

Managing Paravalvular Leaks After TAVR

Will next-generation percutaneous valve technologies address this current limitation?

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Since the first in-man device was implanted more than 10 years ago, transcatheter aortic valve replacement (TAVR) has been established as an exciting treatment option for patients with severe aortic stenosis at high surgical risk. Paravalvular leak (PVL) after TAVR, however, remains a major limitation for early generation devices, with up to 11% of patients experiencing moderate to severe regurgitation after valve deployment.¹

Moderate to severe regurgitation after TAVR confers a poor prognosis and is associated with an increased risk of all-cause mortality.¹ Even mild PVL has been shown to have a negative impact on survival.² Kodali et al reported on the outcomes of patients who underwent TAVR from the randomized cohorts of the PARTNER trial and continued access registries. Data were analyzed from a total of 2,434 patients. PVL was reported as mild in 38% and moderate/severe in 9.1% of patients after TAVR. There was no difference in 30-day mortality. Instead, the adverse effect was expressed later with a significant increase in 1-year all-cause and cardiac mortality and repeat hospitalization in those with worsening PVL.³

This detrimental effect on 1-year survival is in stark contrast to those with native valve regurgitation, which tends to run a less malignant course. In one cohort of 80 patients with moderate aortic regurgitation (AR), all patients were alive at 4 years, and 79% were still alive at 10 years. These patients developed native valve regurgitation over time, giving their ventricles time to adapt to the change in loading conditions. Meanwhile, acute AR after TAVR often occurs in a stiffened, hypertrophied, poorly compliant left ventricle and is therefore poorly tolerated. Interestingly, data from the French registry suggested that patients with baseline mixed aortic stenosis and regurgitation tolerated postprocedure regurgitation better than those with preexisting aortic stenosis only.⁴

ASSESSMENT OF PVL: CHALLENGING!

Accurate assessment and quantification of PVL after TAVR remain a challenge. Angiography, as well as transthoracic and transesophageal echocardiography, remain the mainstay for the assessment of regurgitation. Aortic root angiography is an established technique for assess-

ing AR and is usually performed immediately after valve deployment. However, this particular method relies on the subjective assessment of unidimensional images and can be affected by inter- and intraobserver variability.^{5,6} Angiography is unable to differentiate between paravalvular and transvalvular regurgitation, unlike transthoracic and transesophageal echocardiography. Furthermore, transthoracic and transesophageal echocardiography both allow quantitative assessment of AR and are better suited for serial follow-up assessment. Three-dimensional (3D) imaging, including 3D echocardiography and magnetic resonance imaging (MRI) may be superior to current two-dimensional modalities when attempting to quantify the degree of AR. Two-dimensional transthoracic echocardiography has been shown to underestimate AR by at least one grade when compared to MRI in 44% of patients treated with TAVR.⁷

More recently, the dimensionless AR index as a tool to assess the hemodynamic significance of AR has been described.⁸ Sinning et al reported that the AR index—defined as [(diastolic blood pressure – left ventricular end-diastolic pressure)/systolic blood pressure] X 100—can be useful for defining the severity of AR, with a value of < 25 suggesting severe AR with an increased mortality risk.

The Valve Academic Research Consortium (VARC) suggests semiquantitative evaluation using the proportion of circumference of the prosthesis that involves the PVL, measured in the short-axis view. They define mild, moderate, and severe paravalvular AR as < 10%, between 10% and 29%, and > 30% of the extent of the prosthesis frame circumference, respectively.⁹

FACTORS INCREASING RISK OF PVL: HOW CAN WE REDUCE THE RISK?

Proper aortic valve annulus sizing is paramount to accurate prosthesis sizing. Undersizing of the prosthesis may result in PVL or device migration, whereas oversizing of the device increases the risk of annulus rupture. Many operators advocate using the perimeter or valve area measurements compared to the diameter to optimize sizing and reduce the risk of these complications. Three-dimensional imaging modalities, such as 3D transesophageal echocardiography, computed tomography (CT), and MRI, may be superior in

assessing dimensions, particularly the elliptical geometry,¹⁰⁻¹² although availability and expertise will inevitably vary between different institutions.

Valvular calcification also poses a challenge. Large deposits of calcium on the valve apparatus may prevent complete sealing of the prosthesis, allowing paravalvular regurgitant jets.¹³ Several studies identified that the severity of native aortic valve calcification is related to the occurrence of more-than-mild paravalvular AR.^{14,15} A deep or shallow implantation of the prosthesis has also been associated with PVL.^{16,17}

Multidetector row CT can be very useful. It not only provides an accurate 3D assessment of the aortic annulus taking into consideration the elliptical geometry, but it also provides invaluable information with regard to valve anatomy and, importantly, calcium distribution and quantification around the annulus and leaflets.¹⁸

MANAGING PVL AFTER TAVR

As described previously, PVL after TAVR has three main mechanisms: (1) suboptimal placement of the prosthesis with incomplete sealing of the annulus by the valve skirt; (2) incomplete apposition of the valve stent frame due to calcification of the annulus or native valve leaflets; and (3) undersizing of the prosthesis.

Rapid Ventricular Pacing

In the acute setting, when a temporizing measure is necessary, ventricular pacing at rates of 90 to 110 bpm, reducing diastolic filling time and thus decreasing the regurgitant volume, may offer a short-term solution.¹⁹

Postimplantation Balloon Dilatation

In the presence of significant PVL after deployment of the TAVR device, balloon dilatation of the valve prosthesis should be considered as the first management strategy. Balloon dilatation should allow greater valve expansion and reduction of PVL, although it increases the risk of annulus rupture, stroke, and the potential for promoting transvalvular regurgitation, and caution is required, especially in the presence of extensive calcification. Furthermore, aggressive postdilatation and further expansion of the stent frame may reduce the chances of subsequent paravalvular plug closure, as is subsequently described.

