MitraClip or Ventricular Assist Device?

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Summary
The patient was a 59-year-old female with advanced heart failure and severe functional mitral regurgitation who was classified as INTERMACS profile 4 with repeated hospitalizations despite guideline-directed medical therapy. She was also listed for heart transplantation. After comparing the two major therapeutic strategies: (1) durable left ventricular assist device (LVAD) implantation and (2) percutaneous MitraClip procedure (Abbott Vascular, Abbott Park, IL, USA), we eventually decided to proceed with MitraClip, given her relatively lower B-type natriuretic peptide, lower MAGGIC Heart Failure risk score, and higher predicted survival without LVAD. The post-procedural course was favorable without any comorbidities or worsening of heart failure for 10 months. A diagnostic paradigm to guide which strategy to choose (LVAD or MitraClip) for patients with advanced heart failure and functional mitral regurgitation should be constructed.

Key words: Mitral valve disease, Hemodynamics, Heart failure

Functional mitral regurgitation (FMR) often develops in patients with advanced heart failure. The severity of FMR is associated with the patient’s prognosis, and therapeutic strategies to treat FMR that improve survival are limited.1) The causes of FMR are multifactorial: the worsening of mitral valve coaptation due to enlargement of the left ventricle, the deviation of papillary muscle due to remodeling of the left ventricle, and impairment of the closing force of the mitral valve due to the enlargement of its annulus and impaired myocardium.

The conventional treatment for the FMR is surgical mitral valve repair or replacement, but the clinical outcomes using these two options have not shown a durable survival benefit. The MitraClip system (Abbott Vascular, Abbott Park, IL, USA) is a less invasive percutaneous trans-catheter mitral valve repair procedure, and has shown superiority over the optimal medical therapy for patients with FMR in a recent clinical trial.1) However, exactly how to choose the right patient for MitraClip among patients with advanced heart failure and FMR remains uncertain.

Case Report
A 59-year-old female patient with advanced heart failure due to non-ischemic cardiomyopathy was admitted to our institute for heart failure management. She experienced repeated hospitalizations for IV diuretic therapy despite 2-year guideline-directed medical therapy and cardiac resynchronization therapy.

On admission: Her blood pressure was 84/48 mmHg and her pulse rate was 78/minute. She had received guideline-directed medical therapy including carvedilol 10 mg/day, enalapril 2.5 mg/day, and spironolactone 50 mg, which were the maximum doses she could tolerate due to dizziness. Her plasma levels of B-type natriuretic peptide had remained between 150 and 450 pg/mL and peak exercise oxygen consumption was 11.5 mL/minute/kg.

Transesophageal echocardiography showed a left ventricular end-diastolic diameter of 70 mm and left ventricular ejection fraction of 27%. The tricuspid annular plane systolic excursion was 20 mm, right ventricular fractional area change was 46%, and tricuspid regurgitation was mild. The effective mitral regurgitant orifice area was 0.44 cm² and mitral regurgitant volume was 57 mL (Figure 1). Transesophageal echocardiography showed a coaptation length of 3.0 mm, coaptation depth of 9.4 mm, posterior mitral leaflet mobility of 10 mm, fossa-annulus diameter of 33 mm, and mitral valve area of 3.5 cm².

Right heart catheterization showed pulmonary capillary wedge pressure of 13 mmHg with a v-wave of 20 mmHg and cardiac index of 1.4 L/minute/m². The estimated one-year survival calculated by the Seattle Heart Failure Model was 91% and the MAGGIC Heart Failure survival risk score was 22 (estimated one-year survival was 87.8%).2,3) The STS score for mitral valve replacement was 3.1% and the EURO II score was 2.0%. Given the INTERMACS profile 4 with repeated hospitalizations for heart failure, she was listed for heart transplantation.

In summary, the patient had both (1) advanced heart failure eligible for cardiac replacement therapies including...
Figure 1. Transthoracic echocardiography, transesophageal echocardiography, and right heart catheterization. TTE indicates transthoracic echocardiography; TEE, transesophageal echocardiography; RHC, right heart catheterization; LVDd, left ventricular diastolic diameter; LVDs, left ventricular systolic diameter; LVEF, left ventricular ejection fraction; MR, mitral regurgitation; EROA, effective regurgitant orifice; RV, regurgitant volume; PML, posterior mitral leaflet; MVA, mitral valve area; RAP, right atrial pressure; PAP, pulmonary artery pressure; PCWP, pulmonary capillary wedge pressure; CI, cardiac index; SV, stroke volume; and BP, blood pressure.

Figure 2. Transesophageal echocardiography before and after MitraClip procedure. Severe mitral regurgitant flow improved to the trace flow following two clippings (green arrow) as well as remaining arterial blood pressure and reduced left atrial pressure. ABP indicates arterial blood pressure; and LAP, left atrial pressure.

a durable left ventricular assist device (LVAD) and (2) severe FMR eligible for intervention to the mitral valve including MitraClip therapy. We eventually decided to proceed with a MitraClip instead of LVAD implantation. **MitraClip procedure:** The MitraClip procedure was conducted in a standard manner via the right femoral vein using two clips: the first clip at the medial side of A2-P2 leaflets and the second clip just outside of the first one (Figure 2). Mitral regurgitation was reduced from severe to trace and the mean pressure gradient of transmitral flow after the placement of two clips was only 2.9 mmHg. Left atrial pressure decreased from 18 mmHg to 11 mmHg and there was also a significant reduction in the v-wave from 38 mmHg to 18 mmHg. One week later, her pulmonary capillary wedge pressure had declined to 8 mmHg and the cardiac index increased to 3.3 L/minute/m² (Figure 3).

