Percutaneous Paravalvular Leak Closure – Imaging, Techniques and Outcomes –

Amar Krishnaswamy, MD; Samir R. Kapadia, MD; E. Murat Tuzcu, MD

Paravalvular leak (PVL) is a known complication of surgical and transcatheter valve replacement procedures. Patients most commonly present with congestive heart failure and/or hemolysis, and repeat surgical procedures to correct the PVL carries increased risk with reduced likelihood of success. As a result, percutaneous approaches to PVL closure have been developed, with a considerable emphasis on multimodality imaging for both diagnosis and procedural guidance in the cardiac catheterization laboratory. Several large series of percutaneous PVL closure have been recently published, with encouraging results with respect to both procedural success and clinical outcomes. Here, we give a comprehensive review of imaging and procedural techniques for percutaneous PVL closure and present the data supporting this novel treatment strategy. (*Circ J* 2013; **77**: 19–27)

Key Words: Aortic stenosis; Catheterization; Computed tomography; Mitral valve

Paravalvular leak (PVL) complicating mechanical or bioprosthetic surgical valve replacement may be seen in 2–12% of patients after mitral valve replacement (MVR) and in 1–5% after aortic valve replacement (AVR).^{1–3} In the current era of transcatheter AVR (TAVR) moderate/severe aortic regurgitation (AR) is seen in up to 17% of patients, the majority of whom have paravalvular AR.⁴ Risk factors for PVL in the surgical population include mechanical valve implantation, annular calcification, infectious endocarditis, and previous valve surgery, all of which can result in inadequate suturing of the valve to the native cardiac tissue. In patients undergoing TAVR, risk factors include annular calcification and incorrect preprocedural valve sizing.⁵

Most patients with PVL present within the first year after valve replacement with symptoms of congestive heart failure (CHF) (85%), though hemolysis is also common (13–47% of patients).^{6,7} Some patients fare well with medical therapy of CHF and/or erythropoietic agents and periodic transfusion therapy. However, others remain significantly symptomatic and require definitive correction of the PVL. Re-do surgery carries a high recurrence rate, as well as greater risks of morbidity and mortality than the initial procedure.⁸

Percutaneous approaches to PVL closure have therefore been developed as a less-invasive strategy, and may be accomplished via transseptal (TS) access, apical left ventricular (LV) access, or retrograde arterial access.⁹ Since the first reports of the procedure in 1992, a number of series have been published, with encouraging rates of procedural success and good clinical outcomes.^{10–13} In this review, we will summarize the various techniques of percutaneous closure, and provide an overview of the data supporting its use in the treatment of patients with PVL.

Advanced Imaging

Multimodality imaging using transthoracic (TTE) and transesophageal echocardiography (TEE) usually provides the initial diagnosis of PVL, and procedural guidance often requires the aide of 2D and 3D TEE, intracardiac echocardiography (ICE), fluoroscopy/angiography, and more recently the combination of computed tomography (CT) and fluoroscopy. We will focus here on preprocedural localization of the PVL and imaging modalities for intraprocedural guidance.

Identifying Mitral PVL

For the sake of consistency in nomenclature, the MV is viewed as a clock-face and leak origin defined by the position on the clock (**Figure 1A**) from the left atrial (LA), or “surgeon’s”, view¹⁴. In a large surgical series, the most common location for mitral PVL was anteromedial (between 10 and 11 o’clock) and posterolateral (between 5 and 6 o’clock).⁷ Similar analysis of a percutaneous series revealed the most common mitral PVLs to be between 10 and 2 (45%) and between 6 and 10 o’clock (37%).¹²

When using TEE, localizing the PVL requires reconstruction of the clock-face in the mind of the operator. **Figure 1B** demonstrates the clock-face orientation of the MV as viewed from the left ventricle, which is also the position of the MV in the typical left anterior oblique C-arm angulation. TEE angles are shown in the Figure to demonstrate which portion of the MV is interrogated at each representative angle. Movement of the TEE probe cranial or caudal, and antelexion or retroflexion of the imaging crystal, cuts the valve at planes parallel to those listed.

