2772-9931
https://doi.org/10.1016/j.atssr.2024.09.023

Valve: Short Report

Infrequent Need for Temporary Mechanical Circulatory Support After Mitral Valve Surgery

Tomoki Sakata, MD, PhD,[1] Yuki Nakamura, MD, PhD,[1] Keshava Rajagopal, MD, PhD,[1] Vakhtang Tchantchaleishvili, MD,[1] Konstadinos A. Plestis, MD,[1] John W. Entwistle III, MD, PhD,[1] Joseph E. Bavaria, MD,[1] and Rakesh M. Suri, MD, DPhil[1]

ABSTRACT

BACKGROUND Temporary mechanical circulatory support (tMCS) may be necessary to treat low cardiac output syndrome after mitral valve surgery (MVS) for chronic severe mitral regurgitation (MR). However, prevalence and predictors remain undetermined.

METHODS This single-center retrospective cohort study included 443 patients who underwent primary MVS for degenerative, ischemic, or functional MR between January 2013 and June 2023. Patients requiring tMCS intraoperatively or postoperatively were compared with patients who did not require tMCS. Multivariable logistic regression identified independent risk factors for tMCS requirement.

RESULTS tMCS was required in 12 of 443 patients (2.7%), with degenerative (2.1%), functional (1.8%), and ischemic (8.3%) MR. Independent risk factors for tMCS requirement were preoperative left ventricular ejection fraction <50% (odds ratio, 4.94; $P = .01$) and mitral valve replacement (odds ratio, 5.85; $P = .005$). MR type was not independently influential. The 30-day mortality was 41.7% (5 of 12) in the tMCS group vs 3.5% (15 of 431) in the non-tMCS group ($P < .0001$).

CONCLUSIONS Requirements for tMCS after MVS for MR are infrequent, but tMCS is associated with high mortality. Low preoperative left ventricular ejection fraction and mitral valve replacement are independent risk factors, thus suggesting that careful surgical planning and meticulous postoperative monitoring are warranted in high-risk cases.

(Ann Thorac Surg Short Reports 2025;3:52-56)

Mitral valve surgery (MVS) for mitral regurgitation (MR) is performed to improve survival, prevent and even reverse future left ventricular (LV) remodeling and systolic dysfunction, and relieve heart failure symptoms. Because many patients have preoperative LV systolic dysfunction, postoperative low cardiac output syndrome may be encountered. Moreover, the use of ejection phase indices of LV systolic function, most notably LV ejection fraction (LVEF), is confounded by the fact that all ejection phase indices of contractile function are inversely related to afterload, and MR is an LV afterload-reducing lesion. Thus, the LVEF

IN SHORT

- The need for tMCS after MVS for MR is infrequent (2.7%), but tMCS is associated with high mortality when required.
- Low preoperative LVEF and mitral valve replacement are independent risk factors for requiring tMCS.

Accepted for publication Sep 23, 2024.

[1]Division of Cardiac Surgery, Department of Surgery, Thomas Jefferson University, Philadelphia, Pennsylvania

Address correspondence to Dr Suri, Division of Cardiac Surgery, Department of Surgery, Thomas Jefferson University, 1025 Walnut St, Ste 607 College, Philadelphia, PA 19107; email: rakesh.m.suri@gmail.com.

does not necessarily correlate well or reliably with true intrinsic LV systolic function. Consistent with this, postoperative LV dysfunction after MVS does occur when LVEF is normal.[1] Uncommonly, some patients may have a severe enough low cardiac output syndrome to require temporary mechanical circulatory support (tMCS). However, the frequency of a tMCS requirement after MVS and the risk factors for tMCS needs remain unclear. This study aimed to characterize tMCS in patients undergoing MVS for MR.

MATERIAL AND METHODS

From 2013 to 2023, 646 patients underwent MVS at our institution (Thomas Jefferson University Hospital, Philadelphia, PA). Patients undergoing reoperative MVS, MVS for mitral stenosis, and MVS for MR caused by hypertrophic obstructive cardiomyopathy, rheumatic valve disease, and active infective endocarditis were excluded, leaving 443 patients undergoing primary MVS for degenerative, ischemic, or functional MR (Figure). Among them, 12 patients required tMCS intraoperatively or postoperatively (tMCS group). Patients who required tMCS preoperatively were excluded. These 12 patients were compared with patients who did not require tMCS (non-tMCS group; n = 431). Our detailed tMCS strategy is described in the Supplemental Materials and in the Supplemental Figure.

