Interventional procedure overview of VA ECMO for postcardiotomy cardiogenic shock in adults

Contents

Table 1 Abbreviations

Abbreviation	Definition
AHF	Acute heart failure
AMI	Acute myocardial infarction
ARDS	Acute respiratory distress syndrome
CABG	Coronary artery bypass grafting
CI	Confidence interval
CPB	Cardiopulmonary bypass
CPR	Cardiopulmonary resuscitation
ECMO	Extracorporeal membrane oxygenation
ECLS	Extracorporeal life support
ECPR	Extracorporeal cardiopulmonary resuscitation
ELSO	Extracorporeal life support organisation
GI	Gastrointestinal
HTx	Heart transplant
IABP	Intra-aortic balloon pump
ICU	Intensive care unit
IQR	Interquartile range
OPCABG	Off-pump coronary artery bypass grafting
OR	Odds ratio
PCI	Percutaneous coronary intervention
PCS	Postcardiotomy cardiogenic shock
PE	Pulmonary embolism
PELS	Postcardiotomy extracorporeal life support
PGF/PGD	Primary graft failure/dysfunction (following heart transplantation)
PSM	Propensity score matched
RR	Relative risk
RRT	Renal replacement therapy
RV	Right ventricle
SD	Standard deviation
VA ECMO	Venoarterial extracorporeal membrane oxygenation
VAD	Ventricular assist device

The condition, current treatments, unmet need and procedure

Information about the procedure, condition, current practice and unmet need is available in sections 2 and 3 of NICE's interventional procedures guidance on VA ECMO for postcardiotomy cardiogenic shock in adults.

Outcome measures

The main outcomes included survival or mortality.

Evidence summary

Population and studies description

This interventional procedure overview is focused on VA ECMO in postcardiotomy cardiogenic shock. Two additional overviews have been developed focusing on VA ECMO use in severe acute heart failure and as extracorporeal cardiopulmonary resuscitation. Some of the evidence includes a mix of indications and has been presented in more than one overview.

This interventional procedures overview is based on approximately 49,500 people from 4 systematic reviews (Biancari 2018, Wang 2018, Kowalewski 2020, Alba 2021), 3 retrospective registry studies (4 publications; Kowalewski 2021, Loungani 2021, Biancari 2020, 2021), 1 multicentre retrospective study (Mariani 2023) and 4 single-centre retrospective studies (Chen 2017, Danial 2023, Aboud 2024, Rubino 2017). There were 29 overlaps accounting for 3,830 people in primary studies included across 4 systematic reviews (Biancari 2018, Wang 2018, Kowalewski 2020, Alba 2021). A UK study (Rubino 2017) was included in the systematic review by Kowalewski (2020). This is a rapid review of the literature, and a flow chart of the complete selection process is shown in figure 1. This overview presents 12 studies (13 publications) as the key evidence in table 2 and table 3, and lists 56 other relevant studies in table 5.

The 4 systematic reviews of observational studies included in the key evidence included studies from Asia, Australia, Europe, North America and South America (Wang 2018, Alba 2021), however 2 systematic reviews did not report study location (Biancari 2018, Kowalewski 2020). Three registry studies in the key evidence were done from the Extracorporeal Life Support Organisation (ELSO) which collates data worldwide (Kowalewski 2021), from the RESCUE registry collating data from 3 centres across the US (Loungani 2021), and from the postcardiotomy extracorporeal membrane oxygenation (PC-ECMO) registry gathering data from Asia and Europe (Biancari 2020, 2021). The included propensity matched retrospective study was done at a single centre in Taiwan (Chen 2017), and the 3 other single-centre studies included were done in Germany, France and the UK (Aboud 2024, Danial 2023, Rubino 2017). A multicentre retrospective study from Europe and Asia (Mariani 2023) was also included.

All key evidence studies included people who needed VA ECMO after cardiac surgery. Two systematic reviews (Wang 2018, Kowalewski 2020), 3 studies (Kowalewski 2021, Aboud 2024, Biancari 2021) specifically reported on people with postcardiotomy cardiogenic shock (PCS). One systematic review (Alba 2021), and 1 single-centre retrospective study (Danial 2023) included people with cardiogenic shock of multiple aetiologies, and 1 registry study included people who had VA ECMO for several aetiologies (Loungani 2021).

The systematic review by Biancari et al. (2018) included 31 observational studies reporting on 2,986 adults needing VA ECMO after cardiac surgery. Most primary studies included in this study had populations with a mix of cardiac surgery procedures (29 studies) and 2 studies included isolated coronary surgery patients. The mean age was 58 years and 31% of the population were female. Meta-analyses of the studies pooled survival outcomes from studies with follow-ups of 30 days and hospital discharge.

The systematic review by Wang et al. (2018) included 20 observational studies reporting on 2,877 people with postcardiotomy cardiogenic shock who had ECMO treatment. Risk of bias across studies included in the review was considered high as all studies were retrospective in nature. The baseline characteristics (age and percentage male) of the people in the included studies was not reported. Meta-analyses of the studies reported pooled survival outcomes at hospital discharge, at 1-year, and midterm survival (defined as 3 to 5 years).

The systematic review by Kowalewski et al. (2020) included 54 observational studies reporting on 4,421 people with postcardiotomy refractory cardiogenic shock. It included people who had CABG, valvular surgery and combined surgery at specialist heart transplant and non-heart transplant centres. Studies were considered to have a moderate to severe risk of bias. The age of people included in the studies ranged from 41 to 77 years, and 49% to 93% of the population were female. Meta-analyses of the studies pooled survival outcomes from studies with a follow-up period until hospital discharge.

The systematic review by Alba et al. (2021) included 306 observational studies reporting on 29,289 people with cardiogenic shock of any aetiology. This included 8,231 people with postcardiotomy cardiogenic shock. Risk of bias across studies was considered low in 219 (72%), moderate in 81 (26%), and high in 6 (2%) studies. The age of people included in the studies ranged from 47 to 61 years, and 22% to 59% of the population were female. Meta-analyses of the studies pooled short-term outcomes from studies with follow-ups of 30 days and hospital discharge.

The single-centre retrospective study by Chen et al. (2017) was the only comparative study included in the key evidence. It used propensity score matching to compare outcomes between people admitted for cardiac surgery (CABG or valve surgery) who had PCS and ECMO (n=1,137) and those who did

not have PCS (or ECMO) after cardiac surgery (n=5,685). The mean age was 64 years and 71% of the population were male. Outcomes were reported for a follow-up period until hospital discharge and up to 10 years.

The retrospective ELSO registry study by Kowalewski et al. (2021) reported efficacy and safety outcomes for 7,185 adults having VA ECMO for intra-operative failure to wean from CPB because of right, left or biventricular failure, and post-operative refractory cardiogenic shock or cardiac arrest during the hospitalisation after the surgical procedure. This included people whose primary procedure was CABG, valvular surgery, heart transplant and combined surgery. The mean age was 56 years and 68% of the population were male. Outcomes were reported for a follow-up period until hospital discharge.

The retrospective RESCUE registry study by Loungani et al. (2021) reported efficacy and safety outcomes for 723 adults treated with VA ECMO, including those with persistent circulatory failure postcardiotomy (31%). The mean age was 57 years and 70% of the population were male. Outcomes were reported for a follow-up period until hospital discharge.

The single-centre retrospective study done in France by Danial et al. (2023) included 1,253 adults treated with peripheral VA ECMO for cardiogenic shock, 297 of which were postcardiotomy patients (excluding primary graft dysfunction [PGF] after heart transplant). The mean age was 55 years and 30% of the population were female. Outcomes were reported for a follow-up period until hospital discharge and 5 years.

The single-centre retrospective study done in Germany by Aboud (2024) included 576 people having ECMO for PCS. The mean age was 65 years and 37% of the population were female. Outcomes included both short-term and long-term (up to 15 years) results. The retrospective international multicentre observation PELS-1 study by Mariani (2023) included 2,058 people having postcardiotomy VA ECMO.

The median age was 65 years, with women accounting for 41% of the population. The median follow up was 2.5 years.

The multicentre (19 centres) retrospective registry study by Biancari (2020) included 781 people having postcardiotomy VA ECMO for refractory cardiopulmonary failure. The mean age was 63 years and 32% of the population were female. Of the 19 centres, 17 agreed to collect data on late all-cause mortality. So, 665 people having VA ECMO for PCS were included in the Biancari (2021) study which reported 5-year survival.

The single-centre retrospective cohort study by Rubino (2017) included 101 people having central VA ECMO after cardiac surgery. The mean age was 57 years, with female accounting for 37% of the population.

Table 2 presents the study details.

Figure 1 Flow chart of study selection

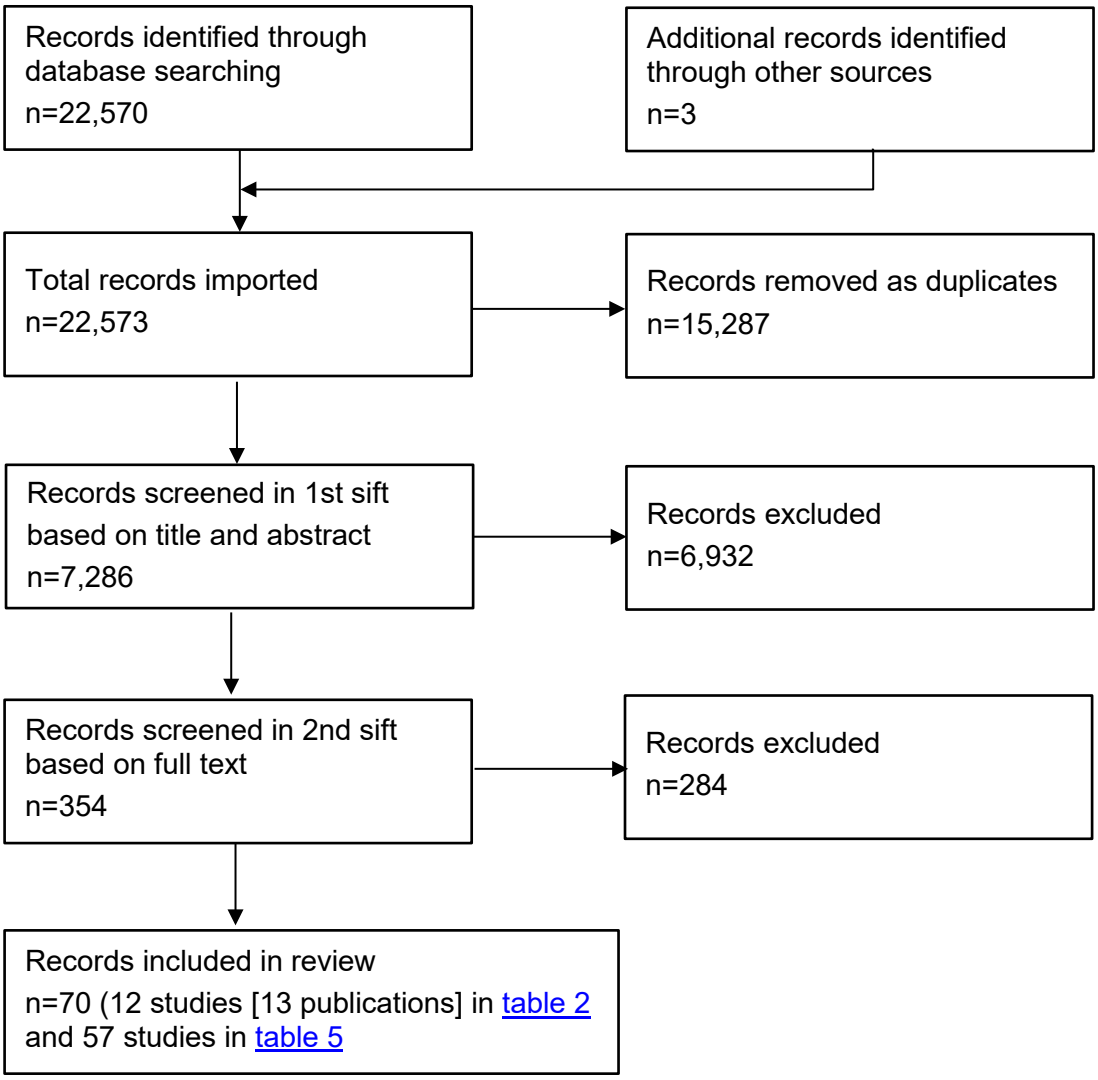

Table 2 Study details

Study no.	First author, date country	Characteristics of people in the study (as reported by the study)	Study design	Inclusion criteria	Intervention	Follow up
1	Biancari, 2018 Countries not reported	**n=2,986** Mean age=58.1 years Female= 30.9% Procedure types prior to ECMO: • Isolated coronary surgery (2 studies) • Mixed cardiac surgery procedures (29 studies) • Proportion of HTx patients in included studies: 4.4% (28 studies, n=2,879)	Systematic review and meta-analysis of 31 studies. Search date: Sept 2016	Adults who required VA ECMO after cardiac surgery procedure.	VA ECMO	1 year
2	Wang 2018, USA, Taiwan, Germany, Italy, China	**n=2,877** Mean age not reported Male % not reported Procedure types prior to ECMO: • CABG: 18 studies • Valve procedure: 14 studies • Aortic surgery: 6 studies • Heart transplant: 5 studies	Systematic review and meta-analysis of 20 retrospective studies.	People after cardiac surgery with postcardiotomy cardiogenic shock (PCS).	VA ECMO	In-hospital, 1 year

