucial to detect non-calcified, soft aortic plaques that could destabilize, mobilize, and embolize during the procedure, potentially causing catastrophic neurological or vascular events. In the presented case, no concerns about femoral cannulation and retrograde perfusion arose.

Surgical techniques

Operation

The operation was performed through the planned access at the fourth intercostal space on the anterior axillary line; a femoral cannulation was achieved through a small surgical access as per our institutional protocol. The patient underwent an aortic valve replacement with a Resilia Inspiris 19 mm bioprosthesis, a mitral valve replacement with a 29 mm Mitris bioprosthesis, and a tricuspid valve repair with the implantation of a Physio Tricuspid 28 mm ring. Additionally, left atrial appendage was occluded using a 40-mm AtriClip device.

Comments

Clinical results

CPB and cross-clamp times were 139 and 100 minutes, respectively. The patient was extubated 2 hours postoperatively. Her postoperative course was uneventful, and she was discharged home on day 6.

Advantages

The transaxillary approach represents a paradigm shift in minimally invasive valve surgery, driving innovation through procedural simplicity rather than technological complexity. To ensure this efficient, direct-vision setup is consistently reproducible and standardized without the need for robotic or endoscopic adjuncts, preoperative CT planning is utilized to gather all the essential anatomical data necessary to perform the procedure and to precisely plan the surgical access. It provides invaluable, patient-specific information regarding the peripheral vascular system, optimal intercostal space selection, and precise spatial orientation of the target valvular planes. By maximizing predictability and safety before entering the operating room, a comprehensive preoperative CT scan is key to the success of minimally invasive valve surgery.

Aligned with the core principles of procedural scalability and widespread accessibility, the analysis of the CT scan does not rely on complex, high-cost technological platforms or sophisticated proprietary software. Instead, a standard and universally available multiplanar reconstruction (MPR) is fully sufficient to extract all the essential anatomical features.

Indeed, a thorough analysis of the preoperative CT can guide the expansion of this approach to highly challenging scenarios, such as patients with severe chest wall deformities (5). Without compromising procedural safety, the standard procedural protocol can be replicated without modifications in these complex cases, provided that the preoperative CT confirms the feasibility of the intervention. In this specific setting, an additional metric is the measurement of the sterno-vertebral distance on the axial plane; this serves as a reliable index of the available intra-thoracic maneuvering space, which may be severely restricted or displaced in patients with severe skeletal deformities.

Caveats

The selection of the correct intercostal space is crucial for the success of the procedure, as it opens the definitive gateway to our surgical target. Opening the “wrong door” would yield a flawed perspective, completely undoing the geometric benefits of the transaxillary approach and making the operation significantly more challenging, or at times, impossible. Entering through an excessively low space, in fact, compromises ascending aorta manipulation and safe aortic cross-clamping; conversely, an incision that is too high increases the working distance, pushing the target structures beyond the surgeon’s optimal ergonomic reach. In both scenarios, however, an incorrect intercostal alignment jeopardizes the perpendicularity of the direct line of sight in relation to the valvular plane. While the absolute value of this angle is not explicitly measured, achieving a trajectory as perpendicular as possible to the valve plane becomes increasingly critical in complex cases. For instance, in the presence of challenging anatomical factors—such as a heavily calcified root, a small annulus, or a severely calcified valve—any deviation from perpendicularity may introduce technical complexity and undermine the advantages of this approach. Preserving this coaxial and perpendicular trajectory is a non-negotiable cornerstone of the transaxillary technique, as it restores physiological hand-eye coordination and minimizes cognitive load, ultimately ensuring that the procedure remains simple, reproducible, and accessible to all surgeons. Therefore, if any of the previously mentioned elements are unfulfilled or not completely satisfactory, the entire assessment must be repeated from the adjacent intercostal space, to choose the best option. In multi-valve procedures, the intercostal space is chosen primarily to accommodate the aortic valve trajectory, as it benefits most from favorable axial alignment. Adequate exposure for the mitral and tricuspid valves can subsequently be optimized through standard atrial retraction and intraoperative positioning.

While checking the peripheral vessels’ viability for cannulation and CPB, should any local femoral concerns arise, or if the safety of retrograde perfusion is deemed unsatisfactory, alternative strategies must be actively considered. In such scenarios, transitioning to an axillary artery cannulation strategy—either via direct cannulation or through the interposition of a side-graft—represents a highly effective and safe tactical alternative, obviously after thorough CT scan evaluation.

Our experience: tips and tricks

With the extensive experience gained over a high volume of cases performed at our center, additional complementary insights have been integrated into our systematic CT

analysis. Among these, is the important consideration of how the CT scan is acquired. Since the scan is performed with the patient's arms elevated, we have modified our intraoperative positioning for aortic valve procedures to replicate this exact posture by fixing the right arm over the patient's head, thereby minimizing any spatial discrepancy between the preoperative imaging and the intraoperative anatomy (conversely, for mitral valve interventions, this minor displacement carries less clinical relevance). Hence, arm positioning with the right arm elevated above the head is not systematically required for all patients; in our practice, this configuration is selectively adopted in procedures involving the aortic valve or in patients with abundant subcutaneous tissue or large breasts, as it helps flatten and displace soft tissue away from the surgical field. For standard cases, conventional arm positioning remains a valid alternative. Furthermore, CT images are routinely captured during deep inspiration, which displaces the diaphragm caudally. Consequently, any diaphragmatic elevation noted on the scan alerts us to the potential need for an intraoperative downward retraction suture placed through its tendinous portion and then exteriorized through the chest wall.

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Footnote

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