Shock and Awe: Percutaneous Edge-to-Edge Repair of Post–Cardiac Surgery Severe Mitral Regurgitation Related to Papillary Muscle Tear

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INTRODUCTION

Acute mitral regurgitation (MR) secondary to papillary muscle rupture/tear is a rare complication of myocardial infarction (MI). It occurs in 1%-5% of cases of MI and is present in 10% of patients with MI-related cardiogenic shock.1

Without surgical intervention, in-hospital mortality is extremely high and can approach 80%.2 Nonetheless, even with surgical correction, in-hospital mortality and 30-day mortality rates are 19% and 53%, respectively.3 Accordingly, transcatheter edge-to-edge repair has been proposed as a potential alternative for this high-risk population.4 Transcatheter edge-to-edge repair with the MitraClip device (Abbott Vascular, Santa Clara, CA) is an approved nonsurgical option in patients with severe chronic MR with high surgical risk; however, its possible use in the setting of acute severe MR secondary to mechanical complications post-MI has been limited to case reports.

In this manuscript, we report a unique presentation of an 80-year-old patient who developed acute severe MR immediately after coronary artery bypass graft surgery (CABG). The patient did not have significant MR prior to cardiac surgery, but post-CABG, severe MR related to partial rupture of the papillary muscle developed and the patient underwent successful repair using the MitraClip device.

CASE PRESENTATION

An 80-year-old woman with dyslipidemia was admitted to hospital with a non-ST segment elevation acute coronary syndrome. She was advanced for cardiac catheterization, which demonstrated severe triple vessel disease with 95% stenosis of the distal right coronary artery, 80% midsegment left anterior descending artery stenosis, and 80% proximal stenoses of both the circumflex and ramus intermedius coronary arteries. Preoperative transthoracic echocardiogram revealed normal left ventricular size with an ejection fraction of 54% with basal coronary arteries. Transthoracic echocardiography is performed due to poor cardiac indices (Table 1). This technically difficult study demonstrated normal left ventricular fraction (LVEF, 59%), moderate diastolic dysfunction with elevated left atrial pressure, trace MR, and no pericardial effusion. The patient developed worsening congestive heart failure and cardiogenic shock. A transesophageal echocardiogram was performed in the intensive care unit. This study demonstrated normal left ventricular systolic function with moderately impaired right ventricular systolic function and severe eccentric MR due to partial rupture of the posteromedial papillary muscle (Videos 3-7 and Figures 2-4).

An intra-aortic balloon pump was inserted, which resulted in some improvement in hemodynamics while further discussions about management were ongoing (Table 1).

Repeat coronary angiography noted unchanged native vessels with patent bypass grafts. Overall, the patient continued to deteriorate, with evidence of progressive multiorgan dysfunction. A heart team review concluded that she had excessive surgical risk (mitral valve replacement) secondary to advanced age, progressive right ventricular dysfunction, and multiorgan failure. Hence a decision was made to attempt percutaneous edge-to-edge mitral valve repair.

After performing transseptal puncture using intraprocedural transesophageal echocardiography, one NT MitraClip was advanced and deployed via the clip delivery system across the medial aspect of the A2-P2 segments of the mitral valve. After implantation of the MitraClip, there was a marked reduction in MR severity to mild (Videos 8 and 9 and Figure 5) accompanied by a significant reduction in LA V-wave pressure from 27 to 15 mm Hg (Figure 6) as well as improvement in systolic antegrade pulmonary vein Doppler velocities (Figure 7). The residual diastolic mitral valve gradient was 2.5 mm Hg at a heart rate of 68 beats per minute. The procedure led to rapid hemodynamic improvement with reduction of vasopressor support and improvement of end organ function within the next 48 hours.

At 2-month follow-up, the patient was clinically doing well with no signs or symptoms of heart failure. Her echocardiogram revealed the presence of mild to moderate residual MR with preserved left ventricular function (Video 10 and Figure 8).

DISCUSSION

Acute MR secondary to papillary muscle rupture is often a mortal complication of MI. The posteromedial papillary muscle is more often involved due to its single source of blood supply from the right coronary artery. Transthoracic and transesophageal echocardiography are key not only to diagnose papillary muscle rupture and evaluation of the MR severity but also to define the mitral valve anatomy, determine treatment options, and ultimately predict transcatheter repair success if that approach is deemed feasible (Table 2).