Figure 2 shows an example of mitral PVL localization. The

Received November 19, 2012; accepted November 19, 2012; released online December 15, 2012

Cardiovascular Medicine, Cleveland Clinic, Cleveland, OH, USA

Mailing address: Amar Krishnaswamy, MD, Cardiovascular Medicine, Cleveland Clinic, 9500 Euclid Avenue Desk J2-3 Cleveland, OH 44195, USA. E-mail: krishna2@ccf.org

ISSN-1346-9843 doi:10.1253/circj.CJ-12-1433

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Figure 1. Mitral valve orientation. (A) Clock-face designation of the mitral and aortic valves (left atrial view). (B) TEE planes (dashed lines) along the mitral valve (viewed from the left ventricle); typical left anterior oblique (LAO) C-arm angulation. LAA, left atrial appendage; L, left coronary cusp; N, noncoronary cusp; R, right coronary cusp; TEE, transesophageal echocardiography. (Panel A reproduced from Krishnaswamy A et al with permission.¹⁴)

Figure 2. TEE localization of mitral paravalvular leak. (A) TEE 90° view demonstrates leak (arrow). (B) TEE 134° view also demonstrates the leak. (C) The 2 TEE planes interrogating the MV: leak is at the intersection (arrow). Ao, aorta; LA, left atrium; LAA, left atrial appendage; LV, left ventricle; MV, mitral valve; TEE, transesophageal echocardiography.

90° TEE view demonstrates the leak origin (**Figure 2A**), which is confirmed by the 134° view (**Figure 2B**), both views showing the PVL origin at approximately 11 o'clock. **Figure 2C** shows the MV with ultrasound beams at each of the angles in panels A and B intersecting at the PVL origin. In this particular patient, the leak was not seen in the 60° TEE view encompassing the medial border of the LA appendage (LAA); if the leak had been seen on that view, it would have implied a wider origin.

TTE can sometimes be used to define the origin of a PVL, but because of shadowing from the MV prosthesis this imaging modality is often inadequate. The mitral clock-face represented on the TTE short-axis image is shown in **Figure 3**.

Identifying Aortic PVL

Position along the perimeter of the aortic valve can also be referenced to a clock-face, as shown in **Figure 1A**. Aortic PVLs are most commonly encountered at the 7–11 o'clock position

(46%), followed by the 11–3 o'clock position (36%).¹² An alternative designation is to identify the origin of the PVL with respect to the native cusp location (ie, right, left, and noncoronary cusps). This can also be helpful in assessing the risk of coronary impingement with percutaneous device placement. The short-axis view of the aortic valve, either by TTE or TEE, is usually the most helpful in defining the leak with respect to the cusps (**Figure 4**).

Echocardiography in the Catheterization Laboratory

As with PVL diagnosis and localization, echocardiography is also instrumental to the closure procedure. We routinely use ICE for puncture of the interatrial septum (IAS), as well as initial wire/catheter guidance if the PVL is well seen (**Figure 5**). Generally, we place the TEE probe after crossing the leak with a wire (if possible) to minimize the duration of TEE intubation

Figure 3. TTE localization of mitral paravalvular leak (PVL). (A) Parasternal short-axis view demonstrates the mitral clock-face with the leak at 10 o'clock (arrow). (B) LAO projection after PVL closure demonstrates the clock-face on fluoroscopy with a closure device in place (dashed outline). AVR, aortic valve replacement; MVR, mitral valve replacement; TTE, transthoracic echocardiography. (Reproduced from Krishnaswamy A et al with permission.¹⁴)

Figure 4. Aortic paravalvular leak localization. (A) Transthoracic echocardiogram in the parasternal short-axis view shows the leak at the native right (R) coronary cusp. (B) Transesophageal echocardiogram in the short-axis view (45°) shows the leak at the noncoronary (N) cusp. L, native left coronary cusp. (Reproduced from Krishnaswamy A et al with permission.¹⁴)

in patients who are usually under conscious-sedation alone (without endotracheal intubation or general anesthesia). In some situations, especially with lateral PVL, the ICE catheter situated in the right atrium is inadequate to provide appropriate procedural guidance, and we use TEE for directing wires and equipment to the PVL origin.