Study no.	First author, date country	Characteristics of people in the study (as reported by the study)	Study design	Inclusion criteria	Intervention	Follow up
		• Other: 9 studies				
3	Kowalewski 2020 Countries not reported	**n=4,421** Age (years): Range 41 to 77 Male %: Range 49 to 93 <u>Procedure types prior to ECMO:</u> • CABG • Valvular surgery • Combined surgeries	Systematic review and meta-analysis of 54 retrospective studies. Search date: March 2018	Postcardiotomy refractory cardiogenic shock	VA ECMO	In-hospital
4	Alba, 2021 Europe, Asia, North America, South America, Australia	**n=29,289** Age (years): Range 47 to 61 Female %: Range 22 to 59 <u>Indication</u> • ECPR: 7,814 (113 cohorts) • Post-AMI: 7,774 (80 cohorts) • **<u>Postcardiotomy: 8,231 (64 cohorts)</u>** • Post-HTx: 771 (25 cohorts) • Heart failure: 3,567 (33 cohorts)	Systematic review and meta-analysis of 306 observational studies. Search date: June 2019	Adults (aged 18 and over) with **cardiogenic shock of any aetiology**, with VA ECMO implantation.	VA ECMO Concomitant IABP: Range 20 to 67%	30 day or in-hospital

Study no.	First author, date country	Characteristics of people in the study (as reported by the study)	Study design	Inclusion criteria	Intervention	Follow up
		• Myocarditis: 906 (13 cohorts) Pulmonary embolism: 221 (10 cohorts)				
5	Chen, 2017 Taiwan	**n=1,137 ECMO** (5,685 propensity matched cohort) Mean age (years)=63.8 (SD 13.2) Male=71.2% <u>Procedure types prior to ECMO:</u> • CABG alone: 63.9% (728) • Valve alone: 24.2% (275) • CABG + Valve: 11.8% (134)	Propensity score-matched retrospective single centre study.	Adults (aged over 18 years) admitted for cardiac surgery (CABG or valve surgery)	Intervention: VA ECMO (people with PCS) Comparator: No VA ECMO (people without PCS) (propensity score matched)	In-hospital, 10 years
6	Kowalewski, 2021 Worldwide	**n=7,185** Mean age (years)=56.3 (range 18 to 86) Male=67.5% Procedure types prior to ECMO:	Retrospective ELSO Registry study Search date: 2010 to 2018	Adults over 18 years old undergoing a single run VA ECMO for refractory PCS.	VA ECMO initiated for intra-operative failure to wean from CPB due to right, left or biventricular failure, and post-operative refractory	In-hospital

Study no.	First author, date country	Characteristics of people in the study (as reported by the study)	Study design	Inclusion criteria	Intervention	Follow up
		• CABG: 26.8% • Valvular surgery: 25.6% • Heart transplant: 20.7% • CABG with valve: 13.4% • CABG with VAD: 8.5%		People with pre-operative ECMO were excluded.	cardiogenic shock or cardiac arrest during the hospitalisation after the surgical procedure.	
7	Loungani, 2021 US	**n=723** Median age (years)=57 Male=69.6% <u>Indication</u> • Postcardiotomy (30.7%) • Cardiomyopathy (26.1%) • MI (16.9%) • Non-cardiogenic shock (11.3%) • HTx/graft dysfunction (8.2%) • Other cardiogenic shock (6.8%)	Retrospective RESCUE Registry study Search date: 2007 to 2017	Adult patients (over 18 years old) treated with ECMO.	VA ECMO	In-hospital
8	Danial, 2023 France	**n=1,253** (n=297 postcardiotomy excluding PGF)	Single centre retrospective study Search date: 2015 to 2018	Adult patients (over 18 years old) treated with peripheral VA ECMO for	VA ECMO	In-hospital, 5 year

Study no.	First author, date country	Characteristics of people in the study (as reported by the study)	Study design	Inclusion criteria	Intervention	Follow up
		Mean age (years)=54.8 (SD:14.9) Female=30% Indication • **Postcardiotomy excluding PGF (n=297)** • PGF (n=245) • AMI (n=233) • Cardiomyopathy (n=171) • Fulminant myocarditis (n=47) • Massive PE (n=41) • Sepsis induced cardiogenic shock (n=29) • Refractory vasoplegia shock (n=9) • Drug overdose (n=25) • Arrhythmic storm (n=30) • Other/unknown aetiology (n=126)		cardiogenic shock.		
9	Aboud A, 2024 Germany	**n=576** Mean age=65 years	Retrospective single-centre cohort study	All people who had ECLS for PCS were included. All types of cardiac	Postcardiotomy ECLS	Up to 15 years

Study no.	First author, date country	Characteristics of people in the study (as reported by the study)	Study design	Inclusion criteria	Intervention	Follow up
		Female gender=37.3% Mean EuroSCORE 2=14.4% 21.7% had isolated coronary bypass, 16.5% single valve surgery, 34.3% combined cardiac surgery and 13.2% had heart transplantation.	Procedures were done between 2008 and 2017	operations were included, except people who had primary surgery for left ventricular assist device implantation.	The median duration on ECLS was 7.4 days. A peripheral ECLS implantation was done in 350 cases (61%). In 36 people (6%), an IABP was implanted before surgery.	98.6% completeness of follow-up.
10	Mariani S, 2023 Austria, Australia, Belgium, Chile, China, Colombia, Czech Republic, France, Germany, Italy, Lithuania, Singapore, South Korea, Thailand, The	**n=2,058** Median age=65.0 years Women=41% Race or ethnicity • Asian=8.8% • Black=0.8% • Hispanic=4.1% • White=77.1% • Other or unknown=9.2% Median EuroSCORE2=7.53 (IQR 3 to 18.5)	Retrospective international multicentre observational PELS-1 (Postcardiotomy Extracorporeal Life Support) study 2000 to 2020	Adults (aged 18 years and over) were included if they had postcardiotomy ECMO between January 2000 and December 2020. Inclusion criteria required cardiac surgery before ECMO (including VA ECMO and veno-venous ECMO). Exclusion criteria comprised	Postcardiotomy VA ECMO (An additional 33 people had venovenous ECMO and were excluded from the analysis) Median ECMO duration was 118 hours (IQR 60 to 192). Cardiogenic shock was reported as the indication for	Median 2.5 years (in hospital survivors)

Study no.	First author, date country	Characteristics of people in the study (as reported by the study)	Study design	Inclusion criteria	Intervention	Follow up
	Netherlands, US			ECMO support after discharge or before surgery, ECMO support after noncardiac surgical procedures, and ECMO implantation not strictly related to cardiac surgery hospitalisation.	ECMO in 25% (n=506) of people, and failure to wean was the indication in 39% (n=788). Other indications included acute pulmonary embolism, arrhythmia, cardiac arrest, pulmonary haemorrhage, right ventricular failure, respiratory failure and biventricular failure.	
11	Biancari F, 2020 Belgium, Czech Republic, Finland, France, Italy, Germany, Saudi Arabia, Sweden, and UK	**n=781** Mean age=63.1 years Female gender=31.9% Complex cardiac surgery=40% (surgery on more than 1 heart valve, aortic surgery, repair of ventricular wall or septal defect, and	Retrospective multicentre cohort study (postcardiotomy extracorporeal membrane oxygenation [PC-ECMO] registry) January 2010 to March 2018	Aged more than 18 years, VA ECMO needed for refractory cardiopulmonary failure occurring during the index hospitalisation after any surgical procedures on the heart valves, coronary arteries,	Postcardiotomy VA ECMO Mean VA ECMO duration=6.9 days • Inserted at primary surgery=60.7% • After weaning attempt with inotropes	Mean or median follow-up not reported

Study no.	First author, date country	Characteristics of people in the study (as reported by the study)	Study design	Inclusion criteria	Intervention	Follow up
		repair of complex congenital defects) Coronary artery bypass graft=50%	All participating centres were tertiary referral hospitals. 9 centres treated more than 30 people, and 6 centres treated more than 50 with postcardiotomy VA ECMO.	ascending aorta, aortic arch or ventricular wall and septum, grown-up congenital heart diseases, and chronic thromboembolic pulmonary hypertension were considered for this analysis. Cardiopulmonary failure in these people was considered not treatable with inotropes and intra-aortic balloon pump. Exclusion criteria: people who were on any ECMO before cardiac surgery or who needed VA ECMO after implantation of a ventricular assist	only=45.3% • After weaning attempt with intra-aortic balloon pump=15.2% • After weaning attempt with Impella=0.1% Arterial cannulation site • Ascending aorta=31.4% • Femoral artery=59.8% Other peripheral artery=8.8%	

Study no.	First author, date country	Characteristics of people in the study (as reported by the study)	Study design	Inclusion criteria	Intervention	Follow up
				device (VAD) or heart transplantation.		
	Biancari F, 2021 Belgium, Czech Republic, Finland, France, Germany, Italy, Saudi Araba, Sweden, and the UK	**n=665** Mean age=62.5 years Female=32.6%	Retrospective multicentre cohort study (postcardiotomy extracorporeal membrane oxygenation [PC-ECMO] registry) January 2010 to March 2018 17 of the 19 participating centres agreed to collect data on late all-cause mortality.	People with PCS following cardiac surgery. Additional detailed information in Biancari (2020)	Please see Biancari (2020)	Mean follow-up of overall cohort=1.7 years (median, 0.04 years, IQR 0.1 to 3.2). Mean follow-up of post-discharge patients=4.6 years (median, 4.4 years, IQR 2.9 to 6.5).
12	Rubino A, 2017 UK	**n=101** Mean age=57.1 years	Single-centre retrospective cohort study	All consecutive patients who had been supported with central VA	Central VA ECMO Median duration of	Mean or median follow-up not

Study no.	First author, date country	Characteristics of people in the study (as reported by the study)	Study design	Inclusion criteria	Intervention	Follow up
		Female=36.6% Surgical groups: • Pulmonary thromboendarterectomy, n=29 • Transplant, n=22 • CABG and valvular, n=16 • CABG and other, n=13 • Valvular, n=12 Other, n=9	Tertiary centre March 2008 to July 2016	ECMO after cardiac surgery.	ECMO=5 days ECMO was started at the end of surgery in 63 people (62.4%), postoperatively to within 24 hours of surgery for 14 (13.9%), between the first and fourth postoperative days for 18 (17.8%), and after the fourth postoperative day for 6 (5.9%).	reported.

