Appendix C: Supplementary Tables

Data Tables for Cardiac Arrest in the Catheterization Lab

Table S1: Incidence and Outcome of Cardiac Arrest in the Cardiac Intervention Laboratory

Author/year	Study design/period	Cardiac arrests in Cath lab n/x (%)	Initial rhythms	Outcomes	Comments
Sharma 2019[1]	Retrospective cohort study (2012–2016)	63/13,112 (0.5%)	PEA 29 (46%); VF/VT 15 (24%); hypotension 19 (30%)	Survived catheterization lab 42 (67%); 1-year Survival 30 (37%)	
Sprung 2006[2]	Retrospective cohort study (1990–2000)	114/51,985 (0.2%)	VF 72 (63.7%); Asystole 30 (26.6%); PEA 11 (9.7%)	Survived procedure: 88/114 (77.2%) Survival to discharge: 64/114 (56.1%)	Long-Term Survival for survivors after cardiac arrest not significantly worse than those who did not have a cardiac arrest: hazard ratio 1.47 (95% CI 0.88-2.46, p = 0.14)
Elkaryoni 2022[3]	Prospective cohort study (2000–2019)	6865 / ?	Asystole 1337 (19.5%), PEA 2951 (43.0%), Pulseless VT 680 (9.9%), VF 1897 (27.6%)	Overall Survival to discharge: 38.1%	GWTG-R

Table S2: Incidence And Outcome From Cardiac Arrest During PCI In The Cardiac Intervention Laboratory Among Patients With And Without Acute ST-Elevation MI

First Author, Year	Study Design / period	Purpose/Primary Objective	Population	Denominator	Number of cardiac arrests	Initial rhythm	Outcome	comments
Addala 2005[4]	Observational Retrospective	Incidence of VF	Unselected (Elective and non-elective procedures)	19,497	164 (0.84%)	VF	Survival to discharge 164 (100%)	Single centre in Michigan. Cardiogenic shock excluded. All patients successfully defibrillated within 1 min from initiation of VF. VF developed during right coronary injection in 98 patients, left coronary injection in 64 patients, and during bypass graft injection in 2 patients (p< 0.05)
Webb, 2002[5]	Observational Retrospective 1996–1999	Incidence of CA	Unselected but with separate reports for stable angina, CS, MI, Cariogenic Shock	4363	Cardiac arrest during PCI 27 (0.6%) All 57 cardiac arrests incidence:1.3% Elective: 0.02% Unstable angina: 0.5%,	All 57 arrests: VF: 36%, VT 28%, bradycardia : 24% asystole: 8% PEA: 2%	24-h survival for all cardiac arrests 37%	Single centre in Vancouver. 57 patients who had CA either during the procedure or later the same day as the procedure. 47% (N=27) had CA during PCI.

					AMI: 15%, Cardiogenic Shock: 10%			Of those who had CA during PCI CA occurred after the initial injection of radiographic contrast into a coronary artery in 12%, after the initial balloon inflation in 60%, and after stent implantation in 13%
Huang 2002[6]	Observational Prospective	Incidence of VF	Elective Procedures: angina despite adequate medical therapy, or ischemia demonstrated during stress testing; and (2) diameter stenosis of >75%	Overall 905, LCA 561, RCA 344	Overall: 2%, LCA 0.5%, RCA 4.6%	VF	NR	Single centre in Taiwan. VF more frequent in RCA PCI

Table S3: Mechanical Chest Compression CPR In The Cardiac Intervention Laboratory

First Author, Year	**Study Design / period**	**Purpose/Primary Objective**	**Population**	**Denominator**	**Number of cardiac arrests**	**Initial rhythm**	**Survival to discharge**	**comments**
Mehta 2009[7]	Observational Retrospective 2004–2006	To evaluate risk factors for and outcomes of patients with VT/VF	STEMI adults presenting within 12 h of symptom onset	5745	180 (3%)*	VT/VF	83.8%*	296 hospitals in 17 countries, (APEX AMI trial) Excluded - Patients with isolated inferior STEMI, pregnant, known or suspected complement deficiency or active infection, other serious medical problems likely to hamper their recovery, or fibrinolytic therapy for the treatment of their qualifying events Including all patients with VT/VF until the end of catheterisation
Demidova, 2015[8]	Observational Retrospective 2007–2012	To analyse clinical predictors of reperfusion VF	STEMI	3274	71 (1.9%)	VF	81.7%	Single centre Lund, Sweden All patients who had VF during reperfusion
Giglioli, 2006[9]	Observational Retrospective 2002–2003	Evaluate incidence, timing and complications from primary PCI in STEMI patients	STEMI within 12 h of onset of symptoms, or within 24 h if signs of persistent ischemia or shock were present.	689	38 (5.5%)	VF	NR	VF was statistically more frequent in patients with inferior AMI than in those with anterior AMI (47 versus 29 patients, P<0.001).

