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Temporary Mechanical Circulatory Support:

Stabilization, Optimization and Recovery

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Allina Health MINNEAPOLIS HEART INSTITUTE

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Outline

- Temporary MCS Options for Cardiogenic Shock

- ECMO Considerations

- Impella
  - Use and Considerations for Placement
  - Current Research
  - Surgical Indications
  - ANW program data

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Case

- 45yo M

- PMHx:
  - Hypertension, dyslipidemia, smoking
  - Lifts weights, uses anabolic steroids
  - Remote Cocaine abuse

- Presented to Mercy ER with flu-like symptoms and AKI -> Admitted

- Cardiac workup: LVEF 40-45%, tnt mildly elevated, BNP 1700, pulmonary edema

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Case

- Suspected HFrEF due to viral illness and concomitant substance use.

- 2 days later:
  - RRT for hypotension, hypoxia, decreased LOC- transfer to ICU
  - TTE: EF 20%, reduced RV function, mild MR
  - CT with bilateral multifocal infectious/inflammatory pneumonitis
  - Cardiogenic shock with AKI, elevated lactate, rising pressor requirements

  - Intubated and cannulated ECPELLA -> ANW
    - 19Fr RCFA with 6fr DPC / 25Fr LCFV / Impella CP via LCFA
    - No coronary disease

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Temporary MCS For Decompensated Shock

- Heart Failure Decision Tree
  - Type of Shock
  - Which pump is the problem?
    - ? Need biventricular support
  - Are they oxygenating?
  - Clinical considerations
    - AI/AS
    - Previous surgeries
    - Vascular disease

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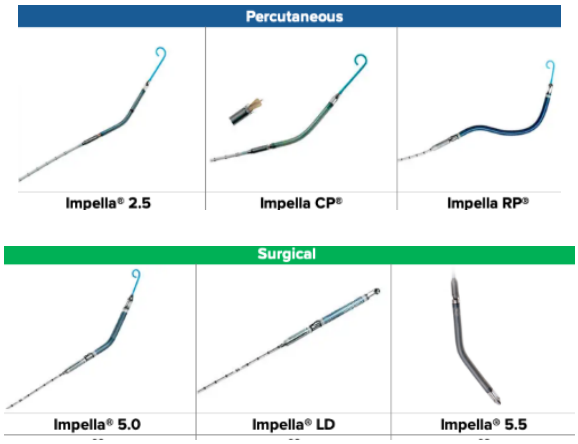
Temporary MCS For Decompensated Shock

- Options
  - IABP
  - Impella
    - CP
    - RP Flex
    - Axillary 5.5
    - 'BIPELLA'
  - ECMO



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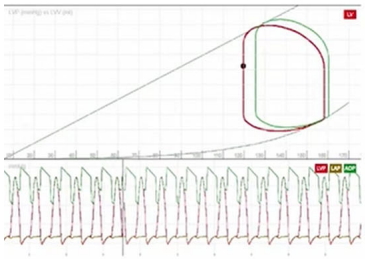
IABP

Advantages:

- Afterload reduction +Coronary Perfusion

Disadvantages:

- **Minimal ↑ CO by 0.5-1 L/min**
- No active LV unloading
- Limits ambulation



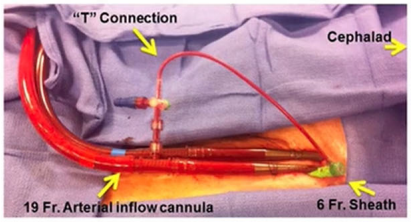
VA ECMO

Advantages:

- Full CPB support
- Rapid initiation

Disadvantages:

- **Worsens myocardial demand and loads injured LV**
- Open chest / limb ischemia



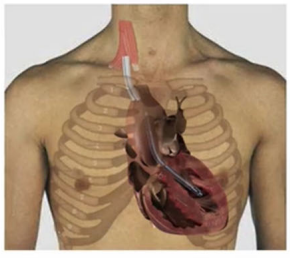
Impella 5.5

Advantages:

- **Active LV unloading with less myocardial demand**

Disadvantages:

- Risk of malposition and hemolysis
- **No direct oxygenation or gas exchange**



Anderson, M. et al (2021) Ann Thorac Surg

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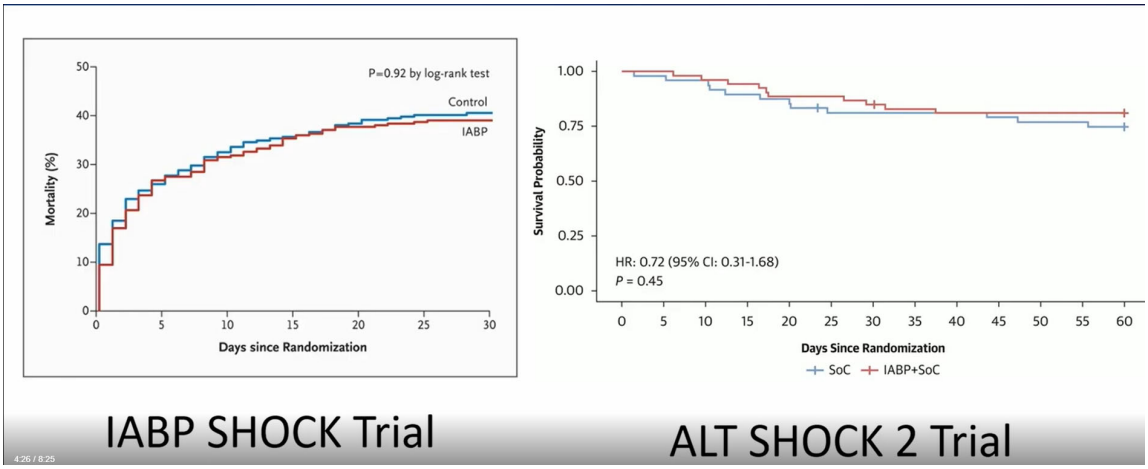
Cardiogenic Shock and IABP



Crit Care Med 2010 Vol. 38, No. 1
Nejm. 2012;367;14

Morici N, et al. JACC. 2025;85(16):1587–1597

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ECMO Considerations

- Oxygenator
- LV +/- RV failure
- Cannula sizing:
  - Concern for distal perfusion
    - ? 15Fr arterial ~ 3.5LPM flow and acceptable circuit pressures
  - Anticipate ambulation on ECMO
- Distal limb perfusion
  - Vascular surgery involvement / DPC
- Venting
  - Impella CP -> usually ~ 1.5-2.5LPM flow
  - (IABP…)

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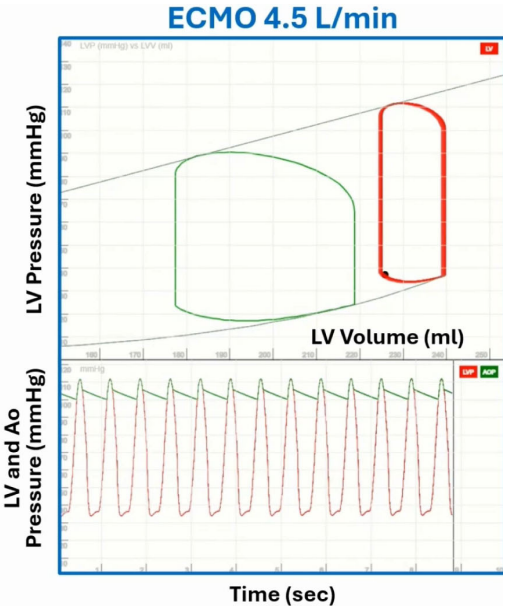
VA ECMO Hemodynamic Effects:

- ↑ MAP + ↑ LV afterload
- ↑ LV EDP
- ↑ PCWP
- ↑ PVA (myocardial demand)

LV distension
Endocardial ischemia
LV thrombus
AV closure + root thrombus
Pulmonary edema
Ventricular arrhythmias



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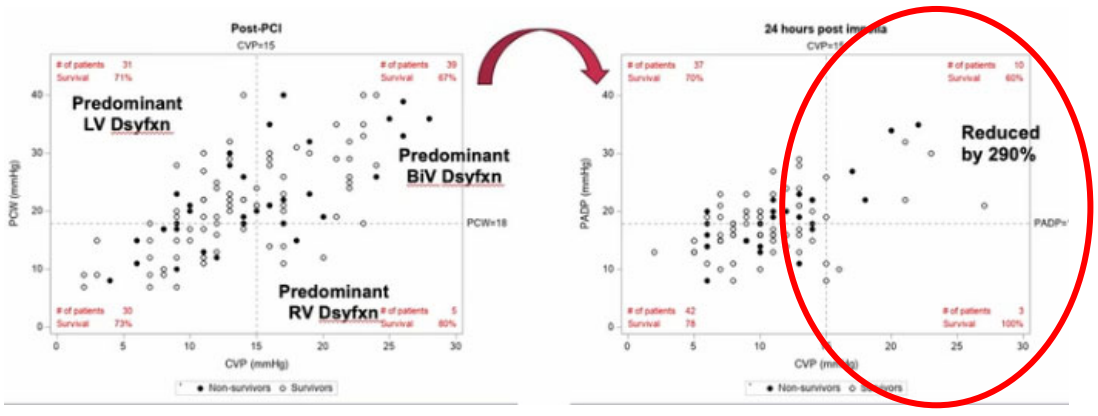
Early Unloading Decreases RV Failure