TEE is integral to the PVL procedure for wire/catheter guidance, evaluation of procedural success and the need for additional device(s), and assessment of complications (such as valve impingement by the device). In many situations, we find that the use of real-time 3D TEE imaging allows better visualization of the PVL and the catheters and devices in the LA (Figure 6), overcoming some of the spatial limitations of the 2D imagery provided by ICE and routine TEE.

Integrating CT and Fluoroscopy

In order to bring intracardiac imaging data to the catheterization laboratory, our group has been involved in the overlay of 3D CT data on to that from real-time procedural fluoroscopy.¹⁵ After identifying the location of the PVL on TEE, markings are made on a preprocedural noncontrast CT (Figure 7A). We then acquire a CT-like image using the catheterization laboratory's C-arm (syngo DynaCT Cardiac, Siemens Healthcare, Forchheim, Germany) to establish the position of the patient on the table. This allows us to register the preprocedural CT to the DynaCT, and then overlay the markings made on the preprocedural CT on to the real-time fluoroscopic image (Figure 7B). Provision of these stenciled "targets" allows optimal guidance for wires and interventional devices, and in our experience results in reduced procedural time and TEE duration (Figure 7C).

Figure 5. Use of intracardiac echocardiography (ICE) to guide mitral paravalvular leak (PVL) closure. (A) Color flow Doppler demonstration of the leak. (B) Wire across the leak (arrow). (Adapted from Krishnaswamy A et al with permission.¹⁴)

Figure 6. 3D TEE guidance of percutaneous posterior paravalvular leak closure (PVL) closure. (A) 3D TEE (LA view) shows the posterior PVL (arrow). (B) Delivery catheter across PVL (arrow). (C) Amplatzer Vascular Plug II in place (arrow). AV, aortic valve; LA, left atrial; TEE, transesophageal echocardiography. (Reproduced from Krishnaswamy A et al with permission.¹⁴)

Techniques for PVL Closure

As previously mentioned, there are a number of possible approaches to both mitral and aortic percutaneous PVL closure. Catheters and devices may be delivered via TS puncture, direct access to the LV apex, or retrogradely via the femoral artery. The choice of access site should be decided on the basis of PVL location, support required for delivery of the bulky closure devices, and presence of other mechanical prostheses that may interfere with wire-snaring/externalization.

TS Approach

In selecting the location for the TS puncture for mitral PVL closure, consideration must first be given to the location of the PVL. Leaks that are lateral are amenable to the routine high stick on the IAS. However, the stick should be lower and more posterior in patients with medial PVL to allow more direct access to the leak origin.

Once the IAS is punctured and dilated, we typically advance

an Agilis NxT steerable guide catheter (St Jude Medical) to the LA. This catheter is an 8.5-Fr system, and is available in 3 different distal curves (small, medium, large) based on PVL location and LA size. Some interventionalists prefer to use a curved guide catheter (eg, JR4, Hockey Stick, etc) in lieu of the Agilis. Telescoping a 120-cm 4-Fr angled Glide catheter (Terumo Medical) into the LA via the Agilis provides an even wider range of directions to direct a wire across the PVL.¹⁶ We typically wire the PVL using an 0.035-inch stiff-angled Glide-wire (SAG; Terumo Medical), but at times we will change to using a hydrophilic 0.014-inch coronary wire if necessary.