Mehta, 2004[10]	Observational Prospective (1990s)	To examine the incidence, predictors, and outcomes of VT/VF occurring in the cardiac catheterization laboratory among patients undergoing primary PCI for STEMI.	STEMI, >=18 years, <12 h form symptom onset	3065	133 (4.3%)	VT/VF	129/133 99.2%	Patients enrolled in 4 Primary Angioplasty in MI trials in the North America/South America/Europe/Middle East and Asia in the 1990's Excluded - Patients with: Contraindications to reperfusion, thrombolytic therapy for index STEMI, renal failure, cardiogenic shock, life expectancy <1 year, child-bearing potential, contraindications to aspirin, heparin, or ticlopidine in later PAMI trials. Sustained VT as well as VF included Patients randomized to the thrombolytic arm in PAMI-1 79% of these patients required defibrillation. So at least 21% were not in CA. CPR was necessary in only 8 patients (6%)
Henriques, 2005[11]	Observational Prospective 1995 – 2001	To compare characteristics of patients with VF during PCI versus patients with VF before PCI	STEMI	2628	74 (3%)	VF	NR	Single centre in the Netherlands. Patients with out-of-hospital resuscitation and VF on arrival of the ambulance were excluded. Patients with VF during PCI had more often RCA-related MI and more frequently TIMI 0 before PCI

Table S4: ECPR In The Cardiac Intervention Laboratory

Author & Year	Study Design/period	Number of cardiac arrests in Cath Lab	Initial rhythm	Outcomes	Comments
Mechanical piston device (LUCAS)					
Wagner, 2016[12]	Prospective observational study 2009–2013	n=32 LUCAS MCC application in cath lab n=10 historical control with manual CPR in cath lab (1999-2003)	LUCAS MCC group PEA 22/32 (69%) Asystole 5/32 (16%) VF/VT 5/32 (16%) Historical control PEA 4/10 (40%) Asystole 2/10 (20%) VF/VT 2/10 (20%)	LUCAS MCC group Hospital Discharge CPC 1-2: 8/32 (25%) 1 year survival CPC 1–2: 7/32 (22%) Historical control Survival (unspecified) 1/10 (10%)	Prospective vs historical groups not readily comparable due to different treatment periods and other characteristics

Wagner, 2010[13]	Retrospective registry analysis 2004–2008	n=43 LUCAS MCC	PEA 28/43 (65%) Asystole 9/43 (21%) VF/VT 6/43 (14%)	Survived cath lab 17 patients (39%) (16 with ROSC and 1 with ongoing MCC). Survival to Hospital Discharge: 12/43 (28%) Survival to Hospital Discharge CPC 1-2: 11/43 (26%)	All 43 included patients arrested in the cath lab Use of LUCAS MCC during PCI or pericardiocentesis after cardiac arrest in the cath-lab Procedure success rate: 27/42 (76%) of the PCI procedures done during MCC were successful. Complications: All survivors experienced rib fractures, and one patient suffered a ruptured spleen due to incorrect application of the device. 4 patients were treated with manual chest compressions and all 4 died.
Larsen, 2007[14]	Retrospective study - LUCAS MCC application during PCI 2005–2006	n=6 LUCAS MCC applied in cath lab n=6 LUCAS MCC applied after OHCA before cath lab arrival	n=6 (VF 2, PEA 1, hypotension 3) LUCAS applied in the cath lab n=6 (VF 5, asystole 1) resuscitated from OHCA before cath lab arrival	n=3 patients survived the intervention no patients were discharged alive.	LUCAS was applied on the cardiac cath table for 6 (for VF in 2, for PEA in 1 & for bradycardia or hypotension in 3). LUCAS was applied after resuscitation from OHCA & before coronary angiography for 6 : for severe hypotension & bradycardia in 5 & VF in 1. LUCAS was applied prehospital for 1 OHCA. Autopsies were performed in 11 of the cases, revealing sternal and costal fractures in 7/11 patients and liver laceration in 1/11 patient. In 2/11 patients small sub-capsular haematomas in the liver were reported. There was 1 case of excessive intra-thoracic bleeding in the catheterisation laboratory (managed by thoracotomy). Lucas device tended to drift distally requiring strap securement.
Venturini, 2017[15]	Retrospective registry analysis 2011–2016	n=43 total cardiac arrests n=20 cath lab arrests (15 LUCAS MCC, 5 Manual CPR). n=11 OHCA (9 LUCAS CPR, 2 Manual CPR). n= 8 ED cardiac arrest (4 LUCAS MCC, 4 Manual CPR) n=3 LUCAS MCC not specified by initial site but eventually received in cath lab n=1 manual CPR not specified by initial site but	LUCAS MCC VF/VT 13/31 (42%) Manual CPR VF/VT 5/12 (42%)	ROSC: LUCAS MCC 22/31 (74%) versus manual CPR 5/12 (42%) 30-day Survival: LUCAS MCC 19% versus manual CPR 8% Survival to Hospital Discharge: LUCAS MCC 13% versus manual CPR 8%	43 patients required chest compressions for cardiac arrest in the cath lab (12 manual CPR, 31 received LUCAS MCC) All patients had the possibility of transitioning to percutaneous mechanical circulatory support (MCS) (MCS - IABP or Impella), or ECLS during resuscitation. 22/31 patients with LUCAS MCC received MCS: 95% of patients who received MCS achieved ROSC compared to 11% without MCS ($p = 0.004$). 14/31 (45%) with LUCAS were bridged to ECLS. Patients receiving ECLS were more likely to achieve ROSC (100% vs. 53%, $p = 0.003$).

