The MITRIS RESILIA Valve: New Skin for a Proven Design

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ABSTRACT

By incorporating the best features of the Carpentier-Edwards PERIMOUNT Magna Mitral Ease valve (Edwards Lifesciences Corporation, Irvine, California) and RESILIA tissue, the MITRIS RESILIA inherits the advantages of the remarkable hemodynamic performance of the former and the durability of the latter. In this paper, we will summarize the process that led to the creation of this new valve and report on the first implant's feasibility and first impression. The MITRIS valve has an overall implantability profile, overlapping the previous generation but compared to its predecessor, the MITRIS valve boasts a more pliable saddle-shaped sewing cuff that is specifically tailored to fit the complex structure of the mitral valve with a lower stent height. This could be particularly beneficial in the context of double-valve replacement, as it may prevent any disturbance to the bioprosthesis located in the aortic position in small annulus. This could also prevent some rare but unpleasant complications such as left ventricle outflow obstruction or rupture of the atrioventricular sulcus. In addition, it could allow for better

adherence to the saddle-shaped annulus of the mitral valve with the possibility of less stress (and therefore fibrosis) on the valve tissue, while further reducing the degeneration time. Furthermore, thanks to the possibility of temporarily adjusting the stent posts inwards, it is possible to ensure greater implantability compared to its predecessor, Carpentier-Edwards PERIMOUNT Magna Mitral Ease valve. Thanks to the RESILIA tissue technology, which prevents the generation of free aldehydes that promote oxidation and calcification of pericardial tissue, it is possible to assume that the durability will probably also improve. This reinforces the trustworthiness of the MITRIS RESILIA valve.

INTRODUCTION

Open and close. In a nutshell, this is what a valve does. Simple as that. And yet the devil is in the details. The human heart needs four valvular devices working at different pressure levels, to cycle a viscous corpuscolated living fluid at least once per second for decades, without any possibility of maintenance.

This explains why the human species, despite our ability to design and maintain many sorts of valves, still struggles to match what Mother Nature can do. The history of heart valve replacement substitutes has seen the development of two parallel strategies: mechanical and biological devices. For the biological alternative, nearly every design focused on mimicking the aortic valve featuring a trileaflet structure.[1]

However, as we also see in natural human valves, the first problem of biological prostheses is structural valve deterioration (SVD) due to calcification. This can lead to bioprosthetic valve dysfunction (BVD), a condition which can necessitate reintervention.

When studied in vivo, risk of calcification is mainly due to the binding between free groups of aldehydes, exposed from the prosthesis leaflets during tissue fixation and storage. Additional threats of calcium are found in the human body. It is the presence of elevated calcium levels which leads to modification of leaflet movements and progressive failure in the form of stenosis or regurgitation—or both.

In this article, we aim to report on two recently commercialized bioprosthetic valve substitutes which feature the addition of the RESILIA tissue (Edwards Lifesciences, Irvine, California), a patented technology that asserts reduced susceptibility to calcification. This is attributed to its two hallmark features: stable capping, permanently blocking the free aldehydes in the tissue, thus diminishing the likelihood of calcium from binding in vivo; and glycerolization, which eliminates the necessity of storage in liquid solution. This latter development facilitates the prevention against exposure to free aldehydes, while protecting and preserving the tissue itself.[2]