The current treatment of choice for papillary muscle rupture is surgical intervention when possible.3 However, urgent surgical interventions are high risk, particularly in patients who are compromised by...
cardiogenic shock and multiorgan failure. Accordingly, transcatheter management has been proposed as an alternative option in this challenging patient population.

Limited evidence is available on the edge-to-edge transcatheter mitral repair therapy in the setting of acute MI-related papillary muscle rupture. Tarsia et al. reported successful MitraClip implantation post-MI. However, in that report the described patient had severe MR without papillary muscle rupture. Bilge et al. published percutaneous MitraClip repair of severe MR, which was a consequence of papillary muscle rupture post-MI. However, in that report the described patient had relatively more stable hemodynamics and the MitraClip procedure was performed 1 week after admission as a semieurgent intervention. Estévez-Loureiro et al. published national registry data from cardiogenic shock and multiorgan failure. Accordingly, transcatheter management has been proposed as an alternative option in this challenging patient population.

### Table 1 Cardiac indices post-CABG and after insertion of IABP

| Parameter       | Postoperation | Post-IABP |
|-----------------|---------------|-----------|
| BP, mm Hg       | 112/61        | 104/55    |
| MAP, mm Hg      | 76            | 68        |
| PAP, mm Hg      | 50/26         | 52/25     |
| mPAP, mm Hg     | 34            | 35        |
| CVP, mm Hg      | 18            | 20        |
| PCWP, mm Hg     | 22            | 25        |
| CI, L/min/m²    | 1.82          | 2.26      |
| SVRI, dyns/cm² m² | 2,547        | 1,697     |
| PVRI, dyns/cm² m² | 527        | 354      |

BP, Blood pressure; CI, cardiac index; CVP, central venous pressure; IABP, intra-aortic balloon pump; MAP, mean arterial pressure; MPAP, mean pulmonary artery pressure; PAP, pulmonary artery pressure; PCWP, pulmonary capillary wedge pressure; PVRI, pulmonary vascular resistance index; SVRI, systemic vascular resistance index.

Video 1: Apical two-chamber transthoracic echocardiogram at the time of presentation showing basal inferior akinesia.

Video 2: Color Doppler apical two-chamber transthoracic echocardiogram at the time of presentation showing trace MR.

Video 3: Transesophageal echocardiography. Midesophageal view at transducer angle 0° showing severe eccentric posteriorly directed MR.

Video 4: Transesophageal echocardiography. Midesophageal view at transducer angle 133° showing severe eccentric posteriorly directed MR.

Video 5: Transesophageal echocardiography. Transgastric midpapillary short-axis view showing partial rupture of the posteromedial papillary muscle.

Video 6: Transesophageal echocardiography. Transgastric two-chamber view showing partial rupture of the posteromedial papillary muscle.

Video 7: Three-dimensional transesophageal echocardiography (surgeon’s view) showing the flail segment of the anterior mitral valve leaflet (A2 and A3 scallops).

Video 8: Transesophageal echocardiography. Midesophageal view at transducer angle 0° showing successful implantation of the MitraClip and reduction in MR severity.

Video 9: Transesophageal echocardiography. Midesophageal view at transducer angle 144° showing successful implantation of the MitraClip and reduction in MR severity.

Video 10: Color Doppler apical four-chamber transthoracic echocardiogram in follow-up showing mild to moderate residual MR.

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Figure 1 Apical two-chamber transthoracic echocardiogram at the time of presentation. (A) basal inferior akinesia and (B) trace MR. LA, Left atrium; LV, left ventricle.
Figure 2  Transesophageal echocardiography. Midesophageal view shows severe posteriorly directed MR (A) at transducer angle 0° and (B) at transducer angle 133°. LA, Left atrium; LV, left ventricle.

Figure 3  Transesophageal echocardiography. Red arrows show partial rupture of the posteromedial papillary muscle: (A) transgastric midpapillary short-axis view and (B) transgastric long-axis view.

