ESC European Society of Cardiology

European Heart Journal - Case Reports (2023) **7**, 1–5
https://doi.org/10.1093/ehjcr/ytad240

CASE REPORT
Structural intervention

Cardiogenic shock and severe secondary mitral regurgitation successfully treated with transcatheter edge-to-edge repair: a case report

Muhammad Asim Shabbir [1]*, Nidhish Tiwari[1], Adam Burdorf[1], Michael Moulton[2], and Poonam Velagapudi [1]

[1]Division of Cardiovascular Medicine, University of Nebraska Medical Center, 42nd and Emile St, Omaha, NE 68198, USA; and [2]Division of Cardiothoracic Surgery, University of Nebraska Medical Center, 42nd and Emile St, Omaha, NE 68198, USA

Received 13 September 2022; first decision 9 November 2022; accepted 5 May 2023; online publish-ahead-of-print 7 June 2023

Background Cardiogenic shock (CS) associated with severe mitral regurgitation (MR) forebodes a high risk of morbidity and mortality. Transcatheter edge-to-edge repair (TEER) is a rapidly evolving technique for severe MR in haemodynamically stable patients. However, the safety and efficacy of TEER for severe MR in CS are not well established.

Case summary An 83-year-old male presented with dyspnoea and was hospitalized for heart failure. Chest X-ray revealed pulmonary oedema. Transthoracic echocardiography showed severely depressed ejection fraction (EF) with severe secondary MR. Right heart catheterization confirmed a low cardiac index. Diuretics and inotropes were administered. Due to persistent hypotension, we could not wean inotropes. The patient was deemed high risk for surgery by the heart team, and a decision was made to proceed with TEER with MitraClip. Under transoesophageal echocardiography and fluoroscopic guidance, two MitraClips were deployed sequentially. The MR grade was reduced to two mild jets subsequently. The patient was weaned off inotropes and eventually discharged. At the 30-day follow-up, he was participating in physical activities such as golf.

Discussion Cardiogenic shock complicated by severe MR carries high mortality. With severe MR, the forward stroke volume is lower than the stated EF leading to poor organ perfusion. Inotropes and/or mechanical circulatory support devices are paramount for initial stabilization; however, they do not treat underlying MR. Transcatheter edge-to-edge repair with MitraClip has been shown to improve survival in CS patients with severe MR in observational studies. However, prospective trials are lacking. Our case demonstrates the utility of MitraClip to treat severe secondary MR refractory to medical therapy in a CS patient. The heart team must evaluate risks and benefits of this therapy in CS patients.

Keywords Cardiogenic shock • Severe mitral regurgitation • Transcatheter edge-to-edge repair (TEER) • MitraClip • Case report • Heart failure • Heart team approach

ESC curriculum 4.3 Mitral regurgitation • 6.4 Acute heart failure • 7.1 Haemodynamic instability • 7.3 Critically ill cardiac patient

* Corresponding author. Tel: 518-316-6672, Fax: 202-979-2406, Email: asimshabbir202@gmail.com
Handling Editor: Andrew Peter Vanezis
Peer-reviewers: Duygu Kocyigit Burunkaya; Marta Cvijic
Compliance Editor: William Crawford
Supplementary Material Editor: Lynsey Hewitson

Learning points

- Transcatheter edge-to-edge repair with MitraClip is a potential option for treatment of severe secondary mitral regurgitation associated with cardiogenic shock.
- Multidisciplinary heart teams should carefully assess risks and benefits of MitraClip therapy and select patients who may be appropriate candidates for this therapy.
- Appropriate patient selection and timely interventions where needed are key to procedural success and improved outcomes for patients.

Introduction

Cardiogenic shock (CS) associated with severe mitral regurgitation (MR) carries a high risk of morbidity and mortality. These patients are often critically ill with extremely high or prohibitive surgical risk.[1] Among patients with heart failure (HF) and severe secondary MR, transcatheter edge-to-edge repair (TEER) of the mitral valve (MV) has been shown to reduce mortality and HF hospitalizations in haemodynamically stable patients on optimally tolerated guideline-directed medical therapy (GDMT) in the COAPT trial.[2,3] In a few retrospective studies, TEER was found to be an acceptable option for the treatment of severe MR in haemodynamically unstable patients.[4,5] Transcatheter edge-to-edge repair could potentially be an effective strategy for transcatheter treatment of severe MR in CS patients who are at high or prohibitive risk for surgery albeit prospective trials are lacking.

