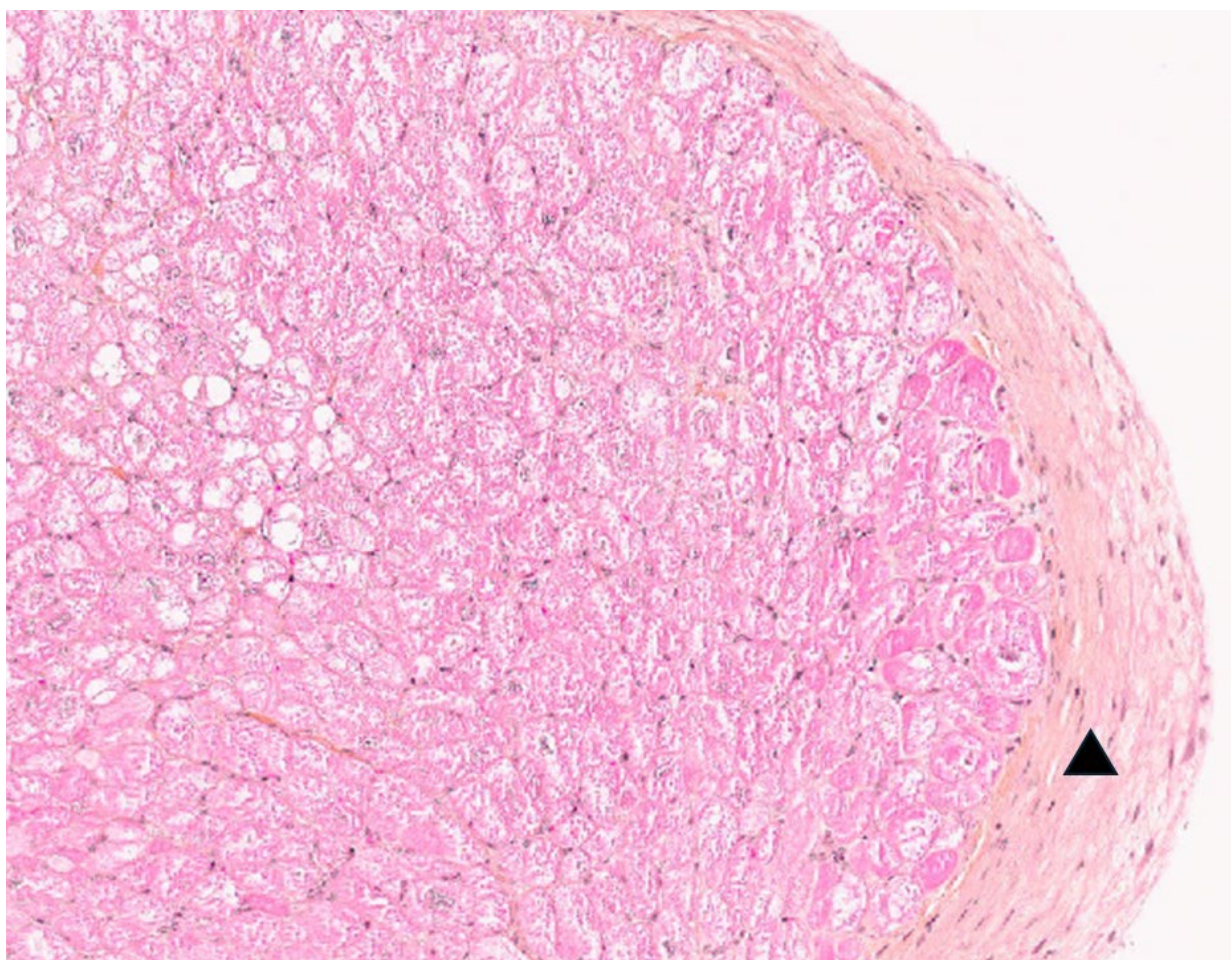


Supplementary material:

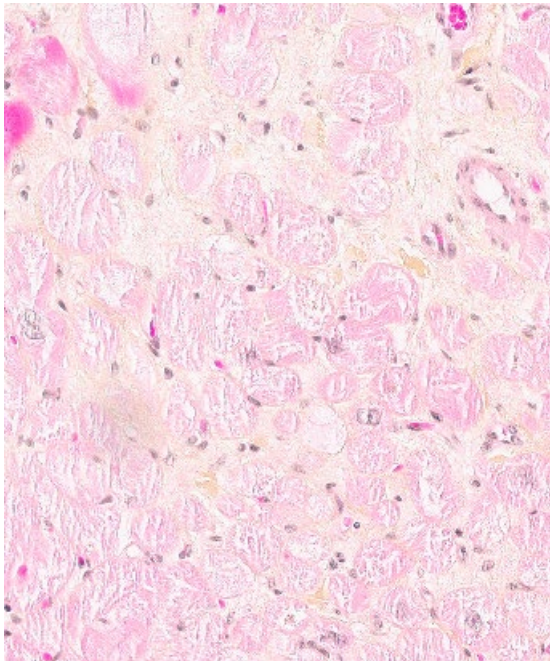
Supplemental figure S1: histological image of myocardial tissue of patient 2.

The histological analysis of the apical fragment retrieved during LVAD implantation revealed nonspecific findings suggestive of cardiomyopathy. These findings included discrete reticular myocardial fibrosis, with occasional collagenous bundles and endocardial fibroelastosis (black triangle).



Supplemental figure S2: disorganization of myocardial architecture by discrete collagen bundles

(discrete fibrosis)



Supplemental Table S1: Patients' characteristics at baseline, before and at ECMO start, and before LVAD of patients 1,2,3.

Characteristics		Patient 1	Patient 2	Patient 3
<i>At baseline</i>				
	Sex, age (yr.)	Male, 36	Male, 38	Male, 44
	BMI	29	23	20
	Alcohol consumption	280 gr/day for 15 y	280 gr/day for 15 y	200 gr/day for 20 y
	Cardiovascular history	No	No	No
	Signs, delay	Dyspnea-cough, 10 days	Dyspnea, abdominal pain-15 days	Dyspnea, cough, 20 days
	Coronary angiography	Normal	Normal	Normal
	MRI	Not done	Not done	Not done
<i>Before ECMO implantation</i>				
	Inotropes	Dobutamine	Dobutamine	Dobutamine
	Vasopressors	-	Norepinephrine	Norepinephrine
	Days from shock onset to ECMO	2	1	0,5
	Cardiac arrest before ECMO	No	No	No
	Heart rate (bpm)	120	140	140
	Lactate (mmol/L)	4	4	6
	Creatinine (umol/L)	132	97	90
	eGFR ml/min	69	104	96
	AST/ALT (IU/L)	41/95	159/195	2380/1450
	Bilirubin (umol/L)	13	30	35
	NTproBNP (ng/L)	5200	3200	8000
	Troponin (ng/L)	10	34	40
<i>Pre-ECMO echocardiography</i>				
	LVEF (%)	20	15	15
	LVEDD (mm)	68	75	63

	LVOT VTI (cm)	5	3	5
<i>At LVAD implantation</i>				
	Days on ECMO	9	10	9
	Inotropes	Levosimendan	Levosimendan, Dobutamine	Levosimendan, Dobutamine
	LVEF (%)	10	15	15
	RV dysfunction	Moderate	Moderate	No
	RV dilatation	Mild	Mild	No
	TAPSE /S'	17/NA	NA/NA	NA/10
	Histological exam of myocardial biopsy	No myocarditis + aspecific finding of CMP	No myocarditis + aspecific finding of CMP	No myocarditis + aspecific finding of CMP
	<i>Time on LVAD (months)</i>	13	12	14
<i>Post-LVAD</i>				
	Concomitant temporary RVAD implantation	Yes	Yes	No
	Inotropes after LVAD, days	0	2	10
	Early complication on LVAD			
	- Infection	Yes	No	Yes
	- Bleeding GI	Yes (gastric ulcer)	Yes (hemorrhagic shock)	No
	- RHF	Yes	Yes	Yes
	- Arrhythmia	Yes (AF paroxysmal)	No	Yes (atrial tachycardia)
	Days in ICU	30	34	34

