

Robotic Mitral Valve Replacement in Extreme Risk

A Preoperative Biventricular Parameter Strategy for Mechanical Support Integration

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① Introduction

Clinical Gap

- Severe FMR with low EF carries a high post-cardiotomy shock risk regardless of prior intervention.
- For patients with prior failed mitral transcatheter edge-to-edge repair (M-TEER) and progressive HF, delayed surgical intervention remains a real-world dilemma.
- MCS is typically deployed reactively; no physiology-based framework exists for proactive integration.

Objective

To evaluate a preoperative **biventricular phenotype-based MCS strategy** that pre-emptively circumvents:

- post-cardiotomy cardiogenic shock (PCCS)
- afterload mismatch (ALM) after MVR on a failing ventricle

Success Criteria

- Freedom from PCCS**
- Cardiorenal rescue:
 - Reverse remodeling (LVEF, LVEDD)
 - Renal recovery (eGFR, Cr)
- Ambulatory discharge

② Biventricular Risk Profile

Patient: 75-y-old male; DCM, severe FMR
M-TEER attempted → **clip not deployed** (procedural MS)
→ withdrawn

Hemodynamic Phenotype vs. Published Cutoffs

Parameter	Patient	Cutoff	Source	Flag
LVEF	22%	≤ 25%	<i>IMPACT</i> ³	✗
CI (L/min/m ²)	1.89	< 2.3	<i>Javorski</i> ²	✗
mean PCWP (mmHg)	24	> 21	<i>Javorski</i> ²	✗
PAPi	1.81	< 2.0	<i>Kang</i> ⁴	✗
CVP (mmHg)	11	> 8	<i>Mullens</i> ⁷	✗

Strategic Implication

- All 5 indices fail published high-risk thresholds.**
- PAPi 1.81 < 2.0 mathematically rules out isolated left-sided support (Kang).⁴
- Isolated Impella → high risk of acute RV failure.
- RV protection must be embedded upfront → V-A ECMO arm of ECPELLA (V-A ECMO + Impella 5.5).
- Reactive rescue is too late on a phenotype this extreme.

Biventricular risk phenotype mandates biventricular support — not as rescue, but as architecture.

★ Dual-Axis Decision Matrix

Where does this patient plot? → Zone 4: Extreme Biventricular Risk

LEFT-SIDED AXIS — Low-Output & Congestion		
PCWP ≤ 21 mmHg CI ≥ 2.3 L/min/m ² (Javorski ²)		PCWP > 21 mmHg CI < 2.3 L/min/m ² (Javorski ²)
RV Reserve OK PAPi ≥ 2.0	Zone 1 No MCS (Standard surgery)	Zone 2 Isolated LV Support (Impella alone)
	Zone 3 RV-Side Support (RVAD / V-A ECMO)	Zone 4 — Extreme Risk ★ ECPELLA (Planned) V-A ECMO + Impella 5.5 ⌚ <i>This case</i> CI 1.89 · PCWP 24 · PAPi 1.81
Isolated LV Support Fails PAPi < 2.0		

③ OR-to-Cath-Lab Integration Protocol

1 **OR**
Robotic MVR

da Vinci bileaflet-preserving MVR. Bileaflet preservation is associated with reduced LV end-systolic wall stress.⁵ Right axillary side-graft preset.

2 **OR**
Seamless CPB → V-A ECMO

Pre-emptive transition from CPB to peripheral V-A ECMO. RV protected from the moment CPB is weaned.

3 **Hybrid OR**
Impella 5.5 via axillary graft

Direct transfer under full support. Fluoroscopy-guided Impella 5.5 insertion → Planned ECPELLA complete.

④ Trajectory & Cardiorenal Rescue

Weaning Sequence

- Post-op MAP: 50s mmHg
- Preoperative CVP 11 → POD 9 CVP 7 mmHg (*crosses Mullens 8-mmHg threshold*⁷)
- ECMO off: POD 1 · Impella off: POD 5 · ICU out: POD 9

Earlier (POD 9) Renal Rescue			Later (POD 11) Reverse Remodeling		
	Pre	POD9		Pre	POD11
Cr (mg/dL)	1.77	0.81	LVEF	22%	42%
eGFR	30.1	70.5	LVEDD	61 mm	49 mm
CVP (mmHg)	11	7	LVESD	54 mm	39 mm

No AKI · No neurologic event · No prosthetic dysfunction

Ambulatory discharge: POD 77

Paradoxical Renal Rescue — Mechanism

Despite permissive post-op hypotension (MAP 50s)⁶, **Impella 5.5 transvalvular unloading** → ↓PVR → ↓RAP/CVP (11→7).

Crossing the Mullens 8-mmHg congestion threshold⁷ optimized **RPP = MAP – CVP**, resolving tubular interstitial edema.

→ *Venous decongestion, not cardiac index, is the primary driver of post-shock renal rescue.*

Conclusion

A preoperative biventricular phenotype profile guided planned ECPELLA integration with robotic bileaflet-preserving MVR, enabling proactive — rather than reactive — mechanical support in an extreme-risk patient.

References

1. Failed M-TEER surgical bailout meta-analysis. Ann Thorac Surg 2020;110:1925 (PMID 33221925). 2. Javorski/Soltesz. JTCVS 2024;168:120 (PMID 38452888) — PCWP > 21 mmHg, CI < 2.3, NICM-PCCS. 3. IMPACT Trial. Am Heart J 2026 (PMID 41895564) — LVEF ≤ 25%, planned Impella 5.5. 4. Kang et al. J Heart Lung Transplant 2016;35:67 (PMID 26212656) — PAPi < 2.0, RV failure after isolated LV support. 5. Ucak et al. Acta Cardiol 2011;66:627 (PMID 22032058) — Bileaflet preservation, LV wall stress. 6. Everett et al. Circ Heart Fail 2021;14:e008616 (PMID 34517730) — Transvalvular unloading paradigm. 7. Mullens et al. JACC 2009;53:589 — CVP > 8 mmHg, worsening renal function (AUC 0.734).

Abbreviations: ALM, afterload mismatch; CI, cardiac index; CVP, central venous pressure; DCM, dilated cardiomyopathy; ECPELLA, V-A ECMO + Impella; FMR, functional mitral regurgitation; LVEF, left ventricular ejection fraction; MAP, mean arterial pressure; MCS, mechanical circulatory support; M-TEER, mitral transcatheter edge-to-edge repair; MVR, mitral valve replacement; NICM, non-ischemic cardiomyopathy; PAPi, pulmonary artery pulsatility index; PCCS, post-cardiotomy cardiogenic shock; PCWP, pulmonary capillary wedge pressure; POD, postoperative day; PVR, pulmonary vascular resistance; RPP, renal perfusion pressure.