Timeline

Presentation	Dyspnoea at rest with pulmonary oedema on X-ray—admitted for heart failure. Known left ventricular ejection fraction of 30%
Day 1	Intravenous furosemide administered with inadequate urine output. Transthoracic echocardiography demonstrated progressively worsening severe secondary mitral regurgitation (MR)
Day 2	Cardiogenic shock requiring inotropic support with milrinone
Days 3–4	Continued inotropic support in addition to aggressive diuresis
Day 5	Unable to wean off inotrope due to persistent hypotension. Transoesophageal echocardiogram: severe secondary MR despite volume optimization
Day 6	Underwent transcatheter edge-to-edge repair with XTW and XT MitraClips. Mitral regurgitation severity was reduced from severe to two mild MR jets. The post-procedure mitral valve area was 3.2 cm^2 with a mean gradient of 4 mmHg
Days 7–8	Inotrope weaned off. Guideline-directed medical therapy introduced
Day 9	Discharged to cardiac rehab
30-day follow-up	The patient felt well, went back to routine physical activity: playing golf
6-month follow-up	Continued to stay stable with good exertional capacity

Case presentation

An 83-year-old male presented with shortness of breath at rest and exertion. He had an extensive past medical and surgical history including coronary artery bypass graft surgery for coronary artery disease, Ross surgery for aortic stenosis, atrial fibrillation, sick sinus syndrome, hypertension, chronic renal insufficiency, and diabetes. In addition, he had a history of ischaemic cardiomyopathy, left ventricular ejection fraction (LVEF) of 30% status post biventricular defibrillator, and secondary MR. The patient had progressive worsening of secondary MR (severe grade) when he was hospitalized for decompensated HF a month prior. Pertinent home medications were aspirin, low-dose apixaban, metoprolol succinate, sacubitril/valsartan, spironolactone, torsemide, rosuvastatin, empagliflozin, and insulin. On index hospitalization, initial vital signs were as follows: blood pressure 100/60 mmHg, heart rate 71 b.p.m., respiratory rate 24/min, and O_2 saturation 96% on 3 L of supplemental O_2 via a nasal cannula. He appeared to be in respiratory distress with bilateral crackles on lung auscultation and bilateral pedal oedema. Serum creatinine was 2.3 mg/dL (reference range: 0.64–1.27 mg/dL), and venous lactic acid was 1.8 mmol/L (reference range: 0.5–2.0 mmol/L). His electrocardiogram showed ventricular paced rhythm. A coronary angiogram did not reveal new lesions. Chest X-ray was consistent with pulmonary oedema. Diuretics were administered with inadequate urine output <30 mL/hour. Transthoracic echocardiography (TTE) showed severely depressed LVEF 30% with global hypokinesis and basal to mid-inferior wall akinesis which was unchanged from previous study. left ventricular outflow tract (LVOT) velocity time integral (VTI) was 7.1 cm. Severe secondary MR (Carpentier Type III) was noted with an effective regurgitant orifice area (EROA) 0.46 cm^2, regurgitant volume 56 mL, vena contracta width 8.6 mm, and regurgitant fraction 40%. Mitral valve leaflets showed apical tethering with restricted motion. There was moderate tricuspid regurgitation and the Doppler-derived pulmonary artery systolic pressure (PASP) was 55 mmHg. The left atrium was severely dilated with a volume of 77.8 mL/m^2. The inferior vena cava was dilated at 2.4 cm with limited respiratory variation (right atrial pressure >15 mmHg). In addition, moderate eccentric aortic valvular regurgitation was noted. Severe MR was a result of progressive dilated cardiomyopathy [LV internal systolic diameter (LVIDs) was 6.4 cm, increased from 5.5 cm a year ago], which resulted in dilation of the mitral annulus. Right heart catheterization showed a pulmonary capillary wedge pressure (PCWP) of 26 mmHg with a prominent v-wave and cardiac index (CI) of 1.4 L/min/m^2 that improved to 1.9 L/min/m^2 following incremental nitroprusside challenge (up to 2.5 μg/kg/min). Milrinone infusion was initiated in addition to diuretics leading to optimization of volume status. However, the patient could not be weaned off milrinone due to hypotension. Transoesophageal echocardiography (TEE) confirmed severe secondary MR with the largest jet at the A2–P2 level (see Supplementary material online, *Videos S1* and *S2*). The mitral annulus was dilated with a mild apical displacement of mitral leaflets resulting in poor central coaptation. At a heart rate of 70 b.p.m., the MV area was 8.4 cm^2 by 3D planimetry. The EROA was 0.56 cm^2 with a posterior leaflet length of 1.6 cm, coaptation length of 0.5 cm, and coaptation depth of 1.1 cm. In addition, multiple small fibrinous deposits