AF: atrial fibrillation; BMI: body mass index; CMP: cardiomyopathy; ECMO: extracorporeal membrane oxygenation; GI: gastrointestinal; ICU: intensive care unit; LVEDD: left ventricular end-diastolic diameter; LVEF: left ventricular ejection fraction; LVOT VTI: left ventricular outflow tract velocity-time integral; MRI: magnetic resonance imaging ; NA: not available; NT-proBNP: N-terminal pro-brain natriuretic peptide; RHF: right heart failure; RV: right ventricle; RVAD: right ventricular assist device; TAPSE: Tricuspid Annular Plane Systolic Excursion

Supplemental Table S2. Patients' characteristics before LVAD inactivation, at 12 months follow-up and the longest follow-up (24 months for Patient 1, 30 months for Patient 2 and 36 months for Patient 3).

		Pre-LVAD inactivation			Follow up 12 months			Long term follow-up		
		P1	P2	P3	P1	P2	P3	P1	P2	P3
Function status	NYHA class	I	I	I	I	I	I	I	I	I
	HF recurrence (%)	0	0	0	0	0	0	0	0	0
HF medication	Beta-blockers (%)	≥ 100	≥ 50	≥ 100	≥ 100	≥ 100	≥ 100	≥ 50	≥ 100	≥ 100
	ACE-I/ARNI (%)	≥ 100	≥ 50	≥ 50	≥ 100	≥ 100	≥ 100	≥ 100	≥ 100	≥ 100
	MRA (%)	≥ 50	≥ 50	≥ 100	≥ 50	≥ 50	≥ 50	≥ 50	0	0
	Gliflozin (%)	≥ 100	0	0	≥ 100	≥ 100	≥ 100	≥ 100	≥ 100	≥ 100
Echocardiography	LVEF (%)	50	60	50	60	55	55	60	58	55
	LVEDD (mm)	39	37	44	57	55	54	57	56	53
	LVOT VTI (cm)	11	14	14	14	16	16	16	17	14
Right heart catheterization	CO (l/min)	4,2	5,1	4,6	5	5,6	4,8	NA	NA	NA
	Mean PAP (mmhg)	11	13	14	20	16	16	NA	NA	NA
	PWCP (mmhg)	7	7	10	14	10	11	NA	NA	NA
Laboratory tests	NTproBNP (ng/l)	421	440	126	208	162	205	200	160	400
	Creatinine (umol/L)	79	71	42	85	74	54	76	72	55
	Bilirubin (umol/L)	6	4	7	7	5	8	7	6	7

ACE: angiotensin-converting enzyme ; ARNI: angiotensin receptor neprilysin inhibitor; CO: cardiac output; LVEDD: left ventricular end-diastolic diameter; LVEF: left ventricular ejection fraction; MRA: aldosterone receptor antagonist; NA: not available ; PAP: pulmonary artery pressure. PCWP: pulmonary capillary wedge pressure. HF medication: indicated in percentage on the maximal dose.

For HF medication, the % indicate the percentage taken of target dose of ACEi/ARB/ARNI, of BB, of MRA.

0: not taking, taking ≥ 50% of target dose, taking ≥ 100% of target dose

Supplemental Table S3: Characteristics of 3 Patients Undergoing Percutaneous LVAD Deactivation in our Cohort

Patient, n	Age (y)	Gender	Etiology of HF (CMP)	LVAD Type. Duration of support	Indication for decommissioning	Closure device	Device size	Antithrombotic medication	Outcomes	Complications after decommissioning
1	36	Male	Alcoholic CMP	HM III. 13 months	Recovery	1x LAA occluder Watchman FLX (Boston)	27 mm	Warfarin	Alive at 24 months	None
2	38	Male	Alcoholic CMP	HM III. 12 months	Recovery	1x LAA occluder Amplatzer Amulet (Abbott)	20 mm	Warfarin	Alive at 30 months	None
3	44	Male	Alcoholic CMP	HM III. 14 months	Recovery	1x LAA occluder Watchman (Boston)	21 mm	Warfarin	Alive at 36 months	None

CMP: cardiomyopathy; HM III, HeartMate III; LAA : left atrial appendage.

Supplemental Table S4: Review of published case series and case reports about percutaneous left ventricular assist device (LVAD) decommissioning.