		eventually received in cath lab			
Chyrchel, 2022[16]	Retrospective cohort study 2013–2020	n= 48 total cardiac arrests received LUCAS MCC 23/48 (48%) had cardiac arrest in the cath lab	PEA 22/48 (46%) Asystole 8/48 (17%) VF/VT 13/48 (27%) Unknown 5/48 (10%)	ROSC was achieved in 31% of patients (15/48). Survival to hospital discharge = 17% (8/48).	Small single hospital group of patients who arrested either before or during angiography. 30 patients who could have been analysed were excluded due to lack of data and clinical history in the notes. In patients with hyperkalemia, survival rate was 50%, while survival rate for those with potassium < 5.0 mmol/L was only 4% (p = 0.0007).
Madsen Hardig, 2019[17]	Retrospective observational study 2004–2013	n=35 total cardiac arrests received LUCAS MCC n=27/35 (77%) in cath lab n=8/35 (23%) taken to cath lab with ongoing CPR.	PEA 17/35 (49%) Asystole 4/35 (11%) Bradycardia 7/35 (20%) VF/VT 7/35 (20%)	ROSC 18/35 (51%) ROSC 14/27 (53%) for arrest in cath lab Survival CPC 1–2 9/35 (26%) Survival CPC 1-2 9/27 (33%) among cath lab arrests ROSC and survival did not differ across presenting rhythms of VF/VT, PEA, asystole or bradycardia. No survivors among those with ongoing CPR on arrival in cath lab	No patient survived who arrived at the cath-lab still requiring CPR (potential candidate for ECPR) The median time of MCC in the cath-lab for those who did survive was 10min versus 45min for those patients not surviving. Initial arrest rhythm did not predict outcome. If a diastolic arterial BP of 30 mmHg can't be achieved, consider escalation to ECPR. This decision should be made within the first 10–20 min of resuscitation efforts in the cath-lab, as longer periods are associated with a decrease in survival. LUCAS CPR time was shorter for those who gained ROSC and survived. Those that arrived at the cath-lab with ongoing CPR had a lower chance of obtaining ROSC than if the arrest occurred in the cath lab (22% vs 53%,p = 0.086). None of the patients survived if resuscitation was ongoing when they were admitted to the cath-lab.
Load-distributing band device (Autopulse)					
Spiro 2015[18]	Retrospective observational study in-hospital cardiac arrest 2011–2013	n=25 received Autopulse-CPR during in-hospital cardiac arrest 15/25 cardiac arrest during invasive procedures (14/15 in cath lab)	14 patients had Autopulse -CPR started in the cath lab due to: VF/T 7/14 (50%) PEA 7/14 (50%)	ROSC 12/25 (48%) with Autopulse-CPR 7/25 (28%) survived to hospital discharge 3/9 (33%) patients who received Autopulse CPR with simultaneous PCI survived to hospital discharge with normal cerebral function (CPC 1-2)	15/25 (60%) of patients received Autopulse-CPR at some stage during an invasive procedure (14/15 in cath lab). In 9/15 (60%) Autopulse -CPR received simultaneous with invasive procedure (4/9 with PCI, 4/9 with angiography+TEE+temp pacer, and 1/9 pericardial drainage) & in 6/15 there was a pause in the invasive procedure whilst the A-Pulse was attached. Complications: Battery depletion (1), difficult backboard placement (1) compression band twist (1), clip detachment (1)

Table S5: Mechanical Circulatory Support In The Cardiac Intervention Laboratory

Author / year	Study Design	Number of cardiac arrests	Initial rhythm	Outcomes	Comments
Shawl, 1990[19]	Case series (time frame not reported)	7	VF or asystole	4 out of 7 patients survived (57%). All survivors NYHA class 1 at 6 months.	Percutaneous cardiopulmonary bypass was instituted for cardiac arrest in cath lab refractory to ACLS (mean cannulation time from cardiac arrest: 21 min). Subsequent interventions included coronary bypass surgery (n=3) and coronary angioplasty (n=2)
Mooney, 1991[20]	Case series (1988 - 1989)	11 (5 arrests in cath lab)	N/A	5/5 (100%) survival (cath lab) 2/6 (33%) survival (outside cath lab)	Percutaneous cardiopulmonary bypass was instituted in 5 patients with cardiac arrest during percutaneous coronary procedures, and 6 patients with cardiac arrest outside the cath lab. Subsequent interventions included coronary bypass surgery (5/5 in the cath lab group, 2/6 in the non-cath lab group.
Grambow, 1994[21]	Retrospective observational study (1988 - 1992)	7 cardiac arrests 23 cardiogenic shock	N/A	0/7 (0%) survival in cardiac arrest 6/23 (26%) survival in cardiogenic shock	Percutaneous cardiopulmonary bypass was initiated after cardiac arrest (mean time: 21 min) or shock during diagnostic or therapeutic cardiac procedures in the cath lab (mean cannulation time 17 min) using portable Bard PCB system - via FA and FV access Subsequent interventions included emergent cardiac surgery (n=14), coronary angioplasty (n=13) and medical therapy (n=3).
Nagao, 1999[22]	Prospective observational study (1994–1997)	32 with refractory VF and STEMI 19 OHCA 13 IHCA (ER)	Refractory VF	ROSC: 28/32 (87.5%) Weaned from ECMO 6 (18.8%) Good Neurological outcome 3/32 (9.4%)	Percutaneous coronary bypass was instituted in 32/32 patients with refractory VF complicating STEMI who were transferred to the cath lab of the Emergency Room. Intravenous rTPA was administered to those patients with MI diagnosed before VF. Subsequent interventions included coronary angiography/ angioplasty if adequate reperfusion had not been achieved.
Goslar, 2016[23]	Retrospective observational study (2010-2015)	12 cardiac arrests in cath lab 11 cardiogenic shock	N/A	Weaned off ECMO 6/12 (50%) Survived to hospital discharge 2 (17%)	VA-ECMO was instituted in patients with refractory cardiac arrest (n=12) or cardiogenic shock (n=11) in the cath lab, and in 33 patients outside the cath lab (ICU, n=8; operating room, n=25). Subsequent interventions included coronary angiography/angioplasty, pulmonary angiography or CT followed by thrombolysis if pulmonary embolism. N=9/23 patients (39%) had concomitant IABP
Parr, 2020[24]	Retrospective observational study (2010–2018)	39 cardiac arrests in the cath lab 23 Cardiogenic shock	VF/VT 19/39 (48.7%) PEA 20/39 (51.3%)	30-day Survival: 17/39 (44%) cardiac arrest; 12/23 (52%) cardiogenic shock 1-year Survival: 16/39 (44%) cardiac arrest; 11/23 (48%) cardiogenic shock	VA-ECMO was instituted in patients with cardiac arrest or cardiogenic shock during percutaneous procedures in the cath lab (median cannulation time from collapse: 38 min). Complications included stroke (32.3%), hemorrhage at the cannula site (33.9%), extremity malperfusion (19.4%), and new acute kidney insufficiency requiring renal replacement therapy (38.7%). Subsequent interventions included IABP (n=13 cardiac arrest, n=3 shock), ventricular assist device (n=2 cardiac arrest, n= 4 shock) and coronary bypass surgery (n=7 cardiac arrest, n=5 shock).

