Structural Heart Interventions

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Structural heart disease encompasses a wide range of noncoronary cardiac disease processes, some of which include valvular disease, patent foramen ovale, and paravalvular leak. Statistics highlight the impact of structural heart disease in the United States alone:

- More than 1 in 8 people aged 75 and older have moderate or severe aortic stenosis.
- Nearly 1 in 10 people aged 75 and older has moderate or severe mitral regurgitation.
- Between 1 and 6 million people are estimated to have moderate or severe tricuspid regurgitation.
- The incidence of patent foramen ovale (PFO) has been shown to be as high as 27%.

While cardiac surgery is often the standard of care for these types of disease, many patients have risk factors that render them ineligible for surgery. For these patients, the advent of transcatheter approaches to structural heart disorders has made percutaneous interventions a viable alternative. In fact, some cardiovascular surgery procedures are being eclipsed by minimally invasive interventions that accomplish the same job with less bleeding, shorter recovery times, and improved postoperative pain. This issue of the *Methodist DeBakey Cardiovascular Journal* features a team of seasoned cardiovascular specialists who explore the current state of minimally invasive cardiac interventions, the imaging methods to plan and perform such interventions, and their impact on congenital and acquired structural heart dysfunction.

We open with a review by Drs. Mohammad Hussain and Faisal Nabi, who delve into the topic of noninvasive cardiac imaging and its function in evaluating and performing complex structural interventions. Computed tomography (CT), echocardiography, fluoroscopy, and fusion imaging are instrumental in all aspects of the treatment process—from assessing the extent of disease, detecting risk factors, and preprocedural planning to intraoperative guidance imaging and postprocedural device surveillance. Modalities such as CT, for example, routinely identify risk factors related to complications during transcatheter valve replacement, including vessel lumen size, tortuosity, calcification, and peripheral vascular disease. The authors explore the role of imaging in planning and guiding complex minimally invasive strategies and discuss which modalities are most suitable for optimizing success in specific types of interventions, including transcatheter aortic valve replacement, mitral valve interventions, and percutaneous left atrial appendage (LAA) closure.

Next, Drs. Amish Dave and Miguel Valderrábano examine the relative benefits and drawbacks of percutaneous LAA closure strategies to prevent stroke in patients with atrial fibrillation (AF). The risk of thromboembolic complications increases with AF, and although oral anticoagulants have been the treatment of choice to prevent stroke in these patients, the increased risk of bleeding makes such medications unsuitable for certain individuals. With roughly 90% of cardioembolic strokes occurring in the LAA, novel percutaneous strategies for LAA closure are being developed and tested as an option for those who are ineligible for anticoagulation therapy. The authors provide an overview of the design, performance, benefits, and shortcomings of these strategies and explore future prospects in preventing AF-related stroke.

From there, Dr. Colin Barker discusses advances in percutaneous repair of mitral regurgitation (MR), the second leading cause of symptomatic valvular heart disease in the United States. Severe symptomatic MR has a poor prognosis, with an annual mortality rate of 6% per year or up to 60% at 5 years when occurring in the setting of advanced heart failure. Surgical intervention is the current preferred treatment in patients with either symptomatic degenerative MR or asymptomatic MR with pulmonary hypertension, atrial fibrillation, or left ventricular dysfunction. Furthermore, valve repair has been shown to improve outcomes and reduce mortality by 70% in patients with degenerative MR. In his review, Dr. Barker explores clinical trials and registry data leading to the 2013 FDA approval of the MitraClip Transcatheter Mitral Valve Repair system for symptomatic degenerative MR in patients who are at high risk for surgery; he also examines promising mitral valve repair devices in development.

This issue then focuses on emerging transcatheter options for tricuspid regurgitation in a review by Drs. Ankur Kalra, Colin Barker, and colleagues. Tricuspid regurgitation (TR) is the most common tricuspid valve pathology encountered in cardiovascular disease and a significant cause of morbidity and mortality. Despite this, treatment options have been slow to develop, particularly for patients with multiple comorbidities and high peri- and postoperative risk. The authors discuss the anatomic and physiological challenges in treating TR and describe several promising new techniques undergoing clinical

investigation, including caval valve implantation, percutaneous tricuspid annuloplasty techniques, edge-to-edge repair with the MitraClip system, the FORMA device for transcatheter TR repair, and the GATE tricuspid atrioventricular valved stent.

