ARCHIVES OF THE TURKISH SOCIETY OF CARDIOLOGY

Official journal of the TURKISH SOCIETY OF CARDIOLOGY

Percutaneous Mitral Valve-in-Ring Procedure in a Case of Severe Mitral Regurgitation Repaired with a Surgical Flexible Ring: A Step-by-Step Description

Esnek Halka ile Tamir Ameliyatı Yapılan Ciddi Mitral Yetersizliği Olgusunda Halka İçine Kapak Uygulaması ve İşlemin Basamak Basamak Tarifi

ABSTRACT

Severe mitral regurgitation (MR) following surgical repair of the mitral valve poses a significant clinical challenge. Patients who have undergone surgery are typically at high risk for a second operation. This report details the case of a 54-year-old male who underwent aortic valve replacement and mitral valve repair using a 34-ring, 14 years prior. The patient presented with severe MR, severe left ventricular (LV) dilation, and a reduced ejection fraction of 20%. A Sovering 34 ring, characterized by its oval, radio-opaque, and flexible nature and completely encircling the annulus, was used. After comprehensive assessment utilizing cardiac computed tomography (CT) and the Valve-in-Valve (ViV) application, a 32 mm balloon-expandable transcatheter heart valve was chosen. The selected valve was the 32 mm Myval (Meril) valve, the largest size available globally. Following careful alignment (left atrium/left ventricle ratio (LA/LV) ratio 20/80) and under rapid pacing, the valve was successfully implanted within the ring. Subsequent transesophageal echocardiography confirmed the valve's functionality, and left ventriculography showed no paravalvular regurgitation. The Mitral Valve-in-Ring (MVIR) procedure emerges as a promising therapeutic option for patients with a history of mitral valve repair and severe MR. This procedure is preferred in centers where structural heart interventions are performed by an experienced team.

Keywords: Mitral regurgitation, mitral ring, mitral valve-in-ring, surgical mitral repair

ÖZET

Mitral kapağın cerrahi tamiri sonrası gelişen ciddi yetmezlik önemli bir problemdir. Hasta cerrahi geçirmiş olduğundan ikinci kez ameliyat bu hastalarda genellikle yüksek risk taşır. 14 yıl önce aort kapak replasmanı ve mitral kapağı ring ile tamir edilmiş olan 54 yaş erkek hastanın ciddi mitral yetmezliği vardı. Sol ventrikül ileri derece dilate ve EF %20 idi. Mitral tamir için Sovering 34 ring kullanılmıştı. Bu ring oval, radio-opak ve fleksible özellikteydi. Anulusu tam olarak dairesel şekilde sarmaktaydı. Kardiyak bilgisayarlı tomografi (BT) çekildi. Bilgisayarlı tomografi bulguları ve kapak aplikasyonu kullanılarak 32mm balon ile genişleyen transkateter kalp kapağı konmasına karar verildi. Mevcut kapaklar içinde en büyük kapak olan Myval (Meril) 32 mm seçildi. Uygun şekilde hizalanarak (LA/LV oranı 20/80) ve hızlı pil uygulaması altında kapak açılarak ringin içerisine yerleştirildi. Çoklu açılardan TEE görüntüleri ve basınç kayıtları alındı. Sol ventrikülografi yapılarak kapakta paravalvüler kaçak olmadığı görüldü. Ring ile mitral kapak tamiri yapılan ve ciddi mitral yetmezliği olan hastalarda ring içine kapak uygulanması iyi bir tedavi seçeneği olabilir. Tecrübeli ekip tarafından yapısal kalp girişimlerinin yapıldığı ve cerrahi desteğin iyi olduğu merkezlerde bu işlem tercih edilebilir.