Hryniewicz, 2021[25]	Retrospective observational study (2012 – 2017)	8 cardiac arrests in the cath lab 11 in other in-hospital locations 7 OHCA	**Cath lab:** VF/VT 6 (75%); PEA/asystole 2 (25%) **IHCA:** VF/VT 7 (64%); PEA/asystole 4 (36%) **OHCA:** VF/VT 4 (57%); PEA/asystole 3 (43%)	Cath lab: 7/8 (88%) survival to discharge and at 6 months; 88% with CPC 1-2 Other IHCA: 6/11 (55%) survival to discharge and at 6 months; 45% with CPC 1-2 OHCA: 5/7 (71%) survival to discharge and at 6 months 71% with CPC 1-2	VA-ECMO was instituted in 8 patients with cardiac arrest in the cath lab, 11 patients in other in-hospital locations and 7 patients with OHCA who were transferred to the cath lab (median cannulation time: 39 min cath lab, 45 min IHCA, 72 min OHCA). Subsequent interventions for patients with cardiac arrest in the cath lab included revascularization (n=7/8 patients), hypothermia (n=2/8 patients). Outcomes were better in patients with initial rhythm VF/VT versus PEA/asystole.
Radsel, 2021[26]	Prospective observational study (2010–2020)	52 cardiac arrests (n=36, 69.2% were cannulated in cath lab) 78 cardiogenic shocks	N/A	Cardiac arrest survival to discharge (CPC 1 or 2) 15/52 (29%).	VA-ECMO was instituted in n=23 patients before percutaneous or surgical interventions and n=17 inmediately after these. Settings of cardiac arrests included OHCA or IHCA (Emergency Room, cardiac ICU, the ward or the cath lab). N=36 patients (69.2%) were cannulated in the cath lab. Interventions before VA-ECMO E-CPR included PCI (15/52, 28.8%), TAVI (1, 1.9%) and electrophysiology procedure (1, 1.9%). Subsequent interventions on VA-ECMO included coronary angiography (38, 73.1%), PCI (n=24, 46.2%)), CABG (4, 7.7%), aortic surgery (3, 5.8%), pericardiotomy, left ventricular assist device, pulmonary embolectomy, abdominal surgery (1 each, 1.9%).
Mazzeffi, 2024[27]	Retrospective cohort study (2020–2023	Total 2515 cardiac arrests 602 cardiac arrests in cath lab	Cath lab arrests: VT 68 (11.3% VF 167 (27.7%) PEA 222 (36.9%) Asystole 57 (9.5%) Unknown 88 (14.6%)	Survival to discharge 235 (39%)	Extracorporeal Life Support Organization (ELSO) registry data. Objective: to explore whether ECPR mortality differs by IHCA location and whether moving patients for cannulation impacts outcome. Pre-ECPR interventions for cardiac arrest in cath lab group: • IABP 51 (8.5%) • RV assist device 2 (0.3%) • Impella 65 (10.8%) Conventional CPR time 25 (14–39) minutes. Adjusted odds ratio (aOR) for mortality higher in patients with cardiac arrest in the ICU (aOR, 1.85; 95% CI, 1.45–2.38; p <0.001) and in patients with cardiac arrest in acute care bed (aOR, 1.68; 95% CI, 1.09–2.58; p = 0.02) compared with in the cath lab. Survival to discharge for cardiac arrests in other locations (and ECPR): • ICU = 243/939 (25.9%) • Acute care bed = 67/242 (27.7%)