Next, we present three papers exploring minimally invasive techniques for valve replacement, starting with Drs. Manuel Reyes and Michael Reardon's overview of risk levels and contemporary outcomes with transcatheter aortic valve replacement (TAVR). Guidelines for patients with symptomatic severe aortic stenosis recommend aortic valve replacement, yet many patients are not deemed to be reasonable surgical candidates due to their age, comorbidities, frailty, or other anatomic risks. TAVR was developed as a less-invasive alternative to surgical replacement and is now a viable option for extreme-risk, high-risk, and intermediate-risk patients with symptomatic severe aortic stenosis. Drs. Reyes and Reardon trace the trajectory of TAVR as a viable option for higher-risk patients and examine the current risk strata being treated with TAVR as well as current outcomes.

In a related review, cardiovascular surgeons Ross Reul, Mahesh Ramchandani, and Michael Reardon consider aortic valve-in-valve (ViV) procedures in patients with bioprosthetic structures. For patients with severe symptomatic aortic valve stenosis or insufficiency, surgical aortic valve replacement using a bioprosthetic or mechanical valve has been the treatment of choice. The recent trend has favored bioprosthetic valves due to their association with fewer bleeding complications, yet they pose a higher risk of reoperation due to structural valve deterioration. For select patients, TAVR is an accepted, less-invasive alternative to surgical replacement, but it has been associated with specific complications and requires extensive preoperative work-up and planning by the heart team. Analyses of results from experimental studies and clinical procedures have led to strategies to improve outcomes of these procedures. By exploring the complexities of the ViV procedure and specific strategies to optimize outcomes, the authors explain how surgeons can make choices during the original surgical valve implantation that can result in a more technically feasible ViV operation in the future.

The discussion then shifts to transcatheter replacement of mitral valves in a review by Drs. Kunal Sarkar, Michael Reardon, and Neal Kleiman. Transcatheter mitral valve replacement (TMVR) is a novel approach for treatment of severe mitral regurgitation and has been successfully used to treat patients with degenerative mitral stenosis (DMS) as well as failed mitral bioprosthesis and mitral repair using transcatheter mitral valve-in-valve/valve-in-ring (TMViV/ViR) repair. These procedures, however, are performed with devices designed for TAVR. Although outcomes data from multicenter registries have confirmed the feasibility of TMVR in patients undergoing TMViV/ViR and TMVR for DMS, the 30-day mortality currently approaches 30%, underscoring the need for improvements in device design and further multicenter randomized studies to determine the role of TMVR in patients with mitral valve disease. The authors shed light on the current state of TMVR and summarize relevant knowledge gleaned from studies involving patients with severe degenerative or functional MR, failed mitral bioprostheses or repair, and DMS.

Finally, in a departure from valve procedures, Drs. John Neill and C. Huie Lin delve into the topic of transcatheter approaches for treating patent foramen ovale (PFO). A necessary part of normal fetal development found in up to 30% of adults, PFO is associated with a higher rate of cryptogenic strokes and has been implicated in a variety of other conditions such as platypnea-orthodeoxia, decompression illness, and migraines. Efficacy data in four trials has led to FDA approval of transcatheter PFO closure for prevention of recurrent cryptogenic strokes, and closure has been explored in other conditions with varying degrees of success. Drs. Neill and Lin discuss historical data on PFO occurrence and treatment, a risk score that can assess the likelihood of a stroke being attributable to a PFO, and current research on the role of transcatheter closure in the treatment of other conditions that may be linked to PFOs.

This collection of contemporary reviews provides a focused summary of the most current state-of-the-art structural heart therapies and technologies. Our goal with this issue is to explore the role of noninvasive imaging guidance as well as clinical outcomes of the most novel percutaneous interventions being used to treat structural heart disease today. We invite readers to visit the Journal's website at journal.houstonmethodist.org, where they will be able to have an open Q&A discussion with the authors of this issue.