MAYO CLINIC

A New Fix for the Bishop's Hat, Let's Give It Time to Wear Before We Pass Judgment

See also page 89

Zhou Enlai (the first premier of the People's Republic of China), when asked his opinion of the impact of the French Revolution (of 1789) in an interview conducted in 1968 during the height of the Paris student riots, is reported to have stated that it was "too early to tell."

The mitral valve is a complex bicuspid valve structure that was fancifully named by medieval anatomists (possibly Leonardo da Vinci [1452-1519 AD]) in honor of the tall, ceremonial, peaked hat traditionally worn by Christian bishops during important religious ceremonies. Galen (129-216 AD), the famous Greek physician of the Roman Empire, already had identified the valves of the human heart, but both Galen and Leonardo failed to understand the circulation of the blood that requires functioning intracardiac valves to prevent blood regurgitation. William Harvey (1578-1657 AD) accurately explained cardiac valve function in 1628, almost 2 centuries later.

Mitral regurgitation is the commonest serious valve disorder; it becomes more prevalent as we age. Severe chronic mitral regurgitation in its early, compensated phase is associated with decreased exercise tolerance, increased incidence of atrial fibrillation, and progressive left ventricular dilatation. If left unrepaired it leads to a later, decompensated phase characterized by left ventricular dysfunction, heart failure, and significantly decreased long-term survival. Mitral regurgitation is classified pathologically into 2 main types: abnormalities in the valve structure or those in the left ventricle. An abnormality of the mitral valve components (ie, leaflets, chordae, papillary muscles) may lead to a failure of leaflet coaptation and is termed *primary* or *degenerative mitral regurgitation*. *Secondary* or *functional mitral regurgitation* is due to left ventricular dysfunction and adverse remodeling with a structurally normal valve, which causes valve regurgitation due to mitral annular dilatation and an imbalance between mitral leaflet tethering and tensing mechanisms.

Open surgical repair of the mitral valve is the standard treatment for severe symptomatic mitral regurgitation in patients who are good operative candidates. Surgical repair is also recommended in centers with experienced mitral valve surgeons for asymptomatic patients with low operative risk and severe mitral regurgitation.[1] Medical management of severe chronic mitral regurgitation does not decrease regurgitation. Many patients with severe mitral regurgitation are elderly, have severe comorbid conditions, and may be considered high-risk surgical candidates because of poor left ventricular function. Mirabel et al[2] reported that up to 49% of patients with severe mitral regurgitation may be denied cardiac surgery because of their high-risk characteristics. Open surgical repair of the mitral valve is a very successful surgery but requires sternotomy and cardiopulmonary bypass. Newer surgical techniques now allow less invasive, video-assisted, robotic approaches to the mitral valve using valve repair techniques similar to those of open surgery without opening the chest. The natural evolution of medical technology is to progress to a nonsurgical, catheter-based mitral valve repair technique, a treatment especially welcome for elderly patients with severe mitral valve regurgitation, who frequently present with pulmonary edema.

The MitraClip system (Abbott Vascular) is currently the only Food and Drug Administration–approved device for use in primary degenerative mitral valve regurgitation. The MitraClip system is an edge-to-edge mitral valve repair technique that uses a clip to approximate the anterior and posterior mitral valve leaflets, creating a double-orifice mitral valve. The MitraClip consists of

Mayo Clin Proc. ■ January 2019;94(1):4-6 ■ https://doi.org/10.1016/j.mayocp.2018.11.019
www.mayoclinicproceedings.org ■

2 major parts: the cobalt-chromium clip (covered by polyester) and the steerable guide catheter (used to advance the clip through a transseptal puncture into the left atrium and direct it toward the mitral valve).

The forerunner of the MitraClip is the surgical Alfieri stitch or "bow-tie" mitral valve repair, an ingenious technique of partial mitral valve repair used in difficult circumstances when complete mitral valve repair or valve replacement is not surgically feasible.[3] The Alfieri stitch converts the usual single-orifice mitral valve into a double-orifice valve by placing a suture in an edge-to-edge technique that significantly lessens, but does not eliminate, the mitral valve regurgitation. Conventional surgical mitral valve repair reduces mitral regurgitation significantly more than either the Alfieri stitch or the MitraClip and is the preferred approach for patients with low operative risk.

Current North American[1] and European[4] guidelines recommend use of the MitraClip device in symptomatic patients with primary mitral regurgitation with high or prohibitive cardiac surgical risk who have favorable anatomy and reasonable life expectancy. Although European guidelines suggest that the MitraClip could be considered for secondary functional mitral valve regurgitation, North American guidelines have thus far not made these recommendations.[1,4] Two recent studies[5,6] published in *The New England Journal of Medicine* have yielded contradictory results for functional mitral valve regurgitation. The MITRA-FR (Multicentre Study of Percutaneous Mitral Valve Repair MitraClip Device in Patients With Severe Secondary Mitral Regurgitation) investigators[6] reported no benefit for the MitraClip system over optimal medical therapy regarding the primary outcomes of all-cause mortality and heart failure hospitalizations. In contrast, the COAPT (Cardiovascular Outcomes Assessment of the MitraClip Percutaneous Therapy for Heart Failure Patients with Functional Mitral Regurgitation) investigators[5] reported a striking reduction in hospitalization rates for heart failure for patients treated with the MitraClip system: 35.8% per patient-year in the device group compared with 67.9% per patient-year in the optimal medical therapy group. The results of the COAPT trial will likely result in further use of the MitraClip system in secondary functional mitral valve regurgitation.