Table S6: Intracoronary Epinephrine In The Cardiac Intervention Laboratory

Author/Year	Study design/ period	Cardiac arrests in Cath lab n/x (%)	Initial rhythms	Outcome	Comments
Bagai Y, 2011[28]	Case series 2006–2009	8/8 (100%)	N/R	7/8 (87.5%) successful support in cardiac arrest or cardiogenic shock; 3/7 (43%) survival to hospital discharge for in-lab cardiac arrest patients treated with Multifunctional Percutaneous Heart (MPH)	
Loehn, 2020[29]	Retrospective observational study (Impella) 2014–2016	43/73 (59%)	Asystole 9/43 (21%), PEA 11/43, VF/VT 23/43 (54%)	Impella implantation during ongoing CPR versus implantation after ROSC had no significant impact on survival to discharge (28.5% vs. 27.2%, p=0.92). Among whole group (those with cardiac arrest and those with cardiogenic shock without cardiac arrest) the overall survival rate at discharge was low in Impella recipients (35.6%) but better when Impella placed pre-PCI (50%) than post PCI (23.1%) p=0.027. In whole group (regardless of when impella was placed), impella was the sole independent predictor of survival at discharge and at 30, 90 & 180 days.	
Vase, 2017[30]	Observational study (Impella) 2014–2016	8	VF 5 (62%), PEA 3 (37%).	For those with rCA, survival to discharge was 4/8 (50%) compared with 7/12 (58%) for those with cardiogenic shock. All patients survived 6 months and were CPC 1–2,	8 patients with refractory CA & 12 with cardiogenic shock. At the time of receiving the Impella device all cardiac arrests were in PEA.
Gerfer, 2023[31]	Retrospective cohort study 2014–2016	59/729 (8%)	37% of CPR patients underwent defibrillation but no further details given about the arrest rhythms	49/59 (83%) survived to hospital discharge	16/59 (27%) cardiac arrest patients required 'heart-lung circulatory support' but their outcomes are not reported separately. Patients who required CPR had a lower ejection fraction and lower aortic gradients than those who did not. Patients with intra-procedural complications such as tamponade and valve displacement had higher incidence of CPR. All complications were higher in the group needing CPR.
Almajed, 2023[32]	Retrospective cohort study (Impella) 2013–2022	6 (5 during TAVR; 1 during BAV)	Not stated	30-day survival 5/6 (83%) 4/5 for TAVR and 1/1 for BAV	2680 procedures: 1965 TAVR and 715 BAV. 120 used Impella support, 26 TAVR and 94 BAV, but only 5 and 1 for cardiac arrest. Cardiogenic shock TAVR Impella cases mortality 35.7 % and cardiogenic shock BAV 44.2%

Orvin, 2021[33]	Observational study (Impella, VA ECMO, TandemHeart) 2011–2020	41/87 (47%)	Not stated	Overall survival to hospital discharge after TAVI with pMCS insertion was 72.5%. 1 yr survival was close to 50%.	For all 87 cases (75.9% VA ECMO, 19.5% Impella CP, 4.6% TandemHeart). No separate data for the 41 cardiac arrest cases.

Resuscitation of Patients with Durable Mechanical Circulatory Support with Acutely Altered Perfusion or Cardiac Arrest: supplementary data tables

Table S7: Details of included studies

Study	Publication Year	Study Type	Continent	Total number of patients with acutely altered perfusion	Population	Mechanical Support Device(s)	Chest Compressions Described
Senman et al[34]	2024	Case Series	North America	58	Both In-and-Out of hospital	LVAD	Yes
	Case series of 58 LVAD supported patients at a single institution who suffered cardiac arrest. Of these, 24 received chest compressions and 34 received no chest compressions. Per review of the notes, the most common reason for withholding of chest compressions was a perceived contraindication to chest compressions in LVAD supported patients. There were no documented cases of device dislodgement. Survival was similar between those who did and did not receive chest compressions, but neurologic outcomes were worse in patients who received chest compressions.						
Sande et al[35]l	2023	Case Report	North America	1	In-hospital	LVAD	No
	Case report of a patient experiencing device alarms after undergoing an ablation procedure shortly after a percutaneous LVAD placement. A bedside echo showed a large circumferential pericardial effusion with right ventricular collapse and tamponade. The patient underwent bedside pericardiocentesis with improved physiology.						
Victor et al[36]	2022	Case Report	North America	1	In-hospital	LVAD	No
	Case report of a patient experiencing increasing dyspnea and hemodynamic instability 6 days after LVAD placement. LVAD flow rate adjustments and vasopressor utilization were unsuccessful, and ultrasound identified a pericardial effusion. Successful operative management was performed.						
Akin et al[37]	2022	Case Report	Europe	1	In-hospital	LVAD	No
	A case report of a patient 10 days after LVAD placement involved a research study for a sublingual microcirculatory imaging tool for microvascular circulation and perfusion. The device revealed severe failure of the microcirculation, and the patient later developed hemodynamic compromise and signs of hypoperfusion. Cardiac tamponade was identified that was subsequently surgically corrected.						
Ratman et al[38]	2022	Case Report	Europe	1	Out-of-Hospital	LVAD	No
	Case report of a patient admitted with low LVAD flows and multiple organ failure. Pump flows and evidence of organ injury improved with fluids.						
Doita et al[39]	2022	Case Report	Asia	1	In-hospital	LVAD	Yes