were seen on the ventricular pacemaker lead in the right atrium (RA). Owing to significant comorbidities, the patient was deemed high risk for MV surgery by the heart team. The Society of Thoracic Surgeons (STS) risk score calculated a 32% risk of mortality and an 87% risk of morbidity or mortality. The decision was made to proceed with TEER using MitraClip. Due to the large coaptation depth, the anatomy of the MV was suitable for XTW MitraClip, which was the largest clip available with a wingspan of 25 mm at 180°. Under TEE and fluoroscopic guidance, XTW MitraClip was advanced across the MV after transseptal puncture and deployed on the A2 and P2 scallops. The MR grade was reduced from severe to moderate with an MV mean gradient (MG) of 2 mmHg and MV area (MVA) of 3.24 cm^2 (see Supplementary material online, *Video S3*; *Figure 1*). Therefore, a second XT MitraClip was deployed laterally to the first clip and subsequent TEE demonstrated two mild residual MR jets that were not pansystolic with EROA of 0.25 and 0.10 cm^2 (see Supplementary material online, *Video S4*; *Figure 2*). The final MV MG was 4 mmHg at a heart rate of 70 b.p.m. The patient was weaned off milrinone within the next 2 days, and GDMT was introduced subsequently. Medications on discharge included sacubitril/valsartan 24–26 mg twice a day, spironolactone 12.5 mg daily, empagliflozin 10 mg daily, torsemide 10 mg daily, rosuvastatin 10 mg daily, and apixaban 5 mg twice a day. He was ultimately discharged to cardiac rehab and then home. At the 30-day follow-up, he was able to participate in physical activities such as golf. Follow-up TTE showed stable MitraClip position with mild residual MR. The LVID dimension was 5.7 cm with an LVEF of 35%. The PASP and CI by Doppler echocardiography were 45 mmHg and 3.1 L/min/m^2, respectively. He continued to do well at the 6-month follow-up.

Discussion

Cardiogenic shock complicated by severe MR forebodes high morbidity and mortality. Medical therapy is the mainstay of initial management though it does not fully treat the spiral of CS and severe MR. Conventionally, these patients are treated with surgical MV repair or replacement if their surgical risk is acceptable. Unfortunately, a major proportion of these patients have prohibitive surgical risk.[1] With severe MR, the forward stroke volume is much lower than the stated LVEF leading to poor organ perfusion and adverse clinical outcomes.[6] Cardiogenic shock is treated with inotropes and/or mechanical circulatory support devices such as an intra-aortic balloon pump, impella, or extracorporeal circulatory membrane oxygenation.[7,8] Though these therapies are paramount for initial stabilization, they do not treat the underlying MR, causing haemodynamic compromise. We initially used milrinone in our patient, which increases cardiac contractility and decreases systemic vascular tone. The latter is particularly helpful in MR by augmenting forward stroke volume.[9] The clinical response, however, was suboptimal.

