ESC European Society of Cardiology

European Heart Journal - Case Reports (2024) **8**, 1–6
https://doi.org/10.1093/ehjcr/ytad621

CASE REPORT
Valvular heart disease

Cardiac rehabilitation for elderly, weak patients who undergo transcatheter edge-to-edge repair: a case report

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Received 8 July 2023; revised 27 November 2023; accepted 7 December 2023; online publish-ahead-of-print 11 December 2023

Background The positive role of rehabilitation programmes for some cardiac patient populations (e.g. coronary artery disease, heart failure, transcatheter aortic valve replacement, and heart transplantation) is now well-known. However, the feasibility and outcomes of rehabilitation, prior to or immediately after percutaneous mitral valve reconstruction, using a clamping procedure have been poorly reported, especially among frail elderly patients.

Case summary An 85-year-old woman with acute heart failure symptoms (New York Heart Association functional class III), who had acute myocardial infarction 3 months ago, was hospitalized. An ultrasound cardiogram showed severe mitral regurgitation, and after a multidisciplinary discussion, transcatheter edge-to-edge repair (TEER) was considered the safest treatment option. Even then, though, due to her poor health status, it was still too risky for the patient to undergo without significant prior preparation. Thus, we decided to begin pre- and post-surgery cardiac rehabilitation (CR) to prepare her for TEER, comprising medicinal, nutritional, and psychological support, as well as exercise and smoking cessation. After pre-operative assessment and rehabilitation, the patient underwent TEER, followed by post-operative reassessment, and continued rehabilitation.

Discussion Our case study demonstrates that CR, both pre- and post-TEER, aids in improving the conditions of elderly patients with poor health, to minimize their risk for developing TEER-related complications. This case provides one possible CR regimen for those patients.

Keywords Transcatheter edge-to-edge repair • Mitral regurgitation • Cardiac rehabilitation • Case report

ESC curriculum 4.3 Mitral regurgitation • 8.7 Prevention and rehabilitation programmes • 7.5 Cardiac surgery • 7.4 Percutaneous cardiovascular post-procedure

Learning points

- Transcatheter edge-to-edge repair (TEER) allows for mitral valve repair, with fewer complications and surgery-related injuries, possibly serving as a suitable option for elderly, frail patients unable to undergo conventional surgery.
- Cardiac rehabilitation, both pre- and post-TEER, could improve prognosis and quality of life for elderly, frail patients.

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Handling Editor: Christoph Sinning
Peer-reviewers: Marianna Garcia-Saldivia; Christoph Clemens Kaufmann; Clea Simone Sabino de Souza Colombo
Compliance Editor: Ralph Makr Louis Neijenhuis

Introduction

Conventional treatment approaches for treating mitral regurgitation (MR), such as surgical mitral valve repair or replacement, have been effective; however, their widespread adoption has been limited due to significant peri-operative risks.[1] As a result, transcatheter edge-to-edge repair (TEER) has become an attractive alternative; as compared with conventional surgery, it has been found in clinical trials to result in lowered hospitalizations for heart failure (HF) and mortality; additionally, TEER can be carried out among patients who are ineligible for conventional approaches.[2–4] More specifically, a clinical trial involving 78 patients found that patients with moderate-to-severe MR, who were still symptomatic even after receiving guideline-directed medical therapy, had lowered hospitalization and mortality rates after the 24-month follow-up period post-TEER.[3] These findings were further reinforced by a larger-scale study of 5000 patients, where even among individuals who, at baseline, had more severe HF and functional limitations, as well as comorbidities, they had significantly lower hospitalization and clinical event rates after receiving TEER.[2] Furthermore, TEER was still able to be performed among frail patients and was effective in improving their quality of life, despite them being more prone to increased mortality and respiratory failure, as well as longer hospital stays, compared with non-frail ones.[5]

With respect to those frail patients, cardiac rehabilitation (CR), especially in light of novel preconditioning models, as well as individually tailored regimens, has become increasingly attractive for improving functional outcomes and shortening hospital stays.[6] This is due to innovations in catheter-based surgical interventions, resulting in increased numbers of frail patients undergoing cardiac surgeries.[6] However, CR is still an underutilized therapeutic approach for treating cardiac diseases.[7,8] In this case study, we highlighted a possible combinatorial treatment approach involving both TEER and personalized CR in a frail elderly patient. This patient was found to benefit from receiving CR, both before and after TEER surgery.