Journal of Cardiac Failure Vol. 30 No. 10 October 2024

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ECMO at Abbott Northwestern Hospital

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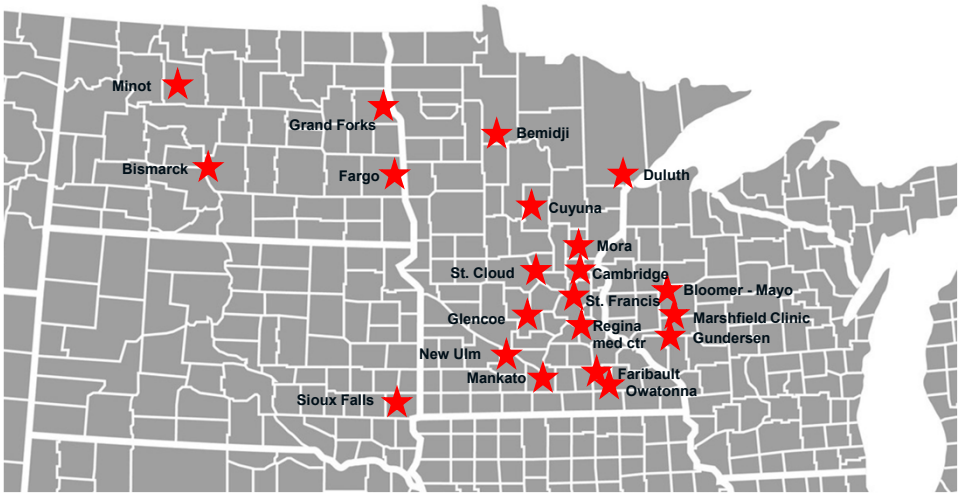
Referral Sites:



Thanks to Katie Christl

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Heart Failure Hotline

- Developed as a one call system to communicate with a member of advanced Heart Failure service 24/7
- Allows for ongoing communication & patient management between our referring and accepting site

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2025 ECMO Volume

Modality	Volume
Cardiac	75
ECPR	51
Respiratory	22
RVAD w/ oxygenator	5
	Total 153

Total ECMO Volume: 32 YTD 2026

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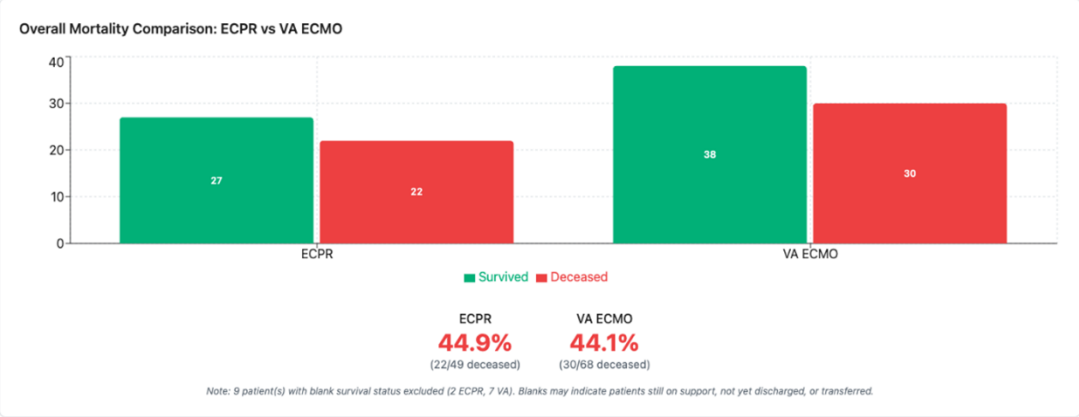
2025' VA ECMO Mortality



- *1 transferred to Mayo on ECMO for transplant*
- *1 transferred to U of M due to network coverage*

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Case continued…

- Started on CRRT
- Full infectious workup by ID -> ? Myocarditis, +Coxsackie virus
- Endomyocardial biopsy : nonspecific inflammation:
  - ? Severe stress induced CM
- Well supported - Weaning vasoactive medications
- Neuro intact, following commands

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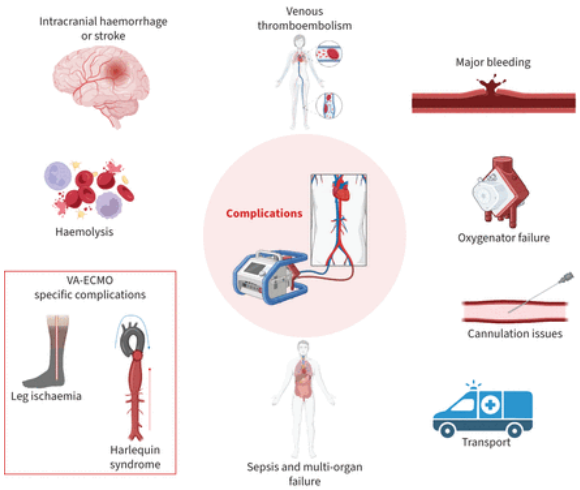
What Comes Next?

- ~ 7-day ECMO run time
- Disadvantage:
  - Lie flat with femoral Impella
  - Less so ECMO – now walking appropriate patients…



Garfield et al. Breathe 2025 21(1): 240119

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Re-Evaluate Support Needs

- Are the lungs recovered?
- What is the status of the right ventricle?
  - Can they be liberated from biventricular support?
  - Daily weaning trials
  - Impella CP can be maximized as a trial of LV support during ECMO turn down.

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Case continued…

- ECMO Day 6: EF < 10%, severe RV dysfunction
  - Failed attempts to wean vent due to agitation
  - Advanced therapies workup started

- ECMO Day 8:
  - Tolerated turn down, Impella to P4.
  - Discussion to transition to Impella 5.5
  - Facilitate safer waking / weaning / extubation

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	Percutaneous		
			
	Impella® 2.5	**Impella CP®**	**Impella RP®**
Indication	HRPCI, CS	HRPCI, CS	RHF, decompensation
Introducer diameter	13 Fr	14 Fr	23 Fr
Pump	12 Fr	14 Fr	22 Fr
Access	Femoral or axillary	Femoral or axillary	Femoral (to PA)
Max average flow	2.5 L/min	3.7 L/min	4.4 L/min
Max duration of support	HRPCI: ≤ 6 hrs CS: ≤ 4 days	HRPCI: ≤ 6 hrs CS: ≤ 4 days	14 days
SmartAssist	N	Y	N
	Surgical		
			
	Impella® 5.0	**Impella® LD**	**Impella® 5.5**
Indication	CS	CS	CS
Introducer diameter	23 Fr	n/a	23 Fr
Pump	21 Fr	21 Fr	19 Fr
Access	Femoral cutdown or axillary	Direct insertion into AA	Axillary cutdown or direct into AA
Max average flow	5.0 L/min	5.3 L/min	5.5 L/min
Max duration of support	14 days	14 days	14 days
SmartAssist	N	N	Y

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The FDA indication for use of Impella CP with SmartAssist has been expanded as follows:

The Impella CP with SmartAssist Catheter, in conjunction with the Automated Impella Controller (collectively, "Impella System Therapy"), are temporary ventricular support devices intended for short term use (≤4 days) and indicated for the treatment of ongoing cardiogenic shock that occurs immediately (<48 hours) following acute myocardial infarction or open heart surgery or in the setting of cardiomyopathy, including peripartum cardiomyopathy, or myocarditis as a result of isolated left ventricular failure that is not responsive to optimal medical management and conventional treatment measures (including volume loading and use of pressors and inotropes, with or without IABP) in adult patients and in pediatric patients weighing ≥52 kg. The intent of Impella System Therapy is to reduce ventricular work and to provide the circulatory support necessary to allow heart recovery and early assessment of residual myocardial function.

The FDA indication for use of Impella 5.5 with SmartAssist has been expanded as follows:

The Impella 5.5 with SmartAssist System is a temporary ventricular support device intended for short term (14 days) use and indicated for the treatment of ongoing cardiogenic shock that occurs immediately (<48 hours) following acute myocardial infarction or open heart surgery or in the setting of cardiomyopathy, including peripartum cardiomyopathy, or myocarditis as a result of isolated left ventricular failure that is not responsive to optimal medical management and conventional treatment measures (including volume loading and use of pressors and inotropes, with or without IABP) in adult patients and in pediatric patients weighing ≥30 kg. The intent of Impella System Therapy is to reduce ventricular work and to provide the circulatory support necessary to allow heart recovery and early assessment of residual myocardial function.