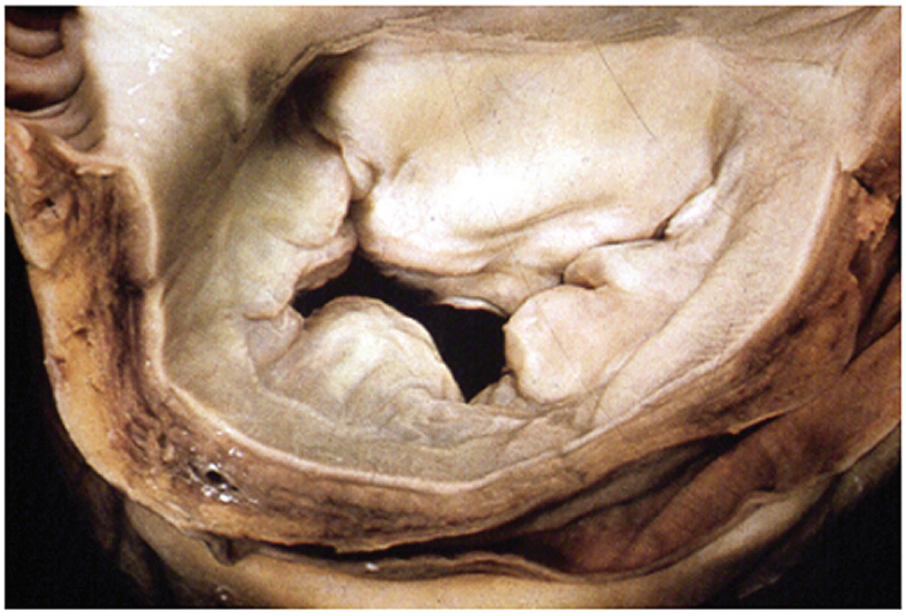

Figure 1. Anatomy of the mitral valve: view of the posterior leaflet and its three scallops. (Property of https://123sonography.com/ebook/anatomy-and-function-mitral-valve 2.)

After reviewing initial studies on juvenile sheep from 2010[3] and a European human feasibility study from 2011,[4] the COMMENCE aortic multicenter IDE trial enrolled 689 patients who received a study valve with the RESILIA tissue. This patient cohort was followed for up to five years. The results demonstrated the device's safety and improvements in transvalvular gradients, and of the effective orifice area, with no incidence of structural valve deterioration or thrombosis.[2]

COMMENCE follow-up was extended, and the seven-year results were published in 2023. The report featured only two cases of SVD.[5]

This tissue technology was incorporated into the development of the INSPIRIS RESILIA aortic valve (Edwards Lifesciences Corporation, Irvine, California) which is based on the proven Edwards Magna Ease design, but with a novel feature called Vfit, which allows controlled stent expansion in the case of possible future valve-in-valve procedures.

To date, more than 15 studies and registries have cumulatively enrolled more than 3200 patients and assessed the performance of the INSPIRIS RESILIA valve. These investigations demonstrate the technology's safety and durability.[6] Compared to COMMENCE, patients enrolled in these real-world clinical studies were younger and with

higher preoperative risk profiles.

Unlike the aortic valve, the mitral valve exhibits a distinct morphology. It features two leaflets, each divided into three scallops (Fig. 1). The mitral valve is supported by chordae tendineae of varying lengths, angles, and arrangement, providing precise motion control. This valve architecture is, up to now, too complex, and valve manufacturers have concluded that replicating a prosthetic valve does not necessarily yield tangible advantages.

The results of the biological mitral substitutes up to now are, it's no secret, less satisfactory in terms of duration than the aortic counterpart.[7-12] This fact is connected to many factors. Undoubtedly, the progressive stiffening of the leaflets due to calcium absorption is one key player, perhaps due to the valve implantation in a higher-pressure chamber like the left ventricle.

MITRAL VALVE PLATFORM

In March 2022, Edwards Lifesciences received Food and Drug Administration (FDA) approval for a new type of trileaflet pericardial bioprosthesis for mitral valve replacement—the MITRIS RESILIA mitral valve, which replicates the low-profile design of its predecessor, the Carpentier-Edwards PERIMOUNT Magna Mitral Ease valve (Edwards Lifesciences Corporation, Irvine, California), but with some meaningful changes. This novel prosthesis obtained CE mark late in 2023.

Regarding its structural architecture, the valve is externally marked along the posteromedial and anterolateral commissures, as well as the anterior valve segment. This allows for fast and easy orientation, suggesting to the surgeon which side to put facing the outflow tract.

To facilitate the valve implantation and seating within a limited anatomical space, the sewing cuff was made softer and the three stent posts can be temporarily folded inward to a 55-degree angle thanks to a dial mechanism and a memory shape stent material. This feature, known as the "cinching" mechanism, was first made popular among surgeons by the porcine Medtronic Mitral Valve (Medtronic, Minneapolis, Minnesota; Fig. 2).

Considering the anatomic limitations of the mitral annulus, the contours of the annular ring have been designed in a saddle shape to provide a better fit within the geometric shape of the mitral annulus and throughout the cardiac cycle. Just like the INSPIRIS RESILIA valve, MITRIS features the RESILIA tissue and does not require a rinse procedure.

In an animal study, the valve's effective orifice area is reported to be similar to the effective orifice area of the Mosaic Mitral valve (1.5 ± 0.5cm^2 vs. 1.56 ± 0.3cm^2) and is slightly bigger than the effective orifice area of the Epic Mitral valve (St. Jude Medical, Saint Paul, Minnesota) (1.4 ±0.7cm^2). Although recent history has taught us that effective orifice area (EOA) size is not necessarily a conclusive metric in judging the overall performance and durability of a valve.[13]

Figure 2. The valve is externally marked along the posteromedial and anterolateral commissures and on the anterior segment. The stents can be temporarily adjusted inward to a 55-degree angle. (Property of Edwards Lifesciences.)