DATA COLLECTION. Patient characteristics, operative and in-hospital outcomes, and follow-up data were extracted from hospital electronic medical records. The tMCS requirement was defined as undergoing device therapy including intraaortic balloon pump (IABP) placement, venoarterial extracorporeal membrane oxygenation (VA ECMO), or temporary LV assist device placement (Impella, Abiomed Inc) for intraoperative or postoperative low cardiac output syndrome. On the basis of previous studies demonstrating that an LVEF <50% is associated with inferior survival in patients undergoing MVS for MR,[2,3] we used this threshold LVEF value. The origin of MR was categorized as degenerative, functional, or ischemic, on the basis of preoperative records.

STATISTICAL ANALYSIS. Categorical variables were presented as percentages and numbers. Continuous variables were presented as median and interquartile range (IQR) and were compared using the χ^2 test. To determine the independent risk factors for tMCS requirement, a multivariable logistic regression analysis was performed, adjusted by the significant factors in univariable logistic regression analysis. All analyses were conducted with JMP software version 12.0 (SAS Institute Inc), and $P < .05$ was the criterion for statistical significance.

RESULTS

PATIENT CHARACTERISTICS. Supplemental Table 1 shows baseline demographics, clinical characteristics, and laboratory findings of the overall cohort, the tMCS group, and the non-tMCS group. The median age in the overall cohort was 65 years (IQR, 57-73 years). Sixty percent of the patients were male. Patients' races were White, Black, Asian, and other in 79%, 14%, 5%, and 2%, respectively.

The median age was also 65 years in both groups. The proportion of male patients was 42% in the tMCS group and 61% in the non-tMCS group. Compared with the non-tMCS group, a higher proportion of the tMCS group had a history of heart failure. The tMCS group was more likely to have higher serum creatinine levels. On echocardiographic assessment, the tMCS group was more likely to have an LVEF <50%, greater LV systolic diameter, higher pulmonary arterial systolic pressure, and worse right ventricular function. The median operative mortality risk calculated by The Society of Thoracic Surgeons risk score was 4.0% in the tMCS group, as opposed to 1.0% in the non-tMCS group.

OPERATIVE DATA. The operative data of the overall cohort, the tMCS group, and the non-tMCS group are shown in Supplemental Table 2. A total of 33% and 24% of the tMCS and non-tMCS groups underwent urgent or emergency surgery,

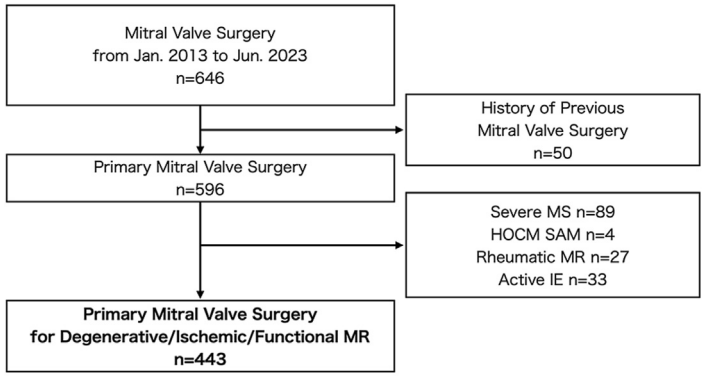

FIGURE Flow chart of patient selection. (HOCM, hypertrophic obstructive cardiomyopathy; IE, infective endocarditis; MR, mitral valve regurgitation; MS, mitral stenosis; SAM, systolic anterior motion.)

respectively. The tMCS group was more likely to undergo mitral valve replacement. In terms of the MR origin, 58%, 8%, and 33% of the tMCS group and 77%, 13%, and 10% of the non-tMCS group had degenerative, functional, and ischemic MR, respectively. Concomitant procedures included coronary artery bypass grafting (33% in tMCS the group; 20% in the non-tMCS group), aortic surgery (8% in tMCS; 2% in non-tMCS), aortic valve surgery (25% in tMCS; 10% in non-tMCS), and tricuspid valve surgery (17% in tMCS; 8% in non-tMCS). The tMCS group tended to have a longer cardiopulmonary bypass time (182 minutes in tMCS; 135 minutes in non-tMCS) and aortic cross clamp time (111 minutes in tMCS; 92 minutes in non-tMCS).