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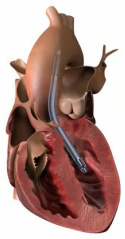
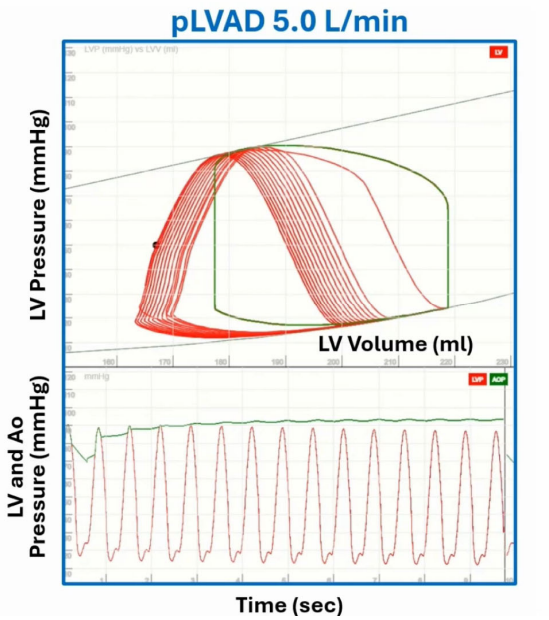
Impella 5.5

- **Active LV unloading**
- Hemodynamic Effects:
  - ↑ CO (2.5 – 5 L/min)
  - ↓ LV EDP
  - LV-Ao Uncoupling
  - **↓ PVA & MVO_2**

Less Hemolysis
Less Leg ischemia
Longer duration support

Surgical intervention





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Microaxial Flow Pump or Standard Care in Infarct-Related Cardiogenic Shock

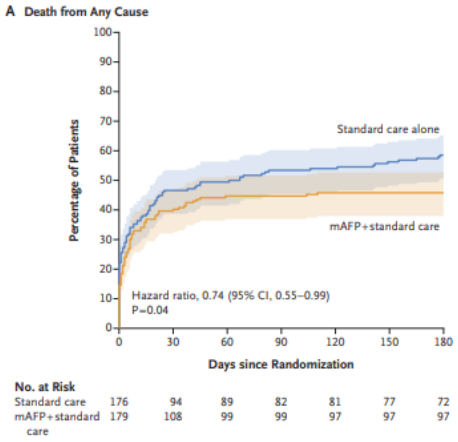

Table 3. End Points and Adverse Events in the Intention-to-Treat Population.*

Event	Microaxial Flow Pump plus Standard Care (N=179)	Standard Care Alone (N=176)	Effect Size (95% CI)†
Primary end point: death from any cause at 180 days — no. (%)	82 (45.8)	103 (58.5)	0.74 (0.55 to 0.99)‡
Secondary end points			
Composite cardiac end point — no. (%)§	94 (52.5)	112 (63.6)	0.72 (0.55 to 0.95)
No. of days alive and out of the hospital (range)¶	82 (0 to 177)	73 (0 to 179)	8 (−8 to 25)
Adverse events			
Composite safety end point — no. (%)‖	43 (24.0)	11 (6.2)	4.74 (2.36 to 9.55)
Moderate or severe bleeding — no. (%)**	39 (21.8)	21 (11.9)	2.06 (1.15 to 3.66)
Limb ischemia — no. (%)	10 (5.6)	2 (1.1)	5.15 (1.11 to 23.84)
Renal-replacement therapy — no. (%)	75 (41.9)	47 (26.7)	1.98 (1.27 to 3.09)
Stroke — no. (%)	7 (3.9)	4 (2.3)	1.75 (0.50 to 6.01)
Cardioversion after ventricular tachycardia or fibrillation — no. (%)	59 (33.0)	52 (29.5)	1.17 (0.75 to 1.83)
Sepsis with positive blood culture†† — no. (%)	21 (11.7)	8 (4.5)	2.79 (1.20 to 6.48)

N ENGL J MED 390;15 NEJM.ORG APRIL 18, 2024

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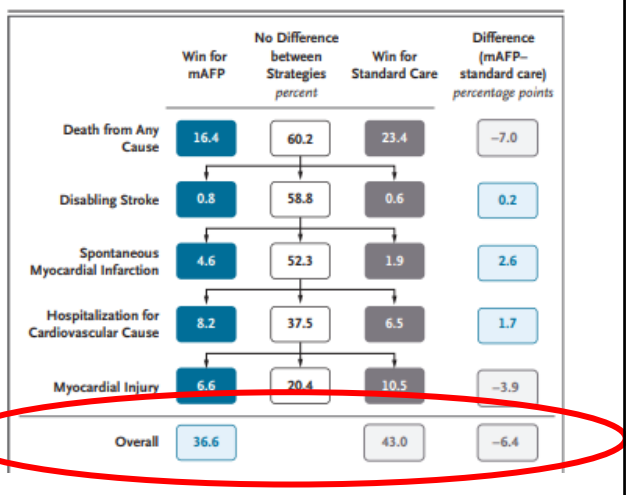
ORIGINAL ARTICLE

Left Ventricular Unloading in High-Risk Percutaneous Coronary Intervention

Divaka Perera, M.D.,[1,2] Matthew Ryan, Ph.D.,[1,2] Saad M. Ezad, Ph.D.,[1,3] Sohail Q. Khan, M.D.,[4] Ian Webb, Ph.D.,[1,5] Peter D. O'Kane, M.D.,[3] Roshan Weerackody, Ph.D.,[6] Matthew Dodd, Ph.D.,[7] Matthew Kwok, M.Sc.,[7] Lynn Laidlaw, B.A.,[7] Laura Van Dyck, B.Sc.,[7] Benjamin Wrigley, M.D.,[8] Julian W. Strange, M.D.,[9] Alan Bagnall, Ph.D.,[10] Farzin Fath-Ordoubadi, M.D.,[11] Vasileios F. Panoulas, Ph.D.,[2] Andrew Ladwiniec, M.D.,[12] John R. Davies, Ph.D.,[13] Alexander Chase, Ph.D.,[14] Colum G. Owens, M.D.,[15] Stuart Watkins, M.D.,[16] Haseeb Rahman, Ph.D.,[1,2] Nilesh Pareek, Ph.D.,[1,5] Krishnaraj Rathod, Ph.D.,[6] John Rawlins, M.D.,[17] Richard Evans, B.A.,[7] Stephen P. Hoole, M.D.,[18] Rod H. Stables, D.M.,[19] Nick Curzen, Ph.D.,[17] and Tim Clayton, M.Sc.,[7] for the CHIP-BCIS3 Investigators*



DOI: 10.1056/NEJMoa2515704

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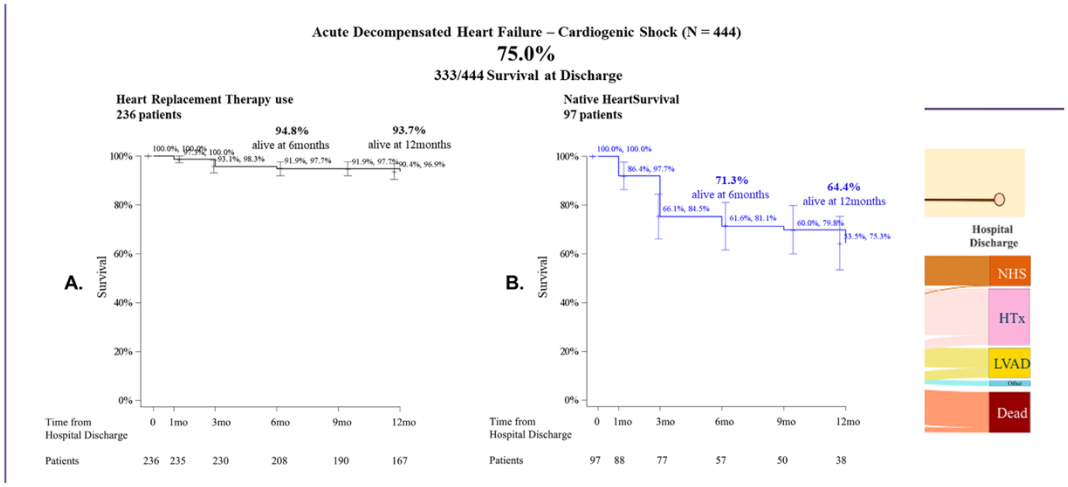
Outcomes of Surgically Implanted Impella Microaxial Flow Pumps in Heart Failure-Related Cardiogenic Shock



Journal of Cardiac Failure Vol. 00 No. 00 2025
Surpass Registry 2020 - 2023

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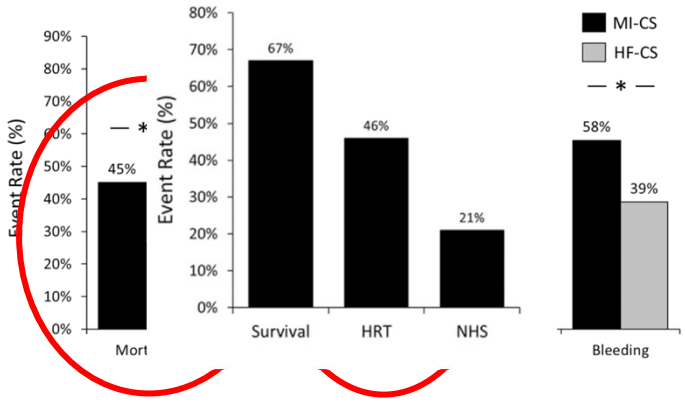
ISHT MEETING

Clinical outcomes among cardiogenic shock patients supported with high-capacity Impella axial flow pumps: A report from the Cardiogenic Shock Working Group

- Multicenter (34 hospitals) cohort
- 2020 – 2023. 6205 (n)



J Heart Lung Transplant 2024;43:1478–

28

Left ventricular assist device bridging to heart transplantation: Comparison of temporary versus durable support