For the high-risk CS population, MV repair is plausible using transcatheter techniques. Transcatheter edge-to-edge repair with MitraClip has been shown to improve in-hospital survival in CS patients with severe MR in observational studies.[5,10–14] Using data from the Centers for Medicare and Medicaid Services, Tang *et al.*[5] noted a 10.6% absolute reduction in in-hospital mortality with MitraClip in patients with CS. Similarly, the multicentre observational MITRA-SHOCK study of MitraClip for CS showed 86% procedural success with an in-hospital mortality of 26%.[10] It is imperative to understand that these patients are critically ill, and their prognosis is frequently poor with or without surgical intervention. The STS risk score demonstrated a 32% risk of mortality in our patient within 30 days. Thus, it is important that the risks and benefits of MitraClip therapy in CS are carefully evaluated by multidisciplinary heart teams.

Currently, TEER of the MV is contemplated as salvage therapy. However, the safety and efficacy of the MitraClip in CS patients need to be established in randomized clinical trials. Our patient had well-suited mitral valve anatomy and LV dimensions (LVIDs <7.0 cm) for MitraClip. We sequentially utilized two clips to reduce the severity of MR. As there was a large coaptation depth with a sufficient leaflet length, we first used XTW MitraClip, which is the largest available clip with a wingspan of 25 mm at 180°. Since it only reduced MR to moderate, we deployed an XT clip lateral to the first one. The residual

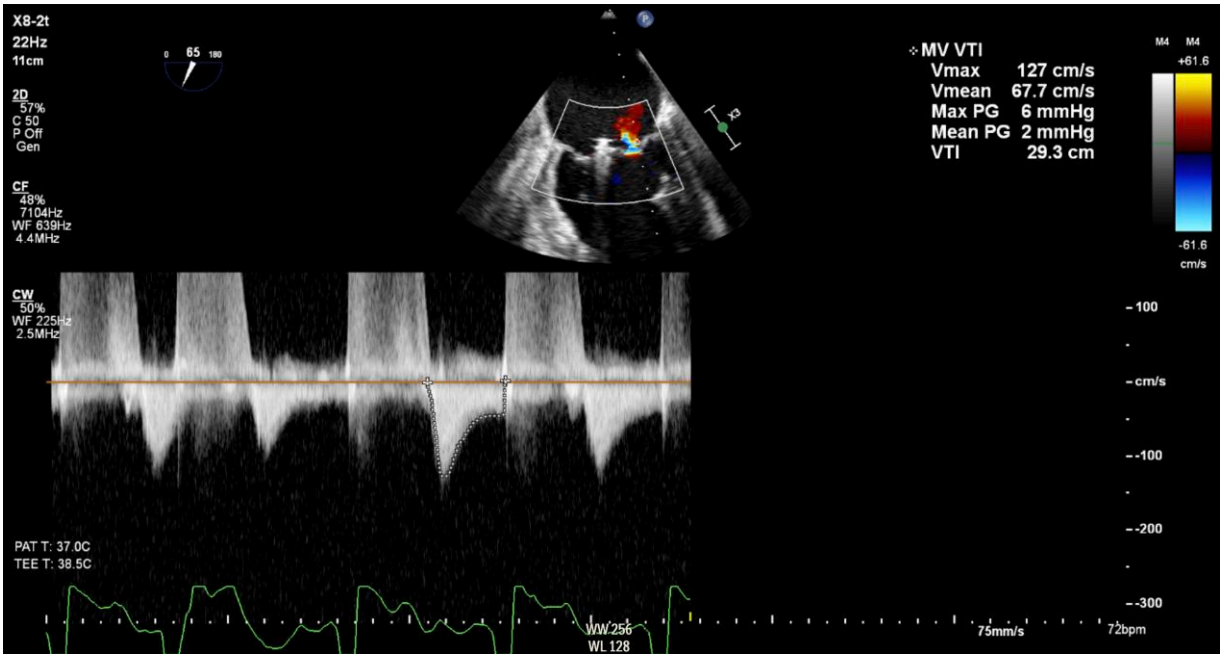

Figure 1 Spectral Doppler after the first XTW MitraClip showing a mitral valve mean gradient of 2 mmHg.

