

MINI-FOCUS ISSUE: PROCEDURAL COMPLICATIONS: PART 2

INTERMEDIATE

CASE REPORT: CLINICAL CASE

Torrential Mitral Regurgitation After Transcatheter Edge-to-Edge Mitral Valve Repair



Jonathan Blossom, MD,^a Catherine Lowe, MD,^a Kellan E. Ashley, MD,^a Brian E. Kogon, MD,^b Steele B. Lee, RN,^a R. Craig Long, MD, PHARM,^a Charles K. Moore, MD,^a Brandon W. Lennep, MD,^a Lampros Papadimitriou, MD,^a Gabriel A. Hernandez, MD^a

ABSTRACT

A patient with severe mitral regurgitation and chronic systolic heart failure taking inotropic support at home presents for transcatheter edge-to-edge mitral valve repair, complicated by torrential mitral regurgitation from damaged mitral leaflets requiring escalating mechanical circulatory support and ultimately expedited orthotopic heart transplantation. (**Level of Difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2021;3:69-73) © 2021 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

A 58-year-old man presented for elective edge-to-edge mitral valve repair. He was undergoing evaluation for dual heart and kidney transplantation with findings of severe pulmonary

hypertension (PH) that was felt to be in part related to functional mitral regurgitation (MR) seen on echocardiography.

MEDICAL HISTORY

His medical history was notable for heart failure with reduced ejection fraction, American Heart Association/American College of Cardiology Stage D on guideline-directed therapies including cardiac resynchronization therapy and home milrinone therapy, as well as Stage IV chronic kidney disease.

DIFFERENTIAL DIAGNOSIS

The differential diagnosis for severe PH can be categorized as pre-, post-, or pre- and post-capillary. Post-capillary PH associated with left heart diseases (Group 2) is the most common form and includes systolic or diastolic dysfunction, and valvular disease

LEARNING OBJECTIVES

- To understand the hemodynamic effects of severe mitral regurgitation in post-capillary pulmonary hypertension and the role of transcatheter edge-to-edge mitral valve repair as a means of alleviating potentially reversible pulmonary hypertension in LV dysfunction.
- To illustrate the acute effects of worsening mitral regurgitation as a complication of the MitraClip procedure and judicious use of mechanical circulatory support when complications arise.

From the ^aDepartment of Medicine, Division of Cardiovascular Diseases, University of Mississippi Medical Center, Jackson, Mississippi, USA; and the ^bDepartment of Surgery, Division of Cardiothoracic Surgery, University of Mississippi Medical Center, Jackson, Mississippi, USA.

The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the [Author Center](#).

Manuscript received September 8, 2020; revised manuscript received November 3, 2020, accepted November 20, 2020.

**ABBREVIATIONS
AND ACRONYMS****ECMO** = extra-corporeal
membranous oxygenation**IABP** = intra-aortic balloon
pump**LAp** = left atrial pressure**LV** = left ventricle**MR** = mitral regurgitation**PA** = pulmonary artery**PH** = pulmonary hypertension**PVR** = pulmonary vascular
resistance

(1). Long-standing post-capillary PH can lead to intimal thickening and medial hypertrophy, with progression to pre- and post-capillary PH, which if severe enough, will be a contraindication to heart transplantation.