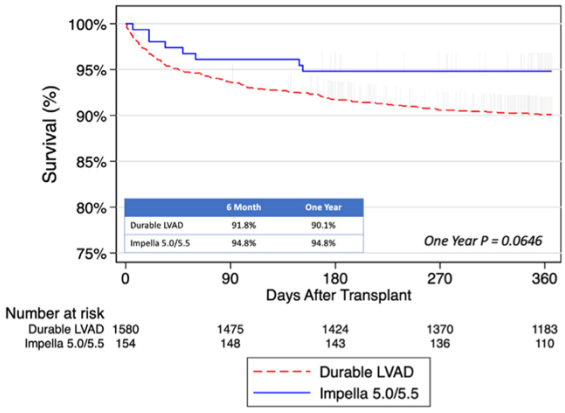


Table 6 Post-Transplant Complications and Outcomes Between Patients Bridged With Either Durable LVAD or Impella to Transplantation

	Durable LVAD N = 1,580	Impella N = 154	*p* value
Time on waitlist, days	223 (51-551)	12.5 (6-33)	<0.001
Renal failure requiring dialysis	238 (15.1%)	22 (14.3%)	0.80
Stroke	85 (5.4%)	4 (2.6%)	0.13
Pacemaker placement	36 (2.3%)	3 (1.9%)	0.79
Hospital length of stay	17 (13-26)	14 (11-20)	<0.001
Treated acute rejection	185 (11.7%)	17 (11.0%)	0.80
30-Day mortality	65 (4.1%)	3 (1.9%)	0.18
90-day mortality	101 (6.8%)	6 (3.9%)	0.22
90-day graft failure	107 (6.8%)	6 (3.9%)	0.17

The Journal of Heart and Lung Transplantation, Vol 42, No 1, January 2023

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Impella 5.5

Improved clinical outcomes associated with the Impella 5.5 compared to the Impella 5.0 in contemporary cardiogenic shock and heart failure patients

Danny Ramzy, MD, PhD,[a] Edward G. Soltesz, MD, MPH,[b] Scott Silvestry, MD,[c] Mani Daneshmand, MD,[d] Manreet Kanwar, MD,[e] and David A. D'Alessandro, MD[f]

Hemolysis 1.7-3.2%
CVA 1.7-3.2%
Bleeding 0.6-2.6%
Vascular Injury 0.6%

N= 1238 patients
290 sites
AMICS, HF-CS, Post-Cardiotomy

Higher Survival with 5.5
AMICS 70.5 vs 56. 8 (p=0.005)
HF-CS 88.1 vs 76.9 (p=0.001)
PCCS 76.1 vs 55.7 (p0.003)

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Case continued…

- Surgery:
  - TTE: LVEF 30-35%, RV function normal
  - ECMO decannulation and Impella 5.5 insertion that day
- Veletri / vent and inotropes weaned
- Extubated next day
- POD #3- robust indices, retrograde flow alarms at P2/3

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Case continued…

- Ambulating to chair
- Impella removed
  - TTE with normal biventricular function
- Discharged to CKRI for rehab
- Doing well at home, followed by cardiology

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Extended Indications Impella 5.5:

- Low EF Cardiac Surgery
  - When do we consider this? (ie. EF cut offs, pathology differences – CABG vs AVR vs MVR)
  - Direct aortic insertion (supraclavicular or 2nd ICS graft tunnel)
- Post infarct VSD
- LV vent- VA ECMO

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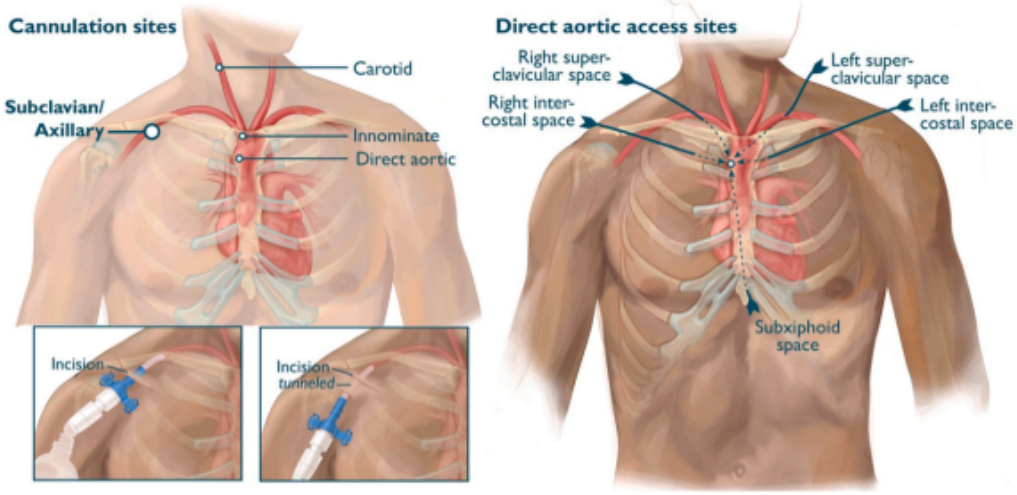

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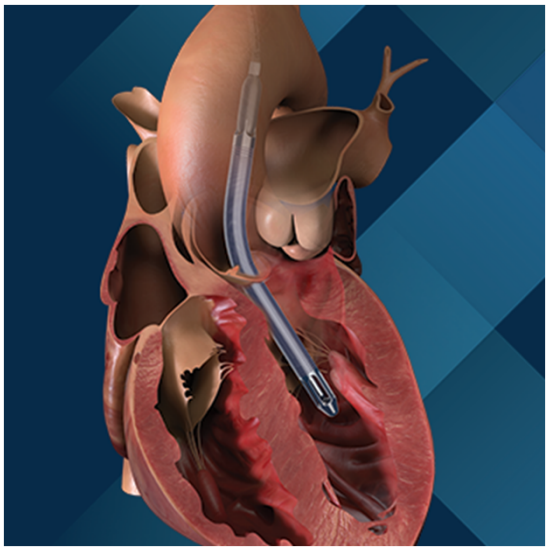
Impella 5.5 Insertion (ECPELLA Decannulation)

Preop Considerations:

- Confirm adequate support (?RV)
- Assess anatomy
  - CTA if possible – axillary size (6-7mm), ?tortuosity, angulation
- Aortic valve pathology
- Decannulation requirements - vascular



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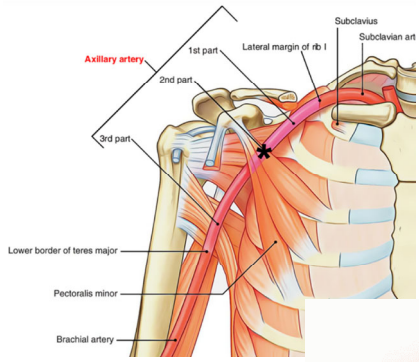
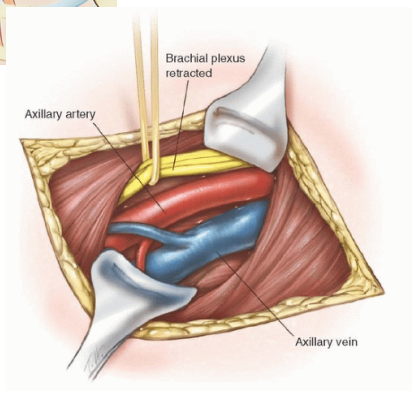
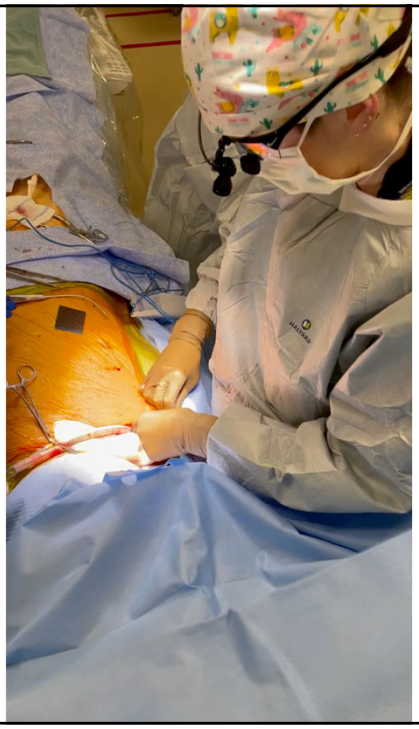

Subclavius
Subclavian art
Axillary artery
1st part
Lateral margin of rib I
2nd part
3rd part
Lower border of teres major
Pectoralis minor
Brachial artery


Brachial plexus
retracted
Axillary artery
Axillary vein



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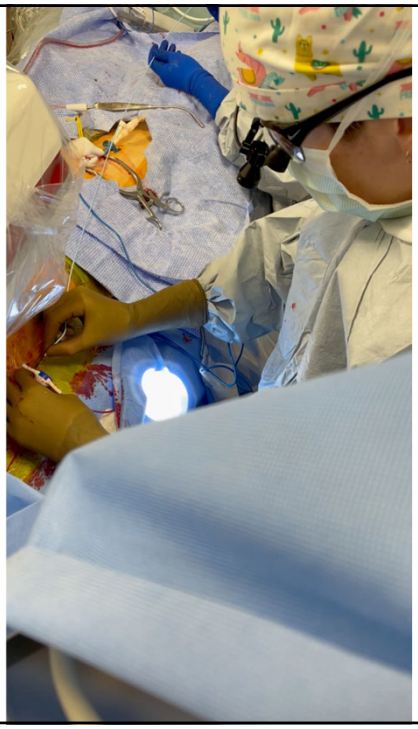