Anahtar Kelimeler: Mitral yetersizliği, mitral halka, mitral halka içine kapak takılması, mitral cerrahi tamir

CASE REPORT
OLGU SUNUMU

Hüseyin Bozbaş[1]
Savaş Aksüyek Çelebi[1]
Mohamed Asfour[1]
Basri Amasyalı[1]
Cem Barçın[2]

[1]*Department of Cardiology, TOBB University of Economics and Technology, Faculty of Medicine, Ankara, Türkiye*
[2]*Department of Cardiology, Gülhane Faculty of Medicine, University of Health Sciences, Ankara, Türkiye*

Corresponding author:
Hüseyin Bozbaş
✉ hbozbas@gmail.com

Received: October 20, 2023
Accepted: February 14, 2024

Cite this article as: Bozbaş H, Çelebi SA, Asfour M, Amasyalı B, Barçın C. Percutaneous mitral valve-in-ring procedure in a case of severe mitral regurgitation repaired with a surgical flexible ring: A step-by-step description. *Turk Kardiyol Dern Ars.* 2025;53(1):68-72.

DOI:10.5543/tkda.2024.41877

Mitral regurgitation (MR) is one of the most common valvular diseases and constitutes a significant health issue.[1] When surgery is necessary for MR, repair is often preferred over valve replacement.[2] Treatment options become limited when MR develops after surgical repair. Patients requiring a second operation for recurrent MR face elevated surgical risks due to the nature of the surgery and the presence of comorbidities.[3] Consequently, there is a preference to avoid redo surgery, and alternative

percutaneous methods such as repair or new valve implantation are considered as viable options.[4,5]

Our aim is to present a case of severe MR following mitral repair surgery involving a ring, in which we performed a percutaneous mitral valve-in-ring (MVIR) procedure using the largest available balloon-expandable transcatheter heart valve. The procedure is described step by step.

Case Report

Our patient, a 54-year-old male, underwent mitral valve repair with a ring and aortic valve replacement (AVR) using a 27 mm ATS (Automatic Tool Systems) mechanical prosthetic valve (Minneapolis, Minnesota, USA) on October 26, 2009. The surgery was necessitated by severe aortic and mitral regurgitation due to rheumatic valve disease. A 34 mm Sovering complete flexible ring (Cocym, London, UK) was utilized for the mitral repair. This radio-opaque, round ring fully encircled the annulus, making it suitable for a valve-in-ring procedure. However, its flexibility posed potential challenges, potentially complicating valve attachment and increasing the risk of embolization.

The patient had been experiencing persistent shortness of breath and fatigue for over a year. Recently, these symptoms intensified to the point where mild exertion caused breathlessness, classifying him as New York Heart Association (NYHA) class 3. Additionally, he had difficulty lying flat and frequently woke up at night due to shortness of breath. A physical examination revealed rales at the base of both lungs, accompanied by leg edema. The electrocardiogram (ECG) showed atrial fibrillation (AF) with a normal ventricular rate and a QRS duration of 105 ms. For primary prevention, a dual-chamber implantable cardioverter-defibrillator (ICD) was implanted. His medication regimen included a renin-angiotensin system (RAS) blocker, a beta-blocker, a mineralocorticoid receptor antagonist (MRA), and a diuretic. In line with the current European Society of Cardiology's heart failure guidelines,[6] a sodium-glucose cotransporter 2 (SGLT2) inhibitor, dapagliflozin, was added to his treatment.

Three months later, the patient's symptoms remained unchanged, maintaining a NYHA class 3 status. Echocardiography showed a severely dilated left ventricle with an ejection fraction (EF) of 20%. Transesophageal echocardiography (TEE) indicated secondary severe eccentric insufficiency of the mitral valve repaired with the ring (Vena contracta 9 mm, effective regurgitant orifice area (EROA): 44 mm^2, regurgitant volume: 67 ml) (Video 1). The length of the anterior mitral leaflet from the base of the annuloplasty ring to the tip of the leaflet measured 24.3 mm on the four-chamber view. Hemoglobin (Hb) level was 15 g/dl, and creatinine was 1.4 mg/dl (glomerular filtration rate (GFR): 57 ml/min). The calculated European System for Cardiac Operative Risk Evaluation II (EuroSCORE II) was 12.4%. Given the high surgical risk due to low EF and previous surgeries, a decision was made to implant a valve percutaneously into the ring. Angiography showed no significant stenosis in the coronary arteries, and cardiac computed tomography (CT) was performed next. The left ventricular end-diastolic diameter measured 99 mm, and the circumference of the mitral annulus/mitral ring was 92.9 mm. The aorto-mitral angle was 52 degrees, and the predicted neo-left ventricular outflow tract (LVOT) area was 1624 mm^2 on CT using a virtual 32-mm Myval (Figure 1). Based on these findings, the risk of developing obstruction in the LVOT was deemed very low.