Implantation of the MitraClip system in clinical practice requires a clear 3-dimensional visualization of mitral valve anatomy and function. Mitral valve leaflets must be seen clearly for effective treatment of mitral valve regurgitation because the MitraClip must be placed precisely at the valve site where mitral regurgitation originates to approximate leaflets and, thus, effectively treat the regurgitant lesion. Unlike transcatheter aortic valve replacement, fluoroscopic imaging is unable to adequately guide the MitraClip procedure because of the complexity of mitral valve anatomy and the requirement to position the device at the exact regurgitant jet origin. Real-time, intraprocedural, multiplanar, 2-dimensional echocardiography is essential in performing the MitraClip procedure. Three-dimensional echocardiography provides incremental value by displaying mitral valve anatomy and function in an easy-to-appreciate 3-dimensional format that allows clear communication between the echocardiologist guiding the procedure and the structural interventionalist deploying the MitraClip system. Bushari et al[7] provide an important step-by-step guide for the intraprocedural echocardiographic guidance of the MitraClip transcatheter mitral valve repair system. Three-dimensional echocardiographic imaging offers an integrated view of the mitral valve and transcatheter system in a single image, allowing the visualization of catheter motion in all planes. Although the use of 3-dimensional echocardiographic techniques has become more widespread in recent times, this technique still requires considerable training and expertise to appreciate the implications of echocardiographic probe movement on the ability to visualize different structures. The instructions by Bushari et al[7] provide numerous tips for optimal image acquisition, a clear understanding of the procedure, and detailed suggestions for image manipulation to visualize the different septal and mitral structural landmarks required at various parts of the

procedure. Several alternative transcatheter mitral valve repair techniques are under clinical development; all rely heavily on the use of echocardiographic imaging to determine suitability for device implantation and guide device deployment. Although the methods described by Bushari et al[7] in this issue of *Mayo Clinic Proceedings* apply directly to the MitraClip system, there is no doubt that these techniques can be extrapolated to future transcatheter mitral valve devices.

We cannot resist the speculation that Leonardo da Vinci, the anatomist who made the first detailed drawings of the mitral valve in the 15th century, would give way to Leonardo the engineer in this, the 500th anniversary of the year of his death in 1519. He would marvel at our 21st-century medical technology that allows repair of the mitral valve in a beating heart without opening the patient's chest.

Joseph G. Murphy, MD
Sushil Allen Luis, MBBS
R. Scott Wright, MD
Department of Cardiovascular Diseases
Mayo Clinic
Rochester, MN

Potential Competing Interests: The authors report no competing interests.

Correspondence: Address to Joseph G. Murphy, MD, Department of Cardiovascular Diseases, Mayo Clinic, 200 First St SW, Rochester, MN 55905 (murphy.joseph@mayo.edu).

REFERENCES

1. Nishimura RA, Otto CM, Bonow RO, et al. 2017 AHA/ACC focused update of the 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Circulation*. 2017; 135(25):e1159-e1195.
2. Mirabel M, Iung B, Baron G, et al. What are the characteristics of patients with severe, symptomatic, mitral regurgitation who are denied surgery? *Eur Heart J*. 2007;28(11):1358-1365.
3. Alfieri O, Maisano F, De Bonis M, et al. The double-orifice technique in mitral valve repair: a simple solution for complex problems. *J Thorac Cardiovasc Surg*. 2001;122(4):674-681.
4. Baumgartner H, Falk V, Bax JJ, et al. 2017 ESC/EACTS guidelines for the management of valvular heart disease. *Eur Heart J*. 2017; 38(36):2739-2791.
5. Stone GW, Lindenfeld J, Abraham WT, et al; for the COAPT Investigators. Transcatheter mitral-valve repair in patients with heart failure [published online September 23, 2018]. *N Engl J Med*. https://doi.org/10.1056/NEJMoa1806640.
6. Obadia JF, Messika-Zeitoun D, Leurent G, et al; for the MITRA-FR Investigators. Percutaneous repair or medical treatment for secondary mitral regurgitation [published online August 27, 2018]. *N Engl J Med*. https://doi.org/10.1056/NEJMoa1805374.
7. Bushari IL, Reeder GS, Eleid MF, et al. Percutaneous transcatheter edge-to-edge MitraClip technique: a practical "step-by-step" three-dimensional (3D) TEE guide. *Mayo Clin Proc*. 2019; 94:89-102.