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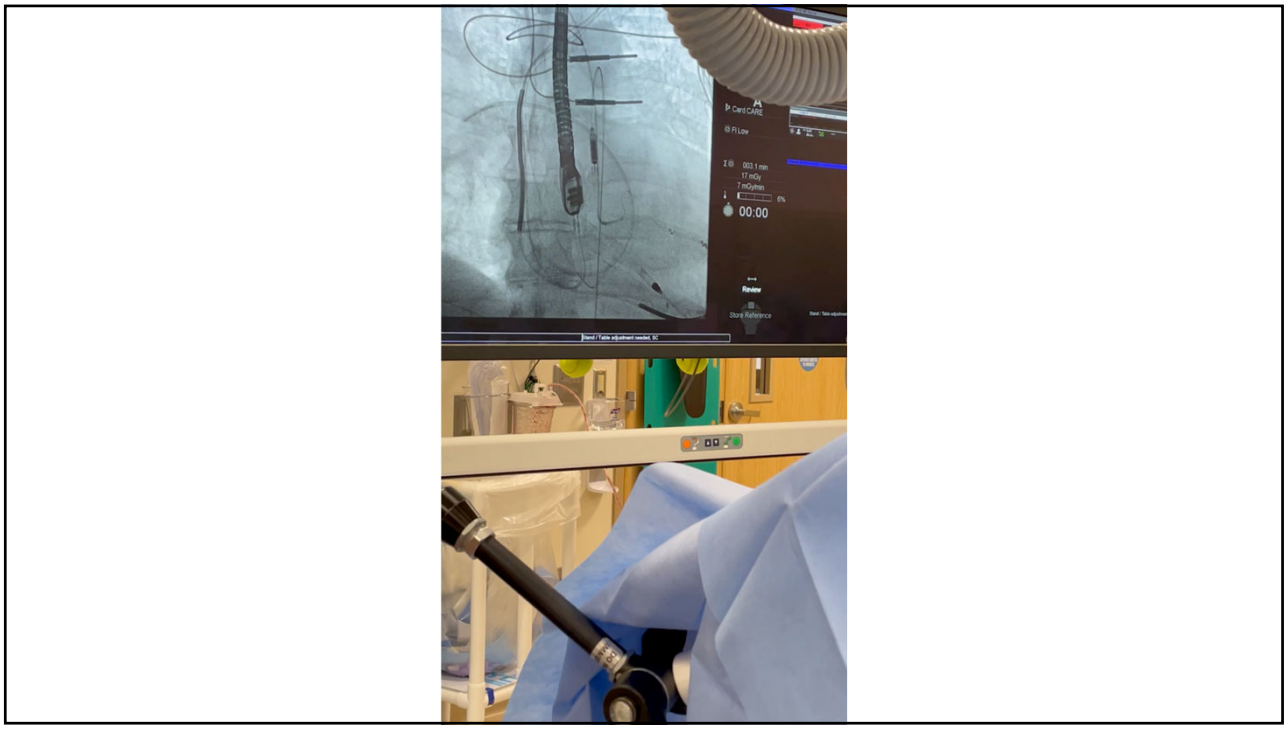

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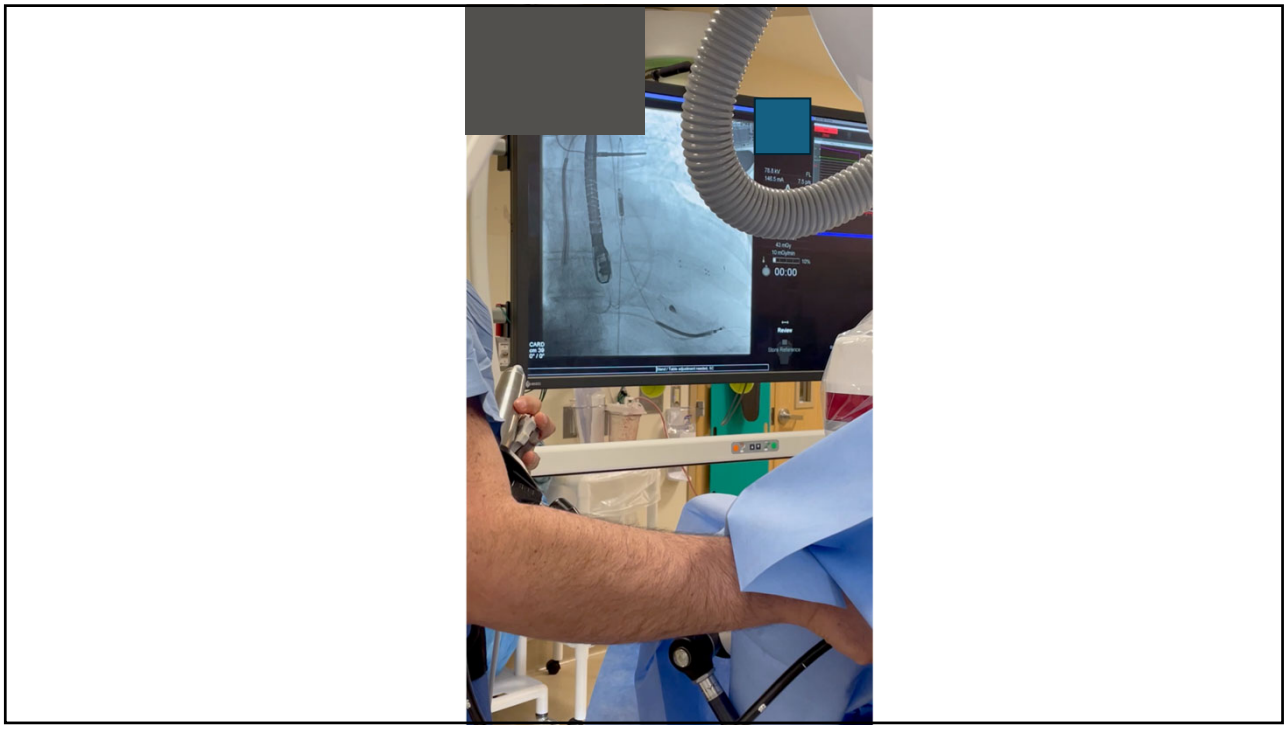

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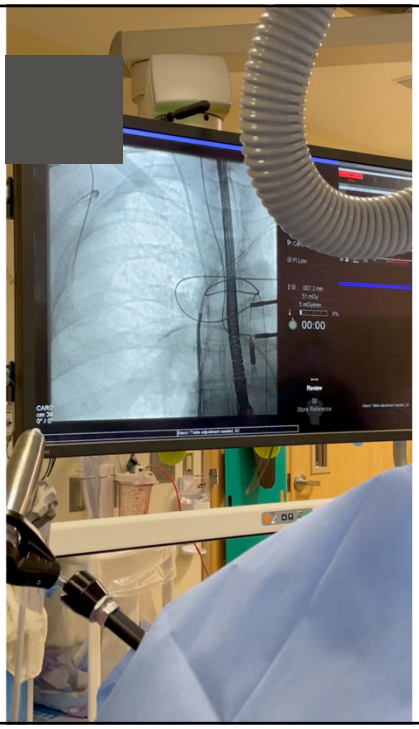

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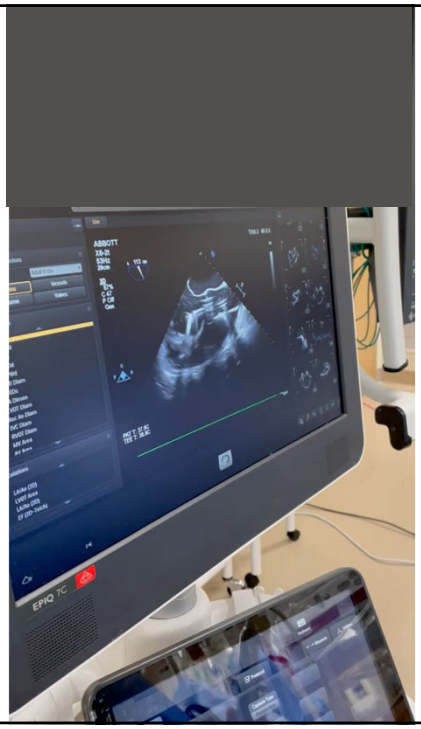