Summary figure

Time	Events
3 months ago (9 June 2021)	·Non-ST-segment-elevation myocardial infarction ·Coronary angiogram: Left anterior descending (LAD) and right coronary artery proximal segment occlusion, both TIMI level 0 ·Underwent percutaneous coronary intervention with a drug-eluting stent in LAD artery
Hospitalization (28 September 2021)	
Pre-operative	·Acute heart failure symptoms (New York Heart Association functional class III) ·Physical examination: 3/6 systolic murmur of the heart and moist rales in the lungs ·Transoesophageal echocardiography: Indicate severe mitral regurgitation ·N-terminal prohormone of brain natriuretic peptide: 2895 pg/mL ·Chest ultrasound: Bilateral pleural effusion ·After multidisciplinary discussion: Transcatheter edge-to-edge repair (TEER) was considered
Pre-operative CR (15 October 2021)	·Evaluation pre-CR: Restrictive ventilatory disturbance, severe reduction in exercise tolerance, exercise cardiac function class D (Weber KT criteria) ·CR programme: Medical treatment; Psychological Therapy; Nutrition prescription; Tailored exercise prescription ·Evaluation post-CR: Improved right-hand grip strength, motion ability, balance (walk with walking aids), self-care ability
TEER	
Post-operative CR (17 October 2021)	·Post-operative CR started based on evaluation ·Post-operative CR: ·Phase 1: Respiratory training and health education; ·Phase 2: Exercise of surgery-unrelated limb joints, balance, strength, and standing gradually added
After-discharge (1 November 2021)	·Stick to individualized CR prescriptions and recheck regularly
1 year after discharge	·Greatly improved quality of life and prognosis: Increased exercise endurance, hand grip strength (both), balance (walk with walking aids), motion ability, and self-care ability

Case summary

An 85-year-old female was admitted to the emergency room, due to acute HF symptoms with dyspnoea and chest tightness, which is a characteristic of New York Heart Association functional class III. Her blood pressure was 105/64 mmHg, and her heart rate was 57 b.p.m. Physical examination revealed moist rales in the lungs, a 3/6 holo-systolic murmur best heard in the apical region, and neck vein engorgement. Her daily medication included aspirin (81 mg), clopidogrel (75 mg), atorvastatin (20 mg), metoprolol (23.75 mg), spironolactone (20 mg), furosemide (20 mg), insulin, dapagliflozin (10 mg), and alprazolam (0.4 mg). Laboratory tests showed that the patient had 93 g/L (normally 115–150) haemoglobin, 0.01 ng/mL (normally 0–0.02) cardiac troponin I, and 13 669 pg/mL (normally 0–900) N-terminal prohormone of brain natriuretic peptide. Chest ultrasounds revealed bilateral pleural effusion, and transthoracic echocardiography indicated the presence of severe MR (see Supplementary material online, *Video S1*). This was further confirmed by transoesophageal echocardiography, which showed that mitral orifice area was 4.04–4.22 cm^2 (normally 4–6 cm^2) in 2D and 2.5–2.9 cm^2 in 3D (see Supplementary material online, *Figure S1*). Additionally, maximal and average pressure differences of the velocity–time integral for mitral valve flow were, respectively, 10 and 2 mmHg.