The detailed definition of the procedure, step-by-step

1. The choice of valve size was determined by assessing the patient's ring circumference[7] using cardiac CT within the application. Based on these findings, it was decided to implant a 32 mm balloon-expandable transcatheter heart valve. The selected valve was the 32 mm Myval valve (Meril Life Sciences Pvt. Ltd., Vapi, Gujarat, India), the only commercially available valve of this size. This valve has a height of 21.1 mm and requires implantation through a 16 mm peripheral sheath. The Myval transcatheter heart valve received CE Mark Approval in April 2019. The main steps of the procedure are outlined in the Table 1.
2. The procedure was conducted under general anesthesia. Vascular sheaths were inserted into the right femoral vein for the main procedure, the left femoral vein for a temporary pacemaker, and the left femoral artery for pressure monitoring.
3. A TEE-guided septostomy was performed from the infero-posterior region. Unfractionated heparin was administered throughout the procedure to maintain an activated clotting time (ACT) above 250.
4. A pigtail catheter was advanced from the left atrium to the left ventricle, with a steerable catheter available as an alternative in case of difficulty.
5. A curved stiff wire (Amplatz SuperStiff) was threaded through the pigtail catheter and knotted at the apex of the left ventricle.
6. To facilitate the valve's passage through the interatrial septum, a 16 mm peripheral balloon was expanded over this rigid wire until the indentation disappeared (Video 2).
7. The sheath was replaced with a 16F Phyton vessel sheath and dilated using an 18F dilator.
8. A temporary pacemaker electrode was advanced to the apex of the right ventricle, ensuring an appropriate threshold for capture.
9. The optimal scopic angle (right cranial) for a single-line view of the mitral ring was determined (Figure 2). The Myval

ABBREVIATIONS

AF	Atrial fibrillation
AVR	Aortic valve replacement
CT	Computed tomography
ECG	Electrocardiogram
EROA	Effective regurgitant orifice area
ICD	Implantable cardioverter-defibrillator
LA/LV	Left atrium/left ventricle ratio
LVOT	Left ventricular outflow tract
MR	Mitral regurgitation
MRA	Mineralocorticoid receptor antagonist
MVIR	Mitral Valve-in-Ring
NYHA	New York Heart Association
RAS	Renin-angiotensin system
SGLT2	Sodium-glucose cotransporter 2
TAVI	Transcatheter Aortic Valve Implantation
TEE	Transesophageal echocardiography
ViV	Valve-in-Valve