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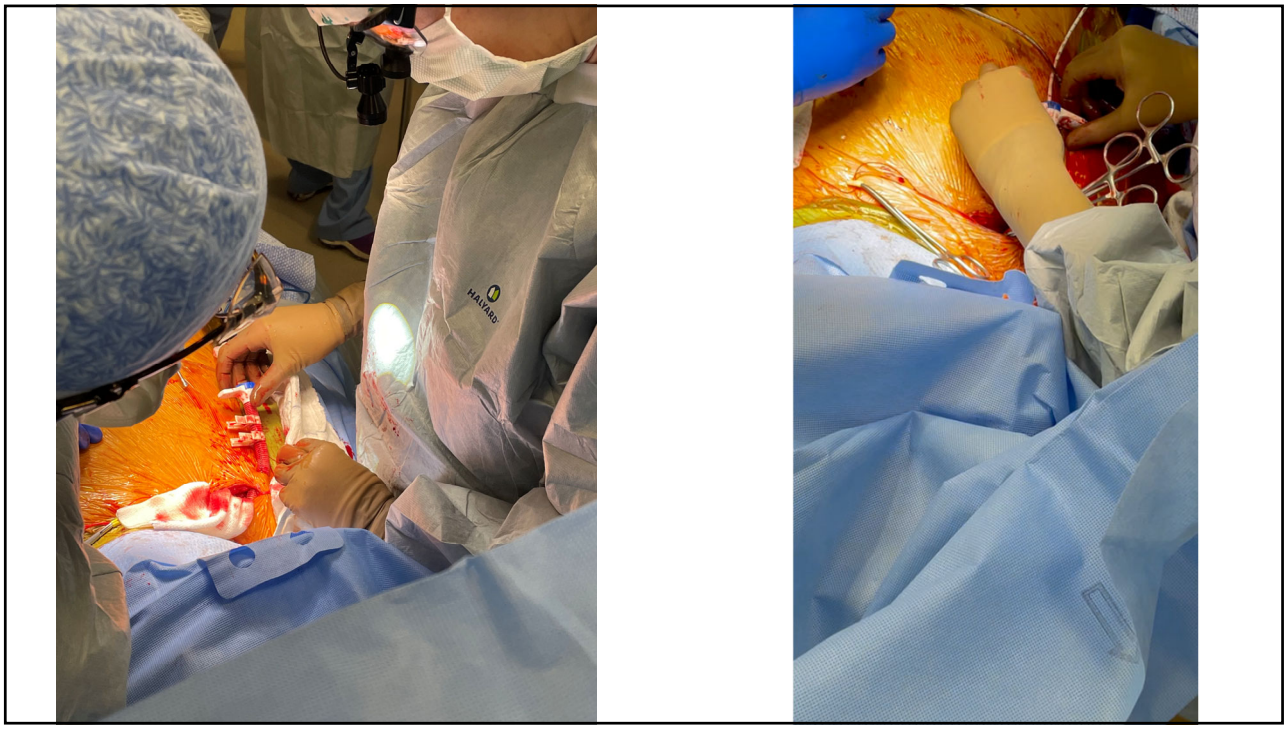
HALYARD

43


Frozen
ABBOTT
X8-2t
53Hz
20cm
2D
74%
C 47
P Orf
Gen
Vessels
Valves
TIS0.2 MI 0.5
PAT T: 37.0C
TEE T: 39.0C
Dist 4.66 cm

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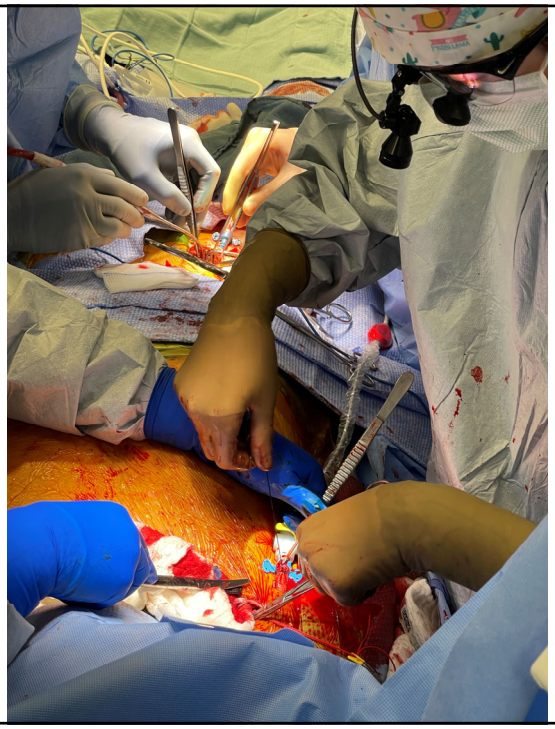

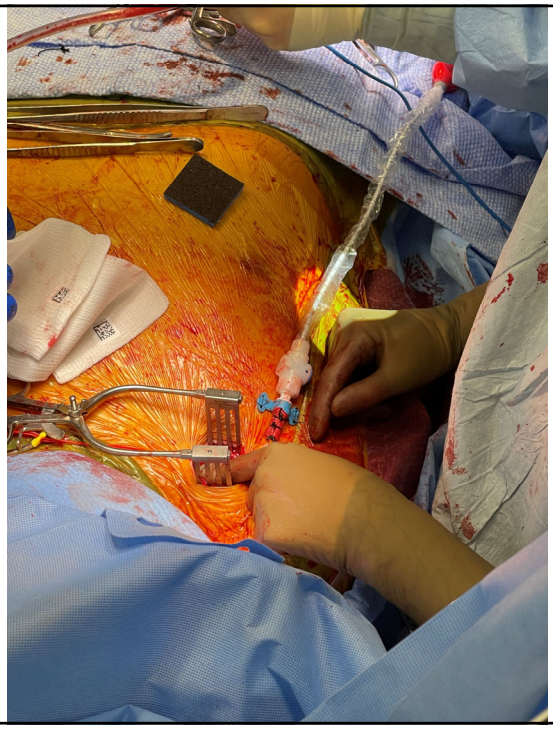

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Impella 5.5 - Multipurpose!

- Low EF Cardiac Surgery
  -Direct aortic insertion (supraclavicular or 2nd ICS graft tunnel)
- Post infarct VSD
- LV vent- VA ECMO
- Alternative access:
  - innominate hemisternotomy

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Impella Supported Low EF Cardiac Surgery

- When do we consider this?
  - LVEF < 20-25%
  - Especially AI + dilated ventricle, MR
- Graft sewn on distal ascending aorta and tunneled out supraclavicular.
- Can be removed in ICU

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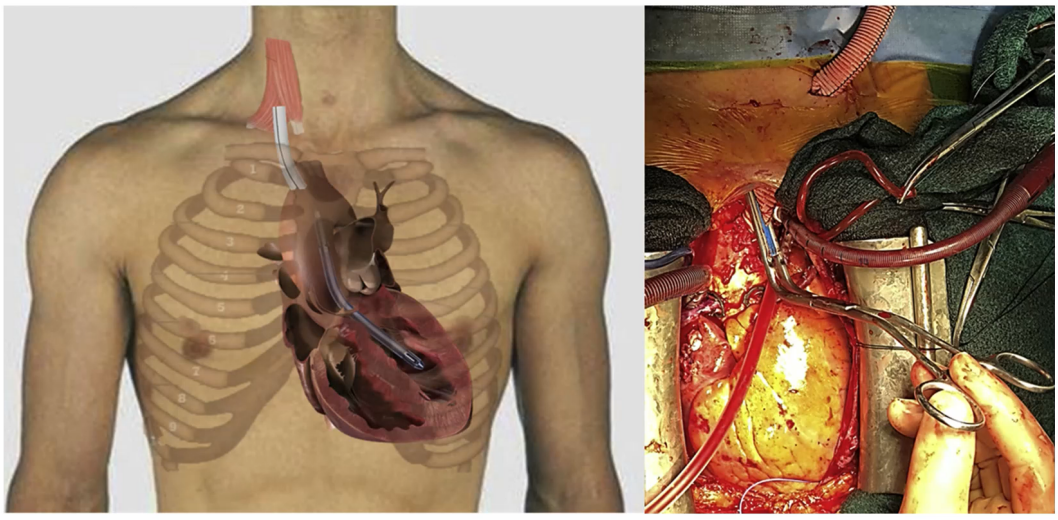
Direct Aortic Impella 5.5 in Post Cardiotomy Shock



Anderson et al. 2021. *The Annals of Thoracic Surgery*.

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EACTS/STS/AATS Guidelines on temporary mechanical circulatory support in adult cardiac surgery

Recommendations	Class[a]	Level[b]	Ref[c]
In patients with post-procedural LCOS, tMCS is recommended.	I	B	(195, 196, 228, 240)
In patients with no likelihood of myocardial recovery and not eligible for dMCS/HTx, tMCS is not recommended.	III	C	(37, 54)
For tMCS-eligible patients who cannot be weaned from CPB despite optimal therapeutic measures, immediate transition to tMCS is recommended.	I	B	(195, 197, 228, 240)

European Journal of Cardio-Thoracic Surgery, ezaf330, https://doi.org/10.1093/ejcts/ezaf330

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Aortic valve			
In patients with cardiogenic shock and a mechanical aortic valve, a transaortic valve mAFP is not recommended.	III	C	(255)
In patients with cardiogenic shock and moderate-to-severe aortic regurgitation, tMCS with active LV unloading should be considered.	IIa	C	-
In patients with cardiogenic shock and severe aortic stenosis, VA-ECLS as a bridge to AVR/TAVI may be considered.	IIb	C	(255, 256)
In patients with cardiogenic shock and severe aortic stenosis, mAFP may be considered.	IIb	C	(255)
Mitral valve			
In patients with severe acute mitral regurgitation and cardiogenic shock, tMCS with active LV unloading should be considered as a bridge to interventional or surgical treatment of the mitral valve.	IIa	C	(193, 261, 262)
In patients with a prosthetic mitral valve on tMCS, strategies to maintain pulsatile transmitral valvular flow are recommended.	I	C	(266-268)
In patients with cardiogenic shock and critical mitral stenosis, ECLS or transseptal pVAD should be considered.	IIa	C	(260)

In patients with acute intraventricular thrombus, an mAFP is not recommended.	III	C

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IMPACT Trial

- Impella-Protected Cardiac Surgery Trial
- High-risk patients undergoing elective cardiac surgery
  - CABG, AVR, MV repair/replacement
- LVEF </= 25% by echo or cMRI, OR </= 35% if severe MR
- Prospective
- Multicenter. 100 (n)
- Primary safety endpoint: all cause mortality, stroke, new CRRT
- Primary effectiveness endpoint: rate of post-cardiotomy cardiac failure at discharge