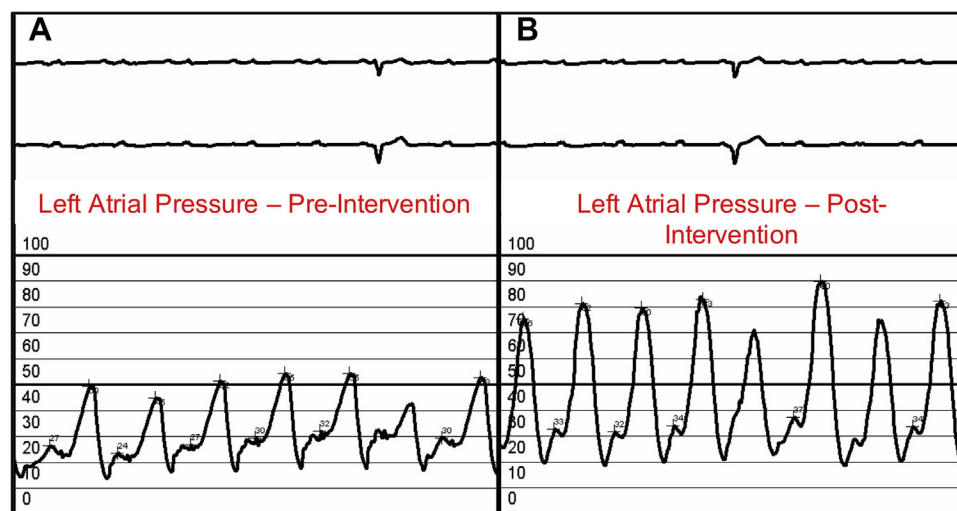
INVESTIGATIONS

The patient had a left ventricular (LV) ejection fraction of 10%-15% with a moderately dilated LV with an end-diastolic diameter of 6 cm, a mitral annular dilation with mild degenerative changes involving the mitral leaflet tips, and a resultant severe MR with a predominantly eccentric, posteriorly directed jet shown on transesophageal echocardiogram (Video 1). On right heart catheterization, severe MR was confirmed, with resultant V waves of 55 mm Hg and a pulmonary vascular resistance (PVR) of close to 4 WU that failed to improve despite continuous use of milrinone. A durable LV assist device was considered as a bridge to candidacy if PVR improved with chronic LV unloading; however, the patient refused such therapy due to a risk of requiring dialysis.

MANAGEMENT

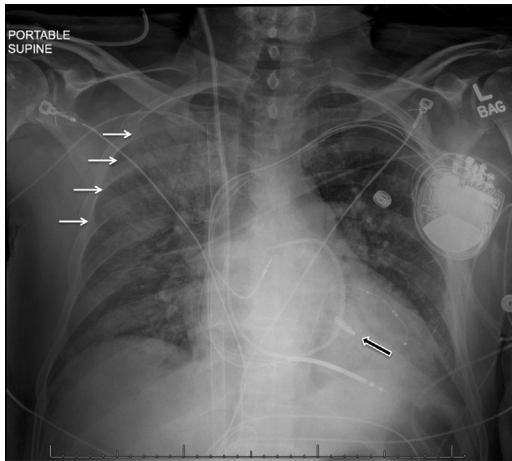
His MR was believed to be contributing to his post-capillary PH, and an edge-to-edge mitral valve

repair was considered for left atrial unloading and reduction in PVR. The degree of mitral annular dilation and subsequent leaflet tethering posed a potential risk for difficult grasping of leaflet tissue and inadequate apposition with the MitraClip (Abbott Laboratories, Abbott Park, Illinois) device; however, with the availability of the XTR MitraClip device (Abbott Laboratories), this was felt to be less of a concern due to its longer clip arms. During the procedure, mean left atrial pressure (LAp) was directly recorded at 32 mm Hg (V waves up to 52 mm Hg) (Figure 1A). An XTR MitraClip device was deployed along the lateral aspect of A2/P2 with resultant echocardiographic improvement in MR from severe to moderate, but no significant decrease in LAp. A second XTR MitraClip was attempted medially to the first clip but required retraction after multiple failed attempts to capture the leaflets, likely related to the significant tethering of the posterior mitral leaflet. Upon one of the retractions, worsened MR was noted, leading to elevated LAp and V waves up to 90 mm Hg (Figure 1B). Transesophageal echocardiography revealed torrential MR with a perforated posterior leaflet (Video 2). He soon required vasopressor escalation, and an intra-aortic balloon pump (IABP) was placed expeditiously for hemodynamic support. His hemodynamic profile equilibrated quickly with counterpulsation, and his LAp improved, with resultant reduction in vasopressor requirements. A

FIGURE 1 Direct Left Atrial Pressure Transduced Through the MitraClip Delivery System

(A) Pre-intervention left atrial pressure (severe mitral regurgitation) with A waves of 29 mm Hg, V waves of 52 mm Hg, and a mean pressure of 32 mm Hg. (B) Post-intervention left atrial pressure (torrential mitral regurgitation) with A waves of 34 mm Hg, V waves of 85 mm Hg, and a mean pressure of 45 mm Hg.