In terms of profile, the MITRIS RESILIA valve stent height is as low as 7mm. This lower silhouette aims to minimize the risk of left ventricular outflow tract obstruction. This makes the posts noticeably lower than other mitral valves on the market, such as the Mosaic mitral valve (Medtronic, Minneapolis, Minnesota) which has a minimum stent height of 11mm (Fig. 3).

To date, the COMMENCE mitral IDE trial recently published its mid-term follow-up results, reporting a five-year freedom from structural valve deterioration of 98.7%.[14]

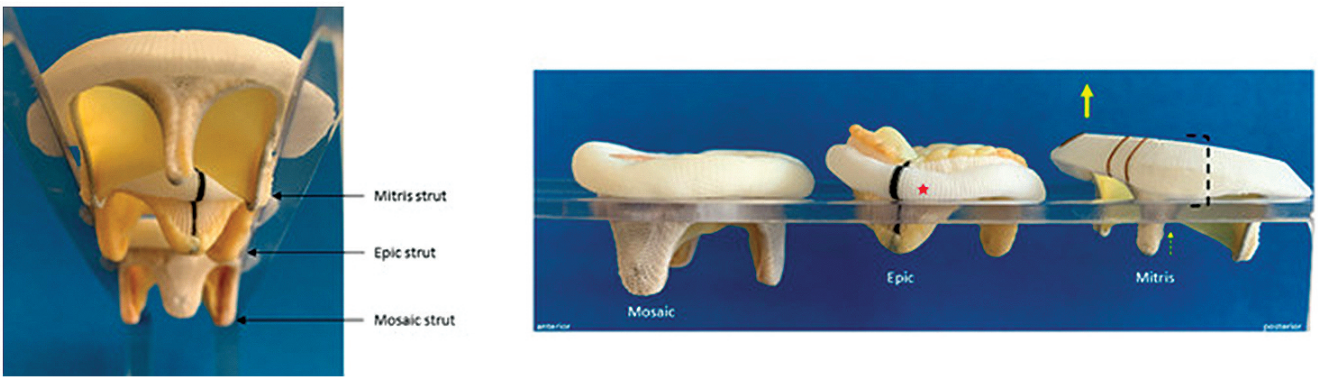

Figure 3. Differences in architecture design of tree types of mitral bioprosthesis: the two pictures show perfectly the saddle shape and the lower stent of the MITRIS RESILIA valve. (Copyright © 2021 The Authors. Journal of Cardiac Surgery published by Wiley Periodicals LLC. This is an open access article under the terms of the http://creativecommons.org/licenses/by/4.0/ License, which permits use, distribution, and reproduction in any medium, provided the original work is properly cited.)

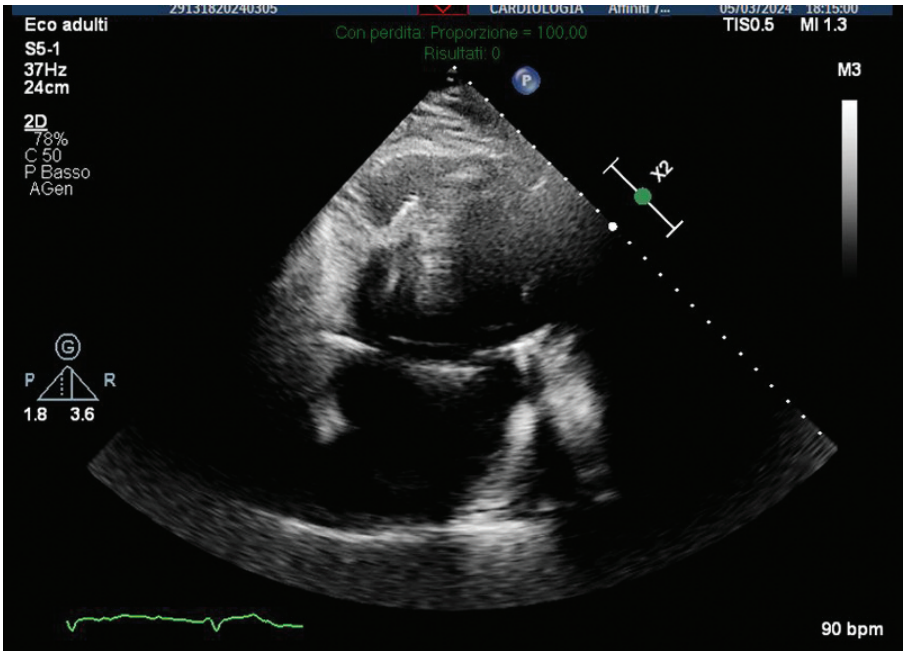

Figure 4. The TTE shows a normally functioning mitral prosthesis with the lower silhouette that fits over the mitral annulus during diastole.