<table>
<tr><td></td><td colspan="7">Case report of an LVAD thrombosis leading to left outflow obstruction. The clot was large enough to occupy the LVAD inflow and resulted in nearly no forward flow from the device. The patient suffered cardiac arrest. Chest compressions were administered but the patient could not be resuscitated.</td></tr>
<tr><td rowspan="2">Barssoum et a[40]</td><td>2022</td><td>Retrospective observational cohort</td><td>North America</td><td>578</td><td>In-hospital</td><td>LVAD</td><td>No</td></tr>
<tr><td colspan="7">Retrospective analysis of the National Inpatient Sample including LVAD patients who sustained cardiac arrest comparing outcomes of those who underwent chest compressions with those who did not. Of 578 patients, 226 (39.1%) survived to hospital discharge. Mortality was 74% for those receiving chest compressions vs. 61% for those who did not achieve chest compressions ($p<0.01$). This study was limited by potential misclassification as only administrative data was used and variables available for abstraction were limited.</td></tr>
<tr><td rowspan="2">Pokrajac et al[41]</td><td>2022</td><td>Retrospective observational cohort</td><td>North America</td><td>1</td><td>In-hospital; Pediatrics Included</td><td>LVAD</td><td>No</td></tr>
<tr><td colspan="7">Single center, retrospective review of 54 emergency department visits in pediatric VAD patients. There were no deaths or cardiac arrests in the ED. 4 patients in the cohort died, with one experiencing cardiogenic shock and organ failure.</td></tr>
<tr><td rowspan="2">Esangbedo et al[42]</td><td>2022</td><td>Case Series</td><td>North America</td><td>4</td><td>In-hospital; Pediatrics Included</td><td>LVAD; BiVAD</td><td>Yes</td></tr>
<tr><td colspan="7">Case series of 5 pediatric patients who underwent chest compressions with VAD in place. Patient 1 had had cardiac arrest due to tamponade and suffered severe neurologic injury. Patient 2 had RVAD disconnect and brief chest compressions. Patient 3 had cardiac tamponade and brief chest compressions prior to chest exploration. Patient 4 had brief chest compressions with tamponade. Of the 4 patients, 3 survived with good outcomes.</td></tr>
<tr><td rowspan="2">Oates et al[43]</td><td>2022</td><td>Case Report</td><td>North America</td><td>1</td><td>In-hospital</td><td>LVAD</td><td>No</td></tr>
<tr><td colspan="7">Case report of patient who deteriorated after attempt at VT ablation with hypoxemia from intratrial shunt.</td></tr>
<tr><td rowspan="2">Ziegler et al[44]</td><td>2021</td><td>Case Report</td><td>North America</td><td>1</td><td>Out-of-Hospital</td><td>LVAD</td><td>No</td></tr>
<tr><td colspan="7">Case report of an emergency repair using splicing of a transected driveline in a left ventricular assist device.</td></tr>
<tr><td rowspan="2">Iwashita et al[45]</td><td>2020</td><td>Case Report</td><td>Asia</td><td>1</td><td>Both In-and-Out of hospital</td><td>LVAD; ECMO</td><td>Yes</td></tr>
<tr><td colspan="7">Case report of cardiac arrest 2 years post LVAD placement. The device was unknown by responders and chest compressions were performed for 40 minutes. On arrival to the hospital a depleted battery was discovered and changed after 50minutes of total chest compressions. Subsequent VT was not responsive to defibrillation and VA-ECMO was initiated. A complicated course led to patient death after ECMO was discontinued.</td></tr>
<tr><td rowspan="2">Eyituoyo et al[46]</td><td>2020</td><td>Case Report</td><td>North America</td><td>1</td><td>Both In-and-Out of hospital</td><td>LVAD</td><td>No</td></tr>
<tr><td colspan="7">A case report of a patient with an LVAD placed 7 years earlier who developed altered mentation and hypotension. Upon EMS arrival, an irregular rhythm was noted and presumed to be artifact from LVAD. In the emergency department, VF was noted and corrected with defibrillation. The patient developed multiorgan failure and later expired.</td></tr>
</table>

Saito et al[47]	2019	Case Report	Asia	1	Out-of-Hospital	LVAD	Yes
	Case report of a patient who suffered from global cerebral ischemia due to LVAD pump stoppage. Chest compressions were performed by paramedics and LVAD function was restored after hospital arrival by exchanging external cables. The patient recovered without any neurological deficit.						
Harper et al[48]	2019	Case Report	North America	1	In-hospital	LVAD	No
	Case report of a patient with an LVAD placed 3 years earlier presenting to the emergency department in refractory VT and experiencing chest pain, dizziness and multiple discharges of his ICD. Received medications and external shocks and LVAD flow rate was decreased to allow better ventricular filling.						
Thiele et al[49]	2018	Case Report	Europe	1	Out-of-Hospital	LVAD	Unclear
	Case report of LVAD driveline disconnect. Patient recovered with re-connecting driveline.						
Ornato et al[50]	2018	Case Report	North America	1	Out-of-Hospital	LVAD	Yes
	Case report of a patient with an LVAD who suffered cardiac arrest. Patient was intubated and ETCO2 was 0 mmHg with confirmation of tube placement. Compressions started and ETCO2 rose to 28 mmHg.						
Godishala et al[51]	2017	Case Series	North America	4	In-hospital	LVAD	No
	Case series of 4 patients suffering acute myocardial infarction while supported by continuous-flow LVADs. Patient 1 received shocks from ICD due to VT, attributed to electrolyte derangement; once corrected the patient was asymptomatic. Patient 2 also received shocks from ICD due to VT which was attributed to complete thrombotic occlusion of left circumflex artery; this was removed but the patient suffered complications and died following intracranial hemorrhage. Patient 3 experienced chest pressure, diaphoresis shortness of breath and presyncope due to coronary artery occlusion; once stented he remained symptom-free. Patient 4 experienced chest pain and shortness of breath due to large thrombus in aortic valve; this was removed but one month later the thrombus returned and the patient died.						
Yuzefpolskaya et al[52]	2016	Case Report	North America	1	In-hospital	LVAD; ECMO	Yes
	This paper presents an algorithm for assessment and management of hospitalized unresponsive LVAD patients. A case study is presented by way of rationale for the algorithm in which a patient who was post-operative day 8 after LVAD implantation developed acute altered perfusion. Chest compressions were not initially performed as the patient was recently post-operative and it was unclear whether cardiac arrest had occurred. Chest compressions were ultimately initiate 15 minutes into the event and the patient was placed on VA-ECMO. After transfer to the ICU, the patient was pronounced brain dead.						
Bouchez et al[53]	2016	Case Report	Europe	2	Both in and out of hospital	LVAD	No
	Two case reports of patients with LVADs who went into VF and developed deteriorating RV function. The authors describe a "treatment protocol" that includes augmenting MAP, addressing wall tension, treating electrical storm, and defibrillation.						
Plymen et al[54]	2015	Case Report	Europe	1	In-hospital	LVAD; RVAD	Yes
	Case report of a patient with LVAD who developed RV failure and arrhythmia after embolism. Patient was treated with a temporary RVAD and ultimately underwent heart transplant.						
Mulukutla et al[55]	2015	Case Report	North America	1	Out-of-Hospital	BiVAD	No
	Case report of patient with BiVAD who developed sustained, unstable VT who underwent VT ablation.						