The detailed early postoperative outcomes of patients in the tMCS group are shown in Supplemental Table 3. The Supplemental Figure shows the tMCS strategy for these 12 patients. Eight patients required tMCS intraoperatively, and 4 required early postoperatively. IABP and VA ECMO were used in 9 and 5 patients, respectively. The most frequent indication for tMCS requirement was LV dysfunction, followed by mixed cardiogenic and distributive shock. In 2 patients with mixed LV failure and distributive shock, IABPs were placed to augment coronary blood flow. In 5 patients undergoing VA ECMO, a temporary LV assist device was added in 1 patient to bridge support and facilitate VA ECMO weaning and decannulation. Two patients initially had IABPs, which were upgraded to VA ECMO for further support. The prevalence of a tMCS requirement in each MR etiologic category was 2.1% (7 of 339) in degenerative, 1.8% (1 of 56) in functional, and 8.3% (4 of 48) in ischemic MR, respectively. Among 4 patients who required tMCS postoperatively, the times from surgery to tMCS initiation were 16.2, 17.5, 33.0, and 49.2 hours, and 2 patients (50%) died before discharge. In patients requiring tMCS intraoperatively, 3 of 8 patients (38%) died before discharge.

POSTOPERATIVE OUTCOMES. Five patients could not be weaned from tMCS and died during the index hospitalization. The remaining patients were able to be discharged and are doing well with regular follow-up. The 30-day mortality rate was 41.7% (5 of 12) in the tMCS group and 3.5% (15 of 431) in the non-tMCS group ($P < .0001$).

RISK FACTORS ASSOCIATED WITH TEMPORARY MECHANICAL CIRCULATORY SUPPORT. The Table shows risk analyses for tMCS requirement. In the univariable model, a history of heart failure (odds ratio [OR], 3.61; IQR, 1.12-13.69; $P = .03$), LVEF <50% (OR, 5.61; IQR, 1.71-18.5; $P = .01$), greater LV systolic diameter (OR, 1.07 per 1 mm increase; IQR, 1.00-1.13; $P = .049$), higher pulmonary arterial systolic pressure (OR, 1.04 per 1 mm Hg increase; IQR, 1.00-1.08; $P = .046$), mitral valve replacement (OR, 6.05; IQR, 1.77-27.54; $P = .004$), ischemic MR origin (OR, 4.40; IQR, 1.14-14.6; $P = .03$), and cardiopulmonary bypass time (OR, 1.01 per 1-minute increase; IQR, 1.00-1.02; $P = .02$) were significantly associated with tMCS requirement.

The multivariable model revealed an LVEF <50% (OR, 4.94; IQR, 1.47-16.6; $P = .01$) and mitral valve replacement (OR, 5.85; IQR, 1.68-26.9; $P = .005$) as independent risk factors for tMCS requirements.

COMMENT

In this study, we provided insights into how frequently tMCS is required in patients undergoing MVS for MR in the modern era and identified risk factors for tMCS needs. Specifically, we found that (1) the prevalence of intraoperative or postoperative tMCS requirement was as low as 2.7% (12 of 443) in patients undergoing MVS for MR and (2) associated with independent risk factors of low preoperative LVEF and mitral valve replacement.