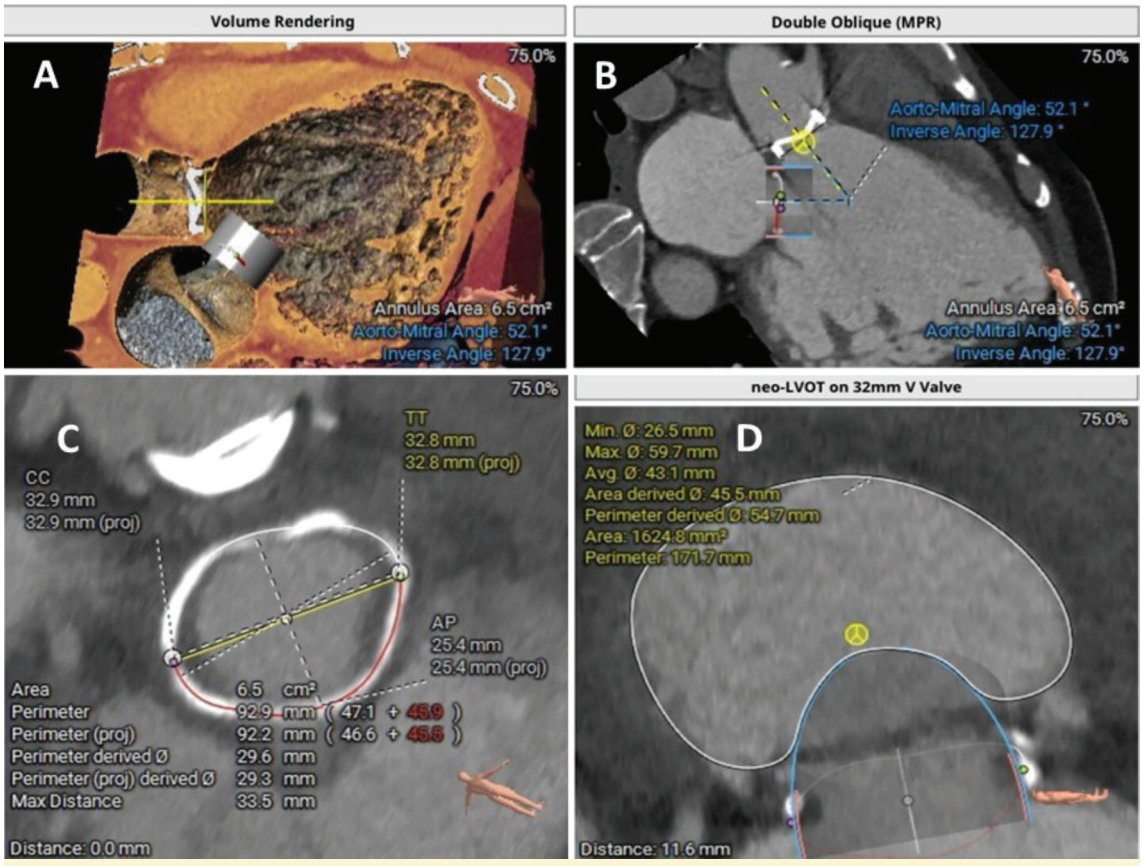

Figure 1. Cardiac CT images. (A) Volume rendering image displaying left ventricular (LV) dilation. (B) Measurement of the aorto-mitral angle. (C) Measurement of mitral annulus and ring circumference. (D) Predicted neo- left ventricular outflow tract (LVOT) area calculated in computed tomography (CT) using a virtual 32-mm Myval transcatheter heart valve.

Table 1. Main steps of the MVIR procedure
Meticulous preprocedural assessment. Estimation of the risk of LVOT obstruction using TEE and cardiac CT findings.
Bilateral femoral venous access. Placement of a temporary pacemaker from left side.
TEE-guided septostomy from infero-posterior region
Passing from LA to LV and placing a curved stiff wire to the apex of LV.
Dilation of the septum with a peripheral balloon of an appropriate size
Advancing the valve into the ring with proper alignment (LA/LV ratio 20/80).
Deployment of the valve under rapid pacing
Post-deployment evalution (TEE imaging, Pressure recordings from LA and LV, Left ventriculography)

MVIR, Mitral valve in ring; LVOT, Left ventricular outflow tract; TEE, Transesophageal echocardiography; CT, Computed tomography; LA, Left atrium; LV, Left ventricle.

32 mm valve was then advanced into the ring and properly aligned (left atrium/left ventricle ratio (LA/LV) ratio 20/80) (Figure 2).

10. Under rapid pacing, the first part of the valve was partially opened to reveal the dog-bone effect. Small, subtle maneuvers were executed for alignment. One operator held the wire while another manipulated the valve. After confirming the appropriate placement, the entire valve was fully deployed and positioned within the ring (Figure 2).
11. TEE images were captured from multiple angles. The mean gradient was recorded at 1.99 mmHg. No paravalvular regurgitation was observed, nor was there any LVOT obstruction (Video 3).
12. Pressure recordings were obtained from both the left ventricle and the left atrium. Left ventriculography (Video 4) showed no signs of paravalvular regurgitation.
13. A figure-of-eight suture was applied to the right femoral vein puncture site, followed by short-term manual compression. Reversal of heparin was not required.