Wilson et al[56]	2014	Case Report	Canada	1	In-hospital	LVAD	No
	Case report of a single patient with recurrent, brief cardiac arrest and loss of consciousness iso LVAD and fused aortic valve. Underwent aortic valve replacement with improvement.						
Shinar et al[57]	2014	Case Series	North America	8	Both In-and-Out of hospital	LVAD	Yes
	Case series of 8 patients who had LVADs and underwent chest compressions with a focus on cannula dislodgement. Eight patient records were reviewed revealing no apparent dislodgement after receiving chest compressions. In all cases with return of effective circulation, post-arrest pump flows were reported as stable. Three patients underwent autopsy, with no device dislodgement found—including an autopsy for a patient who underwent 2.5 hours of chest compressions. 6 of 8 (75%) patients had return of effective circulation and 4 patients (50%) survived with good neurologic outcomes.						
Cubillo et al[58]	2014	Case Report	North America	1	Out-of-Hospital	LVAD	Yes
	Case report of emergency repair of an LVAD driveline that was accidentally transected resulting in cardiac arrest. Chest compressions were initiated by a bystander and then continued by paramedics. Patient was taken to the emergency department where LVAD flows were restored, however patient had sustained substantial neurologic injury.						
Garg et al[59]	2014	Case Series	North America	16	In-hospital	LVAD	No
	Case series of 16 patients with continuous-flow LVADs who suffered in-hospital cardiac arrest. 9 patients (56.3%) received chest compressions and 2 (22.2%) of those who received chest compressions survived. 4 of 9 patients (44.4%) who received chest compressions had delays of at least 2 minutes before chest compression initiation. As compared to a non-LVAD cardiac arrest cohort, time to initiation of chest compressions was substantially longer.						
Haglund et al[60]	2014	Case Report	North America	1	In-hospital	LVAD	No
	Case report of a patient post-operative day 7 from LVAD implantation with acute hyperactive delirium with power source disconnection from his LVAD leading to cardiac arrest. He was found unresponsive and cyanotic. LVAD power was restored with improved perfusion, though low flow alarm continued. Chest compressions were not provided.						
Duff et al[61]	2013	Case Report	North America	2	In-hospital; Pediatrics Included	LVAD; BiVAD	No
	Case report of cardiac arrest in two pediatric patients with ventricular assist devices. Patient 1 involved LVAD failure and circulatory arrest resulting from acute pulmonary hypertension triggered by post-anesthetic hypercarbia. Patient 2 involved episodic hypoperfusion.						
Schweiger et al[62]	2012	Case Report	Europe	1	Out-of-Hospital	LVAD	Yes
	Case report of 2 patients with LVADs—one of which suffered acutely altered perfusion resulting in EMS response. Paramedics unsure of whether to do CPR and wife called VAD specialist. CPR advised but patient's wife declined.						
Brenyo et al[63]	2011	Case Report	North America	1	Out-of-Hospital	LVAD	No
	Case report of patient with LVAD who suffered cardiac arrest with ventricular fibrillation and was defibrillated. He was comatose and treated with therapeutic hypothermia. After rewarming, had neurological						

	recovery other than amnesia around the arrest event.						
Rottenberg et al[64]	2011	Case Report	North America	1	In-hospital	LVAD; ECMO	Yes
	Case report of patient sustaining cardiac arrest during redo sternotomy for LVAD exchange. Abdominal chest compressions were performed to avoid damage to inflow cannula.						
Andersen et al[65]	2009	Case Series	Europe	3	Out-of-Hospital	LVAD	Yes
	Case series of 23 patients with HeartMate II LVADs describing the incidence of VT/VF during 266 total months of follow up. They noted an incidence of 52%, with external defibrillator or ICD shock in 8 patients and significant hemodynamic instability in 3 patients.						

Table S8: Studies Including Patients who Received Chest Compressions

Study	Number of Patients Receiving Chest Compressions	Device	Duration of Implantation prior to Chest Compressions	Cause of arrest	Outcome	Duration of Chest Compressions	Documentation of MCS Dislodgement or other Complication
Senman et al[34]	24	HVAD, Heartmate 2, Heartmate 3	See reference	See reference	Hospital survival, survival with good neurologic outcome	See reference	None
Theeuwes et al[66]	1	Heartmate 3	1.5 years	Unknown	ROSC obtained	2+ hours	None
Doita et al[39]	1	Heartware HVAD	1 year	Thrombosis	Expired in hospital after identification of hypoxemic ischemic encephalopathy	Not reported	None
Barssoum et al[40]	578	Unknown	Non-index admission	See reference	Hospital mortality	See reference	None
Esangbedo et al[42]	4	**Patient 1** Heartmate-3; **Patient 2** Jarvik 2015 LVAD & PediMag RVAD; **Patient 3** HeartMate 3; **Patient 4** Heartware HVAD	**Patient 1** 10 days; **Patient 2** 6 days; **Patient 3** 9 days; **Patient 4** 14-days	**Patient 1** cardiac tamponade; **Patient 2** accidental disconnection; **Patient 3** hemorrhage; **Patient 4** cardiac tamponade	**Patient 1** hypoxemic ischemic encephalopathy and death; **Patient 2** good neurologic outcome and transplantation; **Patient 3** good neurologic outcome; **Patient 4** good neurologic outcome	**Patient 1** 15 minutes; **Patient 2** 4 minutes; **Patient 3** 2 minutes; **Patient 4** 2 minutes	None
Iwashita et al[45]	1	Heartmate 2	2 years	Battery depletion	Hypoxemic ischemic encephalopathy and death	120 minutes	None
Saito et al[47]	1	Jarvik 2000	401 days	Unknown	Good neurologic	Not reported	None