It is well understood that LVEF in the setting of chronic severe MR underestimates intrinsic LV contractility and systolic function.[4] In contrast, a low LVEF (<60%) in the setting of severe MR is a marker of latent significant LV systolic dysfunction.[5,6] Finding that mitral valve replacement was also an independent risk factor for tMCS requirement is also not surprising in that it has been associated with a higher likelihood of postoperative LV dysfunction compared with mitral valve repair in previous studies.[7,8] Even though surgeons attempt to spare as many chords as possible, undoubtedly a varying number of chords is removed to seat a surgical prosthesis securely, and this may impair ventricular-annular continuity in contraction. Additionally, analysis of intraventricular blood flow by using vector flow mapping demonstrated that mitral valve replacement showed an abnormal vortex pattern with greater energy loss compared with valve repair.[9] From an energetics standpoint, this inefficient vortex after valve replacement is also considered to be related to LV dysfunction. It is unknown whether this will translate to the evolving strategy of transcatheter mitral valve

TABLE Logistic Regression Analysis for Temporary Mechanical Circulatory Support Requirement

	Univariable Model		Multivariable Model	
Variables	**OR (95% CI)**	***P* Value**	**OR (95% CI)**	***P* Value**
Male	0.46 (0.13–1.45)	.18	…	…
Age	0.98 (0.94–1.02)	.31	…	…
Race (White/Black)	1.15 (0.17–4.49)	.86	…	…
Body mass index, kg/m^2	0.97 (0.86–1.06)	.56	…	…
Hypertension	0.68 (0.21–2.58)	.54	…	…
Diabetes mellitus	1.21 (0.18–4.74)	.81	…	…
Cerebrovascular disease	1.07 (0.16–4.16)	.93	…	…
Smoking history	0.96 (0.26–3.50)	.95	…	…
Sleep apnea	0.48 (0.03–2.54)	.44	…	…
Immunocompromise	2.21 (0.12–12.42)	.50	…	…
Heart failure	3.61 (1.12–13.69)	**.03**	…	…
Atrial fibrillation	1.36 (0.36–4.40)	.63	…	…
Myocardial infarction	2.37 (0.51–8.23)	.24	…	…
Laboratory data				
White blood cell, 10^9/L	1.02 (0.85–1.09)	.77	…	…
Hematocrit, %	0.97 (0.89–1.07)	.55	…	…
Platelet, 10^3/uL	1.00 (0.99–1.00)	.90	…	…
Albumin, g/dL	0.75 (0.30–2.23)	.59	…	…
Creatinine, mg/dL	1.14 (0.83–1.39)	.32	…	…
Total bilirubin, mg/dL	0.46 (0.04–1.74)	.35	…	…
Previous PCI	2.49 (0.37–9.98)	.30	…	…
Cardiogenic shock	3.47 (0.18–20.42)	.32	…	…
LV ejection fraction <50%	5.61 (1.71–18.5)	**.01**	4.94 (1.47–16.6)	**.01**
LV diastolic diameter, mm	1.05 (0.97–1.13)	.21	…	…
LV systolic diameter, mm	1.07 (1.00–1.13)	**.049**	…	…
RV dysfunction	2.53 (0.54–9.07)	.21	…	…
Systolic PA pressure, mm Hg	1.04 (1.00–1.08)	**.046**	…	…
STS mortality risk score, %	1.11 (0.95–1.25)	.17	…	…
Urgent or emergency status	1.57 (0.41–5.10)	.48	…	…
Robotic surgery	0.27 (0.04–1.04)	.06	…	…
Mitral valve replacement	6.05 (1.77–27.54)	**.004**	5.85 (1.68–26.9)	**.005**
Isolated mitral valve surgery	0.35 (0.10–1.12)	.08	…	…
Mitral cause				
Degenerative	0.42 (0.13–1.44)	.16	…	…
Functional	0.62 (0.03–3.29)	.63	…	…
Ischemic	4.40 (1.14–14.6)	**.03**	…	…
Concomitant procedure				
CABG	1.98 (0.52–6.43)	.29	…	…
Aorta	4.26 (0.22–25.83)	.26	…	…
Aortic valve	2.86 (0.62–9.99)	.16	…	…
Tricuspid valve	2.19 (0.33–8.74)	.36	…	…
Cardiopulmonary bypass time, min	1.01 (1.00–1.02)	**.02**	…	…
Aortic cross clamp time, min	1.01 (0.99–1.02)	.29	…	…

Statistically significant *P*–values are indicated in bold. CABG, coronary artery bypass grafting; LV, left ventricular; OR, odds ratio; PA, pulmonary arterial; PCI, percutaneous coronary intervention; RV, right ventricular; STS, The Society of Thoracic Surgeons.

intervention given that the subvalvular apparatus is left intact. Transcatheter intervention is considered when the risk of operation is deemed to be greater than 5% on assessment by the multidisciplinary heart valve team. Once recommendations of the team are obtained, the patient and family are presented with indications, risk, benefits, and alternatives. An informed discussion is undertaken regarding the preferred approach.