- Dr. C. Lodewyks was the local PI

- Results to be presented at AATS this spring…

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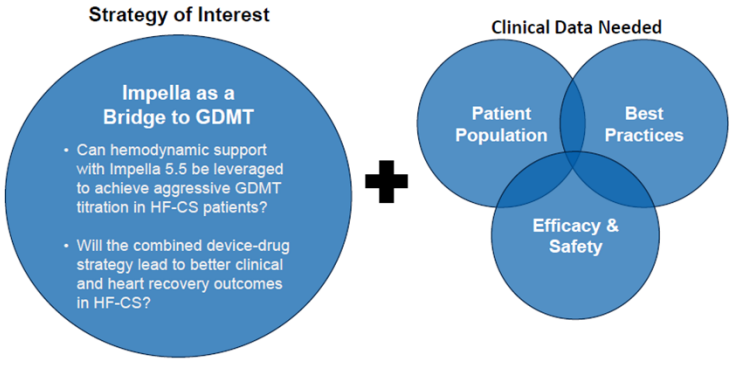
INTEGRATE STUDY- Impella 5.5 and GDMT

Device Enabling Medical Therapy to Promote Heart Recovery



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INTEGRATE STUDY- Impella 5.5 + GDMT

Study Hypothesis & Objectives

Hypothesis

For patients presenting with heart failure complicated by cardiogenic shock (HF-CS), an intentional device-supported strategy with Impella 5.5® for optimization of guideline-directed medical therapy (GDMT) combined with best practices improves outcomes over standard of care.

Study Objectives

To evaluate the impact of a **combined device-drug strategy** with Impella 5.5® with best practices and optimized GDMT on heart recovery outcomes in patients with decompensated heart failure and cardiogenic shock.

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Post Infarct VSD – Contemporary Management

- Historically, early surgery due to hemodynamic instability/high mortality
  - 30-50%
- Benefit to allowing time for tissue to mature

In patients with post-MI VSD, the use of VA-ECLS to support patients in cardiogenic shock prior to VSD closure is recommended.	I	B	(192, 275, 276, 278, 279)
In patients with post-MI VSD, the use of mAFP to support patients in cardiogenic shock prior to VSD closure may be considered.	IIb	C	-
In patients with post-MI VSD on mAFP, serial monitoring of RV function should be considered for escalation of support.	IIa	C	(275)

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VSDs at ANW

- Early implementation of LV unloading
  - Impella CP/5.5, ECPELLA
- ~ 2 week period of support
  - Tissue maturation
  - Optimization of end organ function
  - mobilization

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VSDs at ANW

- January 2025 to present:
  - 7 cases with Impella used
  - Preop:
    - 6/7 MCS Support
    - 3 IABP
    - 2 Impella CP
    - 5 Impella 5.5 (1 upgrade from CP)
    - 3 ECPELLA (2 with 5.5, 1 with CP
  - Average time MCS to procedure: 11 days.

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VSDs at ANW

- Intraop:
  - 3 existing Impella left in situ
  - 1 Impella removed
  - 1 denovo insertion
- Post op Support:
  - 4 Impella 5.5
  - 1 ECPELLA
  - Time to decannulation: average 5 days

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VSDs at ANW

- Major complications Post op
  - 3 CVA
  - No bleeding
  - 2 infection – unrelated to device
  - 1 CRRT
  - 4 Patients discharged home
  - 1 discharged to rehab
  - 1 discharged – home hospice
  - 1 death in hospital

86% discharged from hospital alive
71% remain alive

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Impella Use at ANW – Courtesy of Abiomed

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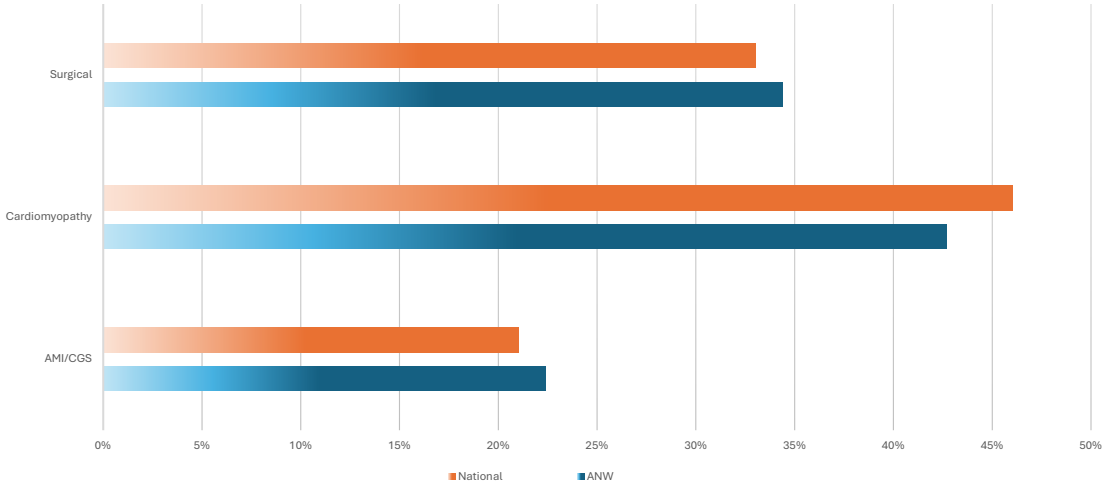
Impella 5.5 Indications



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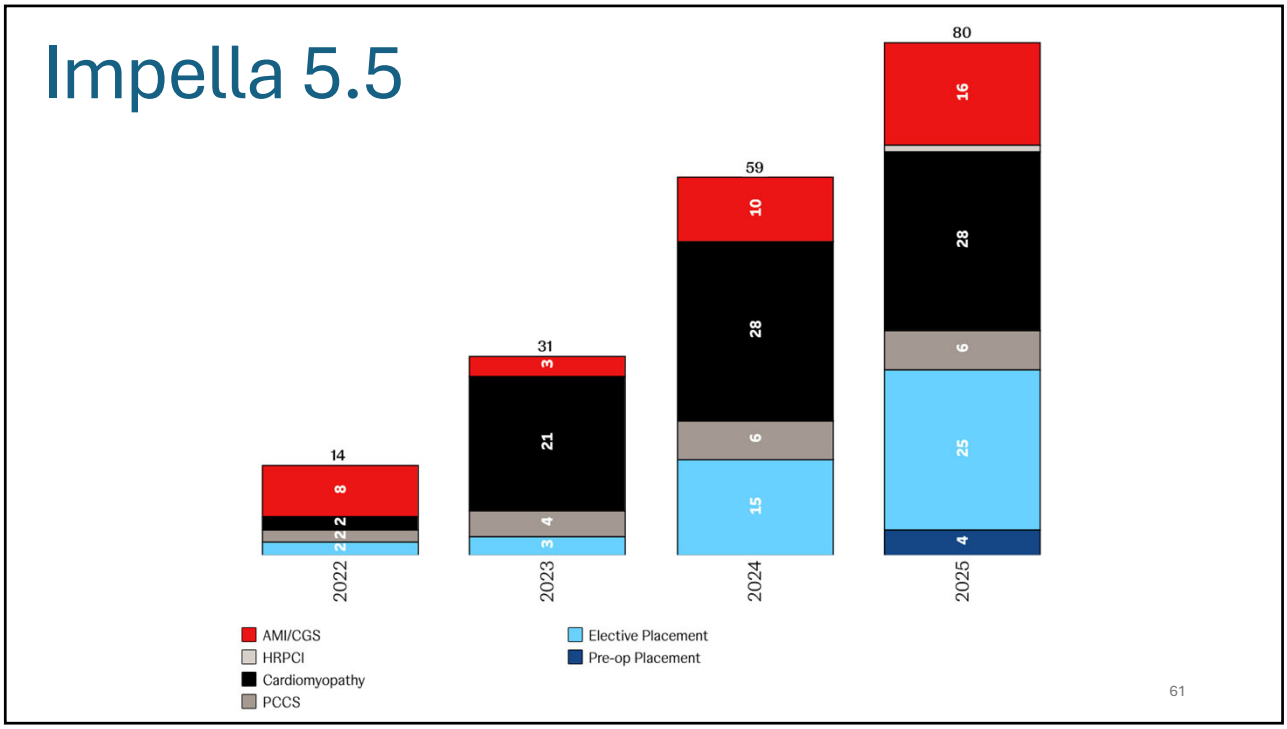
Impella 5.5
14
8
2
2
2
31
3
21
4
3
59
10
28
6
15
80
16
28
6
25
4
2022
2023
2024
2025
AMI/CGS
HRPCI
Cardiomyopathy
PCCS
Elective Placement
Pre-op Placement
61