		LVAD			outcome and transplantation		
Ornato et al[50]	1	Not reported	Not reported	Not reported	Return of spontaneous circulation	Not reported	None
Yuzefpolskaya et al[52]	1	Heartmate 2	8 days	Unknown	Hypoxemic ischemic encephalopathy and death	30 minutes	None
Shinar et al[57]	8	See reference					None
Cubillo et al[58]	1	HeartWare LVAD	1.5 years	Driveline transection	Hypoxemic ischemic encephalopathy and death	Not reported	None
Garg et al[59]	9	See reference					None
Retherford et al[67]	1	Heartmate 2	3 years	Fractured driveline	Good neurologic outcome	30 minutes	None

Mechanical Support for Cardiogenic Shock After Cardiac Arrest: supplementary data tables

Table S9: Evidence Summary for Use of Mechanical Circulatory Support in Post-Cardiac Arrest Patients

Outcomes (importance)	Participants (studies)	Certainty of the evidence (GRADE)	Effect Estimate (95% CI)	Anticipated absolute effect	
				Risk with MCS	95% CI
Survival at 30 days / hospital discharge (critical)	13 RCTs (n=1842)	low	OR 1.16 (0.97-1.40)	37 more per 1000	8 fewer to 82 more
Cardiac Arrest Subgroup	6 RCTs[68-73] (n=766)	low	OR 0.97 (0.73,1.30)	8 fewer per 1000	78 fewer to 64 more
Survival at 6 or 12 months (critical)	10 RCTs [68-71,73-78](n=1733)	low	OR 1.18 (0.95,1.46)	41 more per 1000	13 fewer to 94 more
	10 RCTs[69-71,73,75-80] (n=757)	low	OR 1.21 (0.87,1.68)	48 more per 1000	34 fewer to 129 more
Subgroup microaxial flow pump	1 RCT[73]	low	OR 1.67 (1.10,2.54)		
Cardiac Arrest Subgroup (IPMA)	9 RCTs[80]	low	OR 1.16 (0.83,1.63)		
Cardiac Arrest Subgroup with STEMI or Resuscitation <10 minutes			OR 1.56 (1.13,2.16)		

Survival at longest available follow-up time	14 RCTs[68-79,81,82] (n=1875)	low	OR 1.17 (0.97,1.42)	39 more per 1000	7 fewer to 87 more
Cardiac Arrest Subgroup	11 RCTs[69-73,75-79] (n=816)	low	OR 1.21 (0.91,1.60)	41 more per 1000	13 fewer to 94 more
In-hospital cardiac arrest	1 RCT [72](n=66)	low	OR 0.87 (0.31,2.44)		
Microaxial flow pump	1 RCT[73]	low	OR 1.67 (1.10,2.54)		
IPMA	9 RCTs[80]	low	OR 1.16 (0.83,1.63)		
Subgroup with STEMI or Resuscitation <10 minutes			OR 1.56 (1.13,2.16)		
Favorable Neurological Outcome at Hospital Discharge / 30 Days (Critical)	3 RCTs [68,76,78](n=560)	low	OR 0.85 (0.60,1.21)	37 fewer per 1000	109 fewer to 45 more
Favorable Neurological Outcome at 6 months / 1 year (Critical)	2 RCTs[68,78] (n=534)	low	OR 1.09 (0.77,1.54)	21 more per 1000	60 fewer to 106 more
Favorable Neurological Outcome at Longest Available Follow-up (Critical)	3 RCTs [68,76,78](n=560)	low	OR 1.11 (0.79,1.57)	25 more per 1000	54 fewer to 111 more
Moderate or severe bleeding at 30 days (important)	12 RCTs [68-71,73-79,81](n=1738)	low	OR 2.43 (1.47,4.02)	164 more per 1000	62 more to 284 more
Stroke at 30 days (important)	8 RCTs [68-70,73,74,77,78](n=1626)	low	OR 1.27 (0.66,2.45)	6 more per 1000	7 fewer to 30 more
Hemolysis at 30 days (important)	3 RCTs (n=403)	low	OR 5.40 (0.63,46.0)	39 more per 1000	3 fewer to 93 more
Peripheral Ischemic Vascular Complications at 30 days (important)	11 RCTs [68-71,73-75,77-79,81](n=1710)	low	OR 2.57 (1.60,4.11)	41 more per 1000	16 more to 79 more
Sepsis at 30 days (important)	8 RCTs[68,69,73,77-79,81] (n=1565)	low	OR 1.13 (0.71,1.79)	17 more per 1000	40 fewer to 93 more
Renal replacement therapy at 30 days (important)	8 RCTs [68,69,73,7] (n=1592)	low	OR 1.24 (0.80,1.92)	34 more per 1000	31 fewer to 118 more

Length of stay in ICU (important)	4 RCTs [68-70,73](n=811)	low	Mean Difference 1.5 days (-0.3,3.2)	1.5 days longer	6.6 shorter to 9.8 longer
Length of stay in hospital (important)	4 RCTs [68,70,72,73](n=811)	low	Mean difference 2.4 days (-0.3,4.9)	2.4 days longer	0.28 shorter to 4.98 longer
In-hospital cardiac arrest due to acute coronary syndrome	1 RCT [72](n=60)	low	14 days (IQR 2,45) MCS group vs. 14 days (IQR 5,29) in standard care P=0.73		
Quality of life at 1-year (important)	3 RCTs[68,83] [77](n=1052)	low	No difference		

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