Author, year	Patient age (y)	Gender	Etiology of HF (CMP)	LVAD Type. Duration of support	Indication for decommissioning	Closure device	Device size	Antithrombotic medication	Outcomes	Complications after decommissioning
Zeigler et al., 2014 ¹	70	Female	NICMP (idiopathic)	HM II. 2 years	Recovery	1x AVP II	22 mm	Warfarin	Alive at 3.5 years	None
Sainte et al., 2014 ²	35	Female	NICMP (idiopathic)	CircuLite. 5 months	Recovery	1x AVP II	Not reported	Not reported	Alive at 2 years	None
Pettit et al., 2015 ³	17	Male	NICMP (idiopathic)	HVAD. 22 months	Recovery	2x AVP II	14 mm	Warfarin	Alive at 2 years	None
El sayed Ahmed, 2016 ⁴	14	Female	NICMP (chemotherapy induced)	HM II. 2 years	Recovery	2x AVP II	16 and 14 mm	Warfarin	Alive at 6 months	HF recurrence at 6 months
Grinstein et al., 2016 ⁵	47	Male	ICMP	HVAD. 9 months	Infection and thrombosis	1x ASO	14 mm	None	Alive at 8 months (palliative care)	None
Soon et al., 2017 ⁶	47	Male	NICMP (viral)	HVAD. 18 months	Recovery	2x AVP II	14 and 16 mm	Aspirin 100 mg	Alive at 5 months	None
Pendyal et al., 2017 ⁷	65	Male	NICMP (idiopathic)	HM II. 37 months	Thrombosis	1x AVP II	20 mm	Warfarin	Transplant at 3 months	None
Kidambi et al., 2018 ⁸	Unknown	Unknown	Unknown	HM II	Infection	1x AVP II	22 mm	Not reported	Not reported	
Chowdhury et al., 2020 ⁹	49	Female	NICMP (chemotherapy induced)	HM II. 4 months	Thrombosis (palliation)	2x ASO	20 and 18 mm	Warfarin + ASA 325 mg	In hospital death	Progressive cardiogenic shock
	60	Male	NIMCP (idiopathic)	HVAD. 18 months	Recovery	2 x AVP II	14 mm	Warfarin	Alive at 1.5 years	None
	40	Male	ICMP	HVAD. 6 months	Thrombosis (palliation)	2 x ASO	12 mm	Warfarin + ASA 325 mg	In hospital death	Progressive cardiogenic shock
	47	Female	NICMP (chemotherapy induced)	HM II. 11 months	Recovery	2 x AVP II	20 and 18 mm	Warfarin + ASA 325 mg	Alive at 2 years	None

Albulushi et al., 2020 ¹⁰	68	Male	ICMP	HVAD. 8 months	Thrombosis	3 x AVP II	Not reported	Not reported	Transplant at 2 months	HF recurrence, inotrope dependent
	35	Male	Methamphetamine abuse	HM II. 36 months	Thrombosis and recovery	3x AVP II	Not reported	Not reported	Alive at time of reporting	None
	53	Male	Viral myocarditis	HVAD. 4 months	Recovery	3x AVP II	Not reported	Not reported	Alive at time of reporting	None
	57	Female	NICMP (idiopathic)	HM III. 12 months	GI bleed and recovery	3x AVP II	Not reported	Not reported	Transplant at 3 months	Recurrent cardiomyopathy
	66	Male	ICMP	HM II. 22 months	Recovery	3x AVP II	Not reported	Not reported	Alive at time of reporting	None
	62	Male	ICMP	HM III. 12 months	GI bleed and recovery	3x AVP II	Not reported	Not reported	Alive at time of reporting	GI bleed
	44	Female	PPCM	HM III. 36 months	Recovery	3x AVP II	Not reported	Not reported	Alive at time of reporting	None
Birks et al., 2020 ¹¹	Not reported	Not reported	NICMP	HM II. Not reported	Recovery	1x AVP	Not reported	Coumadin	Alice at 2 years	None
Alkattan et al., 2021 ¹²	23	Male	NICMP (DCM)	HM III. Not reported	Recovery	2x AVP	20 and 16 mm	Warfarin	Alive at 4 months	None
Aoun et al., 2021 ¹³	43	Male	NICMP (Alcoholic)	HM III. 14 months	Recovery	1x LAA occluder	21 mm	Warfarin	Alive at 3 years	None
Moroni et al., 2022 ¹⁴	53	Female	Cardiac sarcoidosis	HM II. 5 years	Transition to palliative care	3x AVP	16 mm	Warfarin	In hospital death	-
	57	Male	NICMP (Idiopathic DCM)	HVAD. 6 months	Recovery	2x AVP	16 mm	Warfarin	Alive at 18 months	None
	51	Female	PPCM	HM II. 4 years	Thrombosis	3x AVP	14 mm	Warfarin	TAH at 5 months	Worsening of HF