Table 3 Study outcomes

First author, date	Efficacy outcomes	Safety outcomes
Biancari, 2018	**Pooled hospital survival** Meta-analysis random effects model, 31 studies (n=2,986) • 36.1% (95% CI 31.5 to 40.8), I^2=84% **Pooled 1-year survival (Kaplan-Meier estimate)**	**Pooled rate of reoperation for bleeding** Meta-analysis random effects model, 18 studies (n=1,779) • 42.9% (95% CI 34.2 to 51.5), I^2=93% **Pooled rate of major neurological events**

First author, date	Efficacy outcomes	Safety outcomes
	Meta-analysis random effects model, 11 studies (n=1,290) • 30.9% (95% CI 24.3 to 37.5), I^2=82% **Pooled weaning from VA ECMO** Meta-analysis random effects model, 24 studies (n=2,049) • 59.5% (95% CI 54.6 to 64.3), I^2=77% **Pooled rate of post-ECMO HTx** Meta-analysis random effects model, 21 studies (n=1,685) • 1.9% (95% CI 1.0 to 2.8), I^2=50% **Pooled hospital survival of post-ECMO HTx recipients** Meta-analysis random effects model, 7 studies (n=18) • 66.2% (95% CI 48.2 to 84.1), I^2=0% **Pooled rate of post-ECMO VAD implantation** Meta-analysis random effects model, 21 studies (n=1,685) • 2.3% (95% CI 1.3 to 3.4), I^2=57% **Pooled hospital survival of post-ECMO VAD recipients** Meta-analysis random effects model, 9 studies (n=45)	Meta-analysis random effects model, 16 studies (n=1,736) • 11.3% (95% CI 7.8 to 14.8), I^2=79% **Pooled rate of limb ischaemia** Meta-analysis random effects model, 16 studies (n=1,909) • 10.8% (95% CI 8.0 to 13.5), I^2=70% **Pooled rate of lower limb amputation** Meta-analysis random effects model, 5 studies (n=330) • 1.1% (95% CI 0.0 to 2.3), I^2=0% **Pooled rate of deep sternal wound infection/mediastinitis** Meta-analysis random effects model, 4 studies (n=490) • 14.7% (95% CI 4.0 to 25.4), I^2=92% **Pooled rate of renal replacement therapy** Meta-analysis random effects model, 19 studies (n=1,979) • 47.1% (95% CI 38.9 to 55.2), I^2=92%

First author, date	Efficacy outcomes	Safety outcomes
	• 45.6% (95% CI 28.0 to 63.1), I^2=43%	
Wang 2018	**Pooled survival to hospital discharge** Meta-analysis random effects model, 20 studies (n=2,877) • 34% (95% CI 30 to 38), I^2=71.8% **Pooled 1-year survival rate** Meta-analysis random effects model, 6 studies (n=1,860) • 24% (95% CI 19 to 30), I^2=75.6% **Pooled midterm survival rate (3- to 5-year)** Meta-analysis random effects model, 4 studies (n=742) • 18% (95% CI 11 to 27), I^2=77.3%	**Pooled rate of leg ischaemia** Meta-analysis random effects model, 11 studies (n=945) • 14% (95% CI 10 to 20), I^2=74.8% **Pooled rate of reoperation for bleeding** Meta-analysis random effects model, 10 studies (n=1,268) • 50% (95% CI 32 to 68), I^2=96.6% **Pooled rate of renal failure** Meta-analysis random effects model, 12 studies (n=1,279) • 57% (95% CI 47 to 66), I^2=87.1% **Pooled rate of neurological complications** Meta-analysis random effects model, 12 studies (n=1,341) • 16% (95% CI 13 to 20), I^2=60.5% **Pooled rate of systemic infection** Meta-analysis random effects model, 9 studies (n=598) • 31% (95% CI 22 to 41), I^2=78.9%

First author, date	Efficacy outcomes	Safety outcomes
Kowalewski 2020	**Pooled survival to hospital discharge** Meta-analysis random effects model, 53 studies (n=4,367) • 35.3% (95% CI 32.5 to 38.2) **Pooled rate of bridge to HTx** • 3.5% (95% CI 1.8 to 6.6) **Pooled rate of bridge to short or long term VAD** • 4.3% (95% CI 2.8 to 6.5) **Successful weaning from ECMO** • 55.3% (95% CI 31.4 to 100%)	**Pooled limb complications** Meta-analysis random effects model, 30 studies (n=2,766) • 13.0% (95% CI 32.5 to 38.2) **Pooled rate of reoperations for bleeding** Meta-analysis random effects model, 33 studies (n=2,832) • 41.2% (95% CI 35.6 to 47.1) **Pooled neurological complications** Meta-analysis random effects model, 33 studies (n=2,730) • 14.1% (95% CI 11.8 to 16.8) • Included 7.9% brain deaths: n=88 **Pooled rate of sepsis** Meta-analysis random effects model, 29 studies (n=1,860) • 20.7% (95% CI 17.0 to 24.9) **Pooled rate of acute kidney injury** Meta-analysis random effects model, 34 studies (n=3,199) • 47.3% (95% CI 41.5 to 53.1)

First author, date	Efficacy outcomes	Safety outcomes
Alba, 2021	**Pooled short-term mortality (30 day and in-hospital)** • Overall: 61% (95% CI 59 to 63) 306 studies n=29,289 • ECPR OHCA: 76% (95% CI 69 to 82), I^2=94%, 41 studies n=2,974 • ECPR IHCA: 64% (95% CI 59 to 69), I^2=81%, 46 studies n=2,987 • Post AMI: 60% (95% CI 59 to 64), I I^2=87%, 80 studies n=7,774 • **Postcardiotomy: 59% (95% CI 56 to 63**), I^2=**87%, 64 studies n=8,231** • AHF: 53% (95% CI 46 to 59), I^2=89%, 33 studies n=3,567 • Post-HTx: 35% (95% CI 29 to 42), I^2=64%, 25 studies n=771 • Myocarditis: 40% (95% CI 33 to 46), I^2=65%, 13 studies n=906 • PE: 52% (95% CI 38 to 66), I^2=75%, 10 studies n=221 **Probability of HTx** Meta-analysis • Post AMI: 2.8%, 95% CI 0.8 to 5.5, 19 studies • **Postcardiotomy: 0.4%, 95% CI 0.0 to 1.1, 34 studies** • Post-HTx: 0.0%, 95% CI 0.0 to 0.5, 5 studies	**No safety outcomes were reported**

First author, date	Efficacy outcomes	Safety outcomes
	• AHF: 13.1%, 95% CI 5.5 to 23.7, 16 studies • Myocarditis: 4.5%, 95% CI 0.3 to 11.7, 5 studies • PE: 0.0%, 95% CI 0.0 to 22.8, 1 study **Probability of VAD** Meta-analysis • Post AMI: 9.0%, 95% CI 4.2 to 15.1, 22 studies • **Postcardiotomy: 0.8%, 95% CI 0.2 to 1.8, 35 studies** • Post-HTx: 2.4%, 95% CI 0.0 to 6.8, 5 studies • AHF: 29.0%, 95% CI 17.3 to 42.1, 17 studies • Myocarditis: 2.3%, 95% CI 0.2 to 5.6, 5 studies • PE: 0.0%, 95% CI 0.0 to 22.8, 1 study	
Chen, 2017	**In-hospital mortality** • ECMO for PCS: 61.7% (701/1,137) • Non-ECMO (without PCS): 6.8% (385/5,685) OR 22.34 (95% CI 19.06 to 26.18), p<0.001 **1-year survival (Kaplan-Meier estimate)** • ECMO for PCS: 24.1% (95% CI 21.6 to 26.6) • Non-ECMO (without PCS): 83.4% (95% CI 82.4 to 84.4) Log rank test p<0.001 **5-year survival (Kaplan-Meier estimate)**	**Re-exploration for bleeding** • ECMO for PCS: 11.3% (129/1,137) • Non-ECMO (without PCS): 2.5% (141/5,685) OR 5.04 (95% CI 3.93 to 6.45), p<0.001 **Massive blood transfusion (PRBC >8 Units)** • ECMO for PCS: 79.1% (899/1,137) • Non-ECMO (without PCS): 15.3% (870/5,685) OR 21.25 (95% CI 18.09 to 24.96), p<0.001 **New onset ischaemic stroke** • ECMO for PCS: 3.2% (36/1,137)

First author, date	Efficacy outcomes	Safety outcomes
	• ECMO for PCS: 17.7% (95% CI 14.7 to 20.7) • Non-ECMO (without PCS): 66.0% (95% CI 64.3 to 67.6) **10-year survival (Kaplan-Meier estimate)** • ECMO for PCS: 9.7% (95% CI 4.0 to 15.5) • Non-ECMO (without PCS): 50.2% (95% CI 46.7 to 53.7)	• Non-ECMO (without PCS): 3.5% (201/5,685) OR 0.89 (95% CI 0.62 to 1.28), p=0.534 **New onset haemorrhagic stroke** • ECMO for PCS: 1.1% (12/1,137) • Non-ECMO (without PCS): 0.4% (23/5,685) OR 2.63 (95% CI 1.30 to 5.29), p=0.007 **Acute renal failure and need for haemodialysis** • ECMO for PCS: 32.9% (374/1,137) • Non-ECMO (without PCS): 7.4% (418/5,685) OR 6.26 (95% CI 5.34 to 7.35), p<0.001 **Postoperative infection** • ECMO for PCS: 13.2% (150/1,137) • Non-ECMO (without PCS): 4.5% (256/5,685) OR 3.23 (95% CI 2.61 to 4.00), p<0.001 **Fasciotomy or amputation** • ECMO for PCS: 2.3% (26/1,137) • Non-ECMO (without PCS): 0.8% (47/5,685) OR 2.81 (95% CI 1.73 to 4.56), p<0.001
Kowalewski 2021	**Successful weaning from ECMO** • 56.4% (4,051/7,185)	**Limb complications: 6.3% (456/7,185)** • Ischaemia 4.3% (312)

First author, date	Efficacy outcomes	Safety outcomes
	Survival to hospital discharge • Overall: 41.7% (2,997/7,185) **Mortality by primary surgery type** • CABG: 65.4% • Vascular aortic: 69.6% • Heart transplant: 46.0%	• Limb compartment syndrome 1.5% (106) • Fasciotomy 2.0% (143) • Amputation 0.6% (43) **Haematological complications: 42.5% (3,052/7,185)** • Disseminated intravascular coagulation: 2.8% (200) • Haemolysis: 4.0% (290) • Surgical site bleed: 26.4% (1,897) • Cannulation site bleed: 15.7% (1,130) • Mediastinal cannulation bleeding: 1.4% (98) • Cardiac tamponade: 7.6% (547) • GI bleeding: 4.1% (298) **Neurological complications: 9.1% (654/7,185)** • Diffuse ischaemia confirmed by US/CT/MRI: 0.1% (7) • Haemorrhage confirmed by US/CT/MRI: 1.7% (122) • Infarction confirmed by US/CT/MRI: 4.5% (326) • Intra/extra parenchymal haemorrhage confirmed by US/CT/MRI: 0.3% (19) • Intraventricular haemorrhage confirmed by US/CT/MRI: 0.1% (7) • Neurosurgical intervention performed: 0.0% (1) • Seizures confirmed by EEG: 0.4% (32) • Seizures clinically determined: 1.1% (78)

First author, date	Efficacy outcomes	Safety outcomes
		• Brain death: 2.5% (18) **Sepsis: 12.1% 871/7,185** • Culture proven infection: 10.7% (771) **Kidney failure: 48.9% 3,510/7,185** • Serum creatinine 1.5 to 3: 22.1% (1,591) • Serum creatinine >3: 10% (715) • Continuous renal replacement therapy: 36.1% (2,593) **Cardiovascular complications: 54.2% 3,894/7,185** • Cardiac arrhythmia: 15.9% (1,141) • CPR required >3 times: 2.9% (206) • Hypotension requiring vasodilators: 3.1% (222) • Inotropes on ECMO: 44.5% (3,196) **Metabolic complications: 26.9% 1,934/7,185** • Glucose <40: 1.4% (104) • Glucose >240: 10.5% (758) • Hyperbilirubinemia: 13.1% (941) • pH <7.2: 8.6% (620) • pH >7.6: 2.9% (208) **Pulmonary complications: 3.8% 271/7,185**

First author, date	Efficacy outcomes	Safety outcomes
		• Pneumothorax: 1.3% (91) • Pulmonary haemorrhage: 2.6% (187)

Loungani, 2021	**Overall survival to discharge**
	• 40% (290/723)
	  ○ Survival without need for permanent cardiac support (n=235)
	  ○ Survival with HTx (n=7)
	  ○ Survival with LVAD (n=48)
	
	Survival to discharge by aetiology
	• **Postcardiotomy: 36.0%**
	• HTx/PGD: 57.6%
	• MI: 39.3%
	• Cardiomyopathy: 40.7%
	• Other cardiogenic shock: 42.9%
	• Non-cardiogenic shock: 36.6%
		Death during ECMO or hospitalisation by aetiology
		• **Postcardiotomy: 64.0% (142)**
		• HTx/PGD: 42.4% (25)
		• MI: 60.7% (74)
		• Cardiomyopathy: 59.3% (112)
		• Other cardiogenic shock: 27.1% (28)
		• Non-cardiogenic shock: 63.4% (52)
		
		Complications on ECMO (n=723)
		• Infection: 21.3% (154)
		• Acute renal dysfunction: 35.5% (257)
		• Major bleeding: 36.1% (261)
		• Clinically significant coagulopathy: 14.2% (103)
		• Disseminated intravascular coagulopathy: 2.2 (16)
		• Deep venous thrombosis: 2.6% (19)
		• Pulmonary embolism: 0.4% (3)
		• Haemothorax:3.5% (25)
		• Pneumothorax: 3.0% (22)
		• Diffuse cerebral oedema/hypoxic encephalopathy: 3.9% (28)
		• Intracranial haemorrhage/haemorrhagic stroke: 2.4% (17)
		• Ischaemic stroke/embolisation: 2.4% (17)