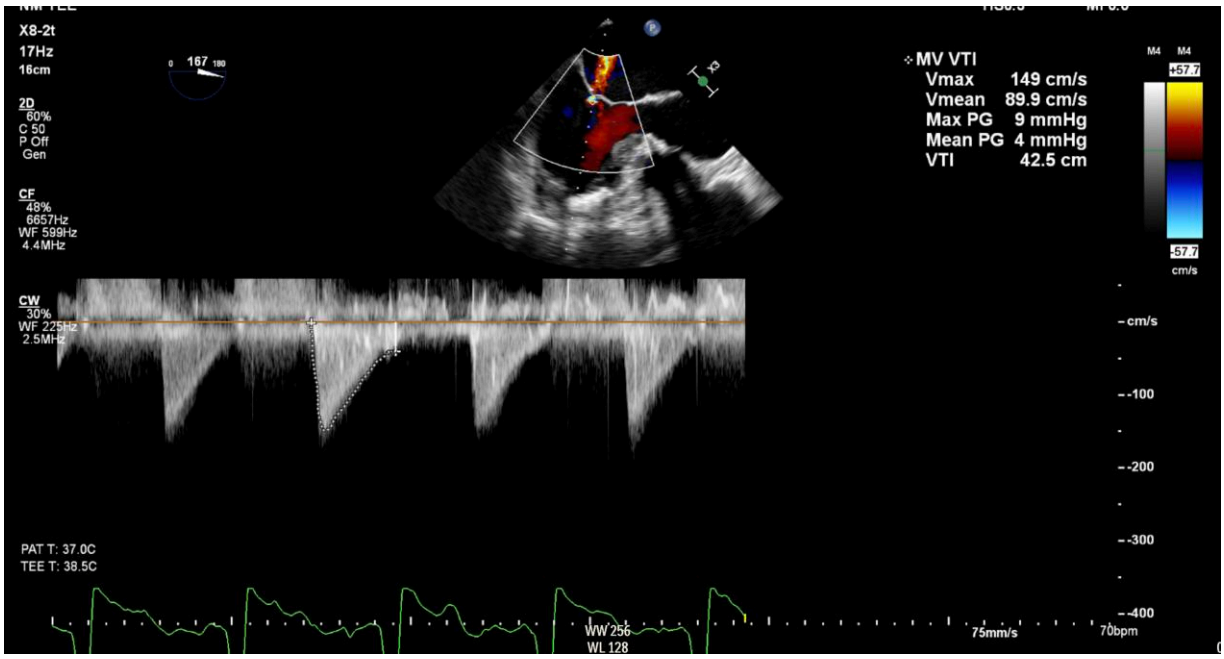

Figure 2 Spectral Doppler after the second XT MitraClip showing a mitral valve mean gradient of 4 mmHg.

MR was reduced to two mild jets with EROA of 0.25 and 0.10 cm^2. Further correction of MR was not pursued to avoid the risk of iatrogenic mitral stenosis since the final MV MG was already 4 mmHg at a heart rate of 70 b.p.m. The goal was to help the patient overcome the acute phase of CS by reducing MR severity and improving haemodynamics. Our patient also had small fibrinous deposits on the ventricular lead in the RA, which posed a second challenge. Therapeutic anticoagulation was maintained throughout the procedure, and the delivery catheter was manoeuvered to minimize contact with the pacemaker lead. This case underscores the utility of MitraClip to successfully treat severe secondary MR refractory to medical therapy in a clinically complex elderly patient with CS. Our patient demonstrated excellent recovery within a few days and resumed intense physical activity within a month.

Lead author biography

Muhammad Asim Shabbir, MD, is a cardiology fellow in training at the University of Nebraska, Omaha, NE, USA. He completed his Internal Medicine training and chief residency at Albany Medical College, NY, USA. His area of interest includes transcatheter valvular interventions and cardiac imaging.

Supplementary material

Supplementary material is available at *European Heart Journal – Case Reports*.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as Supplementary data.