	64	Male	NICMP (Idiopathic DCM)	HM III. 20 months	Recovery	3x AVP	14 mm	Apixaban	Alive at 6 months	None
	45	Male	NICMP (Alcoholic)	HM III. 21 months	Recovery	3x AVP	14 mm	Apixaban	Alive at 5 months	None
Pereira et al., 2023 ¹⁵	48	Male	NICMP (Idiopathic DCM)	HM II. 3 years	Recovery	1x LAA occluder	18 mm	Warfarin	Alive at 10 months	Ventricular tachycardia

Note: Relevant articles were identified through systematic search of MEDLINE using a combination of the following keywords: “LVAD”, “left ventricular assist device,” “heart function recovery,” “discontinuation,” “withdrawal,” “decommissioning,” and “percutaneous decommissioning.”

Abbreviations: ASA, aspirin; ASO, Amplatzer septal occluder; AVP, Amplatzer vascular plug; AVP2, Amplatzer Vascular Plug II ; AVSD, Amplatzer ventricular septal defect muscular occluder; CMP, cardiomyopathy; DCM: dilated cardiomyopathy; HM II, HeartMate II; HM III, HeartMate III; HVAD, Medtronic HVAD Support system; LAA : left atrial appendage; GI, gastrointestinal; ICMP: ischemic cardiomyopathy; NICMP: non ischemic cardiomyopathy; NYHA, New York Heart Association; PPCM: peripartum cardiomyopathy.

Managing and Monitoring Potential Recovery Candidates

1. Medical Optimization

Standard guidelines recommend medical therapy (GDMT) and devices for Heart Failure with Reduced Ejection Fraction (HFrEF), as per the ESC HF 2021 guidelines. This includes:

- Beta-blockers
- ARNI/ACE-inhibitor/ARB
- Aldosterone antagonists
- SGLT inhibitors

Neurohormonal therapy is initiated early after LVAD implantation and titrated as clinically tolerated to promote recovery.

- If necessary, a cardiac resynchronization therapy device is also considered.

2. LVAD Optimization

Adjustments in LVAD speed to optimize unloading are likely to enhance the potential for recovery. An echocardiogram is performed before discharge post-LVAD implantation, with speed set to ensure the septum is midline, the aortic valve is mostly closed at rest, and mitral regurgitation is minimal.

A hemodynamic ramp test is conducted at 3 months post-HeartMate 3 (HM3) implantation to determine optimal speed change. Suboptimal parameters trigger a new ramp test 3 months post-medical optimization.

Optimal device settings aim for: $CI > 2.2 \text{ L/min/m}^2$, $PCWP < 15 \text{ mmHg}$, and $RAP < 8 \text{ mmHg}$.

Following hemodynamic assessment and echocardiographic assessment performed every 3 months, RPM should be adjusted and lowered to the minimum speed to achieve intermittent aortic valve opening, minimal mitral regurgitation, and minimal aortic regurgitation.

Medications are adjusted based on results, with diuretics adjusted according to RAP and PWCP, and afterload adjusted according to MAP.

3. Recognizing Recovery Candidates

Echocardiography is conducted at 1-month post-implantation and every 3 months for at least 1 year.

Patients meeting criteria of normal LVEDD $< 60 \text{ mm}$, improvement of LVEF $> 45\%$, and \leq grade 1 mitral and/or aortic valve regurgitation during full LVAD support proceed to further recovery testing. Progressive increase in duration and frequency of aortic valve openings during unchanged pump rate also indicates LV function improvement, prompting additional evaluation.