First author, date	Efficacy outcomes	Safety outcomes
		• Seizures: 0.4% (3) • Limb ischaemia: 12.2% (88) • Fasciotomy: 3.5% (25) • Peripheral wound: 1.7% (12) • Hyperperfusion: 0.4% (3) • Air embolism: 0.1% (1) • Cannula dislodgement: 0.8% (6) • Oxygenator failure: 1.1% (8) • Pump malfunction: 0.8% (6) • Thrombosis: 1.1% (8) • Tubing rupture: 0.1% (1)
Danial, 2023	**In-hospital survival** • **Postcardiotomy excluding PGF: 34.6%** • PGF: 73.3% • Drug overdose: 58.6% • Cardiomyopathy: 53.2% • Arrhythmic storm: 51.6% • Massive PE: 46.8% • Sepsis induced cardiogenic shock: 44.4% • Fulminant myocarditis: 37.9% • AMI: 37.3% • Refractory vasoplegia shock: 11.1% • Other/unknown aetiology: 25.7%	**Complications (entire cohort) n=1,253** • Site infection: 19% (240) • Limb ischaemia: 9% (118) • Limb amputation: 0.9% (11) • Vascular cannulation adverse event: 3% (34) • Vascular decannulation adverse event: 9% (71) • Sensory-motor deficit: 4% (34) • General bleeding: 25% (316) • Neurological adverse event: 16% (194) • Ischaemic stroke: 7% (81) • Intracranial bleeding: 4% (53) • Brain oedema: 2% (22) • Brain death: 9% (107)

First author, date	Efficacy outcomes	Safety outcomes
	5-year survival • **Postcardiotomy excluding PGF: 33.3%** • PGF: 57.3% • Drug overdose: 54.0% • Arrhythmic storm: 50.0% • Cardiomyopathy: 45.3% • Sepsis induced cardiogenic shock: 42.4% • Massive PE: 38.3% • Fulminant myocarditis: 32.9% • AMI: 31.5% • Refractory vasoplegia shock: 0.0% • Other/unknown aetiology: 22.8%	• Renal failure requiring haemodialysis: 52% (630) • Hydrostatic pulmonary oedema: 9% (11) **Complications (postcardiotomy) n=297** • Site infection: 13% (37) • Limb ischaemia: 11% (34) • Limb amputation: 0.3% (1) • Vascular cannulation adverse event: 3% (9) • Vascular decannulation adverse event: 9% (16) • Sensory-motor deficit: 3% (5) • General bleeding: 34% (101) • Neurological adverse event: 14% (41) • Ischaemic stroke: 6% (18) • Intracranial bleeding: 4% (13) • Brain oedema: 1% (2) • Brain death: 5% (16) • Renal failure requiring haemodialysis: 58% (170) • Hydrostatic pulmonary oedema: 6% (17)
Aboud, 2024	**Reasons for ECLS termination** • Weaning=47.2% (272/576) • End of unsuccessful therapy=47.6% (274/576) • Switch to VAD=4.7% (27/576) • Heart transplant=0.5% (3/576) **In-hospital mortality=66.0% (380/576)**	**In-hospital outcomes** • Stroke=18.8% (108/576) • Re-thoracotomy for bleeding=60.2% (347/576) • Myocardial infarction=6.3% (36/576) • Laparotomy=6.8% (39/576) • Arterial vascular complication=18.6% (107/576) • Cardiac arrest=26.0% (150/576)

First author, date	Efficacy outcomes	Safety outcomes
	Actuarial cumulative overall survival • 1 year=22.3% (95% CI 19.1 to 26.1) • 2 years=20.1% (95% CI 16.9 to 23.8) • 5 years=15.7% (95% CI 12.5 to 19.8) • 10 years=11.0% (95% CI 3.6 to 18.4) People who survived the in-hospital period had a 10-year survival rate of 32.4% (95% CI 12.3 to 52.5) Exclusion of people who had a VAD (n=27) implant or a heart transplantation (n=3) resulted in 1-year, 5-year and 10-year survival rates of 21.7% (95% CI 18.2 to 24.2), 15.4% (95% CI 12.3 to 18.5%) and 10.6% (95% CI 7.9 to 13.4%), respectively. Multivariable analysis suggested that severe aortic stenosis, previous cardiac surgery and IABP support were risk factors for in-hospital mortality (OR 1.71, 95% CI 1.04 to 2.83, p=0.04; OR OR 1.62, 95% CI 1.08 to 2.42, p=0.018; OR 2.46, 95% CI 1.05 to 5.87, p=0.043, respectively). Peripheral cannulation reduced the risk of mortality both in hospital and in the long follow-up. Advanced age, insulin dependent diabetes and severe mitral regurgitation were all strong negative predictors for long-term mortality, and peripheral cannulation was protective.	• Dialysis=83.9% (483/576) • Low output syndrome=82.1% (473/576)
Mariani, 2023	**In-hospital mortality=60.5%** In-hospital survivors were discharged after a median of	**Postoperative outcomes (percentages were calculated excluding missing values)** • Postoperative bleeding=57.2% (n=1,156)

First author, date	Efficacy outcomes	Safety outcomes
	38 (IQR 26 to 60) days, whereas in-hospital death happened at a median of 11 (IQR 4 to 22) days after surgery. Independent variables associated with in-hospital mortality were age (HR 1.02, 95% CI 1.01 to 1.02) and preoperative cardiac arrest (HR 1.41, 95% CI 1.15 to 1.73). **Overall survival probabilities** • 1 year=32.4% (95% CI 30.3 to 34.6) • 2 years=30.9% (95% CI 28.8 to 33.1) • 5 years=27.8% (95% CI 25.7 to 30.1) • 10 years=19.5% (95% CI 16.7 to 22.8) **Survival in hospital survivors** • 1 year=89.5% (95% CI 87.0 to 92.0) • 2 years=85.4% (95% CI 82.5 to 88.3) • 5 years=76.4% (95% CI 72.5 to 80.5) • 10 years=65.9% (95% CI 60.3 to 72.0) Variables associated with post-discharge mortality included older age, atrial fibrillation, emergency surgery, type of surgery, postoperative acute kidney injury, and postoperative septic shock.	○ Needing re-thoracotomy=39.7% (n=765) ○ Cannulation site bleeding=12.2% (n=246) ○ Diffuse non-surgery related=25.4% (n=472) • Brain oedema=4.3% (n=84) • Cerebral haemorrhage=3.4% (n=66) ○ Minor=43.8% (n=21) ○ Disabling=31.3% (n=15) ○ Fatal=25.0% (n=12) • Seizure=2.1% (n=41) • Stroke=10.6% (n=217) ○ Minor=46.9% (n=83) ○ Disabling=32.2% (n=57) ○ Fatal=20.9% (n=37) • Arrhythmia=33% (n=624) • Cardiac arrest=16.1% (n=304) • Pacemaker implantation=3% (n=56) • Bowel ischaemia=5.7% (n=107) • Right ventricular failure=21% (n=389) • Heart transplant=7.2% (n=111) • Acute kidney injury=56.7% (n=1,069) • Pneumonia=22.2% (n=411) • Septic shock=16.8% (n=310) • Vasoplegic syndrome=9.5% (n=176) • Acute respiratory distress syndrome=5.5% (n=104) • Multiorgan failure=34.3% (n=697) • Embolism=6.1% (n=113)
Biancari, 2020	**In-hospital mortality=64.4% (503/781)** **Death on VA ECMO=46.1% (360/781)**	• **Arterial complications** ○ Aortic rupture=0.3% (2/781) ○ Type A aortic dissection=1.0% (8/781) ○ Type B aortic dissection=0.4% (3/781)

First author, date	Efficacy outcomes	Safety outcomes
	Survival at 1 year=32.8% **Survival at 5 years=28.5%** Hospital mortality after VA ECMO therapy for more than 7 days was 60.5%. 3.6% (28/781) of people had VAD insertion or heart transplantation after postcardiotomy VA ECMO, and their hospital and 1-year mortality were 42.9% and 53.6%, respectively. 14 people had heart transplantation, and their hospital and 1-year mortality after heart transplantation were 21.4% and 28.6%, respectively. Among 14 people who had insertion of a VAD without heart transplantation, hospital mortality was 64.3% and 1-year mortality was 78.6%. 28 octogenarians had hospital and on VA ECMO mortality rates of 82.1% (p=0.046) and 71.4% (p=0.009), respectively, which were statistically significantly higher than in those younger than 80. Logistic regression identified advanced age (crude rates: less than 60 years, 52.2%; 60 to 69 years, 64.4%; 70 years or above, 76.1%), female gender (crude rates: 69.5% versus 62.0%), stroke or unconsciousness immediately before surgery (crude rates: 88.9% versus 63.5%), prior cardiac surgery (crude rates: 71.5% versus 62.2%), aortic arch surgery (crude rates: 82.1% versus 63.5%), and arterial lactate level 6 mmol/l or	○ Peripheral artery dissection=1.2% (9/781) ○ Vascular perforation=0.9% (7/781) ○ Arterial thrombosis=5.5% (43/781) ○ Major lower limb amputation=1.3% (10/781) • **Tracheostomy=23.0% (180/781)** • **Pancreatitis=1.5% (12/781)** • **Liver failure=34.0% (265/781)** • **Gastrointestinal complication needing surgery=5.5% (42/781)** • **Multiorgan failure=49.9% (390/781)** • **Major neurological complications=18.9% (147/781)** ○ Stroke, non-disabling=3.6% (28/781) ○ Stroke, disabling=7.8% (61/781) ○ Global brain ischaemia=7.4% (58/781) • **Infectious complications** ○ Deep sternal wound infection or mediastinitis=3.7% (29/781) ○ Vascular access site infection=8.6% (67/781) ○ Pneumonia=36.5% (285/781) ○ Bloodstream infection=22.9% (179/781) • **Renal replacement therapy=53.4% (409/781)** • **Red blood transfusion (mean units)=23.4** • **Red blood transfusion of 10 or more units=70.1% (547/781)** • **Reoperation for intrathoracic bleeding=42.1% (328/781)** • **Reoperation for peripheral arterial bleeding=8.5% (66/781)**

First author, date	Efficacy outcomes	Safety outcomes
	greater at start of VA ECMO (crude rates: 71.6% versus 57.9%) as independent predictors of hospital death. Centres that had treated more than 50 people with postcardiotomy VA ECMO during the study period had a statistically significantly lower hospital mortality rate than those with lower volume of postcardiotomy VA ECMO (60.9% versus 70.2%, p=0.009). A postcardiotomy ECMO score was derived by assigning a weighted integer to each independent pre-VA ECMO predictor of hospital mortality as follows: female gender (1 point), advanced age (60 to 69 years, 2 points; 70 years or older, 4 points), prior cardiac surgery (1 point), arterial lactate 6.0 mmol/l or greater before VA ECMO (2 points), aortic arch surgery (4 points), and preoperative stroke or unconsciousness (5 points). **Hospital mortality rates according to the postcardiotomy ECMO score:** • 0 point=45.6% • 1 point=40.5% • 2 points=51.1% • 3 points=57.8% • 4 points=70.7% • 5 points=68.3% • 6 points=77.5% 7 points or more=89.7% (p<0.0001)	

First author, date	Efficacy outcomes	Safety outcomes
Biancari, 2021	**Survival to hospital discharge=36.1% (240/665)** **5-year survival=27.7%** **5-year survival according to postcardiotomy ECMO score:** • 0 point=50.9% • 1 point=44.9% • 2 points=40.0% • 3 points=34.7% • 4 points=21.0% • 5 points=17.6% • 6 points or more=10.7%, p<0.0001 The EuroSCORE 2 was statistically significantly higher in people who had died at 5-years (p<0.0001). Factors independently associated with 5-year mortality were advanced age, female sex, recent myocardial infarction, active endocarditis, increased pre-VA ECMO arterial lactate level, and participating centres. Kaplan-Meier estimate of 5-year survival was 12.2% in people older than 70 years and 34.4% in younger people (log-rank test, p<0.0001, adjusted HR 1.840, 95% CI 1.522 to 2.224). This difference persisted among post-discharge people (52.0% versus 83.0%, log-rank test, p<0.0001, adjusted HR 3.080, 95% CI 1.686 to 5.627).	In-hospital safety outcomes for the whole cohort are described in Biancari (2020).