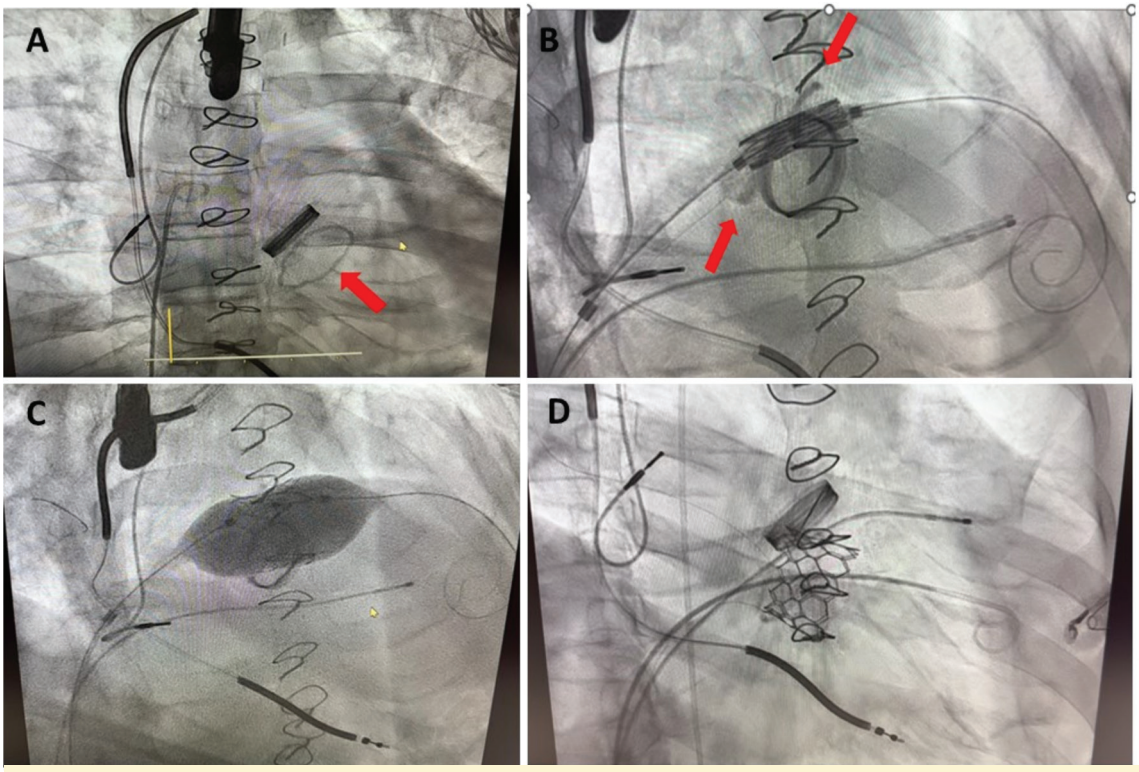

Figure 2. A) Appearance of the mitral ring (Sovering 34) in fluoroscopy on anteroposterior (AP) projection (red arrow). B) Alignment of the Myval inside the ring in fluoroscopy on right cranial projection (red arrows pointing to the ring). C) Deployment of the transcatheter heart valve inside the ring. D) Post-deployment image of the transcatheter heart valve in the ring on AP projection.

The results following the procedure were deemed satisfactory. The calculated gradient on the valve was within the normal range, and the leaflets of the new valve moved optimally. No paravalvular insufficiency was observed. The patient was extubated after four hours in the intensive care unit and reported improved sleep comfort the night following the procedure. He was subsequently discharged after a two-night hospital stay.

At a three-month follow-up, the patient reported significant improvement in his functional class, transitioning from NYHA class 3 to 2. Transthoracic echocardiography (TTE) examination revealed a well-functioning transcatheter heart valve with no paravalvular leak, although an iatrogenic atrial septal defect (ASD) was noted (Video 5).