Once across the leak, the wire is advanced to the descending aorta. The decision can then be made whether further support is needed, and if so the wire can be snared and externalized via a femoral artery sheath. If the patient has a mechanical AVR, the initial wire can be exchanged in the LV for a stiffer one, such as an Amplatzer Super-Stiff or Lunderquist (Cook Medical) via an 0.035-inch compatible microcatheter. The Agilis is then removed and the IAS is dilated. We then

Figure 7. Integration of computed tomography (CT) and real-time fluoroscopy. (A) Areas of interest are marked on the preprocedural CT (LAO projection). (B) CT markings are overlaid onto the real-time fluoroscopic image in the catheter laboratory (LAO). (C) Markings facilitate crossing of the leak (RAO projection). RA, right atrium; IVC, inferior vena cava; Ao, aorta; LAO, left anterior oblique; LPA, left pulmonary artery; PVL, paravalvular leak; MVA, mitral valve annulus; RAO, right anterior oblique; SAG, stiff-angled Glide wire. (Reproduced from Krishnaswamy A et al with permission.¹⁴)

Figure 8. Transseptal approach to medial mitral PVL closure. (A) Agilis steerable catheter in the LA (via right femoral vein), through which an angled Glide catheter and stiff-angled Glidewire (SAG) were used to cross the leak. (B) The wire was advanced to the descending aorta for support. (C) A 9-Fr TorqVue delivery sheath was advanced across the leak to the LV (markings made using DynaCT are also shown). (D) The LV side of the Amplatzer PDA occluder was deployed. Final position of the occluder device in RAO (E) and LAO (F) projections. Asc Ao, ascending aorta; Desc Ao, descending aorta; LA, left atrium; LAO, left anterior oblique; LV, left ventricle; MV, mitral valve; PVL, paravalvular leak; RA, right atrium; RAO, right anterior oblique; TPM, temporary pacemaker. (Reproduced from Krishnaswamy A et al with permission.¹⁴)

typically advance a 9- or 10-Fr Amplatz TorqueVue delivery sheath to the LA, though depending on the size and type of closure device required a 6-Fr MultiPurpose Guide alone may be adequate. **Figure 8** provides a step-by-step demonstration of the TS approach.

Some mitral PVL are large enough to require 2 (or more) closure devices. In such cases, operators may choose to ini-

tially advance the Agilis to the LV and pass a second 0.035-inch wire to the ventricle, which allows placement of 2 delivery sheaths and 2 simultaneous devices (but also requires a large, 20-Fr femoral venous sheath) (**Figure 9**). Alternatively, an 0.014-inch wire may be advanced to the LV via the delivery sheath (once in the LV) alongside the 1st device, thereby keeping access to the leak if necessary after the 1st device is

Figure 9. Simultaneous deployment of 2 closure devices in a mitral paravalvular leak (PVL). (A) After crossing the PVL using a stiff-angled Glidewire (SAG), the Agilis was advanced to the left ventricle and a 2nd SAG advanced to the descending aorta. (B) The Agilis was removed, delivery sheaths were advanced over each wire, and 2 Amplatzer VSD occluder devices were deployed in sequence. VSD, ventricular septal defect. (Reproduced from Krishnaswamy A et al with permission.¹⁴)

deployed.

Aortic PVL closure via the TS approach follows the same procedures, though use of a sharply curved catheter (ie, IMA) may be of most use in directing wires from the LV across the aortic PVL. Special considerations include taking care not to traumatize the MV apparatus (delivery of devices retrograde after externalization of the wire is a useful strategy). Patients with a prosthetic MVR are not candidates for this approach.

Femoral Approach

For closing mitral PVL, this approach is not often used, because access to the leak can be difficult, requiring an acutely angled or reverse-curve catheter from the LV after crossing the AV. Additionally, this approach is not feasible in patients with a mechanical AVR. If this approach is used, delivery of devices from the aorta to the MV leak is cumbersome and usually requires the added support of snaring the wire via TS puncture and externalization at the femoral vein.