Previous medical history included acute myocardial infarction 3 months ago, as well as subsequent percutaneous coronary intervention, using a drug-eluting stent in the left anterior descending artery. Furthermore, she had undergone several episodes of acute HF since

Table 1 Patient performance indices at first hospitalization, as well as after pre-operative cardiac rehabilitation, surgery, and post-operative cardiac rehabilitation

Items		1st hospitalization (28 September 2021)	Pre-surgery (15 October 2021)	1st day post-surgery (17 October 2021)	Discharge (1 November 2021)
Athletic ability	Exercise endurance [metabolic equivalent (MET) score]	2.74 METs	6-min walk test: 60 m Cardiopulmonary exercise test: Level D	Not applicable	3.62 METs
	Limb muscle strength (MMT score)	IV	IV	Upper limbs: IV Left lower limb: Ⅲ	IV
	Hand grip strength (kg)	Left: 7.5; right: 5.5	Left: 7.5; right: 6.8	Left: 7.3; right: 7.1	Left: 10.9; right: 8.5
	Balance (Berg scale, points)	7 (no balance while standing)	21 (walk with walking aids)	Not applicable	29 (walk with walking aids)
	Motion ability (MRMI score, points)	12	15	14	19
Frailty	FRAIL scale (points)	5 (obvious weakness)	4 (obvious weakness)	4 (obvious weakness)	3 (obvious weakness)
Sleeping	Pittsburgh Sleep Quality Index (points)	6 (mild sleep disorder)	6 (mild sleep disorder)	4	4
Psychological status	Patient Health Questionnaire-9 (points)	15 (moderate anxiety)	Not applicable	Not applicable	7 (moderate anxiety)
	General Anxiety Disorder-7 (points)	10 (moderate depression)	Not applicable	Not applicable	9 (moderate depression)
Nutritional status	Nutritional Risk Screening (points)	5 (high malnutrition risk)	Not applicable	Not applicable	4 (high malnutrition risk)
Self-care ability	Activities of Daily Living scale	45	55	45 (surgery-related limb constrained)	70
Cognitive function	S5q score Mini-Mental State Examination (MMSE, points)	5 (fully cooperative)	5 (fully cooperative)	5 (fully cooperative) MMSE 21 (mild cognitive impairment)	5 (fully cooperative)
Pain intensity	VAS score (points)	0	0	3 (surgery area pain mildly disturbs sleep)	0
Ultrasound cardiogram	LVIDd (mm)	49.6	53.6	53.9	—
	Left atrial diameter (mm)	45	42	44	—
	PASP (mmHg)	47	29	24	—

LVIDd, left ventricular internal diameter end diastole; MMT, Manual Muscle Testing; MRMI, Modified Rivermead Mobility Index; PASP, pulmonary artery systolic pressure; VAS, visual analogue scale.

then. Additionally, the patient had type 2 diabetes for over 30 years, several bone fractures, and a hip replacement, which made her unwilling to exercise.

After a multidisciplinary discussion, TEER with MitraClip was considered the safest treatment option. However, the patient was found to fall into the IV class, under the American Society of Anesthesiologists physical status classification system, as well as having European system for cardiac operative risk evaluation (EuroSCORE) ≥ 6.[9] Therefore, we decided that the patient should undergo pre-operative CR prior to being administered TEER. Cardiac rehabilitation involved the activities of a transdisciplinary group of health professionals, in which the regimen was initially prescribed by the CR physician, followed by execution under the guidance of specialized therapists. It comprised five major tenants: medicinal, nutritional, psychological support, exercise and smoking cessation.

Based on the pre-CR patient evaluation (*Table 1*; *Figure 1*), the patient had poor cardiorespiratory endurance and extremely weak muscle strength, being unable to stand up with her legs. As exercise prescription was a key element of CR, one was tailored for the patient, consisting of low-intensity exercises, such as joint-movement gymnastics, along with respiratory, balance, hand grip muscle strength, and passive muscle stretch training. Patient heart rate was monitored during exercises and maintained at no more than the resting heart rate, plus 20 b.p.m. The detailed pre-operative CR regime was outlined in *Table 2*. After 2 weeks of pre-TEER CR, the patient was able to stand up with support and walk 60 m with the assistance of a walking aid in the 6-min walk test. She was also graded 'IV', under the Manual Muscle Testing score, in the muscle strength test, as well as being able to complete respiratory training and two rounds of seated calf raise training unassisted (*Table 1*).