Discussion

In cases of severe regurgitation following mitral repair with a ring, percutaneous implantation of a transcatheter valve into the ring is a valid treatment option in patients carrying high surgical risk.

Since many rings have different features, it should be known what type of ring is used.[8] Rings are categorized into two groups based on annular coverage and rigidity: A) Rings that fully cover the annulus (fully enveloping ring, complete) or do not cover fully (partially enveloping ring, incomplete), and B) those classified as rigid, semi-rigid, or flexible. Furthermore, four ring properties are also important for the procedure: 1) achieving circularity upon transcatheter heart valve deployment, 2) ensuring good anchoring, 3) ring size, and 4) radio-opacity. For example, an incomplete and flexible ring may compromise anchoring, increasing the risk of embolization of the implanted valve. Conversely, a rigid ring may provide good anchoring but may not achieve circularity upon new valve deployment, potentially resulting in paravalvular leakage.

In our patient, the ring's round and complete characteristics were favorable for the procedure, although its flexibility posed some challenges. The complexity of the procedure increased when placing the transcatheter heart valve inside a flexible ring, potentially compromising optimal anchoring and elevating the risk of embolization. Due to the ring's flexibility, we opted for a larger valve for our patient. Implementing necessary precautions, such as selecting the appropriate valve size and dilating the septum with a 16 mm peripheral balloon, enabled us to successfully complete the procedure. To the best of our knowledge, this is the largest balloon-expandable transcatheter heart valve used in a MVIR procedure. The radio-opaque nature of the ring in our patient was a feature that made this procedure easier when aligning the valve in the ring.

The MVIR procedure is associated with two important complications: first, the potential embolization of the valve, and second, the risk of developing obstruction in the LVOT.[8] Patients should be evaluated meticulously for these two complications. A critical aspect is understanding the characteristics of the ring used, particularly in terms of the risk of embolization.

In contrast to the Transcatheter Aortic Valve Implantation (TAVI) procedure, the risk of embolization in MVIR increases due to a higher pressure difference between the LA and LV. Therefore, alignment should be done properly so that most of the valve positioning is on the left ventricular side. In our patient, we aligned the valve with an LA/LV ratio of approximately 20/80 as recommended. To achieve precise placement and minimize the risk of embolization, the valve was implanted under rapid pacing.

Echocardiographic, particularly cardiac CT findings, play a pivotal role in predicting the risk of left ventricular outflow tract (LVOT) obstruction.[9] Several risk factors, including an acute aorto-mitral angle, increased septum thickness, elongated anterior mitral leaflet, and a small left ventricle, contribute to this complication. The native anterior mitral leaflet, displaced toward the interventricular septum during the cardiac cycle, is a key factor causing LVOT obstruction. Notably, the length of the anterior mitral leaflet is directly proportional to the risk, making longer leaflets more susceptible.

In our patient, with a severely dilated left ventricle and a non-acute aorto-mitral angle, the predicted neo-LVOT area on cardiac CT exceeded the recommended lower limit of 200 mm^2. This observation led us to conclude that the risk of LVOT obstruction was very low.

For patients at high risk of LVOT obstruction, surgery is the preferred initial option. However, if surgery poses a prohibitive risk, alternatives such as the LAMPOON (intentional laceration of the anterior mitral leaflet to prevent outflow obstruction) procedure or septal alcohol ablation may be considered.[10] Kılıç et al.[11] successfully performed the first LAMPOON procedure in Türkiye for a patient with a long anterior mitral leaflet (30 mm) and a predicted neo-LVOT value of 169 mm^2. They used a Myval 26 mm in that case. In contrast, our patient's anterior mitral leaflet was not elongated, and the calculated neo-LVOT value was large. As anticipated, no LVOT obstruction occurred in our case.

Conclusion

In conclusion, MVIR can be a performed in patients at high risk of redo surgery who had mitral repair with a ring if the ring used is suitable for the procedure. In this context, the characteristics of the ring should be well known. Patients should undergo meticulous evaluation before the procedure through cardiac CT and echocardiographic measurements. Comprehensive information regarding the procedure should be provided to both patients and their relatives. After all these preparation stages, the MVIR can be performed in centers with experienced operators and cardiac surgery support.