**Post-procedural course:** One week later, her plasma level
Figure 3. Clinical parameters before and after MitraClip procedure (one week later and 6 months later). PCWP indicates pulmonary capillary wedge pressure; PAP, pulmonary artery pressure; CI, cardiac index; SV, stroke volume; BNP, B-type natriuretic peptide; LVEDd, left ventricular end-diastolic diameter; LVESd, left ventricular systolic diameter; LVEF, left ventricular ejection fraction; MR, mitral regurgitation; VO₂, peak oxygen consumption; and VE/VO₂, ventilator equivalent for carbon dioxide.

of B-type natriuretic peptide decreased to 41 pg/mL and the dose of carvedilol was titrated up to 20 mg/day. Peak oxygen consumption improved from 11.5 to 12.5 mL/kg/minute. At 6 months follow-up, transthoracic echocardiography showed persistently well-controlled mitral regurgitant fraction, remaining left ventricular end-diastolic diameter of 68 mm, improved left ventricular ejection fraction up to 39%, and decreased left ventricular end-diastolic volume from 145 mL to 125 mL as expected. Her hemodynamics remained stable, including a pulmonary capillary wedge pressure of 8 mmHg and cardiac index of 2.6 L/minute/m². She has been followed-up without any heart failure re-hospitalizations for 10 months.

Discussion

Therapeutic strategy of FMR with advanced heart failure: It is challenging to propose an optimal therapeutic strategy for a patient with both FMR and advanced heart failure in terms of whether the dilated ventricle or regurgitant mitral valve is the culprit for the observed functional decline. Traditionally, various types of surgical mitral valve plasty have been proposed to treat FMR. However, most are not promising strategies.

LVAD implantation: Given the recent studies demonstrating the improvement of FMR following LVAD implantation alone, LVAD implantation alone might be a good option for patients with FMR, particularly for those with an INTERMACS profile 1-3. Others reported that significant MR remained in some patients despite LVAD therapy and such residual MR may be associated with worse outcomes. Patient selection for concomitant mitral valve replacement at the time of LVAD implant is an area of the field which needs more investigations.

LVAD implantation in patients with an INTERMACS profile 4 is controversial. Several large-scale studies including the ROADMAP trial and REVIVE-IT trial might not support aggressive LVAD therapy in such less sick cohorts given frequent readmissions due to device-related comorbidities. Nevertheless, a certain number of cohorts with specific risk factors, including severe ventricular tachyarrhythmias and elevated B-type natriuretic peptide, may still be good candidates for LVAD therapy. We did not select LVAD therapy as a first choice in this case, given the patient’s relatively low B-type natriuretic peptide, lower MAGGIC Heart Failure risk score, and an estimated one-year survival as high as HeartMate 3 LVAD cohorts (i.e., the patient would enjoy satisfactory survival without LVAD support).

The MitraClip procedure is not a complete solution of FMR. We should follow the heart failure function and the recurrence of FMR even after the MitraClip procedure, and consider LVAD implantation if applicable.

MitraClip treatment: The COAPT trial demonstrated the superior clinical outcomes of MitraClip therapy over the optimal medical therapy in patients with FMR. MitraClip is a less invasive procedure performed via a venous approach. Furthermore, the hemodynamic improvement following the MitraClip procedure might allow the up-titration of heart failure-specific medical therapy, thus prolonging survival and reducing heart failure specific morbidities.

Nevertheless, the MitraClip procedure for those with heart failure that is too advanced may not result in any improvement in hemodynamics, ventricular structure, or function and functional class. Consistently, the MITRA-FR trial, which included those with a more remodeled left ventricle than the COAPT trial, did not demonstrate the
survival benefit of MitraClip over optimal medical therapy.

This specifically occurred as patients in the MITRA-FR trial had mitral regurgitation that was proportional to their degree of left ventricular dilation, whereas patients in the COAPT trial instead had disproportionate mitral regurgitation relative to left ventricular diameter.\(^{11}\)

Several other indexes other than INTERMACS profiling might be keys to prioritize MitraClip therapy rather than LVAD implantation among those with INTERMACS profile 4-7 as we did.\(^{8}\) For example, the absence of pulmonary hypertension is associated with better clinical outcomes following the MitraClip procedure.\(^{12}\) Further investigations of key parameters to optimize patient selection for the MitraClip therapy are warranted.

**Conclusion**

We present a patient with advanced heart failure and FMR, which required considerable discussion using several unique indexes for the optimal therapeutic strategy. An optimal indication of the MitraClip procedure in patients with advanced heart failure and FMR remains an area in need of more data.

**Disclosure**

**Conflicts of interest:** None.

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