OUR EXPERIENCE

In early 2024, the MITRIS RESILIA valve became available to our facility and was implanted in two patients. The first was a 71-year-old man with heart failure, reduced ejection fraction, mitral regurgitation (MR), and symptoms of dyspnea on mild exertion (NYHA functional class III). His clinic conditions worsened despite an optimal medical therapy and monocameral ICD implantation. Transthoracic echocardiogram (TTE) revealed severe MR, moderate tricuspid regurgitation (TR), moderate aortic regurgitation (AR), moderate dilatation of the left ventricle (LV mass index 135g/m², RWT 0.28), and severe reduced left ventricular ejection fraction (30%) with inferior-basal akinesia and the hypokinesia of the remaining segments. The MR was caused by an annular enlargement (functional etiology-like) and tethering of the posterior mitral leaflet, and TR was caused by a annular dilation/dysfunction. Both MR and TR had been progressive for years. The patient underwent double-valve replacement and tricuspid pasty via a standard median sternotomy. Cardiopulmonary bypass was performed by ascending aortic perfusion and bicaval drainage, followed by the induction of cardioplegic arrest. The mitral valve was exposed via a right-sided left atriotomy. The anterior mitral leaflet was excised and the posterior mitral leaflet was preserved. The 29-mm mitris valve was implanted in the mitral intra-annular position using 2-0 Ti-Cron™ U-stitches. Subsequently, the aortic valve was exposed via transverse aortotomy and excised. The Edwards PERIMOUNT Magna Ease 23mm aortic prosthesis valve was implanted in the aortic supra-annular position using 2-0 Ti-Cron™ U-stitches (Medtronic, Minneapolis, Minnesota). After resumption of cardiac activity in regular supraventricular rhythm and the snaring of the vena cava, a right atriotomy was performed as well as a tricuspid plasty with the Edwards Physio Tricuspid 30mm ring. The heartbeat resumed smoothly, and cardiopulmonary bypass was weaned successfully. Aortic clamping time was 106 minutes and cardiopulmonary bypass (CPB) time was 146 minutes.

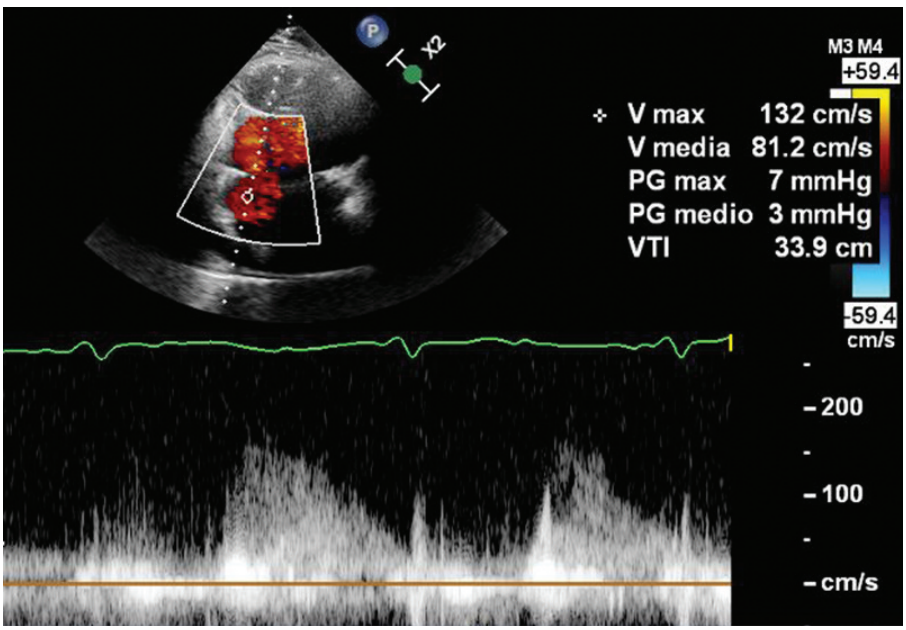

Figure 5. The TTE shows a normally functioning mitral prosthesis with absence of macroscopic paraprosthetic leaks. The transvalvular gradients was maximum 7mmHg and mean 3mmHg, with a transvalvular maximum velocity of 132cm/s and mean 81.2cm/s and VTI 33.9cm.