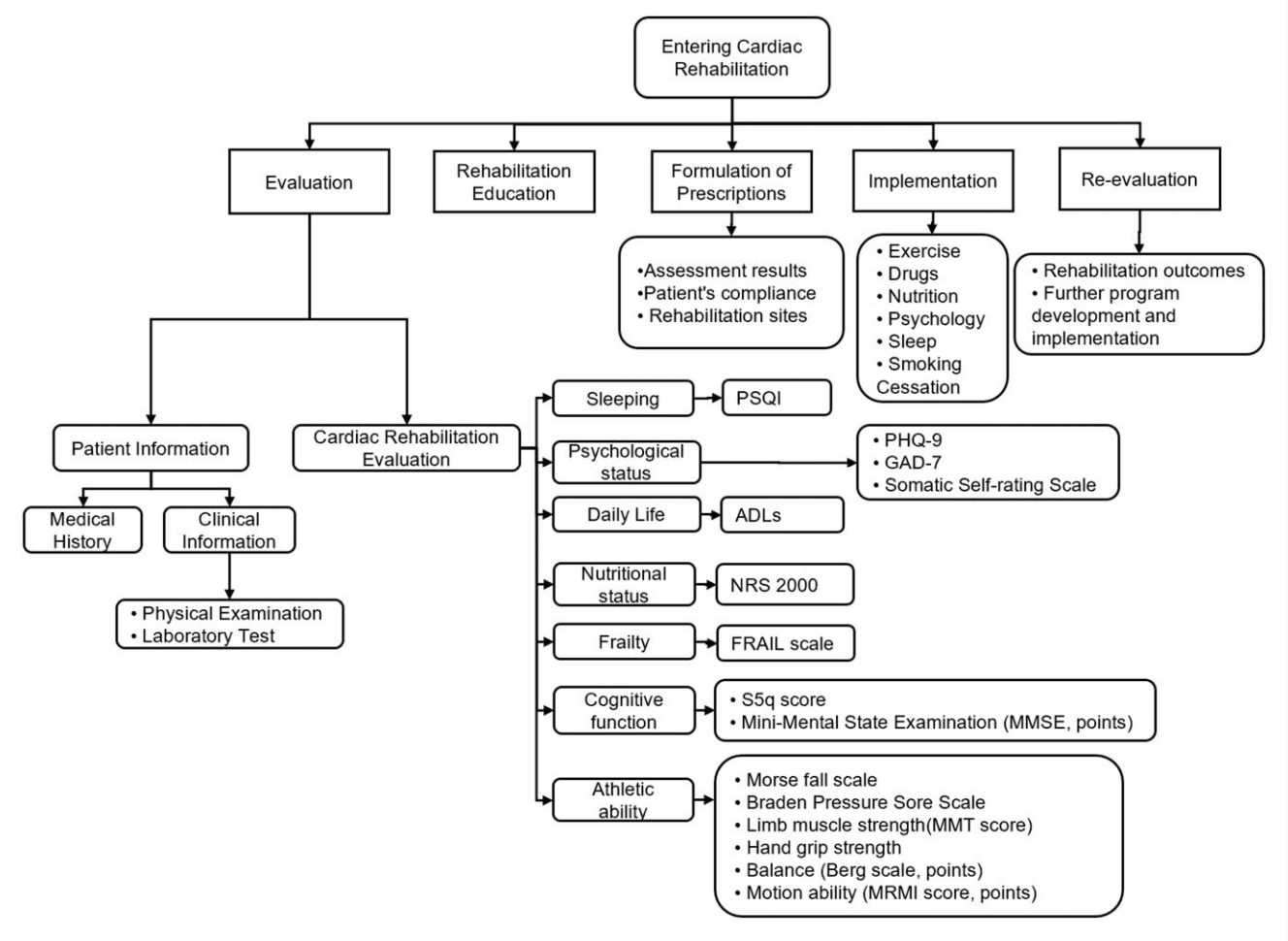

Figure 1 Flow diagram of cardiac rehabilitation, both before and after surgery. ADLs, Activities of Daily Living scale; GAD-7, General Anxiety Disorder-7; MMSE, Mini-Mental State Examination; MMT, Manual Muscle Testing; MRMI, Modified Rivermead Mobility Index; NRS, Nutritional Risk Screening; PHQ-9, Patient Health Questionnaire-9; PSQI, Pittsburgh Sleep Quality Index.

Table 2 Pre-operative cardiac rehabilitation exercise regimen

Exercise type	Exercise duration (min)	Times/ day	Days/ week	Intensity
Gymnastics	5	~1–2	~3–5	Heart rate (HR)
Respiratory training	~10–15	~1–2		< resting
Seated calf raise	~5–8	~2–3		HR + 20,
Hand grip strength	~5–8	~2–3		Borg scale
Seated balance training	5	~2–3		~11–12
Passive muscle stretch	5	~1–2		

After pre-operative assessment, rehabilitation, and post-operative reassessment, we successfully completed TEER, using MitraClip. Post-operative CR was then initiated, comprising of two periods in the intensive care unit (Phases 1 and 2) and the general ward (Phases 3–5), which was outlined in *Table 3*. Briefly, in Phase 1, respiratory training and health education were chosen as the main training regimens, since the operative area was motion constrained. This was coupled with active surgery-unrelated limb joint exercises in Phase 2. After the patient was transferred into the general ward, more challenging training, such as balance, strength, and standing exercises, was gradually added in Phases 3–5 until the time of discharge. Exercise intensity was kept low, even with gradual patient improvements, to avoid excessive heart burden or TEER complication onset. Prior to discharge, a tailored at-home exercise regimen, as shown in *Table 4*, was developed, and the patient was asked to regularly recheck her health. After the 1-year follow-up period, the patient remained at a similar condition to that of post-discharge, on 1 November 2021, in that she had increased exercise endurance, hand grip strength (both), balance (walk with walking aids), motion and self-care ability, compared to pre-TEER. She also continued to receive CR training.