The risk factors in this study are important in predicting cases that may progress to a critical state requiring tMCS, as demonstrated in this study reflective of modern era practice. In 4 of 12 cases, tMCS was required 16 to 44 hours after patients returned to the intensive care unit. This

finding calls for extra vigilance in the intensive care unit or before transition to stepdown to prevent the need for urgent rescue of hemodynamic instability related to myocardial dysfunction for up to 48 hours after surgery.

STUDY LIMITATIONS. To examine the independent factors, we conducted multivariable logistic regression analysis. However, unknown confounding factors could not be assessed, and the results of this study on the basis of only 12 patients with tMCS cannot be generalized. Larger multicenter or national database studies are necessary to confirm our results.

CONCLUSION. The requirement for tMCS after MVS for MR is infrequent in the modern era, but tMCS is associated with high mortality when it is used. Low preoperative LVEF and mitral valve replacement are independent risk factors, thus suggesting that careful surgical planning and meticulous postoperative monitoring are warranted in these high-risk cases.

The Supplemental Material can be viewed in the online version of this article [https://doi.org/10.1016/j.atssr.2024.09.023] on http://www.annalsthoracicsurgery.org.

FUNDING SOURCES

The authors have no funding sources to disclose.

DISCLOSURES

Joseph E. Bavaria reports a relationship with Edwards Lifesciences that includes: consulting or advisory; with Abbott that includes: consulting or advisory and serving as chair of the data safety monitoring board; and with Medtronic that includes: consulting or advisory. All other authors declare that they have no conflicts of interest.

REFERENCES

1. Quintana E, Suri RM, Thalji NM, et al. Left ventricular dysfunction after mitral valve repair—the fallacy of "normal" preoperative myocardial function. *J Thorac Cardiovasc Surg*. 2014;148:2752–2762.

2. Enriquez-Sarano M, Tajik AJ, Schaff HV, Orszulak TA, Bailey KR, Frye RL. Echocardiographic prediction of survival after surgical correction of organic mitral regurgitation. *Circulation*. 1994;90:830–837.

3. Noack T, Marin Cuartas M, Kiefer P, et al. Isolated mitral valve repair in patients with reduced left ventricular ejection fraction. *Ann Thorac Cardiovasc Surg*. 2019;25:326–335.

4. Kamperidis V, Marsan NA, Delgado V, Bax JJ. Left ventricular systolic function assessment in secondary mitral regurgitation: left ventricular ejection fraction vs. speckle tracking global longitudinal strain. *Eur Heart J*. 2016;37:811–816.

5. Suri RM, Schaff HV, Dearani JA, et al. Recovery of left ventricular function after surgical correction of mitral regurgitation caused by leaflet prolapse. *J Thorac Cardiovasc Surg*. 2009;137:1071–1076.

6. Hu X, Jiang W, Li H, Yan G, Wang Y. Timing of valve repair for asymptomatic mitral regurgitation and preserved left ventricular function. *Ann Thorac Surg*. 2021;111:862–870.

7. Enriquez-Sarano M, Schaff HV, Orszulak TA, Tajik AJ, Bailey KR, Frye RL. Valve repair improves the outcome of surgery for mitral regurgitation. A multivariate analysis. *Circulation*. 1995;91:1022–1028.

8. Lee EM, Shapiro LM, Wells FC. Superiority of mitral valve repair in surgery for degenerative mitral regurgitation. *Eur Heart J*. 1997;18:655–663.

9. Akiyama K, Nakamura N, Itatani K, et al. Flow-dynamics assessment of mitral-valve surgery by intraoperative vector flow mapping. *Interact Cardiovasc Thorac Surg*. 2017;24:869–875.