The second patient was a 66-year-old woman with rheumatic mitral valve disease causing severe mitral stenosis, associated with moderate-severe functional tricuspid regurgitation and moderate pulmonary hypertension. She experienced dyspnea on exertion in New York Heart Association functional class III disease. Her heart failure symptoms were progressive despite an optimal medical therapy. The transthoracic echocardiogram revealed significant MR caused by fusion of the posteromedial commissure, partial fusion of the anterolateral commissure, diffuse calcific thickening of the body of the flaps, slight calcific involvement of the chordal apparatus, and a dilated mitral annulus (39mm AP x 37mm IC). The left ventricle was of normal size and wall thickness, with preserved global and regional systolic function. MR was associated with functional moderate-severe tricuspid regurgitation, due to a dilated tricuspid annulus (41mm SL x 38mm AP), and mild-moderate pulmonary insufficiency. The patient underwent DVR and left auricular closure via a standard median

sternotomy. Cardiopulmonary bypass was performed by ascending aortic perfusion and bicaval drainage, followed by the induction of cardioplegic arrest. The mitral valve was exposed via a right-sided left atriotomy. We observed deformation and severe calcification of the mitral valve leaflets and annular enlargement. The left atrial appendage orifice was closed. The anterior mitral leaflet was excised, and the posterior mitral leaflet was preserved. The 27mm MITRIS valve was implanted in the mitral intra-annular position using 2-0 Ti-Cron™ U-stitches. Subsequently, by right atriotomy, a tricuspid plasty was performed with the implantation of the Edwards Physio Tricuspid 30mm ring using detached U-shaped points in 2/0 Ti-Cron™. The heartbeat resumed after direct current (DC) shock, and cardiopulmonary bypass was weaned successfully. Aortic clamping time was 105 minutes and CPB time was 82 minutes.

The implant was 29mm in the first patient and 27mm in the second patient. No periprocedural complications arose in either patients. All patients survived the acute phase and were discharged to rehab then home; the hospital stay was 12 days for the male patient and 13 days for the female patient (Fig. 4).

Echo findings showed mean gradient of 3 and 5mmHg, respectively, for the first and second patients, no left ventricular outflow tract (LVOT) obstructions, and absence of paravalvular leaks in both patients at discharge. The gradients did not change substantially at short-term follow up (up to one month) (Fig. 5).

CONCLUSION

By incorporating the features of the Carpentier-Edwards PERIMOUNT mitral valves and RESILIA tissue, the MITRIS valve inherits the advantages of the remarkable hemodynamic performance of the former and the durability of the latter.

In our early experience, the MITRIS valve offers an overall enhanced implantability profile, overlapping the previous generations with no added structural challenges. However, compared to the PERIMOUNT Magna Mitral Ease, the MITRIS valve features a more pliable saddle-shaped sewing cuff that is specifically tailored to fit the complex structure of the mitral valve with a lower stent height (7mm). This could be particularly beneficial in the context of double-valve replacement, as it may prevent any disturbance to the bioprosthesis located in the aortic position in small annulus. The intention is to prevent some rare but unpleasant complications, such as left ventricle outflow obstruction or rupture of the atrioventricular sulcus. The more suitable anatomical fit (due to the saddle-shape annulus of the mitral valve) reduces stress (and therefore fibrosis) on the valve tissue. It could also contribute to improving the degeneration time. Furthermore, thanks to the possibility of being temporarily adjusted inwards up to an angle of 55 degrees, it is possible to ensure greater implantability compared to the previous-generation Edwards mitral valves. Thanks to the RESILIA tissue technology, which addresses the generation of free aldehydes that promote oxidation and calcification, it is possible to assume that the durability will probably also improve. Of course, further clinical, and echocardiographic follow ups are warranted to confirm these potential advantages over both the previous generation and other competitors. Similar to how natural evolution, over an extended selection process, has resulted in the existence of our remarkable biological valves—constantly opening and closing without ever ceasing—research endeavors must tirelessly focus on creating a device that aligns more closely with Mother Nature's design. STI

AUTHORS' DISCLOSURES

The authors have no conflicts of interest to disclose.

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