FIGURE 2 Asymmetric Right-Sided Pulmonary Edema

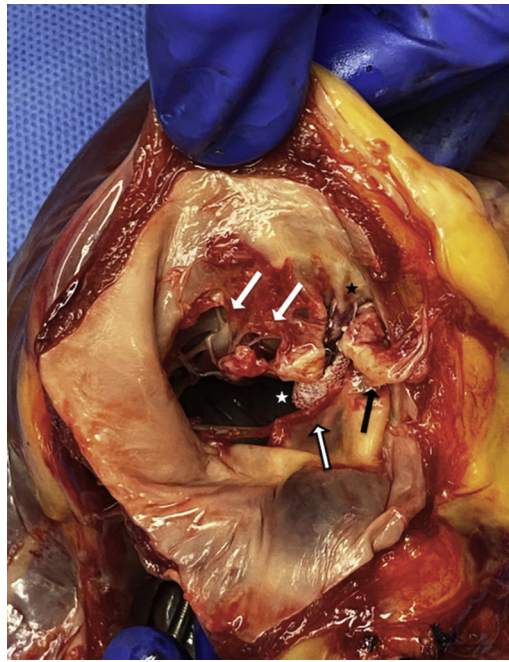


Chest radiograph in PA projection shows asymmetric right-sided pulmonary edema (**open arrows**). The jet of torrential mitral regurgitation caused by a perforation in the posterior mitral leaflet is directed preferentially toward the right pulmonary veins, with resultant asymmetric pulmonary edema, as demonstrated in the current patient. The MitraClip device is shown as well (**solid and open arrows**).

pulmonary artery (PA) catheter was placed, showing a PA pressure of 62/32 mm Hg with PVR of 2.6 WU.

He was emergently listed as United Network for Organ Sharing (UNOS) Status 2 for dual heart and kidney transplantation. He remained intubated post-procedure with predominantly right-sided pulmonary edema (**Figure 2**); however, with diuresis, his oxygenation and lactic acidosis (peaking at 14.3 mmol/l) improved, and he was extubated. Within 24 h of extubation, he developed supraventricular tachycardia refractory to overdrive pacing with worsening PA and pulmonary capillary wedge pressures, associated with increased vasopressor requirements. Due to the inability of the IABP to augment with tachycardia and the worsened cardiac output, extra-corporeal membrane oxygenation (ECMO) was initiated, and IABP was removed on hospital day 3, with temporary clinical and biochemical improvement. His transplantation status was upgraded to UNOS Status 1. In an effort to protect his lungs from elevated LA pressures, an Impella CP catheter (Abiomed, Danvers, Massachusetts) was placed. On hospital day 4, a matching donor for heart and kidney transplantation was procured, and the patient underwent successful dual-organ transplant. He was ultimately discharged home. The explanted heart revealed a posterior mitral leaflet perforation and anterior leaflet tear (**Figure 3**).

