EDITORIAL

Quantification of paravalvular regurgitation after transcatheter aortic valve implantation: improved accuracy means better standardization

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> If you think of standardization as the best that you know today, but which is to be improved tomorrow; you get somewhere
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> Henry Ford

Aortic stenosis (AS) is the most common valvular heart disease in western countries. Because of the ageing population, AS is being an increasing health problem with sizeable economic impact.[1] AS is a gradually progressive disease, characterized by a long asymptomatic phase, lasting several decades, followed by a shorter symptomatic phase associated with severe narrowing of the orifice of the aortic valve. Once symptoms occur, the prognosis is poor and without treatment; patients usually die within 2−3 years.[2,3] Surgical aortic valve replacement is considered the standard treatment for symptomatic AS. Transcatheter aortic valve implantation (TAVI) has recently emerged as an alternative therapy for patients with severe AS who are not candidates for surgery or are at high risk for complications due to surgery.[4] TAVI is non-inferior to surgery in terms of early and mid-term mortality and is likely to be superior if the patient has vascular anatomy and vessels that are healthy enough to be treated with the use of a transfemoral approach.[4,5] However, despite its favourable haemodynamics, paravalvular aortic regurgitation (PVAR) is common after TAVI.[6] PVAR is an independent predictor of short- and long-term mortality, though the impact of mild regurgitation remains controversial.[4,5]

The accurate assessment of PVAR severity is warranted but remains challenging. Doppler echocardiography is the most used imaging technique to assess AR severity.[7] The origin and direction of the jets should be evaluated.[8] The optimal views for detection of regurgitant jets include the parasternal long-axis, short-axis (SAX), apical long-axis, and five-chamber views. Because PVAR jets travel along the natural curvature of the prosthesis annular interface (eccentric jets), imaging in multiple planes including off-axis views is necessary. Colour Doppler evaluation should be performed just below the valve stent for paravalvular jets and at the coaptation point of the leaflets for central regurgitation. The entire circumference of the valve ring must be assessed using the parasternal short-axis view. Apical views should thus be carefully examined to properly detect and quantitate potential posterior jets that maybe missed in the parasternal views (shadowing effect of the stent).[9]

Generally, the same principles and methods used for quantification of other prosthetic valves are used with determination of flow convergence zone, measurement of the vena contracta, and extent of regurgitation into the left ventricle and spectral Doppler parameters such as the pressure half-time and diastolic flow reversal into the descending aorta.[10] However, there are very limited data on the application and validation of these parameters (e.g. vena contracta width, effective regurgitant orifice area, regurgitant volume) in the context of TAVI. Recently, the Valve Academic Research Consortium (VARC) has revisited the echocardiographic criteria for defining PVAR severity after TAVI.[8] The VARC-II adopted the SAX criterion as 'critical' in assessing the number and severity of paravalvular jets. With this approach, identification of the true neck of the jet is mandatory.

Due to the complexity of certain PVARs and the limitation of the echocardiography in certain situations (acoustic shadowing, eccentric jets, multiple jets), the evaluation of the PVAR might need to be completed with other imaging techniques [3D echocardiography, cardiac magnetic resonance (CMR), computed tomography (CT), invasive angiography].[11,12] 3D echocardiography, especially during transoeophageal echocardiography, is ideal for imaging the entire aortic prosthesis, the whole ring, and the extent of paravalvular leak. Limited echocardiographic windows, tissue dropout, poor temporal resolution, and the lack of validated data are the commonest limitations of 3D echocardiography. ECG-gated CT with 3D reconstruction is a promising tool in PVARs evaluation. CMR might be a useful supplement to echocardiography and might be the modality of choice when there is discordance in grading from different echocardiographic windows. However, the lack of evidence, inconsistency of definitions of PVAR severity, and its limited availability represent the main limitations to the widespread use of CMR for assessing AR after TAVI. After implantation, the angiographic grading of PVAR is an easy-to-use method. PVAR can be classified

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according to the visually estimated density of opacification of the LV into three degrees (mild, moderate, and severe) adapted to the VARC-II 2 criteria.[8] Its major challenge is the delimitation of the 3D anatomic and spatial characteristics of the leak. Hence, a considerable overlap from one grade to another can be possible.

In recent studies, the angiographically assessed degree of PVAR correlated with echocardiography in patients with TAVI.[13] These data are consistent with those elegantly reported by Abdelghani *et al.*[14] in a total of 165 patients treated with a self-expanding bioprosthesis who underwent contemporary angiographic and transthoracic echocardiography (TTE). In this study, the authors sought to investigate inter-technique (angiography and TTE) reproducibility of the assessment of PVAR after TAVI. Consistency between angiography and colour Doppler TTE, using the VARC-II criteria, in the grading of post-TAVI PVAR was modest. These data underscore the difficulty to visualize complex PVAR jets, which can run unpredictable and variable courses (e.g. multiple jets; jets originating at the non-coronary sinus, jets spreading out in all directions; jets running in a circumferential direction into the inflow area of the stent frame).[15] To adequately image the origin of the PVAR jet in the SAX, a colour Doppler scanning over the entire height of the stent is necessary. However, as shown by Abdelghani *et al.*, long-axis (LAX) colour Doppler (combining parasternal and apical views) was better correlated with angiography than SAX evaluation. Moreover, the combination of colour Doppler data (=PVAR jet circumferential extent (%) + LAX score) with pressure half-time improved the predictive value of TTE, yielding good positive (85%) and negative (81%) predictive values for identifying greater than mild PVAR. In practice, this methodology although unsatisfactory is easy to use for initial evaluation and monitoring after the procedure. However, the most appropriate time point to assess PVAR after TAVI remains undefined. In their study, TTE was obtained at a maximum interval of 7 days after angiographic evaluation. The different haemodynamic circumstances and the continuing expansion of the nitinol frame of the CoreValve after implantation might have hampered the accuracy of TTE assessment of AR. Therefore, generalization of the results to other devices or when TTE is performed in the cath lab should be done with caution.

In conclusion, the main current limitation for PVAR quantification is the absence of a method of reference. Aortic root angiography is the first screening method in the majority of laboratories while echocardiography often serves to confirm and monitor TAVI results. At present, integrating multiple TTE qualitative, semi-quantitative, and quantitative findings should remain the recommended approach for assessing PVAR. With regard to AR, more specific, reproducible, and quantitative criteria need to be developed with the goal of determining the 'total' AR, reflecting the total volume load imposed on the left ventricle. Comparison of regurgitant volumes obtained by new quantitative colour Doppler approaches, 3D derived volumetric methods, and CMR might refine the perceived meaning of AR and provide a standardized imaging approach.

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