

# Computed tomography to improve TAVI outcomes

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Transcatheter aortic valve implantation (TAVI) has been a breakthrough therapy for patients with severe symptomatic aortic stenosis (AS) and at high risk or having contraindications for conventional surgical aortic valve replacement (SAVR). Advances in device development (prosthetic valves and delivery systems), learning curves and improvement in visualisation of the aortic root anatomy and spatial orientation have resulted in improved outcomes with procedural success in over 95% of cases.<sup>1</sup> In addition, data from the PARTNER B trial demonstrated 20% absolute reduction in one-year mortality for patients treated with TAVI compared with patients medically treated and an additional 16.9% reduction between one and two-year follow-up. Besides patient selection, including careful evaluation of frailty and associated comorbidities that may limit the benefits of TAVI, accurate selection of prosthesis size and procedural approach as well as accurate procedural guidance are the cornerstones to maximise the TAVI outcomes and minimise complications.

Undersizing of the transcatheter prosthesis may result in significant paravalvular aortic regurgitation (PAVR) or, more rarely, in prosthesis migration.<sup>2</sup> In contrast, oversizing the prosthesis has been associated with a lower incidence of significant PAVR, but an increased risk of annulus rupture, which is a rare and fatal complication.<sup>3</sup> Data from the PARTNER trial and several other registries have demonstrated the clinical implications of moderate and severe PAVR; in the PARTNER trial the presence of PAVR doubled the mortality risk of patients treated with TAVI (hazard ratio 2.11; 95% confidence interval 1.43-3.10;  $p < 0.001$ ).<sup>4</sup> Furthermore, inadequate selection of transfemoral access has been associated with a significant risk of vascular complications which double the procedural mortality. The rates of vascular complications reported in the PARTNER trial (cohorts A and B) and several multicentre registries ranged between 10% and 18%.<sup>4,6</sup> Small arterial diameters, tortuous arteries as well as the extent and location of vascular calcification are predictors of major vascular complications. Finally, the current expert consensus document on TAVI recommends the use of hybrid rooms with the capability for advanced X-ray imaging and echocardiography, anaesthesia and cardiopulmonary support.<sup>7</sup> Accurate procedural guidance is key to optimising the positioning and deployment of the prosthesis and to minimising the number of repeated injections of iodinated contrast that may increase the risk of acute kidney injury.

Until now, echocardiography and invasive angiography have been the most widely used techniques to size the aortic annulus, select the access (transfemoral or transapical) and guide the procedure. However,

accumulating evidence shows the relevant role of MDCT to address all these issues, providing comprehensive information on aortic annulus dimensions and anatomy of the peripheral arteries and permitting anticipation of the X-ray angiographic projections to deploy the prosthesis.<sup>8</sup> In addition, intraoperative three-dimensional (3-D) rotational angiography (Dyna-CT) permits alignment of the nadirs of the aortic valve sinuses to derive the angiographic angle automatically and to obtain the precise aortic annulus plane to deploy the prosthesis.

In the current issue of the Journal, two articles confirm the relevance of MDCT and 3-D rotational angiography in TAVI procedures.<sup>9,10</sup> Hayashida and coworkers demonstrated that selection of prosthesis size based on MDCT measurements of the aortic annulus resulted in significantly reduced incidence of significant PAVR as

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compared with a selection based on two-dimensional (2-D) transoesophageal (TEE) echocardiographic measurements (15.4% versus 24.0%;  $p = 0.04$ ).<sup>9</sup> These results confirm and extend previous findings showing the independent association between aortic annulus dimensions assessed with MDCT and the presence of significant PAVR.<sup>2,11</sup> Jilalihawi et al described a significantly higher incidence of at least mild PAVR in patients in whom the prosthesis size was selected based on 2-D TEE compared with patients in whom the prosthesis size was selected based on MDCT measurements.<sup>2</sup> MDCT permits accurate cross-sectional assessment of the aortic annulus dimensions and frequently yields larger diameters than 2-D echocardiography resulting in the selection of a larger prosthesis. Indeed, several studies have suggested that a certain grade of prosthesis oversizing results in a lower incidence of significant PAVR. Willson et al showed that a large difference between the transcatheter aortic valve size and the MDCT aortic annular dimensions (undersized prosthesis) was predictive of PAVR.<sup>11</sup> Importantly, oversizing the transcatheter aortic valve resulted in reduced incidence of PAVR without increasing the incidence of annulus rupture, underexpansion or malfunction of the prosthesis. Although current recommendations do not indicate the preferred imaging modality for aortic annulus sizing, the evidence shows that 3-D imaging techniques, and particularly MDCT, may provide better TAVI outcomes than 2-D imaging modalities.