First author, date	Efficacy outcomes	Safety outcomes
	In people who had implantation of a ventricular assist device or heart transplant (3.2%), the 5-year survival was 42.9% and 63.6%, respectively.	
Rubino, 2017	**Hospital survival=33.7% (34/101)** **1-year survival=27.7% (28/101)** **2-year survival=20.8% (21/101)** Regression analysis showed that an age older than 70 years was the strongest mortality predictor (OR 7.82; 95% CI 1.71 to 35.65; p=0.001). Lactate level after central VA ECMO was the strongest post- operative predictor for hospital mortality (OR 3.20; 95% CI 1.35 to 7.57; p=0.008). 63 people (62.4%) had lactate levels greater than 4 mmol/l during the first 48 hours of ECMO support, and only 23.8% (n=15) of those were discharged from the hospital; the survival rate was 50% (n=19) for those with lower lactate levels (n=38). **Successful weaning from VA ECMO support=57.4% (58/101)** 9 people (8.9%) were bridged to peripheral veno-venous ECMO, 2 (2%) were bridged to peripheral VA ECMO and 2 (2%) were converted to a temporary biventricular assist device. Six people (5.9%) on central VA ECMO support were bridged either to a heart transplantation or long-term mechanical cardiovascular support. Three patients (3%)	**Complications during ECMO support** • Bleeding=97.3% (98/101) • Lactate more than 4 millimoles/litre=62.5% (63/101) • Renal failure=64.4% (65/101) • Hepatic failure=27.7% (28/101) • Bilirubin more than 17 micromoles/litre=80.2% (81/101) • Rethoracotomy=25.7% (26/101) • Stroke=13.9% (14/101) • Tamponade=11.9% (12/101) • Limb ischaemia=5.9% (6/101) • Left ventricle or aortic valve thrombosis=4.9% (5/101) • Ventricular tachycardia or ventricular fibrillation=4.9% (5/101) • Mesenteric ischaemia=7.9% (8/101) Hepatic failure happened in 23.7% (OR 4.18; p=0.015) of hospital mortalities and renal failure was present in 49.5% of hospital mortality cases (OR 3.72; p=0.003). Mean units of red blood cells used=17.7

First author, date	Efficacy outcomes	Safety outcomes
	received a heart transplantation, and 3 (3%) had central VA ECMO converted to a long-term VAD. **Hospital survival by surgical group, OR for in-hospital mortality** • Pulmonary thromboendarterectomy=37.9% (OR 0.76, 95% CI 0.31 to 1.88, p=0.362; n=11) • Transplantation=63.6% (OR 0.19, 95% CI 0.07 to 0.52, p=0.001, n=14) • CABG and valvular=12.5% (OR 4.22, 95% CI 0.9 to 19.82, p=0.04, n=2) • CABG and other=23.1% (OR 1.81, 95% CI 0.46 to 7.07, p=0.298, n=3) • Valvular=16.7% (OR 2.81, 95% CI 0.57 to 13.61, p=0.158 • Other=22.2% (OR 1.86, 95% CI 0.26 to 9.51, p=0.360, n=2) **1-year survival by surgical group** • Pulmonary thromboendarterectomy=34.5% (10/29) • Transplantation=54.5% (12/22) • CABG and valvular=12.5% (2/16) • CABG and other=15.4% (2/13) • Valvular=8.3% (1/12) • Other=11.1% (1/9)	

Procedure technique

Of the 12 studies, none detailed the ECMO device or combination of devices used. VA ECMO was inserted during the initial cardiac surgery in the cases of circulatory instability during or immediately after weaning from CPB in 2 systematic reviews (54% Biancari 2018, 43% Kowalewski 2020). One study noted that the exact timing of ECMO implantation was unavailable, so the study authors presumed that most ECMO implantation occurred after cardiac surgery (Chen 2017). Three studies noted the location of ECMO initiation as either the operating room, intensive care unit, catheterisation laboratory, emergency department, or transferred from other institutions already on ECMO support (Kowalewski 2020, Loungani 2021, Danial 2023).

Peripheral cannulation was preferred and most common strategy for VA ECMO in the 7 studies that detailed cannulation procedure (Biancari 2018, Mariani 2023, Aboud 2024, Danial 2023, Kowalewski 2020, Kowalewski 2021, Loungani 2021). However, 39% of people included in Aboud (2024) and 46% of people included in Kowalewski (2021) were noted to be centrally cannulated. Left ventricular unloading using concomitant IABP was used in 31% (Kowalewski 2021) and 62% of people (Biancari 2018). Of the 12 studies, 7 detailed the length of time on ECMO (Kowalewski 2020, Kowalewski 2021, Loungani 2021, Aboud 2024, Biancari 2020, Mariani 2023, Rubino 2017). The median duration of ECMO ranged from 4.9 to 7.4 days, and the mean duration of ECMO was 6.6 days in Rubino (2017) and 6.9 days in Biancari (2020).

Efficacy

Survival

In-hospital survival

Of the 12 key evidence studies, 7 reported the in-hospital survival of people having ECMO postcardiotomy.

In meta-analyses from 3 systematic reviews, pooled in-hospital survival ranged from 34 to 36% (Biancari 2018, Wang 2018, Kowalewski 2020). Meta-regression analysis by Biancari (2018) showed a trend toward lower hospital survival in studies with higher mean age (p=0.064). The pooled analysis of 12 studies showed that hospital survivors (n=387) were significantly younger than people who died after VA ECMO (pooled mean age, 56 versus 64 years; mean difference, -7.223 years, 95% CI -9.777 to - 4.669, I^2=53%, p=0.015)

In the registry study of 7,185 people with refractory PCS, in-hospital survival was 42% (Kowalewski 2021). In the registry study of 723 adults treated with VA ECMO (31% postcardiotomy), the survival in the overall population was 40% and 36% in postcardiotomy patients (Loungani 2021).

In the single centre retrospective study of people treated with VA ECMO for cardiogenic shock, among those with PCS (n=297), in-hospital survival was 35% (Danial 2023). Hospital survival was 34% in the single-centre retrospective cohort study of 101 people having central VA ECMO after cardiac surgery (Rubino 2017). Regression analysis showed that an age older than 70 years was the strongest hospital mortality predictor (OR 7.82; 95% CI 1.71 to 35.65; p=0.001). Lactate level after central VA ECMO was the strongest post-operative predictor for hospital mortality (OR 3.20; 95% CI 1.35 to 7.57; p=0.008).

In the multicentre retrospective registry study of 665 people having VA ECMO for postcardiotomy cardiogenic shock, survival to hospital discharge was 36% (Biancari 2021).

1-year survival

Of the 12 key evidence studies, 7 reported the 1-year survival of people having ECMO postcardiotomy.

In the systematic review of 31 studies of people who required VA ECMO following cardiac surgery, the pooled 1-year survival in a meta-analysis was 31% (95% CI 24.3 to 37.5), I^2=82% (11 studies [n=1,290]; Biancari 2018). In the systematic review of 20 studies of people having ECMO for PCS following cardiac surgery, the pooled 1-year survival in a meta-analysis was 24% (95% CI 19 to 30), I^2=76% (6 studies [n=1,860]; Wang 2018).

In the registry study of 576 people having ECMO for PCS, the actuarial cumulative 1-year survival was 22% (95% CI 19.1 to 26.1). Exclusion of people who had a VAD implant or a heart transplantation resulted in a 1-year survival rate of 22% (95% CI 18.2 to 24.2; Aboud 2024). In the multicentre retrospective registry study of 781 people having postcardiotomy VA ECMO for refractory cardiopulmonary failure, the survival rate at 1 year was 33% (Biancari 2020).

In the retrospective international multicentre observation PELS-1 study of 2,058 people having postcardiotomy VA ECMO, the 1-year overall survival probability was 32% (95% CI 30.3 to 34.6). In the subgroup of hospital survivors, the 1-year survival rate was 90% (95% CI 87.0 to 92.0; Mariani 2023).

In the propensity score-matched study of people admitted for cardiac surgery who had VA ECMO (n=1,137), the cumulative 1-year survival using Kaplan-Meier estimate was 24% (95% CI 21.6 to 26.6) in those who had ECMO for PCS (Chen 2017).

In the single-centre retrospective cohort study of 101 people having central VA ECMO after cardiac surgery, the 1-year survival rate was 28% (Rubino 2017).

Mid-term survival

Of the 12 key evidence studies, 6 studies reported mid-term survival rates in people having ECMO postcardiotomy, with a 5-year survival available in 5 studies. .

In the systematic review of 20 studies of people with PCS following cardiac surgery, the pooled 3- to 5- year survival in a meta-analysis was 18% (95% CI 11 to 27), I^2=77% (4 studies [n=742]; Wang 2018). In the single centre retrospective study of 1,253 people treated with VA ECMO for cardiogenic shock (297 with PCS), the 5-year survival for people postcardiotomy (excluding PGF) was 33% (Danial 2023). The authors also reported that the 5-year survival rate was 57% for PGF.

In the retrospective international multicentre observation PELS-1 study of 2,058 people having postcardiotomy VA ECMO, the overall survival probability was 31% (95% CI 28.8 to 33.1) at 2 years and was 28% (95% CI 25.7 to 30.1) at 5 years (Mariani 2023). In the subgroup of hospital survivors, the 2-year survival rate was 85% (94% CI 82.5 to 88.3) and the 5-year survival rate was 76% (95% CI 72.5 to 80.5).

In the propensity score-matched study of people admitted for cardiac surgery who had VA ECMO (n=1,137), the cumulative 5-year survival using Kaplan-Meier estimate was 18% (95% CI 14.7 to 20.7) (Chen 2017). The authors note that although the risk of all-cause mortality was greater in the group receiving ECMO for PCS than in the group without PCS (non-ECMO) ($p<0.001$) in the first year of follow-up, no difference was observed after the first year of follow-up ($p=0.209$; Chen 2017).

In the registry study of 576 people having ECMO for PCS, the actuarial cumulative 2- and 5-year survival rates were 20% (95% CI 16.9 to 23.8) and 16% (95% CI 12.5 to 19.8), respectively. Exclusion of people who had a VAD implant or a heart transplantation resulted in a 5-year survival rate of 15% (95% CI 12.3 to 18.5; Aboud 2024).

In the multicentre retrospective registry study of 781 people having VA ECMO for refractory cardiopulmonary failure following cardiac surgery, the survival rate at 5 year was 29% (Biancari 2020). In the Biancari (2021) study of 665 people having VA ECMO for PCS, the 5-year survival rate was 28%. The EuroSCORE 2 was statistically significantly higher in people who had died at 5 years ($p<0.0001$). Factors independently associated with 5-year mortality were advanced age, female sex, recent myocardial infarction, active endocarditis, increased pre-VA ECMO arterial lactate level, and participating centres (Biancari 2021).

In the single-centre retrospective cohort study of 101 people having central VA ECMO after cardiac surgery, the 2-year survival rate was 21% (Rubino 2017).

Long-term survival

Of the 12 key evidence studies, 3 reported the 10-year survival of people having ECMO postcardiotomy. In the propensity score-matched study of 6,822 people admitted for cardiac surgery with (n=1,137) or without (n=5,685) VA ECMO, the cumulative 10-year survival using Kaplan-Meier estimate was 10% (95% CI 4.0 to 15.5) in those who had ECMO for PCS following cardiac surgery compared to 50% (95% CI 46.7 to 53.7) in those who did not (Chen 2017). Again, the authors note that although the risk of all-cause mortality was greater in the ECMO for PCS group than in the non-PCS group ($p<0.001$) in the first year of follow-up, no difference was observed after the first year of follow-up ($p=0.209$; Chen 2017).

In the registry study of 576 people having ECMO after cardiac surgery, the actuarial cumulative 10-year survival was 11% (95% CI 3.6 to 18.4; Aboud 2024).

People who survived the in-hospital period had a 10-year survival rate of 32% (95% CI 12.3 to 52.5). Exclusion of people who had a VAD implant or a heart transplantation resulted in a 10-year survival rate of 11% (95% CI 7.9 to 13.4).

In the retrospective international multicentre observation PELS-1 study of 2,058 people having postcardiotomy VA ECMO, the 10-year overall survival probability was 20% (95% CI 16.7 to 22.8; Mariani 2023). In the subgroup of hospital survivors, the 10-year survival rate was 66% (94% CI 60.3 to 72.0).

Successful weaning from ECMO

Of the 12 key evidence studies, 5 reported the proportion of people successfully weaned from ECMO postcardiotomy. In the systematic review of 31 studies of people who required VA ECMO following cardiac surgery, the pooled proportion successfully weaned in a meta-analysis was 60% (95% CI 54.6 to 64.3), I^2=77% (24 studies [n=2,049]; Biancari 2018). In the systematic review of 54 studies reporting on 4,421 people with refractory PCS, 55% (31 to 100%) of people were successful weaned from ECMO (Kowalewski 2020).

In the registry study of 7,185 people with refractory PCS, 56% were successfully weaned from ECMO (Kowalewski 2021). In the registry study of 576 people with PCS, the proportion of people who successfully weaned from ECMO was 47% (Aboud 2024).

In the single centre retrospective cohort study of 101 people having central VA ECMO after cardiac surgery, 57% (n=58) were successfully weaned from VA ECMO (Rubino 2017). Of the 58 people, 9 people were bridged to peripheral veno-venous ECMO, 2 were bridged to peripheral VA ECMO and 2 were converted to a temporary biventricular assist device.