Informed Consent: Written informed consent was obtained from the patient.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – H.B.; Design – C.B.; Supervision – C.B.; Resource – B.A.; Data Collection and/or Processing – M.A.; Analysis and/or Interpretation – H.B.; Writing – H.B.; Critical Review – S.A.Ç.

Use of AI for Writing Assistance: Artificial intelligence was not used in this paper.

Conflict of Interest: The authors have no conflicts of interest to declare.

Funding: The authors declared that this study received no financial support.

Video 1. Transesophageal echocardiography (TEE) examination showing significant eccentric mitral regurgitation after mitral valve repair using a ring.

Video 2. Dilation of the interatrial septum using a 16 mm peripheral balloon until the indentation disappears.

Video 3. Post-procedure TEE examination shows the satisfactory movement of the newly deployed bioprosthetic valve in the mitral ring without evidence of LVOT obstruction.

Video 4. Left ventriculography following the valve implantation detected no paravalvular regurgitation.

Video 5. Transthoracic echocardiography at a 3-month follow-up shows a normally functioning mitral bioprosthetic valve and an iatrogenic atrial septal defect (ASD), resulting in a left-to-right shunt.

References

1. Iung B, Delgado V, Rosenhek R, et al. Contemporary presentation and management of valvular heart disease: The eurobservational research programme valvular heart disease II survey. *Circulation.* 2019;140(14):1156–1169. [CrossRef]
2. Badhwar V, Rankin JS, He X, et al. The Society of Thoracic Surgeons mitral repair/replacement composite score: A report of the Society of Thoracic Surgeons quality measurement task force. *Ann Thorac Surg.* 2016;101(6):2265–2271. [CrossRef]
3. Mehaffey HJ, Hawkins RB, Schubert S, et al. Contemporary outcomes in reoperative mitral valve surgery. *Heart.* 2018;104(8):652–656. [CrossRef]
4. Urena M, Himbert D, Brochet E, et al. Transseptal transcatheter mitral valve replacement using balloon-expandable transcatheter heart valves: A step-by-step approach. *JACC Cardiovasc Interv.* 2017;10(19):1905–1919. [CrossRef]
5. Yoon SH, Whisenant BK, Bleiziffer S, et al. Outcomes of transcatheter mitral valve replacement for degenerated bioprostheses, failed annuloplasty rings, and mitral annular calcification. *Eur Heart J.* 2019;40(5):441–451. [CrossRef]
6. McDonagh TA, Metra M, Adamo M, et al. 2023 focused update of the 2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. *Eur Heart J.* 2023;44(37):3627–3639. [CrossRef]
7. Bapat V. Valve-in-valve apps: Why and how they were developed and how to use them. *EuroIntervention.* 2014;10 Suppl U:U44–U51. [CrossRef]
8. Pirelli L, Hong E, Steffen R, Vahl TP, Kodali SK, Bapat V. Mitral valve-in-valve and valve-in-ring: Tips, tricks, and outcomes. *Ann Cardiothorac Surg.* 2021;10(1):96–112. [CrossRef]
9. Blanke P, Naoum C, Dvir D, et al. Predicting LVOT obstruction in transcatheter mitral valve implantation: Concept of the Neo-LVOT. *JACC Cardiovasc Imaging.* 2017;10(4):482–485. [CrossRef]
10. Babaliaros VC, Greenbaum AB, Khan JM, et al. Intentional percutaneous laceration of the anterior mitral leaflet to prevent outflow obstruction during transcatheter mitral valve replacement: First-in-human experience. *JACC Cardiovasc Interv.* 2017;10(8):798–809. [CrossRef]
11. Kılıç T, Coşkun Ş, Çakır Ö, et al. Tip-to-base LAMPOON to prevent left ventricular outflow tract obstruction in a valve-in-ring transcatheter mitral valve replacement: First LAMPOON procedure in Turkey and first LAMPOON case for transseptal Myval™ implantation. *Anatol J Cardiol.* 2021;25(5):363–367. [CrossRef]