Consent: Informed written consent was obtained from the patient on the form provided by *European Heart Journal – Case Reports* in accordance with COPE guidelines.

Conflict of interest: M.A.S., N.T., M.M., and A.B.: None declared. P.V.: Medtronic, speakers bureau; Abiomed, speaking fees and advisory board; Sanofi, advisory board; and Opsens, speaking fees.

Funding: None declared.

Data availability

Unidentified data is available on request.

References

1. Briosa EGA, Hinton J, Sirohi R. Cardiogenic shock due to acute severe ischemic mitral regurgitation. *Am J Emerg Med* 2021;**43**:292.e1–292.e3.
2. Stone GW, Lindenfeld J, Abraham WT, Kar S, Lim DS, Mishell JM, *et al.* Transcatheter mitral-valve repair in patients with heart failure. *N Engl J Med* 2018;**379**:2307–2318.
3. Otto CM, Nishimura RA, Bonow RO, Carabello BA, Erwin JP, Gentile F, *et al.* 2020 ACC/AHA guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. *Circulation* 2021;**143**:e72–e227.
4. Flint K, Brieke A, Wiktor D, Carroll J. Percutaneous edge-to-edge mitral valve repair may rescue select patients in cardiogenic shock: findings from a single center case series. *Catheter Cardiovasc Interv* 2019;**94**:E82-E87.
5. Tang GHL, Estevez-Loureiro R, Yu Y, Prillinger JB, Zaid S, Psotka MA. Survival following edge-to-edge transcatheter mitral valve repair in patients with cardiogenic shock: a nationwide analysis. *J Am Heart Assoc* 2021;**10**:e019882.
6. Yousef HA, Hamdan AES, Elminshawy A, Mohammed NAA, Ibrahim AS. Corrected calculation of the overestimated ejection fraction in valvular heart disease by phase-contrast cardiac magnetic resonance imaging for better prediction of patient morbidity. *Egypt J Radiol Nucl Med* 2020;**51**:11.
7. Tehrani BN, Truesdell AG, Sherwood MW, Desai S, Tran HA, Epps KC, *et al.* Standardized team-based care for cardiogenic shock. *J Am Coll Cardiol* 2019;**73**:1659–1669.

8. Russo JJ, Aleksova N, Pitcher I, Couture E, Parlow S, Faraz M, *et al.* Left ventricular unloading during extracorporeal membrane oxygenation in patients with cardiogenic shock. *J Am Coll Cardiol* 2019;**73**:654–662.
9. Ayres JK, Maani CV, Milrinone. *StatPearls*. Treasure Island (FL): StatPearls Publishing; 2022.
10. Falasconi G, Pannone L, Melillo F, Adamo M, Ronco F, Carrabba N, *et al.* Use of MitraClip system for severe mitral regurgitation in cardiogenic shock: results from a multicentre observational Italian experience (the MITRA-SHOCK study). *Eur Heart J* 2020;**41**:ehaa946–2635.
11. Garcia S, Alsidawi S, Bae R, Cavalcante J, Eckman P, Gössl M, *et al.* Percutaneous mitral valve repair with MitraClip in inoperable patients with severe mitral regurgitation complicated by cardiogenic shock. *J Invasive Cardiol* 2020;**32**:228–231.
12. Jung RG, Simard T, Kovach C, Flint K, Don C, Di Santo P, *et al.* Transcatheter mitral valve repair in cardiogenic shock and mitral regurgitation: a patient-level, multicenter analysis. *JACC: Cardiovasc Intervent* 2021;**14**:1–11.
13. Jung RG, Simard T, Di Santo P, Hibbert B. Transcatheter edge-to-edge repair in patients with mitral regurgitation and cardiogenic shock: a new therapeutic target. *Curr Opin Crit Care* 2022;**28**:426–433.
14. Martinez-Gomez E, McInerney A, Tirado-Conte G, de Agustin JA, Jimenez-Quevedo P, Escudero A, *et al.* Percutaneous mitral valve repair with MitraClip device in hemodynamically unstable patients: a systematic review. *Catheter Cardiovasc Interv* 2021;**98**:E617–E625.