Bridged to heart transplant

Of the 12 key evidence studies, 5 studies (6 publications) reported the proportion of people bridged to heart transplant following ECMO. The pooled rate of heart transplantation post-ECMO from a meta-analysis of 21 studies (n=1,685) was 2% (95% CI 1.0 to 2.8, I^2=50%) in the systematic review of people who required VA ECMO following cardiac surgery (Biancari 2018). Of these heart transplant recipients, 66% (95% CI 48.2 to 84.1, I^2=0%) survived until hospital discharge (Biancari 2018). In the systematic review of 54 studies reporting on 4,421 people with refractory PCS, the pooled rate of heart transplantation was 3.5% (95% CI 1.8 to 6.6) (Kowalewski 2020). The pooled rate of heart transplantation in those with PCS was 0.4% (95% CI 0.0 to 1.1) in a meta-analysis of 34 studies in the systematic review by Alba et al. (2021).

In the registry study of 576 people with PCS, less than 1% (n=3) of people bridged to heart transplant following ECMO (Aboud 2024). In the registry study of 781 people having postcardiotomy VA ECMO for refractory cardiopulmonary failure, 2% (n=14) of people had heart transplantation, and their hospital and 1-year mortality after heart transplantation were 21% and 29%, respectively (Biancari 2020). In the Biancari (2021) study of 665 people having VA ECMO for PCS, 2% (n=11) of people had heart transplantation.

In the single centre retrospective cohort study of 101 people having central VA ECMO after cardiac surgery, 3% (n=3) received a heart transplantation (Rubino 2017).

Bridged to long term VAD

Of the 12 key evidence studies, 5 studies (6 publications) reported the proportion of people bridged to a ventricular assist device (VAD) using ECMO. The pooled rate of VAD implantation post-ECMO from a meta-analysis of 21 studies (n=1,685) was 2% (95% CI 1.3 to 3.4, I^2=57%) in the systematic review of people

who required VA ECMO following cardiac surgery (Biancari 2018). Of these VAD recipients, 46% (95% CI 28.0 to 63.1, I^2=43%) survived until hospital discharge (Biancari 2018). In the systematic review of 54 studies reporting on 4,421 people with refractory PCS, the pooled rate of heart transplantation was 4.3% (95% CI 2.8 to 6.5) (Kowalewski 2020). The pooled rate of heart transplantation in those with PCS was 0.8% (95% CI 0.2 to 1.8) in a meta-analysis of 35 studies in the systematic review by Alba et al. (2021).

In the registry study of 576 people with PCS, 5% (27) of people switched to VAD following ECMO (Aboud 2024). In the registry study of 781 people having VA ECMO for refractory cardiopulmonary failure following cardiac surgery, 3% (n=21) of people had insertion of a VAD (Biancari 2020). Of these people, 14 people inserted a VAD without heart transplantation, and their hospital mortality was 64% and 1-year mortality was 79%. In the Biancari (2021) study of 665 people having VA ECMO for postcardiotomy cardiogenic shock, 21 people had implantation of a VAD or heart transplant, and 5-year survival was 43% of people who had a VAD device implanted.

In the single centre retrospective cohort study of 101 people having central VA ECMO after cardiac surgery, 3% (n=3) were converted to a long-term VAD (Rubino 2017).

Mortality

Of the 12 key evidence studies, 7 reported on mortality. In the registry study of 7,185 people with refractory PCS, in-hospital mortality by primary surgery type was 65% for CABG, 70% for vascular aortic surgery and 46% for heart transplant surgery (Kowalewski 2021). Older age was significantly associated with in-hospital mortality. Of the patients aged over 70 years, 70% did not survive to discharge compared to 55% those younger than 70 years (p<0.001).

In the systematic review of 306 studies of CS of any aetiology, the pooled overall short-term mortality (30-day and in-hospital) for those with PCS was 59% (95% CI 56 to 63, I^2=87%, 64 studies). Univariate meta regression analysis stratified by aetiology also showed an 8% increase in mortality per 10-year increase in cohort's age (Alba 2021).

In the registry study of 723 adults treated with VA ECMO (31% postcardiotomy), 64% postcardiotomy patients died during ECMO or hospitalisation (Loungani 2021). Multivariable regression analysis identified older age as a risk factor for mortality on ECMO (OR 1.26; 95% CI 1.12 to 1.42, p<0.001). Mortality rates while on ECMO support increased from 26% in those aged 35 to 44 years to 54% in those 75 years or older (Loungani 2021).

In the propensity score-matched study of 6,822 people admitted for cardiac surgery with (n=1,137) or without (n=5,685) VA ECMO, in-hospital mortality was 62% in those who had ECMO for PCS following cardiac surgery compared to 7% in those who did not have PCS or ECMO (OR 22.34, 95% CI 19.06 to 26.18, p<0.001; Chen 2017).

In the registry study of 576 people having ECMO for PCS, in-hospital mortality was 66% (Aboud 2024). Multivariable analysis suggested that severe aortic stenosis (OR 1.71, 95% CI 1.04 to 2.83, p=0.04), previous cardiac surgery (OR 1.62, 95% CI 1.08 to 2.42, p=0.018) and IABP support (OR 2.46, 95% CI 1.05 to 5.87, p=0.043) were risk factors for in-hospital mortality. Peripheral cannulation reduced the risk of mortality both in hospital and in the long follow up.

In the multicentre retrospective registry study of 781 people having VA ECMO for refractory cardiopulmonary failure following cardiac surgery, in-hospital mortality was 64% and mortality on VA ECMA was 46% (Biancari 2020). When the duration of VA ECMO therapy was greater than 7 days, the crude hospital mortality was 61% compared with 66% in people in whom VA ECMO lasted 7

days or less (p=0.10; Biancari 2020). Centres that had treated more than 50 people with postcardiotomy VA ECMO during the study period had a statistically significantly lower hospital mortality rate than those with lower volume of postcardiotomy VA ECMO (61% versus 70%, p=0.009). Logistic regression identified advanced age, female gender, stroke or unconsciousness immediately before surgery, prior cardiac surgery, aortic arch surgery, and arterial lactate level 6 mmol/l or greater at start of VA ECMO as independent predictors of hospital death.

In the retrospective international multicentre observation PELS-1 study of 2,058 people having postcardiotomy VA ECMO, in-hospital mortality was 61% (Mariani 2023). Independent variables associated with in-hospital mortality were age (HR 1.02, 95% CI 1.01 to 1.02) and preoperative cardiac arrest (HR 1.41, 95% CI 1.15 to 1.73). Variables associated with post-discharge mortality included older age, atrial fibrillation, emergency surgery, type of surgery, postoperative acute kidney injury, and postoperative septic shock.

Safety

Bleeding

Of the 12 key evidence studies, 10 reported bleeding adverse events or complications. In the propensity score-matched study of 6,822 people admitted for cardiac surgery with (n=1,137) or without (n=5,685) VA ECMO, re-exploration for bleeding was statistically significantly higher in those on ECMO for PCS (11.3% [129 of 1,137]) compared to those who did not have PCS or ECMO (2.5% [141 of 5,685], OR 5.04, 95% CI 3.93 to 6.45, p<0.001; Chen 2017). Massive blood transfusion (PRBC more than 8 Units) was also statistically significantly higher in those on ECMO for PCS (79% [899 of 1,137]) compared to those who did not have PCS or ECMO (15% [870 of 5,685], OR 21.25, 95% CI 18.09 to 24.96, p<0.001; Chen 2017).

In the systematic review of 31 studies of people who required VA ECMO following cardiac surgery, the pooled rate of reoperation for bleeding was 43% (95% CI 34.2 to 51.5, I^2=93%) in the meta-analysis of 18 studies (n=1,779; Biancari 2018). In the systematic review of 20 studies of people with PCS following cardiac surgery, the pooled rate of reoperation for bleeding was 50% (95% CI 32 to 68, I^2=97%, 10 studies, n=1,268; Wang 2018). The pooled rate of reoperations for bleeding was 41% (95% CI 35.6 to 47.1) in the meta-analysis of 33 studies (n=2,832) from the systematic review of people with refractory PCS (Kowalewski 2020).

In the registry study of people with refractory PCS, haematological complications were reported in 43% of people (3,052 of 7,185), including surgical site bleed 26% (1,897), cannulation site bleed 16% (1,130), mediastinal cannulation bleeding 1% (98), cardiac tamponade 8% (547), GI bleeding 4% (298), and haemolysis 4% (290) (Kowalewski 2021). In the registry study of adults treated with VA ECMO, major bleeding was reported in 36% (261 of 723), clinically significant coagulopathy in 14% (103 of 723), and disseminated intravascular coagulopathy in 2% (16 of 723) of the overall population (Loungani 2021).

In the registry study of 576 people having ECMO for PCS, the rate of re-thoracotomy for bleeding was 60% (347 of 576; Aboud 2024). In the multicentre registry study of 781 people, red blood transfusion of 10 or more units was reported in 70% (n=547) of people (Biancari 2020). The rates of reoperation for intrathoracic bleeding and reoperation for peripheral arterial bleeding were 42% (n=328) and 9% (n=66), respectively.

In the retrospective international multicentre observation PELS-1 study of 2,058 people having postcardiotomy VA ECMO, postoperative bleeding was reported in 57% (n=1,156) of people, including bleeding needing re-thoracotomy (40%, n=765), cannulation site bleeding (12%, n=246) and diffuse non-surgery related bleeding (25%, n=472) (Mariani 2023).In the single centre retrospective cohort

study of 101 people having central VA ECMO after cardiac surgery, bleeding was reported in 98% (n=98) of people and re-thoracotomy in 26% (n=26) (Rubino 2017).

Neurological events

Of the 12 key evidence studies, 8 reported neurological adverse events or complications. The pooled neurological complication rates reported in 3 systematic reviews, were 11% (95% CI 7.8 to 14.8, I^2=79%, 16 studies [n=1,736]; Biancari 2018), 16% (95% CI 13 to 20, I^2=61%, 12 studies [n=1,341]; Wang 2018) and 14% (95% CI 11.8 to 16.8, 33 studies [n=2,730]; Kowalewski 2020).

In the registry study of people with refractory PCS, the rate of neurological complications was 9% (654 of 7,185). This included clinically determined seizures 1% (78), brain death 3% (18), haemorrhage confirmed by US/CT/MRI 2% (122), and infarction confirmed by US/CT/MRI 5% (326; Kowalewski 2021). In the registry study of adults treated with VA ECMO, diffuse cerebral oedema or hypoxic encephalopathy occurred in 4% (28 of 723) of the overall population (Loungani 2021).

In the single centre retrospective study of people with PCS, rates of neurological adverse events were 14% (41 of 297). This included sensory-motor deficit 3% (5), intracranial bleeding 4% (13), brain oedema 1% (2) and brain death 5% (16) (Danial 2023). In the retrospective international multicentre observation PELS-1 study of 2,058 people having postcardiotomy VA ECMO, brain oedema was reported in 4% (n=84) of people, cerebral haemorrhage in 3% (n=66), seizure in 2% (n=41) and stroke in 11% (n=217) (Mariani 2023).

In the multicentre registry study of 781 people, major neurological complications were reported in 19% (n=147) of people. These complications included non-

disabling stroke (4%, n=28), disabling stroke (8%, n=61) and global brain ischaemia (7%, n=58; Biancari 2020).

Limb complications

Of the 12 key evidence studies, 10 reported limb adverse events or complications. The pooled limb complication rates reported in 3 systematic reviews, were 11% (95% CI 8.0 to 13.5, I^2=70%, 16 studies [n=1,909]; Biancari 2018), 14% (95% CI 10 to 20, I^2=75%, 11 studies [n=945]; Wang 2018) and 13% (95% CI 32.5 to 38.2, 30 studies [n=2,766]; Kowalewski 2020).

In the registry study of people with refractory PCS, rates of limb complications were 6% (456 of 7,185), including ischaemia 4% (312) and limb compartment syndrome 2% (106) (Kowalewski 2021). In the registry study of adults treated with VA ECMO 12% (88 of 723) of the overall population were reported with limb ischaemia (Loungani 2021).

In the single centre retrospective study of people with PCS, rates of limb ischaemia were 11% (34 of 297; Danial 2023). This was 7% (11 of 169) in the multicentre retrospective study of adults having ECMO following cardiac surgery (Bonacci 2020).

Rates of limb fasciotomy were 2% (143 of 7,185) in the registry study of people with refractory PCS, and 4% (25 of 723) in the overall population in the registry study of adults treated with VA ECMO (Loungani 2021), and 3% (4 of 169) in the single centre retrospective study of people undergoing CABG who had PCS (Bonacci 2020).