FIGURE 3 Gross Examination of the Perforated Mitral Leaflet

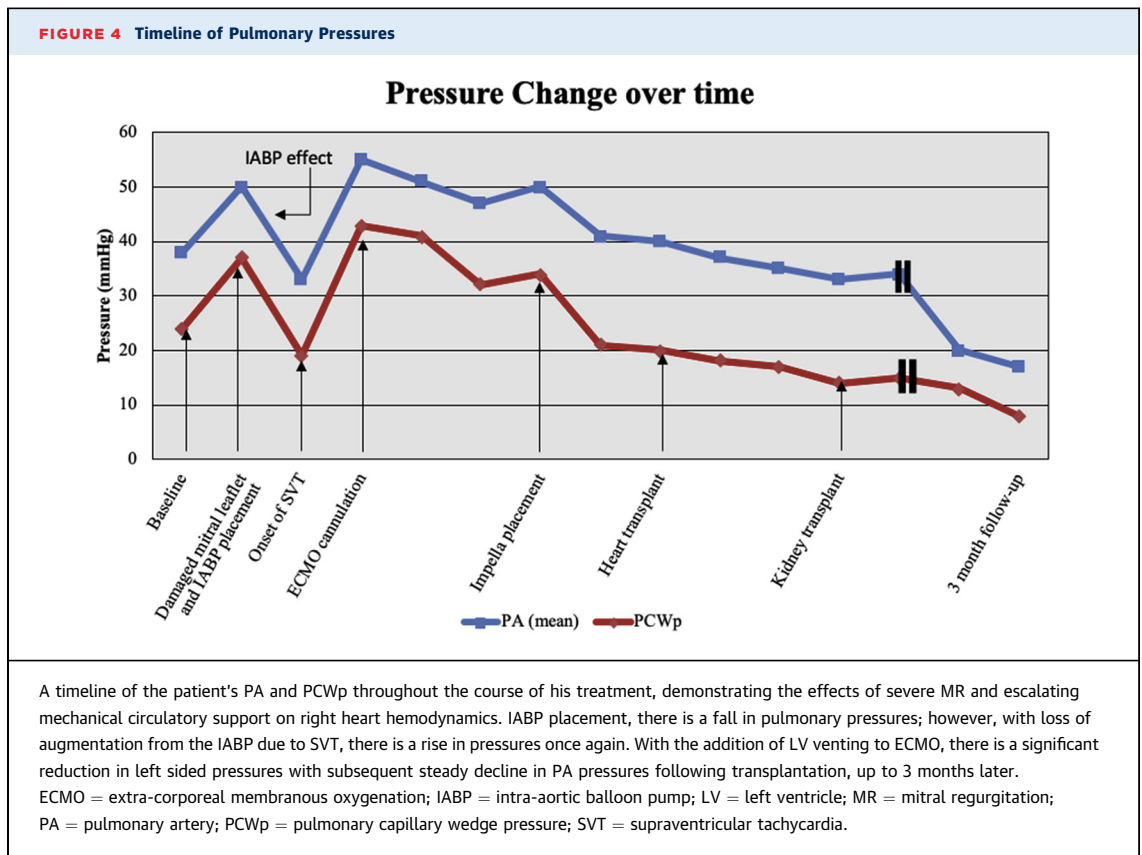


Macroscopic image of explanted heart showing the XTR MitraClip body (**open star**) and grippers (**solid star**). There is a large perforation of the posterior leaflet (**open arrows**) and a tear of the anterior leaflet (**solid and open arrows**) with a flail portion (**solid arrow**).

DISCUSSION

PH is frequently encountered in end-stage heart failure, yet can be quite difficult to correct under certain circumstances without advanced therapies. Severe PH portends higher morbidity and mortality following heart transplantation. Consequently, it is crucial to attempt improvement in PA pressures prior to definitive therapy. LV assist devices have been previously shown to reverse PH in patients being bridged to transplantation candidacy (2). Furthermore, with direct, continuous LV unloading, MR becomes a less relevant phenomenon.

The advent of the MitraClip for primary and later for functional MR opened the door for those patients at prohibitive risk for surgical mitral valve replacement. The COAPT (Cardiovascular Outcomes Assessment of the MitraClip Percutaneous Therapy for Heart Failure Patients with Functional Mitral Regurgitation) study showed the benefits of MitraClip implantation in addition to optimal medical therapy in those with functional MR (3). The 2-year follow-up showed symptomatic improvement, decreased



hospitalizations, and lower all-cause mortality in those who underwent MitraClip implantation. However, patients requiring inotropic support were excluded from the COAPT study. Recently, the TRAMI (Transcatheter Mitral Valve Interventions) registry has shown that MitraClip implantation is feasible and safe in cases of severe PH, with significant improvement in clinical and hemodynamic parameters (4,5). Theoretically, improvement in LAP elevation and decrease in regurgitant fraction with MitraClip implantation would be of benefit if forward flow can be maintained with inotropic therapy.

Overall, procedural morbidity and mortality are notably higher in patients with severe LV dysfunction, yet this risk must be weighed against the benefit of the procedure itself. Patients with dilated ventricles or complex mitral anatomy are more prone to leaflet damage (6), as multiple grasping maneuvers are needed to adequately position the clip, and thus increased risk of tissue damage. In cases where more than 1 clip is needed, the risk of tissue damage increases, as the additional clip(s) further alter remaining leaflet anatomy. Isolated leaflet damage has been described in 2% of patients

using the XTR MitraClip device, and in most cases surgery is required (7). With the XTR MitraClip device, there is an extra 3-mm length with each gripper arm, allowing for more tissue grasp, which can be key in treating functional MR. However, it is possible the extra clip arm length leads to more likelihood of leaflet damage.