For all exercise regimens (*Tables 2–4*), patient's physical condition and vital signs were closely monitored with cardiac monitoring equipment. Exercises were immediately halted if symptoms indicating a lack of exercise tolerance, such as chest pain, obvious shortness of breath, palpitations, and dyspnoea, were present. Exercises were also stopped under the following conditions: Increase in heart rate of

Table 3 Post-operative cardiac rehabilitation exercise regimens

Phases	Respiratory training	Joint movement exercises	Strength training	Body position changes	Bowel functional recovery
1	Respiration pattern	Passive	Not applicable	Lying to half-lying	Not applicable
2	Training with movement	Passive (operation-related limbs) Active (operation-unrelated limbs)	Not applicable	Half lying to sitting	Bowel self-massage
3	Inspiratory muscle	Active	Upper limbs Core muscle	Sitting	Bowel self-massage
4	Respiratory gymnastics	Active	Lower limbs Core muscle	Standing and stepping with walking aids Shifting centre of mass with support	Not applicable
5	Respiratory gymnastics	Active	Resistance training with resistance band	Walking with a walking aid	Not applicable

Table 4 At-home cardiac rehabilitation regimen post-discharge

Exercise type	Duration (min)	Times/day	Days/week	Intensity
Gymnastics	5	~1–2	~3–5	HR < resting HR + 20
Aerobic exercise	~10–15	1		
Standing calf raise/ resistance band	~5–8	~2–3		Borg scale ~11–12
Hand grip strength	~5–8	~2–3		
Standing balance training	~5	~2–3		
Passive muscle stretch	~5	~1–2		

>20 b.p.m. during exercise, diastolic blood pressure of ≥110 mmHg, systolic blood pressure increase of >40 mmHg or decreases >10 mmHg, compared with resting values, respiratory frequency of >30 b.p.m., SpO2 < 95%, obvious ventricular or atrial tachycardia, second- or third-degree atrioventricular block, or electrocardiogram with ST dynamic changes.