In the propensity score-matched study of 6,822 people admitted for cardiac surgery with or without VA ECMO, statistically significantly more people were reported with limb fasciotomy or amputation on ECMO for PCS 2% (26 of 1,137), than those not on ECMO without PCS 1% (47 of 5,685), OR 2.81 (95% CI 1.73 to

4.56, p<0.001; Chen 2017). The pooled rate of lower limb amputation was 1% (95% CI 0.0 to 2.3, I^2=0% in a meta-analysis of 5 studies (n=330) in the systematic review of people who required VA ECMO following cardiac surgery (Biancari 2018), and the registry study of people with refractory PCS by Kowalewski et al. (2021) also reported amputation rates of 1% (43 of 7,185).

In the multicentre registry study of 781 people, major lower limb amputation was reported in 1% (n=10) of people (Biancari 2020).

Limb ischaemia was reported in 6% (6 of 101) of people in the single centre retrospective cohort study of people having central VA ECMO after cardiac surgery (Rubino 2017).

Infection and sepsis

Of the 12 key evidence studies, 9 reported infection or sepsis events or complications. In the propensity score-matched study of 6,822 people admitted for cardiac surgery with or without VA ECMO, significantly more people were reported with post-operative infection on ECMO for PCS 13% (150 of 1,137), than those not on ECMO without PCS 5% (256 of 5,685), OR 3.23 (95% CI 2.61 to 4.00, p<0.001; Chen 2017). In the systematic review of people who required VA ECMO following cardiac surgery, the rate of deep sternal wound infection or mediastinitis was 15% (95% CI 4.0 to 25.4, I^2=92%) in a meta-analysis of 4 studies (n=490; Biancari 2018). Pooled systemic infection rates were 31% (95% CI 22 to 41, I^2=79%) in the systematic review of people with PCS following cardiac surgery (9 studies [n=598]; Wang 2018). In the registry study of adults treated with VA ECMO (31% postcardiotomy), infection rates were 21% (154 of 723) (Loungani 2021). Site infection occurred in 13% (37 of 297) of people with PCS in the French single centre retrospective study (Danial, 2023).

In the systematic review of people with refractory PCS, pooled rates of sepsis were 21% (95% CI 17.0 to 24.9) in a meta-analysis of 29 studies (n=1,860;

Kowalewski 2020). The rate of sepsis was reported as 12% (871 of 7,185) in the registry study of people with refractory PCS (Kowalewski 2021). Septic shock was reported in 17% (310 of 2,058) of people in the retrospective multicentre observational study (Mariani 2023)..

In the multicentre registry study of 781 people, infectious complications included deep sternal wound infection or mediastinitis (4%, n=29), vascular access site infection (9%, n=67), and bloodstream infection (23%, n=179; Biancari 2020).

Renal complications

Of the 12 key evidence studies, 10 reported renal adverse events or complications. In the propensity score-matched study of 6,822 people admitted for cardiac surgery with or without VA ECMO, statistically significantly more people were reported with acute renal failure and need for haemodialysis on ECMO for PCS 33% (374 of 1,137), than those not on ECMO 7% (418 of 5,685), OR 6.26 (95% CI 5.34 to 7.35, p<0.001; Chen 2017).

The pooled rates of RRT, renal failure, or acute kidney injury were reported in 3 systematic reviews. Rates were 47% (95% CI 38.9 to 55.2, I^2=92%, 19 studies [n=1,979]; Biancari 2018), 57% (95% CI 47 to 66, I^2=87%, 12 studies [n=1,279]; Wang 2018) and 47% (95% CI 41.5 to 53.1, 34 studies [n=3,199]; Kowalewski 2020), respectively.

In the registry study of people with refractory PCS, rates of kidney failure were 49% (3,510 of 7,185), and rates of RRT were 36% (2,593 of 7,185; Kowalewski 2021). Acute renal dysfunction was reported as 36% (257 of 723) in the registry study of adults treated with VA ECMO (31% postcardiotomy) (Loungani 2021).

Renal failure requiring haemodialysis was reported in 58% (170 of 297) in the single centre retrospective studies of people with PCS in France (Danial 2023).. The rate of in-hospital dialysis was 84% (483 of 576) in the registry study of 576

people having ECMO for PCS (Aboud 2024). The rate of renal failure was 64% in the single centre retrospective cohort study of 101 people having central VA ECMO after cardiac surgery (Rubino 2017). RRT was needed in 53% (409 of 781) of people in the multicentre registry study (Biancari 2020).

Acute kidney injury occurred at a rate of 57% (1,069 of 2,058) in the retrospective international multicentre observation PELS-1 study of people having postcardiotomy VA ECMO (Mariani 2023).

Stroke

Of the 12 key evidence studies, 4 reported stroke events. In the propensity score-matched study of 6,822 people admitted for cardiac surgery with or without VA ECMO, rates of new onset ischaemic stroke were 3% (36 of 1,137) for those on ECMO for PCS, compared to 4% (201 of 5,685) in those not on ECMO (OR 0.89, 95% CI 0.62 to 1.28, p=0.534; Chen 2017). Rates of new onset haemorrhagic stroke for those on ECMO for PCS were 1% (12 of 1,137), compared to less than 1% (23 of 5,685) in those not on ECMO without PCS (OR 2.63, 95% CI 1.30 to 5.29, p=0.007; Chen 2017).

Intracranial haemorrhage or haemorrhagic stroke and ischaemic stroke or embolisation were both reported as 3% (17 of 723) in the registry study of adults treated with VA ECMO (31% postcardiotomy) (Loungani 2021).

Ischaemic stroke was reported in 6% (18 of 297) in the single centre retrospective studies of people with PCS in France (Danial 2023). Stroke occurred at a rate of 14% (14 of 101) in the single centre retrospective cohort study of people having central VA ECMO after cardiac surgery (Rubino 2017). The rate of in-hospital stroke was 19% (n=108) in the registry study of 576 people having ECMO for PCS (Aboud 2024).

Cardiovascular complications

Of the 12 key evidence studies, 5 reported cardiovascular adverse events or complications. In 1 registry study, cardiovascular complications occurred in 54% (3,894 of 7,185) of people with refractory PCS (Kowalewski 2021). These included cardiac arrhythmia 16% (1,141), CPR required more than 3 times 3% (206), hypotension requiring vasodilators 3% (222), and inotropes on ECMO 45% (3,196) (Kowalewski 2021). In the retrospective international multicentre observation PELS-1 study of 2,058 people having postcardiotomy VA ECMO, arrhythmia was reported in 33% (n=624) of people, cardiac arrest in 16% (n=304), pacemaker implantation in 3% (n=56), right ventricular failure in 21% (n=389), vasoplegic syndrome in 10% (n=176) and embolism in 6% (n=113) (Mariani 2023)..

In the registry study of 576 people having ECMO for PCS, the rates of in-hospital cardiac arrest, myocardial infarction, low output syndrome and arterial vascular complication were 26% (n=150), 6% (n=36), 82% (n=473) and 19% (n=107), respectively (Aboud 2024).

The multicentre registry study of 781 people reported arterial complications, including aortic rupture (0.3%, n=2), type A aortic dissection (1%, n=8), type B aortic dissection (0.4%, n=3), peripheral artery dissection (1%, n=9), vascular perforation (1%, n=7), and arterial thrombosis (6%, n=43) (Biancari 2020).

In the single centre retrospective cohort study of 101 people having central VA ECMO after cardiac surgery, left ventricle or aortic valve thrombosis was reported in 5% (n=5) of people, and ventricular tachycardia or ventricular fibrillation in 5% (n=5) (Rubino 2017).

Metabolic complications

Of the 12 key evidence studies, 1 registry study reported metabolic adverse events or complications in 27% (1,934 of 7,185) of people with refractory PCS. These included glucose levels below 40 (1%, n=104), glucose levels greater than

240 (11%, n=758), hyperbilirubinemia (13%, n=941), pH lower than 7.2 (9%, n=620), and pH higher than 7.6 (3%, n=208) (Kowalewski 2021).

Pulmonary complications

Of the 12 key evidence studies, 5 reported pulmonary adverse events or complications. In one registry study, pulmonary complications occurred in 4% (271 of 7,185) of people with refractory PCS, including pneumothorax 1% (91), and pulmonary haemorrhage 3% (187) (Kowalewski 2021). In other registry study of 723 adults treated with VA ECMO (31% postcardiotomy), complications included pulmonary embolism less than 1% (3), haemothorax 4% (25), and pneumothorax 3% (22) (Loungani 2021).

Hydrostatic pulmonary oedema was reported in 6% (17 of 297) of people with PCS, in the single centre retrospective study done in France (Danial 2023). Pneumonia was reported in 22% (411 of 2,058) of people and acute respiratory distress syndrome in 6% (104 of 2,058) in the retrospective multicentre observational study (Mariani 2023). Tracheostomy was reported in 23% of people (180 of 781) and pneumonia in 37% (285 of 781) in the multicentre registry study (Biancari 2020).

GI complications

Of the 12 key evidence studies, 2 reported GI complications. One multicentre registry study reported GI complication needing surgery in 6% (42 of 781) of people (Biancari 2020). In the single centre retrospective cohort study, mesenteric ischaemia was reported in 8% (8 of 101) of people having central VA ECMO after cardiac surgery (Rubino 2017).

Hepatic complications

Of the 12 key evidence studies, 2 studies reported hepatic complications. In the multicentre registry study of 781 people, the rates of pancreatitis and liver failure were 2% (n=12) and 34% (n=265), respectively (Biancari 2020). In the single

centre retrospective cohort study of 101 people having central VA ECMO after cardiac surgery, hepatic failure was reported in 28% (n=28) of people (Rubino 2017).

Multiorgan failure

Of the 13 key evidence studies, 2 studies reported multiorgan failure. The rate of multiorgan failure was 50% (n=380) in the multicentre registry study of 781 people having VA ECMO for refractory cardiopulmonary failure following cardiac surgery (Biancari 2020) and was 34% (n=697) in the retrospective multicentre observational study of 2,058 people having postcardiotomy VA ECMO (Mariani 2023).

Technical complications

Of the 12 key evidence studies, 2 reported technical adverse events or complications. In 1 registry study of adults treated with VA ECMO (31% postcardiotomy), oxygenator failure rates were 1% (8 of 723), and air embolism, cannula dislodgement, pump malfunction and tubing rupture were reported in less than 1% of the overall population (Loungani 2021). In the single centre retrospective study of 297 people with PCS, vascular cannulation and decannulation adverse event rates were 3% (9) and 9% (16), respectively (Danial 2023).

Anecdotal and theoretical adverse events

Expert advice was sought from consultants who have been nominated or ratified by their professional society or royal college. They were asked if they knew of any other adverse events for this procedure that they had heard about (anecdotal), which were not reported in the literature. They were also asked if they thought there were other adverse events that might possibly occur, even if they had never happened (theoretical).

They listed the following anecdotal and theoretical adverse events:

- Left ventricle overloading
- Deep vein thrombosis
- Arteriovenous fistula
- Pseudoaneurysm
- Harlequin syndrome
- Haemolysis
- Intra-cerebral haemorrhage
- Major pulmonary bleed
- Failure to cannulate during cardiac arrest
- Malposition of the cannula
- Device clotting
- Differential oxygenation
- Lower body hyperoaxemia/hypocapnia
- Air entrapment
- Oxygenator failure
- Consumption coagulopathy
- Acquired Von Willebrand syndrome
- Systemic inflammatory response syndrome (SIRS).

Sixteen professional expert questionnaires were submitted. Find full details of what the professional experts said about the procedure in the specialist advice questionnaires for this procedure.

Validity and generalisability

- Most studies included in the key evidence had a large number of participants from a variety of countries, although only 1 UK-specific study (Rubino 2017) was included.

- Due to the nature of the procedure, randomised controlled trials in the postcardiotomy population are not possible. There was therefore a lack of comparative studies included in the key evidence. Chen et al. (2017) was the only comparative study. This study compares those who had ECMO for PCS following cardiac surgery, to a propensity matched sample with the same cardiac surgery who did not have PCS or ECMO. This comparison is a clinically lower risk group compared to those who had ECMO.
- Some studies did not include definitions of PCS or qualifying clinical reasons for requiring ECMO postcardiotomy.
- The studies included people with a mix of primary surgery types and only 1 study (Rubino 2017) stratified outcomes by cardiac surgery type.
- Many studies lacked pre-, intra-, and postoperative information including differences between institutions in terms of patient selection, volume and expertise, treatment strategy as well as availability of ventricular assist devices and heart transplantation, which may impact outcomes.
- Follow-up for most studies was short, reporting key efficacy outcomes at hospital discharge. Five-year survival was reported in 5 studies and 10-year survival in 3 studies.