This case illustrates the hemodynamic changes in torrential MR, with V waves that match systolic ventricular pressures. Posterior leaflet pathology has been previously described as causing predominantly right-sided pulmonary edema, as demonstrated in the present case (Figure 2) (8). However, gross examination showed not only posterior leaflet perforation but also anterior leaflet tearing. Short-term mechanical circulatory support has been helpful as a bailout strategy in patients undergoing structural interventions, especially in sick individuals who typically are not surgical candidates. Even though in the 2013 ACCF/AHA Guideline for the Management of ST-Elevation Myocardial Infarction, the IABP use has been largely downgraded for the management of cardiogenic shock, it is still recommended for the management of acute MR and

papillary muscle rupture related to myocardial infarction (9). This case also illustrates how IABP is a rapid and safe way of acutely reducing afterload and counteracting severe MR. TandemHeart (LivaNova, London, United Kingdom) is an attractive tool in the setting of MR due to direct left atrial unloading. At the time of this case, the use of a left atrial-to-aorta bypass with TandemHeart was considered; however, the patient stabilized with IABP support alone. In retrospect, initial use of higher level support such as the Impella CP or TandemHeart might have minimized the use of different devices; however, all of the unilateral ventricular support devices (IABP, TandemHeart, or Impella CP) would have shared the same UNOS listing priority (Status 2). The following day, given patient instability, it was decided to escalate support directly to ECMO and list him as UNOS Status 1. It is important to mention that ECMO does not provide LV unloading and that the increase in afterload in the presence of an incompetent mitral valve will certainly lead to further pulmonary congestion, thus the importance of LV venting (10). The EPELLA configuration was chosen (Impella CP plus ECMO) to vent the LV and stabilize the patient while waiting for a potential transplant donor.

FOLLOW-UP

At the patient's 3-month follow-up, during routine biopsy results, no further evidence of persistent pulmonary hypertension was demonstrated (Figure 4). He has had an uncomplicated post-transplantation course.

CONCLUSIONS

Mitral valve damage at the time of transcatheter edge-to-edge mitral valve repair is not negligible, and operators should have a bailout strategy in patients who are not surgical candidates. In the present case, transplant eligibility became the goal for to judiciously escalate mechanical circulatory support.

AUTHOR DISCLOSURES

The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

ADDRESS FOR CORRESPONDENCE: Dr. Gabriel A. Hernandez, Division of Cardiology, University of Mississippi Medical Center, 2500 North State Street, Jackson, Mississippi 39216, USA. E-mail: gghernandez@umc.edu. Twitter: @GHernandezMD.

REFERENCES

1. Guazzi M, Ghio S, Adir Y. Pulmonary hypertension in HFpEF and HFrEF: JACC Review Topic of the Week. *J Am Coll Cardiol* 2020;76:1102-11.
2. Nair PK, Kormos RL, Teuteberg JJ, et al. Pulsatile left ventricular assist device support as a bridge to decision in patients with end-stage heart failure complicated by pulmonary hypertension. *J Heart Lung Transplant* 2010;29:201-8.
3. Stone GW, Lindenfeld J, Abraham WT, et al. Transcatheter mitral-valve repair in patients with heart failure. *N Engl J Med* 2018;379:2307-18.
4. Eggebrecht H, Schelle S, Puls M, et al. Risk and outcomes of complications during and after MitraClip implantation: Experience in 828 patients from the German TRANscatheter mitral valve interventions (TRAMI) registry. *Catheter Cardiovasc Interv* 2015;86:728-35.
5. Tigges E, Blankenberg S, von Bardeleben RS, et al. Implication of pulmonary hypertension in patients undergoing MitraClip therapy: results from the German transcatheter mitral valve interventions (TRAMI) registry. *Eur J Heart Fail* 2018;20:585-94.
6. Gheorghie L, Ielasi A, Rensing BJWM, et al. Complications following percutaneous mitral valve repair. *Front Cardiovasc Med* 2019;6:146.
7. Praz F, Braun D, Unterhuber M, et al. Edge-to-edge mitral valve repair with extended clip arms: Early experience from a multicenter observational study. *J Am Coll Cardiol Intv* 2019;12:1366-8.
8. Young AL, Langston CS, Schiffman RL, Shortsleeve MJ. Mitral valve regurgitation causing right upper lobe pulmonary edema. *Texas Heart Inst J* 2001;28:53-6.
9. O'Gara PT, Kushner FG, Ascheim DD, et al. 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction. *J Am Coll Cardiol* 2013;29:485-510.
10. Saxena A, Garan AR, Kapur NK, et al. Value of hemodynamic monitoring in patients with cardiogenic shock undergoing mechanical circulatory support. *Circulation* 2020;141:1184-97.

KEY WORDS cardiac assist devices, complication, hemodynamics, pulmonary hypertension, valve repair

APPENDIX For supplemental videos, please see the online version of this paper.