On the other hand, the femoral approach is the most common for closure of aortic PVL. The step-by-step process is illustrated in [Figure 10](#). The PVL is crossed using a hydrophilic 0.035-inch wire (ie, SAG) via a guide catheter that allows precise control and directability in the aortic root (ie, AL-1 or MP). Once the PVL is crossed, we routinely exchange the SAG for a stiffer wire to provide support (Lunderquist or Amplatz Super-stiff) via an angled Glide catheter. The delivery sheath is then advanced over the stiff wire and the device of choice is deployed in the PVL. If greater support is required for device delivery, consideration can be given to snaring the wire via TS puncture or direct LV apical access. Care must also be taken to avoid impingement of the closure device upon the coronary ostia.

Transapical Approach

Direct LV apical access may be necessary for patients in whom the TS or femoral approach is either inadvisable or has been previously unsuccessful. Additionally, for patients with mechanical AVR or MVR undergoing PVL closure, snaring the

PVL wire (crossed via the femoral or TS approach, respectively) via the apex may be the only route that provides better wire support for catheter and/or device delivery.

Access is gained at the LV apex under fluoroscopic guidance and using a micropuncture system. Care should be taken to avoid the left anterior descending artery, for which left coronary angiography prior to access may be useful. The approach to PVL crossing and closure is similar to the other approaches. Once the leak is crossed, the wire may be advanced to the descending aorta or snared from the femoral artery (for AV leaks) or advanced to the LA or snared via TS puncture and externalized at the femoral vein (for MV leaks). The degree of support required dictates which of these wire management strategies is the most optimal.

It is best to minimize sheath size at the LV apex in order to perform the procedure percutaneously and without the need for surgical closure of the apex. Therefore, depending on the device required, it may be necessary to externalize the apical wire and deliver the devices via the femoral or TS approach. We have found when using 5- or 6-Fr sheaths at the apex, it is often possible to simply withdraw the sheath; the scarred pericardium usually provides hemostasis. If this approach is chosen, it is of course important to carefully observe, using echocardiography, for apical leak. Alternatively, Jelnin et al have described the successful use of arterial closure systems (Per-close Proglide) and PDA occluder devices to seal the apical access point.¹⁷

Choice of Approach

Access site is decided on the basis of which approach will provide access to the PVL and also allow adequate support for the delivery of bulky catheters and devices. In the case of mitral PVL, the TS approach is most commonly used. Most anterior and lateral leaks can be accessed via the TS approach. Leaks that are posterior and medial may be more difficult to engage, because of the acute angles that are presented after TS puncture; the apical or retrograde aortic approach may be considered either as a default strategy or after failure of the TS

Figure 10. Femoral approach to aortic paravalvular leak (PVL) closure. (A) Stiff-angled glide wire (SAG) is advanced across the PVL via an AL-1 guide catheter; (B) The Glide catheter is advanced to the left ventricle (LV) to exchange the SAG for a stiffer Lunderquist wire. (C) Delivery sheath is advanced to the LV and (D) Amplatzer Vascular Plug II deployed.

approach (depending on operator and institutional experience and comfort). In the setting of severe calcification of the IAS, the TS approach may not be possible and an alternate approach may be required.

In patients with aortic PVL, the retrograde femoral artery approach is most commonly used. The TS or apical approach is sometimes considered. In patients with concomitant MVR, externalization of the wire via TS puncture is not possible, and may alter the closure strategy. When externalization of the wire is carried out via TS puncture, care must be taken to not damage or disrupt the MV apparatus.

Device Selection for PVL Closure

There are no specific devices created for PVL closure, in large part because of the heterogeneity in the size and shape of the defects. Instead, operators choose from the currently available vascular and septal occluder devices to approximate the shape or size of the leak (Figure 11). This requires a great deal of thought and planning based on preprocedural imaging, as well as the intraprocedural response to device closure; in some cases, deployment of 1 device may prompt the use of a second device either in addition or in substitution. Proximal structures (mechanical leaflets, coronary ostia) must also be considered when choosing a device. As stated previously, we often place an extra wire across the PVL prior to deployment of a device in case an additional or different device is necessary for successful closure.