Discussion

Cardiac rehabilitation has been found to have beneficial effects on multiple cardiac diseases[7,10] and has been evaluated after TAVR in elderly patients, in which it was found to be a feasible, safe, and effective approach.[10] However, their effect on patients undergoing mitral valve reconstruction, using MitraClip, has not been fully examined. In this case report, we present an elderly female patient with severe MR, who benefited from TEER coupled with CR. There, CR, both pre- and post-operatively, was able to reduce TEER risk and increase its success rate, thereby improving patient prognosis and quality of life.

For these frail elderly patients, exercise could be beneficial, yet also difficult and dangerous. Therefore, the intensity should not be too high and should be determined based on pre-operative assessments, rehabilitation, and post-operative reassessments of individual patients.[11,12] Patients should be under full surveillance during exercise by physicians and nurses, and blood pressure and oxyhaemoglobin saturation levels should be measured pre-, during, and post-exercise. Psychological symptoms are also common among cardiovascular disease patients,[12,13] in which uncontrolled emotional extremes could lead to symptoms, such as hypertension, which increase adverse cardiovascular event incidence and mortality.[13,14] Therefore, mental health should always be considered during CR.

Post-TEER MitraClip complications, though relatively rare,[15] also need to be considered when planning post-operative CR regimens. One of the most common complications is clip detachment, which could be avoided by maintaining low-level exercise intensities.[15] Furthermore, post-operation CR is often divided into different phases, as well as different body areas. For instance, in Phase 1, the most important task for physicians is to monitor vital signs, as well as possible bleeding and infection of the operative area, to prevent MitraClip-related complications, while for patients, CR in this phase involves health education and respiratory practices learned prior to the operation. During this phase, motion-constraining methods are used to prevent patient complications. Phase 2 involves joint and passive limb exercises, which aid in avoiding joint stiffness and muscle atrophy outside of operation-related body areas. Additionally, deep vein thrombosis should be prevented during patient bed stays. For Phases 3–5, additional exercises could be gradually added to the CR prescription, though high-intensity exercises should still be forbidden. There, limb strength training, particularly for lower limbs, was gradually added to the daily CR regimen, allowing the patient to walk with a walking aid instead of remaining bedridden or requiring a wheelchair, which significantly increased her quality of life. Cardiac rehabilitation after discharge is also considered a good method to prevent adverse cardiovascular event recurrence.[12] However, patient compliance and safety are unable to be guaranteed without medical staff surveillance. Thus, it is recommended that the patient be referred to the appropriate CR facilities for further treatment.

Conclusion

This case study demonstrates that pre- and post-surgery CR aids in improving patient conditions so that they could successfully undergo surgery and minimize the risk of TEER-related complications, among elderly patients in frail health.

Lead author biography

Jingjin Liu, MD, PhD, is the director of the cardiac rehabilitation centre and deputy chief physician at Shenzhen People's Hospital. Currently, she concentrates on the development of remote advanced digital cardiac rehabilitation programmes for valvular heart disease.

Supplementary material

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

Acknowledgements

The authors thank Shenzhen People's Hospital for providing this case.

Consent: The authors confirm that written consent for submission and publication of this case report including the images and associated text has been obtained from the patient in line with COPE guidance.

Conflict of interest: None declared.

Funding: This work was supported by the National Natural Science Foundation (Project #82200315), the Guangdong Basic and Applied Basic Research Foundation (2021A1515111145), Sanming Project of Medicine in Shenzhen (No. SZSM201412012), and Major Scientific Research Project of Shenzhen People's Hospital (SYWGSJCYJ202301).

Data availability

The data underlying this article are available in the article and its online Supplementary material.

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