In addition, the article by Poon and colleagues shows the role of 3-D rotational angiography to define the angiographic angles in determining the optimal aortic plane to deploy the prosthesis.<sup>10</sup> The implementation of the novel aortic valve guide software (Siemens AG, Erlangen,

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Germany) to the currently available Dyna-CT system (Siemens AG) permits automatic registration of the coronary artery ostia and the most inferior points of the coronary sinuses as well as alignment of the three cusps at equal distances to each other. The optimal angiographic angle is subsequently calculated and the C-arm is automatically positioned to display the selected angle. This novel methodology was used in 43 patients undergoing TAVI. The procedural outcomes in this group were compared with two other groups where conventional Dyna-CT or angiography were used to assess the optimal angiographic angle. The use of the aortic valve guide software resulted in significantly shorter fluoroscopy times and fewer number of aortograms. In addition, the incidence of at least mild PAVR at follow-up was significantly lower in the group of patients in whom the novel algorithm was applied. However, it should be noted that the amount of iodinated contrast volume used was not significantly reduced. In this population of patients with severe aortic stenosis and associated comorbidities such as renal dysfunction, the use of iodinated contrast should be kept to a minimum to avoid acute kidney injury, a relatively frequent complication (incidence between 12% and 36%) that has been associated with increased 30-day and one-year mortality.<sup>12,13</sup>

Therefore, the use of MDCT before the procedure and 3-D rotational angiography during the procedure results in more accurate aortic annulus sizing and prosthesis size selection and better orientation of the X-ray fluoroscopy angles, leading to a reduced incidence of PAVR. While the use of MDCT to evaluate patients who are candidates for TAVI (specifically measuring the aortic annulus and assessing the peripheral arteries) has been increasing in recent years, there is less experience with the use of 3-D rotational angiography for procedural guidance and its impact on TAVI outcomes may require further studies with larger populations. However, the promising results reported in the present issue of EuroIntervention indicate that 3-D imaging modalities may also be important for superior procedural guidance.