Briefly, the Amplatzer Vascular Plug (AVP) is commonly used and comes in 2 widely available forms: the AVP I and the AVP II. The AVP I has a cylindrical design with large spaces in the nitinol mesh, and is therefore not often used. The

AVP II has discs on either side of the central cylinder, which forms a better seal. The lack of an inner fabric (to promote tissue ingrowth) is a negative point for both the AVP I and II. The Amplatzer ASD occluder has an inner fabric, but is a very large device and may therefore interfere with the valve (especially with a tilting-disc mechanical valve). The Amplatzer VSD occluder also has an inner fabric, but is a very stiff device and is thought to cause more hemolysis than some of the other devices. The PDA occluder is a very easily delivered device that has an inner fabric; its major drawback is the limited number of sizes available.

Outcomes of Percutaneous PVL Closure

After the first report of percutaneous PVL closure in 1992, a number of case reports and small series of clinical experience were published.¹¹ Although the results were variable, overall they lent credence to the idea of percutaneous PVL closure as an alternative to re-do open heart surgery.

Recently, 2 groups have provided more comprehensive data on the procedure. Ruiz et al performed 57 PVL procedures (43 patients, majority MV leaks) with a procedural success of 86% and a 30-day all-cause mortality rate of 5.4%; similar surgical series have demonstrated a mortality of 6%.^{6,12} Importantly, 10 patients required a re-do percutaneous procedure, and 2 patients required 3 procedures total. Therefore, it is important to understand that an unsuccessful, or limitedly successful, procedure does not imply complete failure of the percutaneous approach. Furthermore, additional devices may need to be placed after even a successful closure, because of further valve/tissue dehiscence. Another important finding was that although 35% of patients developed worsened hemolysis, the

Figure 11. Devices used for paravalvular leak (PVL) closure. (A) Amplatzer Vascular Plug I (AVP I). (B) Amplatzer Vascular Plug II (AVP II). (C) Amplatzer Septal Occluder. (D) Amplatzer Muscular VSD Occluder. (Reproduced from Krishnaswamy A et al with permission.¹⁴)

number of patients requiring regular transfusion or erythropoietic agents decreased from 56 to 5%.

Sorajja et al published short-term outcomes of closure for 141 defects (115 patients, 78% MV, 22% AV) and long-term outcomes on closure of 154 defects (126 patients).^{13,18} Procedural success was 77% (slightly lower in the mitral group, 76% vs. 80%), with 8.7% of patients experiencing a major adverse event at 30 days. Only 10% of patients were left with regurgitation >3+. Only 1 patient required emergency surgery because of valve interference by a device that could not be retrieved percutaneously, and there were no procedural deaths. At 3 years, survival was 64%, unrelated to the degree of regurgitation. In total, 93% of the patients presented with CHF, but at 3 years 72% of those patients who survived had minimal or no exertional dyspnea. Of the 37% of patients who presented with hemolysis, almost 50% of the survivors (14 of 29 patients) had continued hemolysis, but this too was unrelated to the degree of residual regurgitation; only 1 patient had worsened hemolysis.

Overall, small reports and the large series have demonstrated the safety and efficacy of percutaneous PVL closure. Certainly, there is a high rate of mortality among patients undergoing these procedures, but in large part this is likely to reflect the significant comorbidities of these patients. Nevertheless, given the significant functional limitations that PVL places on patients, and the often poor results of re-operation, percutaneous PVL closure presents a promising treatment that is sure to improve with time and technology.

PVL After TAVR

TAVR is a promising alternative to medical management or surgical AVR in appropriately selected patients suffering from symptomatic, severe aortic stenosis (AS). Recently, the incidence, cause, and consequences of paravalvular AR (PAR) have become better understood.