The size of the balloon for postdilatation should conform to the aortic annulus dimension. For the CoreValve prosthesis (Medtronic plc), a valvuloplasty balloon with a maximum diameter 1 mm smaller than the valve prosthesis has previously been used with success. Therefore, a 22-, 25-, 28-, and 30-mm balloon is recommended for the 23-, 26-, 29-, and 31-mm CoreValve, respectively.²⁰

For PVL associated with the Sapien prosthesis (Edwards Lifesciences), balloon postdilatation can be performed using the same balloon as used for delivery with the addition of

1 mL of saline to the total volume, thus increasing the diameter. This can then be repeated in a controlled stepwise manner.²¹

Valve-in-Valve Implantation

Suboptimal placement of the prosthesis with incomplete sealing of the annulus by the valve skirt may result in significant PVL; the valve may have been deployed too deep or too shallow. When faced with this clinical situation, a valve-in-valve approach with a second TAVR prosthesis can save the day and prevent the need for bailout cardiac surgery. The second valve is deployed, ensuring sealing with the native aortic annulus. The procedural success rate is high (up to 90%), and this is also a viable treatment option for transvalvular AR that may occur due to TAVR device leaflet dysfunction.²²⁻²⁴

Snare Technique

The snare technique is an alternative option when faced with a malpositioned CoreValve that has been deployed too deep into the ventricle. In this technique, a snare catheter may be used to pull the device upward by engaging one of the anchoring hooks.²⁵ However, this technique is unpredictable and may result in embolization of the device as well as vascular complications, such as aortic dissection. Failing this, a valve-in-valve approach may be considered to prevent the need for emergency surgical correction.^{20,26}

Percutaneous PVL Closure

PVL may persist despite deployment of the valve in an adequate position and after deployment balloon dilatation. This is usually due to heavy calcification of the native aortic valve resulting in a localized regurgitant jet. In this situation, percutaneous transcatheter device closure is a possible treatment strategy. Successful closure has been reported with both the Sapien²⁷⁻²⁹ and CoreValve prostheses, using vascular plugs,^{30,31} and in a technique also reported for closure of PVL associated with surgical aortic valve replacements.³²

More recently, percutaneous PVL closure immediately after implantation of a 26-mm Sapien valve prosthesis has been reported.³³ In this case, moderate/severe PVL persisted despite postimplantation balloon dilatation with a 26-mm Z-Med II balloon (B. Braun Interventional Systems Inc.). Unlike a self-expanding valve that continues to exert a radial force after deployment, the balloon-expandable Sapien prosthesis lacks the capacity to expand further, and thus the degree of regurgitation was unlikely to improve over time. The patient subsequently underwent successful same-sitting PVL closure with an Amplatzer Vascular Plug 4 device (St. Jude Medical, Inc.).

The Amplatzer Vascular Plug 4 device, unlike its predecessors, is able to pass down a 0.038-inch lumen, making it ideal for percutaneous PVL closure as it can be passed

down standard diagnostic catheters, including a 4-F multipurpose catheter. This negates the need for an exchange to larger catheters, as was previously the case with the Amplatzer Vascular Plug 2 and Amplatzer Vascular Plug 3, thus reducing manipulation and risk of dislodgement of the newly deployed valve prosthesis. Other potential risks of percutaneous PVL closure include vascular complication, interference of the valve prosthesis with the plug, stroke, embolization of the vascular plug, and hemolysis, although this tends to improve after endothelialization of the device.³⁴

THE NEXT GENERATION OF DEVICES

The next generation of TAVR devices has been specifically developed to overcome many of the limitations of the first-generation devices. A number of the newer devices allow accurate valve positioning with the ability to recapture, retrieve, and reposition the valve. Other improvements in design include specific sealing skirts and cuffs that conform to the native aortic annulus, thus minimizing PVL. Early reports are very promising, with reductions in moderate/severe PVL.³⁴⁻³⁹

The Direct Flow Medical aortic valve (Direct Flow Medical, Inc.) is a nonmetallic, percutaneous, bioprosthetic valve with an inflatable ring cuff frame. The inflatable polyester cuff conforms to the native aortic annulus, thereby anchoring the device and minimizing PVL. The upper (aortic) and lower (ventricular) ring balloons can be independently inflated by injecting a mixture of saline and contrast agent. The valve can be repositioned and retrieved by deflating the balloons as necessary. Once optimal placement is achieved, the saline contrast mixture is replaced with a quick-curing polymer that solidifies and secures the valve in place. Early results are promising, with 99% (73 of 74) of patients demonstrating mild or no aortic regurgitation on echocardiography following device implantation.³⁹

The Lotus valve system (Boston Scientific Corporation) consists of a bioprosthetic valve mounted on a self-expanding nitinol frame and a catheter-based delivery system for transfemoral delivery and implantation. The valve has a central radiopaque marker to aid positioning and can be retrieved and repositioned at any time prior to final release. The ventricular portion of the device has an adaptive polyurethane/polycarbonate outer seal that conforms to the irregular surfaces of the aortic annulus, thus minimizing PVL. Early outcomes from the REPRISE II study reported moderate PVL in only one patient (1%) at 30 days. None of the patients had severe regurgitation. These findings are very encouraging indeed.³⁶ ■

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