### Conflict of interest statement

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### References

1. Webb JG, Wood DA. Current status of transcatheter aortic valve replacement. *J Am Coll Cardiol*. 2012;60:483-92.
2. Jilaihawi H, Kashif M, Fontana G, Furugen A, Shiota T, Friede G, Makhija R, Doctor N, Leon MB, Makkar RR. Cross-sectional computed tomographic assessment improves accuracy of aortic annular sizing for transcatheter aortic valve replacement and reduces the incidence of paravalvular aortic regurgitation. *J Am Coll Cardiol*. 2012;59:1275-86.
3. Blanke P, Reinohl J, Schlensak C, Siepe M, Pache G, Euringer W, Geibel-Zehender A, Bode C, Langer M, Beyersdorf F, Zehender M. Prosthesis oversizing in balloon-expandable transcatheter aortic valve implantation is associated with contained rupture of the aortic root. *Circ Cardiovasc Interv*. 2012;5:540-8.
4. Kodali SK, Williams MR, Smith CR, Svensson LG, Webb JG, Makkar RR, Fontana GP, Dewey TM, Thourani VH, Pichard AD, Fischbein M, Szeto WY, Lim S, Greason KL, Teirstein PS, Malaisrie SC, Douglas PS, Hahn RT, Whisenant B, Zajarias A, Wang D, Akin JJ, Anderson WN, Leon MB. Two-year outcomes after transcatheter or surgical aortic-valve replacement. *N Engl J Med*. 2012;366:1686-95.
5. Gilard M, Eltchaninoff H, Lung B, Donzeau-Gouge P, Chevrel K, Fajadet J, Leprince P, Leguerrier A, Lievre M, Prat A, Teiger E, Lefevre T, Himbert D, Tchetché D, Carrie D, Albat B, Cribier A, Rioufol G, Sudre A, Blanchard D, Collet F, Dos SP, Meneveau N, Tirouvanziam A, Caussin C, Guyon P, Bosch J, Le BH, Collart F, Houel R, Delpine S, Souteyrand G, Favereau X, Ohlmann P, Doisy V, Grollier G, Gommeaux A, Claudel JP, Bourlon F, Bertrand B, Van BE, Laskar M. Registry of transcatheter aortic-valve implantation in high-risk patients. *N Engl J Med*. 2012;366:1705-15.
6. Thomas M, Schymik G, Walther T, Himbert D, Lefevre T, Treede H, Eggebrecht H, Rubino P, Colombo A, Lange R, Schwarz RR, Wendler O. One-year outcomes of cohort 1 in the Edwards SAPIEN Aortic Bioprosthesis European Outcome (SOURCE) registry: the European registry of transcatheter aortic valve implantation using the Edwards SAPIEN valve. *Circulation*. 2011;124:425-33.
7. Holmes DR, Jr., Mack MJ, Kaul S, Agnihotri A, Alexander KP, Bailey SR, Calhoun JH, Carabello BA, Desai MY, Edwards FH, Francis GS, Gardner TJ, Kappetein AP, Linderbaum JA, Mukherjee C, Mukherjee D, Otto CM, Ruiz CE, Sacco RL, Smith D, Thomas JD. 2012 ACCF/AATS/SCAI/STS expert consensus document on transcatheter aortic valve replacement. *J Am Coll Cardiol*. 2012;59:1200-54.
8. Delgado V, Ewe SH, Ng AC, van der Kley F, Marsan NA, Schuijff JD, Schalij MJ, Bax JJ. Multimodality imaging in transcatheter aortic valve implantation: key steps to assess procedural feasibility. *EuroIntervention*. 2010;6:643-52.
9. Hayashida K, Bouvier E, Lefevre T, Hovasse T, Morice MC, Chevalier B, Romano M, Garot P, Mylotte D, Farge A, Donzeau-Gouge P, Cormier B. Impact of CT-guided valve sizing on post-procedural aortic regurgitation in transcatheter aortic valve implantation. *EuroIntervention*. 2012;8:546.
10. Poon KK, Crowhurst J, James C, Campbell D, Roper D, Chan J, Incani A, Clarke A, Tesar P, Aroney C, Raffel OC, Walters DL. Impact of optimising fluoroscopic implant angles on paravalvular regurgitation in transcatheter aortic valve replacement - utility of 3-dimensional rotational angiography. *EuroIntervention*. 2012;8:538.
11. Willson AB, Webb JG, LaBounty TM, Achenbach S, Moss R, Wheeler M, Thompson C, Min JK, Gurvitch R, Norgaard BL, Hague CJ, Toggweiler S, Binder R, Freeman M, Poulter R, Poulsen S, Wood DA, Leipsic J. 3-dimensional aortic annular assessment by multidetector computed tomography predicts moderate or severe paravalvular regurgitation after transcatheter aortic valve replacement: a multicenter retrospective analysis. *J Am Coll Cardiol*. 2012;59:1287-94.
12. Bagur R, Webb JG, Nietlispach F, Dumont E, De LR, Doyle D, Masson JB, Gutierrez MJ, Clavel MA, Bertrand OF, Pibarot P, Rodes-Cabau J. Acute kidney injury following transcatheter aortic valve implantation: predictive factors, prognostic value, and comparison with surgical aortic valve replacement. *Eur Heart J*. 2010;31:865-74.
13. Khawaja MZ, Thomas M, Joshi A, Asrress KN, Wilson K, Bolter K, Young CP, Hancock J, Bapat V, Redwood S. The effects of VARC-defined acute kidney injury after transcatheter aortic valve implantation (TAVI) using the Edwards bioprosthesis. *EuroIntervention*. 2012;8:563.