Figure 4  Three-dimensional transesophageal echocardiography (surgeon’s view). The red arrow indicates the flail segment of the anterior mitral valve leaflet (A2 and A3 scallops). Standard 3D image showing viewing angle from 2D images (Yellow arrow indicates viewing direction). 2D, Two-dimensional; 3D, Three-dimensional.
Figure 5 Transesophageal echocardiography (midesophageal view). Successful implantation of the MitraClip and reduction in MR severity (A) at transducer angle 0° and (B) at transducer angle 144°. LA, Left atrium; LV, left ventricle.

Figure 6 Left atrial V-wave pressure (A) pre-MitraClip and (B) post-MitraClip.

Figure 7 Pulmonary venous Doppler profiles of left superior pulmonary vein (A) pre-MitraClip and (B) post-MitraClip.
Spain on 185 patients treated with transcatheter mitral valve repair between 2010 and 2015. Most of these procedures were done for chronic MR, but five out of the 185 patients (2.7%) underwent a MitraClip procedure in the setting of acute MI-related MR. All of these patients had a significant reduction in degree of MR postprocedure and during follow-up. However, none of these five cases had MR related to papillary muscle tear or rupture and all procedures were performed days to weeks after the index MI.

In our case, one of the heads of the posteromedial papillary muscles had partially ruptured, with the second being intact. This anatomy provided a somewhat stable anchoring site for chordae to be supported by the intact head.

Given the favorable mitral valve anatomy and high surgical risk, a transcatheter intervention with edge-to-edge repair was implemented with significant reduction in MR that resulted in medical stabilization of our patient.

**CONCLUSION**

Papillary muscle rupture is often a fatal complication of acute MI. This case demonstrates transcatheter repair (MitraClip) as a possible alternative treatment strategy for this high surgical risk population to ameliorate cardiogenic shock and refractory pulmonary congestion related to acute MR.

Despite a paucity of good-quality data to guide off-label use of percutaneous repair in a setting of acute MR, the authors believe that there is a subset of patients at excessive risk for complications with cardiac surgical intervention that might benefit from this less invasive procedure (see Table 2 for optimal patient selection and challenging echo feature section). However, this approach should only be undertaken after multidisciplinary discussion focusing on parameters such as perioperative risk, anatomical consideration, and the possibility of procedural success. Eventually, higher quality data are needed, particularly on long-term outcomes in patients like the one described in this report.

**Table 2** Echocardiographic features determining suitability for the MitraClip

| Ideal echo features | Challenging echo features | Relative echo contraindications |
|---------------------|---------------------------|-------------------------------|
| **Location of pathology** | Segment 2 | Segment 1 or 3 | Body of leaflet (i.e., perforation or cleft/deep fold) |
| Calciﬁcation | None | Mild, outside grasping zone; extensive annular calcification | Severe calciﬁcation at site of grasping zone |
| Mitral valve area | >4 cm² | >3.5 cm² and <4 cm² with small body surface area or mobile leaflets | <3.5 cm² and ≥4 mm Hg |
| Mean mitral valve gradient | <4 mm Hg | ≥4 mm Hg | <3.5 cm² and ≥4 mm Hg |
| Grasping zone length | >10 mm | 7–10 mm | <7 mm |
| Functional MR | Normal thickness and mobility; coaptation depth < 11 mm | Carpentier III B (restricted); coaptation depth > 11 mm | Carpentier II A (rheumatic thickening and restriction) |
| Degenerative MR | Flail width < 15 mm; flail gap < 10 mm | Flail width < 15 mm with large valve area and option for > 1 MitraClip; flail gap > 10 mm with possibility of adjunctive measures | Barlow’s disease with significant regurgitation segments 1–3 |
| Other pathology | Annuloplasty ring with adequate mitral valve area and leaflet length; hypertrophic obstructive cardiomyopathy with systolic anterior motion; extreme disease (markedly dilated annulus or Effective regurgitation orifice area ≥ 70.8 mm²); partial papillary muscle rupture | |
SUPPLEMENTARY DATA

Supplementary data related to this article can be found at https://doi.org/10.1016/j.case.2021.01.002.

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