In the PARTNER IA trial, patients undergoing TAVR with the Edwards SAPIEN (n=348) had a significantly increased rate of PAR than those patients who underwent surgical AVR (n=351) at 2 years (6.9% vs. 0.9%, $P<0.001$), despite a non-inferior overall clinical outcome.¹⁹ In a group of 667 patients undergoing TAVR with either the Edwards SAPIEN or CoreValve prosthesis, Tamburino et al reported an incidence of PAR of 21%.²⁰ Although this variability in PAR reporting underscores the rationale behind the development of the Valve Academic Research Consortium (VARC) outcome classification, it is reasonable to conclude that the incidence of PAR after TAVR is significant.

In the PARTNER I group, the incidence of moderate or severe PAR was an independent predictor of mortality (hazard ratio [HR] 2.11). Even mild PAR was associated with worse mortality at 2-year follow-up. Tamburino et al also identified moderate/severe PAR as a significant independent predictor of mortality (HR 3.8). Substantial attention has therefore turned to minimizing PAR.

Valve undersizing, malpositioning of the aortic prosthesis (too aortic or too ventricular), or bulky calcification of the leaflets are all implicated as causes of PAR. Of these, valve sizing has recently received the most attention. Although surgical sizing of the AV prosthesis allows the luxury of sizing surgical dilators prior to suturing the valve in place, annulus sizing for TAVR must occur noninvasively. Furthermore, accurate sizing is necessary to minimize both undersizing (leading to valve embolization or PAR) and oversizing (annular rupture, heart block, etc). Over time, operators have come to understand that echocardiography is limited by its 2D imaging structure, and quite often underestimates the true annulus size by 1–1.5 mm.²¹

On the other hand, multidetector CT (MDCT) provides a 3D dataset that can be reconstructed in a number of projections and thereby enables more accurate sizing of the annulus. Willson et al recently demonstrated that sizing of the aortic

annulus by MDCT accurately predicts PAR, and that undersizing by only 0.7 mm could result in moderate/severe PAR.²² Furthermore, Jilaihawi et al compared a prospective CT- vs. TEE-guided sizing strategy for TAVR and the CT-guided group demonstrated significantly less PAR (7.5% vs. 21.9%, $P=0.045$).⁵ Initial trials of TAVR were conducted using echocardiographic sizing criteria, and operators similarly treated patients using echo-based annulus measurement. With newer data on the methods and benefits of CT-guided annulus sizing and valve selection, as well as improvements in equipment and techniques, we are hopeful of seeing a lower incidence of PAR in the future.

In cases of PAR after TAVR, there are a number of procedural approaches that may be undertaken to reduce the regurgitation. Proper valve positioning is important, especially with the Edwards SAPIEN because it cannot be moved once in place; the CoreValve can be snared and repositioned if it is initially too ventricular. If the valve is well-positioned but PAR exists, consideration may be given to post-dilation of the prosthesis to provide better apposition between the stented valve and the aortic annulus. This is necessary in approximately 10% of patients, and care should be taken to not over-aggressively dilate the valve (thereby risking annular trauma). If PAR is still clinically significant even with post-dilation, or post-dilation is not possible because of concerns about exacerbating central/valvular AR, then a 2nd valve may be positioned within the 1st prosthesis (valve-in-valve). If these methods to seal the PVL are unsuccessful, it is also possible to perform percutaneous PVL closure as described in this review.

Conclusions

PVLs are neither frequent nor uncommon after surgical valve replacement. Although some patients may not suffer clinical consequences of the PVL, others require treatment for CHF or hemolysis. Re-operation in these cases confers substantial risk, and results are not always durable. As such, percutaneous PVL closure has gained greater favor in recent years. Multimodality imaging is the cornerstone of diagnosis and procedural guidance. Currently, operators must use catheters and devices originally constructed for other applications, though equipment specifically designed for PVL closure is under development. TAVR heralds a new era of valve therapy, though even in this arena paravalvular regurgitation is a significant concern and may require percutaneous closure using methods similar to those used for surgical valve PVL closure.

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