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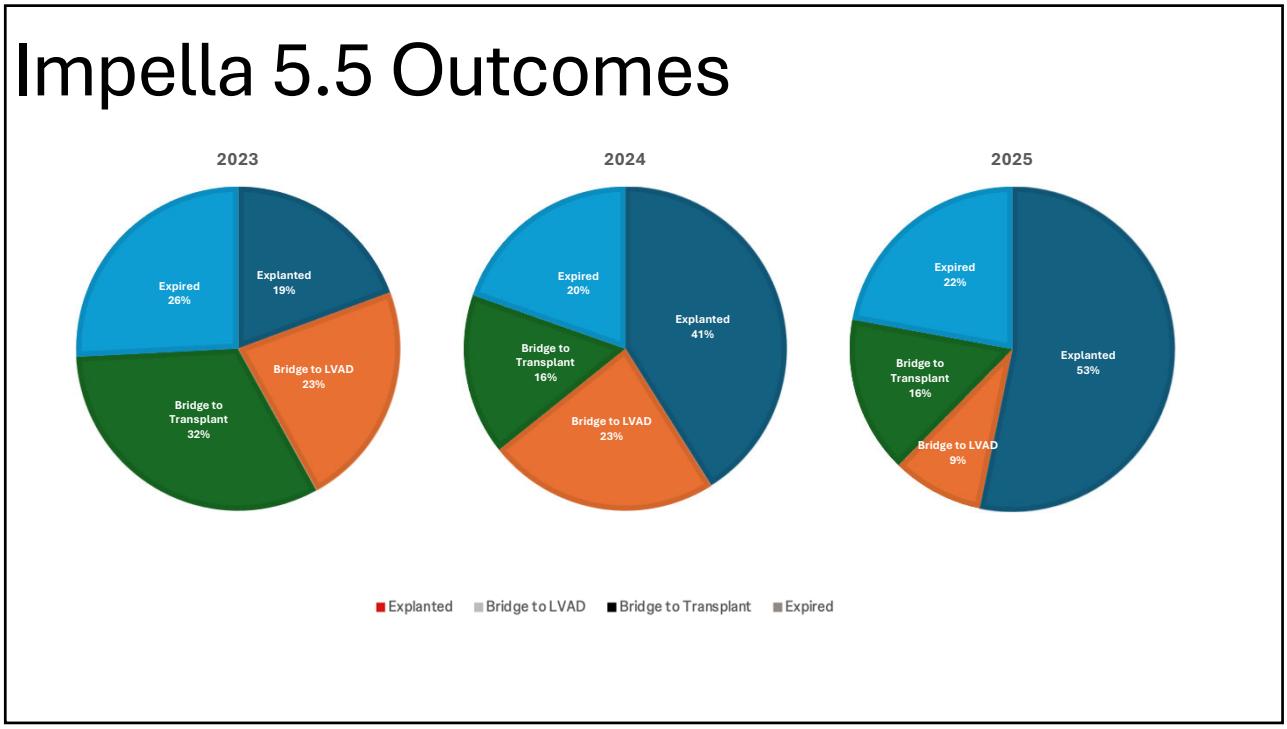
Impella 5.5 Outcomes
2023
Expired 26%
Explanted 19%
Bridge to LVAD 23%
Bridge to Transplant 32%
2024
Expired 20%
Explanted 41%
Bridge to Transplant 16%
Bridge to LVAD 23%
2025
Expired 22%
Explanted 53%
Bridge to Transplant 16%
Bridge to LVAD 9%
Explanted
Bridge to LVAD
Bridge to Transplant
Expired

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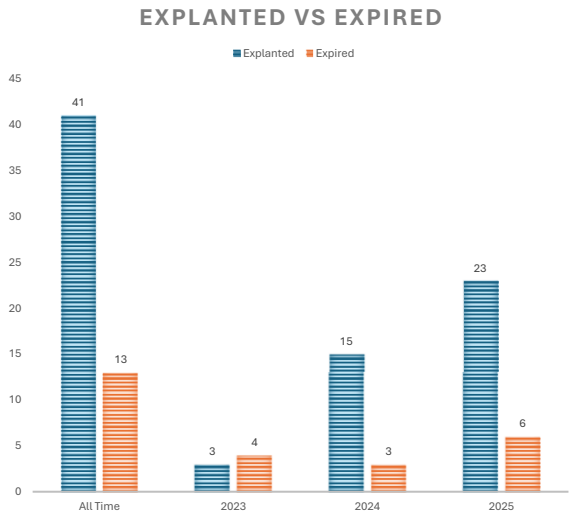
Surgical

Highlights

- Increased usage by 72%
- Explant rate remain stable – 74.2%

- PCCS Expiration Rates Decreased
  - 2023: 75% expired
  - 2024: 66.7% expired
  - 2025: 40% expired — clear improvement



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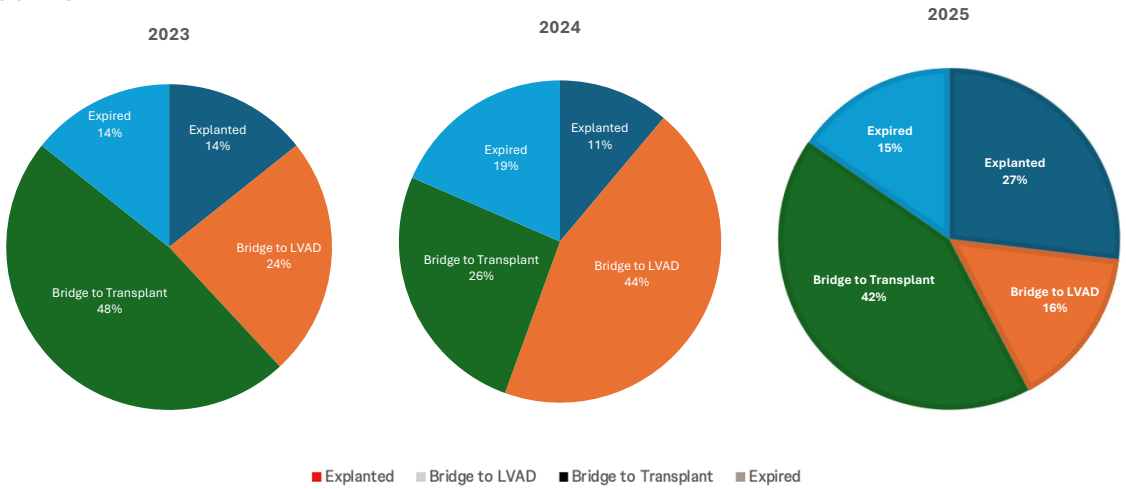
Cardiomyopathy

OUTCOMES BY YEAR



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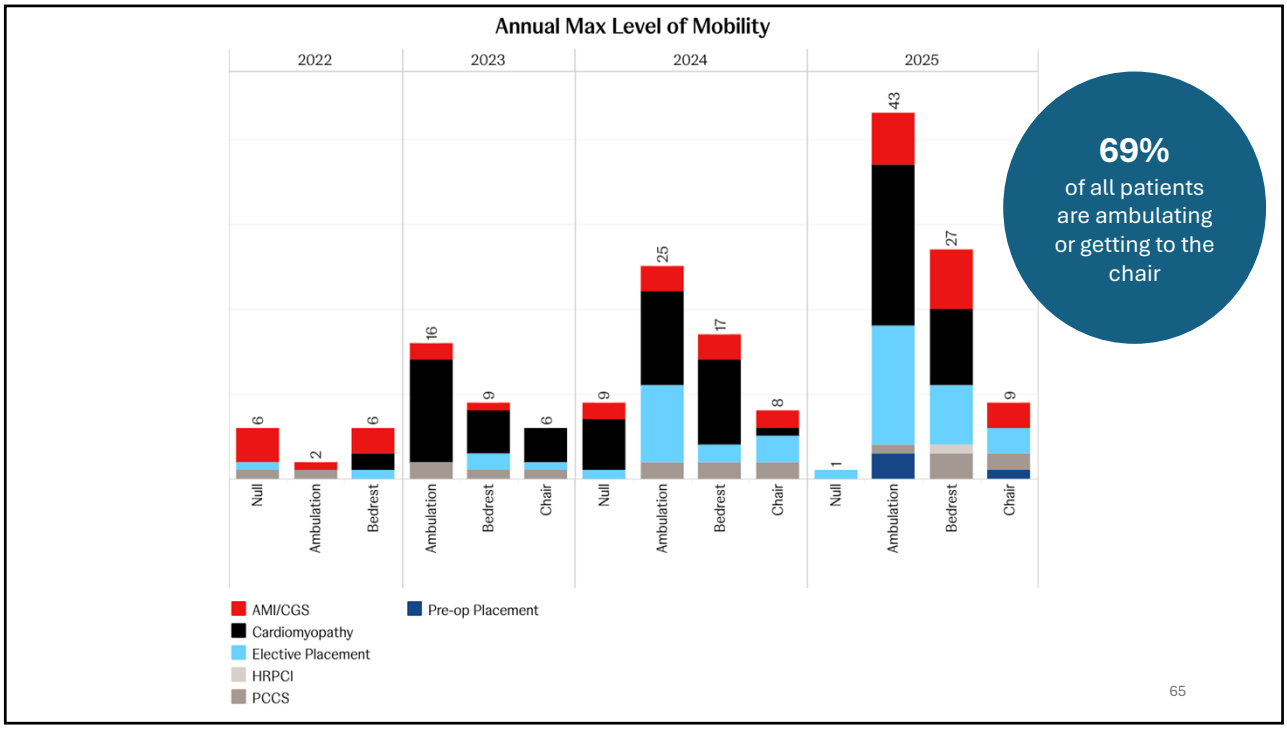

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Conclusions

- Management of cardiogenic shock is a team sport
- Overall outcomes are improving
- Temporary MCS is a critical tool
  - Important to consider patient and clinical factors in choosing best option
  - Requirements frequently change…
  - Re-evaluate often!

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Questions?

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