Upon serial screening echos meeting criteria above, LVAD weaning evaluation testing on minimal LVAD support (RPM Turn-Down) is conducted, including echocardiography and right heart catheterization.

Protocol for assessing weaning from LVAD HeartMate 3 recipients based on Echocardiography (ECHO) and Right Heart Catheterization (RHC) during a Ramp test:

1. Ensure effective anticoagulation with an INR between 1.8 and 3 for at least 3 weeks.
2. Patient fasting is required.
3. Conduct procedure in the cardiac catheterization laboratory with interventional cardiologist, imaging cardiologist, and cardiac anesthesiologist present.
4. Administer general anesthesia.
5. Perform Transesophageal Echocardiography (TEE) to rule out intra-LV thrombus and assess aortic root.
6. Conduct right heart catheterization preferably via humeral route; alternatively, use right femoral or right jugular route.
7. Procedure is interrupted in case of poor clinical tolerance, recurrence of heart failure signs/symptoms, significant left ventricular enlargement (LVEDD > 60 mm), arrhythmias, or drop in systemic arterial pressure. Return to pre-weaning LVAD speed is recommended.
8. Reduce LVAD Pump Speed (RPM) to 5000 RPM; after 2-3 minutes, record hemodynamic and echocardiographic measurements.
9. Decrease LVAD speed by 300 RPM every 10-15 minutes, recording hemodynamic and echocardiographic measurements at each interval.
10. Decrease LVAD speed to minimum recommended by manufacturer to prevent thrombosis, down to 4200 RPM for HM3.
11. Perform cardiac echocardiography at each step, including assessment of LVEF, LVEDD, LVESD, aortic valve opening, interventricular septum position, mitro-aortic valvulopathy, LVOT and RVOT VTI, RVEDD, and right ventricular function.
12. Take hemodynamic measurements at each step, including PAP, PAWP, CO, and SvO₂.

Patients meeting weaning criteria on zero net flow undergo weaning evaluation testing:

Echocardiographic Criteria:

- Normal and stable size/geometry of both ventricles, with LVEDD ≤ 60 mm and LVESD ≤ 50 mm.
- LVEF ≥ 45%.
- Stable stroke volume, with VTI in LVOT or RVOT >10 cm.
- No or mild cardiac valve regurgitations (≤ grade I).
- Aortic valve opening observed every heartbeat.

Hemodynamic Criteria:

- Cardiac index > 2.4 L/min/m².
- PCWP ≤ 15 mmHg.
- RAP < 10 mmHg.

Date of the procedure:						
Patient's name:						
Parameters of Heart Mate 3						
RPM	5500	5200	4900	4600	4400	4200
PI						
PP, Watt						
PF, L/min						
Hemodynamic parameters						
Heart rate, bpm						
MAP, mmHg						
PAPs, mmHg						
PAPd, mmHg						
PAPm, mmHg						
PCWP, mmHg						
RAP, mmHg						
CO, L/min						
CI, L/min/m ²						
SvO ₂ , %						
Echocardiographic parameters						
LVEF, %						
LVEDD, mm						
LVESD, mm						
LVOT VTI, cm						

RVOT VTI, cm						
Aortic valve opening						
Mitral valve regurgitation						
Tricuspid valve regurgitation						
TAPSE, mm						
S' tricuspid, cm/s						
RVEDD, mm						

CI, cardiac index; CO: cardiac output; LV, left ventricle; LVEDD, LV end-diastolic diameter; LVESD, LV end-systolic diameter ; LVEF, LV ejection fraction; LVOT, LV outflow tract; MAP: mean arterial pressure ; PCWP, pulmonary capillary wedge pressure; PF, pump flow; PI, pulsatility index; PP, pump power; RAP, right atrial pressure; RPM: revolutions per minute; RV, right ventricle; RVEDD, right ventricle end-diastolic diameter SV, stroke volume; SvO2, Venous oxygen saturation; TR, tricuspid regurgitation; TAPSE , Tricuspid Annular Plane Systolic Excursion; VTI, velocity-time integral.