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THE PRESENT AND FUTURE

STATE-OF-THE-ART REVIEW

Transcatheter Therapies for the Treatment of Valvular and Paravalvular Regurgitation in Acquired and Congenital Valvular Heart Disease

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ABSTRACT

Transcatheter therapies in structural heart disease have evolved tremendously over the past 15 years. Since the introduction of the first balloon-expandable valves for stenotic lesions with implantation in the pulmonic position in 2000, treatment for valvular heart disease in the outflow position has become more refined, with newer-generation devices, alternative techniques, and novel access approaches. Recent efforts into the inflow position and regurgitant lesions, with transcatheter repair and replacement technologies, have expanded our potential to treat a broader, more heterogeneous patient population. The evolution of multimodality imaging has paralleled these developments. Three- and 4-dimensional visualization and concomitant use of novel technologies, such as fusion imaging, have supported technical growth, from pre-procedural planning and intraprocedural guidance, to assessment of acute results and follow-up. A multimodality approach has allowed operators to overcome many limitations of each modality and facilitated integration of a multidisciplinary team for treatment of this complex patient population. (J Am Coll Cardiol 2015;66:169–83)

The recent "epidemic" of valve heart disease (VHD) has growing clinical impact and significant economic burden. Increasing longevity of the population is mostly responsible for the rise in incidence and prevalence of VHD. Advancements in valve surgery and, more recently, in transcatheter valve techniques, are rapidly shifting therapeutic management by enabling less invasive options for patients. In addition, concurrent progress in imaging technologies has provided higher-fidelity information about valvular anatomy and function, and has allowed improved image integration for pre-procedural planning and guidance. Recognition of the applicability and effectiveness of catheter-based valve therapies has further increased interest in these treatment modalities. This state-of-the-art review is

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ABBREVIATIONS AND ACRONYMS

AR = aortic regurgitation

CI = confidence interval

CMR = cardiac magnetic resonance

CTA = computed tomography angiography

FIM = first-in-man

LV = left ventricle/ventricular

MR = mitral regurgitation

OR = odds ratio

PA = pulmonary artery

PAR = para-annular ring regurgitation

PR = pulmonary regurgitation

PVL = paravalvular leak

RV = right ventricle/ventricular

RVOT = right ventricular outflow tract

TA = transapical access

TAVR = transcatheter aortic valve replacement

TEE = transesophageal echocardiography

THV = transcatheter heart valve

TMVR = transcatheter mitral valve replacement

TPVR = transcatheter pulmonary valve replacement

TR = tricuspid regurgitation

VARC = Valvular Associate Research Consortium

VHD = valve heart disease

ViR = valve-in-ring

ViV = valve-in-valve

focused on examining current transcatheter therapies for acquired and congenital valvular regurgitation, as well as for regurgitant lesions after valve replacement or repair (**Central Illustration**).

CLINICAL IMPLICATIONS OF VALVULAR REGURGITATION

OUTFLOW VALVES. Aortic regurgitation (AR) may develop with native valves or in patients who have undergone previous surgical or transcatheter valve interventions. Transvalvular AR results from mechanical leaflet malfunction or structural degeneration following aortic valve replacement, repair, or a valve-sparing procedure. However, a paravalvular leak (PVL) is an abnormal communication between the sewing ring of a surgical prosthesis or sealing skirt of transcatheter prosthesis and the native leaflets. Although the true incidence of aortic PVLs following surgery is unknown, rates as high as 11% have been reported (1,2). PVL is more common following transcatheter aortic valve replacement (TAVR), with rates as high as 85%, but the pooled estimate of residual moderate or severe PVL is 7.4% (3). Predictors of PVL include calcium burden and location, valve undersizing or underexpansion, and depth of implantation (4). AR leads to left ventricular (LV) volume overload, ventricular dilation, and failure (5). The clinical presentation of PVL may be similar to native AR; however, prosthetic dysfunction or PVL may also cause intravascular hemolysis.

Pulmonary regurgitation (PR) is commonly seen in patients with congenital heart disease, particularly with a previous repaired tetralogy of Fallot or significant pulmonary valve stenosis for which balloon or open valvuloplasty has been performed (6). Surgical repair may involve a transannular patch and/or resection of the pulmonary valve leaflets. Patients with a history of pulmonary valve replacement using either a biological conduit (i.e., homograft) or bioprosthetic tissue valve as part of the original repair or a subsequent surgery are also at risk for conduit valve dysfunction over time (7). Right ventricular (RV) volume overload resulting from chronic PR eventually causes RV dilation, progressive systolic and diastolic dysfunction, and tricuspid regurgitation (TR) that are due to annular dilation. This can result in exercise intolerance, heart failure, arrhythmias, and risk for sudden cardiac death (8). RV enlargement may also lead to adverse RV/LV interaction, resulting in dysfunction (9). Timely consideration of pulmonary valve replacement, together with other interventions as needed for any potential abnormalities of RV afterload (e.g., central or peripheral pulmonary artery [PA] stenosis, pulmonary arterial hypertension), is integral in optimizing long-term outcomes (10).

INFLOW VALVES. Native mitral regurgitation (MR) or MR after mitral valve replacement or mitral valve repair is not uncommon. The incidence of prosthetic regurgitation depends on the type of prosthesis either bioprosthetic or mechanical. Like aortic PVLs, the true incidence of mitral PVLs is unknown; however, rates as high as 32% have been reported (11). Volume overload from MR induces progressive unfavorable remodeling of the LV and left atrium. At later stages, patients develop pulmonary hypertension, congestive heart failure, and atrial fibrillation (12). Hemodynamics and clinical implications of prosthetic MR are similar to that of native valve regurgitation, with the clinical course depending on the severity and chronicity of the MR, as well as the underlying etiology that led to its development. Hemolytic anemia is a well-recognized complication of mitral prosthetic regurgitation, especially with mechanical valves, and is commonly seen in mitral PVL.

TR, by contrast, results in elevated right atrial pressure and progression to right heart failure with venous engorgement, peripheral edema, ascites, protein-losing enteropathy, cardiac cirrhosis, and cardiac cachexia. The presence of residual TR in patients undergoing other valve interventions is commonly associated with suboptimal outcomes (13). Additionally, patients who develop progressive TR late after left-sided valve surgery represent a particular challenge (14). In this subgroup, despite medical management, surgical correction is associated with a higher risk of morbidity and mortality as a result of the presence of variable degrees of RV dysfunction, pulmonary vascular disease, and right heart failure. The pre-operative condition of the RV and the severity of secondary renal and hepatic impairment are predictors of survival.

IMAGING OF VALVULAR REGURGITATION

Echocardiography is the gold-standard imaging modality for the evaluation of regurgitant valvular and PVL lesions (15,16). Severity is assessed on the basis of qualitative and quantitative measures. Qualitative measurements include the area of regurgitant color flow, the density and contour of the regurgitant signal, and other indexes such as the time velocity