Related NICE guidance

Interventional procedures

Extracorporeal membrane oxygenation (ECMO) for acute heart failure in adults (2014) NICE interventional procedures guidance [IPG 482]. (Recommendation: special arrangements).

NICE guidelines

Acute heart failure: diagnosis and management (2014 updated 2021) NICE guideline CG187 - At an early stage, the specialist should have a discussion with a centre providing mechanical circulatory support about: people with potentially reversible severe acute heart failure or people who are potential candidates for transplantation.

Professional societies

- The Intensive Care Society
- Society for Cardiothoracic Surgery in Great Britain & Ireland
- Royal College of Anaesthetists
- Royal College of Surgeons
- Faculty of Intensive Care Medicine
- British Society for Heart Failure
- NHS Blood and Transplant
- British Cardiovascular Society
- European Extracorporeal Life Support Organisation

Company engagement

NICE asked companies who manufacture a device potentially relevant to this procedure for information on it. NICE received 2 completed submissions. These were considered by the interventional procedures technical team and any relevant points have been taken into consideration when preparing this overview.

References

1. Biancari F, Perrotti A, Dalen M et al. (2018) Meta-Analysis of the outcome after postcardiotomy venoarterial extracorporeal membrane oxygenation in adult patients. Journal of Cardiothoracic and Vascular Anesthesia 32(3): 1175-1182

2. Wang L, Wang H, Hou X (2018) Clinical outcomes of adult patients who receive extracorporeal membrane oxygenation for postcardiotomy cardiogenic shock: a systematic review and meta-analysis. Journal of Cardiothoracic and Vascular Anesthesia 32(5): 2087-2093
3. Kowalewski M, Raffa GM, Zielinski K et al. (2020) The impact of Centre's heart transplant status and volume on in-hospital outcomes following extracorporeal membrane oxygenation for refractory post-cardiotomy cardiogenic shock: A meta-analysis. BMC Cardiovascular Disorders 20(1): 10
4. Alba AC, Foroutan F, Buchan TA et al. (2021) Mortality in patients with cardiogenic shock supported with VA ECMO: A systematic review and meta-analysis evaluating the impact of etiology on 29,289 patients. The Journal of heart and lung transplantation : the official publication of the International Society for Heart Transplantation 40(4): 260-268
5. Chen S-W, Tsai F-C, Lin Y-S et al. (2017) Long-term outcomes of extracorporeal membrane oxygenation support for postcardiotomy shock. The Journal of Thoracic and Cardiovascular Surgery 154(2): 469-477e2
6. Kowalewski M, Zielinski K, Brodie D et al. (2021) Venoarterial extracorporeal membrane oxygenation for postcardiotomy shock-analysis of the Extracorporeal Life Support Organization Registry. Critical Care Medicine 49(7): 1107-1117
7. Loungani RS, Fudim M, Ranney D et al. (2021) Contemporary use of venoarterial extracorporeal membrane oxygenation: insights from the multicenter RESCUE registry. Journal of Cardiac Failure 27(3): 327-337
8. Danial P, Olivier M-E, Brechot N et al. (2023) Association between shock etiology and 5-year outcomes after venoarterial extracorporeal membrane oxygenation. Journal of the American College of Cardiology 81(9): 897-909
9. Aboud A, Huting F, Fujita B et al. (2024) Outcomes of 576 patients with extracorporeal life support for the treatment of perioperative cardiogenic shock. Interdisciplinary Cardiovascular and Thoracic Surgery 39: ivae147
10. Mariani S, Heuts S, van Bussel BCT et al. (2023a) Patient and Management Variables Associated With Survival After Postcardiotomy Extracorporeal Membrane Oxygenation in Adults: The PELS-1 Multicenter Cohort Study. Journal of the American Heart Association 12: e029609
11. Biancari F, Dalén M, Fiore A et al. (2020) Multicenter study on postcardiotomy venoarterial extracorporeal membrane oxygenation. Journal of Thoracic and Cardiovascular Surgery 159: 1844–54
12. Biancari F, Perrotti A, Ruggieri VG et al. (2021) Five-year survival after post-cardiotomy veno-arterial extracorporeal membrane oxygenation. European Heart Journal. Acute Cardiovascular Care 10(6): 595–601

13. Rubino A, Costanzo D, Stanszus D et al. (2018) Central Veno-Arterial Extracorporeal Membrane Oxygenation (C-VA-ECMO) After Cardiothoracic Surgery: A Single-Center Experience. Journal of Cardiothoracic and Vascular Anesthesia 32: 1169–74

Appendix A: Methods and literature search strategy

Methods and literature search strategy

NICE has identified studies and reviews relevant to venoarterial extracorporeal membrane oxygenation (VA ECMO) in the following indications from the medical literature:

- acute heart failure in adults
- extracorporeal cardiopulmonary resuscitation (ECPR) in adults in refractory cardiac arrest
- postcardiotomy cardiogenic shock in adults.

The search was initially developed for the acute heart failure indication only (Tables 4a and 4b) and then modified and updated to cover the additional two indications (Table 4c).

Search strategy design and peer review

This search report is informed by the Preferred Reporting Items for Systematic reviews and Meta-Analyses literature search extension (PRISMA-S).

A NICE information specialist ran the literature searches for acute heart failure in adults on 18 September 2024 and updated them on 12 May 2025. The search strategy was modified and updated on 19 June 2025 to incorporate the 2 additional interventions. See the search strategy history for the full search strategy for each database. Relevant published studies identified during consultation or resolution that are published after this date may also be considered for inclusion.

The principal search strategy was developed in MEDLINE ALL (Ovid interface). It was adapted for use in each of the databases listed in table 4a, taking into account the database's size, search functionality and subject coverage. The MEDLINE ALL strategy was quality assured by a NICE senior information specialist. All translated search strategies were peer reviewed to ensure their accuracy. The quality assurance and peer review procedures were adapted from

the Peer Review of Electronic Search Strategies (PRESS) 2015 evidence-based checklist.

Review management

The search results were managed in EPPI-Reviewer version 5 (EPPI-R5). Duplicates were removed in EPPI-R5 using a 2-step process. First, automated deduplication was done using a high-value algorithm. Second, manual deduplication was used to assess low-probability matches. All decisions about inclusion, exclusion and deduplication were recorded and stored.

Limits and restrictions

The CENTRAL database search removed trial registry records and conference material. The Embase search excluded conference material, letters and editorial. We excluded the following publication types in MEDLINE: letter, historical article, comment, editorial, news and case reports. English language limits were applied to the search when possible in the database.

The search was limited from March 2013 to the latest update. The date limit was included to update searches undertaken for an earlier version of this guidance.

The limit to remove animal studies in the searches is standard NICE practice, which has been adapted from Dickersin K, Scherer R, Lefebvre C (1994) Systematic Reviews: Identifying relevant studies for systematic reviews. BMJ 309(6964): 1286.

Main search

Table 4a Main search results

Database	Date searched	Database platform	Database segment or version	Number of results downloaded
Cochrane Central Register of Controlled Trials (CENTRAL)	18/09/24	Wiley	Issue 8 of 12, August 2024	410
Cochrane Database of Systematic Reviews (CDSR)	20/09/24	Wiley	Issue 9 of 12, September 2024	13
Embase	20/09/24	Ovid	1974 to 2024 September 17	2101
INAHTA International HTA Database	18/09/24	https://database.inahta.org/	-	24
MEDLINE ALL	18/09/24	Ovid	1946 to Sept 17, 2024	1454

Update search

Table 4b Update search results 1

Database	Date searched	Database platform	Database segment or version	Number of results downloaded
Cochrane Central Register of Controlled Trials (CENTRAL)	12/05/2025	Wiley	Issue 4 of 12, April 2025	39
Cochrane Database of Systematic Reviews (CDSR)	12/05/2025	Wiley	Issue 5 of 12, May 2025	0
Embase	12/05/2025	Ovid	1974 to 2025 May 09	54
INAHTA International HTA Database	12/05/2025	https://database.inahta.org/		4
MEDLINE ALL	12/05/2025	Ovid	1946 to May 09, 2025	195

Additional update search

Table 4c Update search results 2

This version of the search was modified to include 2 additional indications and searched from March 2013 to latest update.

Database	Date searched	Database platform	Database segment or version	Number of results downloaded
Cochrane Central Register of Controlled Trials (CENTRAL)	19/06/25	Wiley	Issue 6 of 12, 2025	295
Cochrane Database of Systematic Reviews (CDSR)	19/05/25	Wiley	Issue 6 of 12, 2025.	0
Embase	19/06/25	Ovid	1974 to 2025 June 17	4461
INAHTA International HTA Database	19/06/25	https://database.inahta.org/	-	29
MEDLINE ALL	19/06/25	Ovid	1946 to June 18, 2025	4707

Search strategy history – initial search strategy September 2024

MEDLINE ALL search strategy

1 , Heart Failure/th , 29,868

2 , Acute disease/th , 1,194

3 , 1 and 2 , 11

4 , *Cardiomyopathies/th , 1,150

5 , *Shock cardiogenic/th , 2,135

6 , Myocardial Stunning/th [Therapy] , 155

7 , Myocarditis/th [Therapy] , 1,294

8 , *Myocardial infarction/ , 138,977

9 , Out-of-Hospital Cardiac Arrest/th [Therapy] , 5,734

10 , ((acute* or server*) adj (heart* or cardiac* or myocard* or cardio* or ventric*) adj (failur* or decompensation* or insufficient* or dysfunct* or stand* or still* or fault* or shock*)).ti,ab. , 9,513

11 , Myocardit*.ti,ab. , 21,440

12 , ((Postpartum* or post-parttum* or peripartum* or peri-partum*) adj cardiomyopath*).ti,ab. , 1,697

13 , PPCM.ti,ab. , 671

14 , (myocard* adj (stun* or hibernat* or infract*)).ti,ab. , 2,258

15 , Primary Graft Dysfunction/th [Therapy] , 99

16 , (primary* adj graft* adj dysfunct*).ti,ab. , 1,392

17 , or/3-16 , 182,062

18 , *Cardiopulmonary Resuscitation/mt [Methods] , 4,116

19 , *Extracorporeal Membrane Oxygenation/ , 13,895

20 , ECMO.ti. , 3,217

21 , *Extracorporeal Circulation/mt [Methods] , 1,090

22 , (extracorp* adj circulat*).ti,ab. , 8,596

23 , (extracorp* adj ((cardiopulmon* adj resuscitat*) or CPR)).ti,ab. , 1,229

24 , ECPR.ti. , 154

25 , (Biomedicus adj pump*).ti,ab. , 45

26 , (Maquet* adj rotaflow*).ti,ab. , 12

27 , (jostra adj (pump* or rotaflow*)).ti,ab. , 5

28 , (levitronix adj (centrimag* or pump* or system* or oxygen*)).ti,ab. , 54

29 , (Medos adj (Hilite* or oxygen*)).ti,ab. , 22

30 , left ventricle assist device.ti,ab. , 106

31 , or/18-30 , 28,477

32 , 17 and 31 , 2,725

33 , animals/ not human/ , 5,225,551

34 , 32 not 33 , 2,680

35 , limit 34 to english language , 2,503

36 , limit 35 to ed=20130331-20240930 , 2,028

37 , limit 36 to (letter or historical article or comment or editorial or news or case reports) , 574

38 , 36 not 37 , 1,454

[Embase] search strategy

1 , heart failure/th [Therapy] , 15,752

2 , acute disease/th [Therapy] , 2,395

3 , 1 and 2 , 10

4 , *cardiomyopathy/th [Therapy] , 1,144

5 , *cardiogenic shock/th [Therapy] , 2,129

6 , stunned heart muscle/th [Therapy] , 53

7 , myocarditis/th [Therapy] , 864

8 , *heart infarction/ , 110,365

9 , primary graft dysfunction/th [Therapy] , 94

10 , "out of hospital cardiac arrest"/th [Therapy] , 3,862

11 , ((acute* or server*) adj (heart* or cardiac* or myocard* or cardio* or ventric*) adj (failur* or decompensation* or insufficient* or dysfunct* or stand* or still* or fault* or shock*)).ti,ab. , 17,537

12 , Myocardit*.ti,ab. , 31,093

13 , ((Postpartum* or post-parttum* or peripartum* or peri-partum*) adj cardiomyopath*).ti,ab. , 2,835

14 , PPCM.tw. , 1,261

15 , (myocard* adj (stun* or hibernat* or infract*)).ti,ab. , 3,555

16 , (primary* adj graft* adj dysfunct*).tw. , 3,009

17 , or/3-16 , 173,201

18 , *resuscitation/ , 60,473

19 , *extracorporeal oxygenation/ , 16,545

20 , ECMO.ti. , 7,837

21 , *extracorporeal circulation/ , 9,094

22 , (extracorp* adj circulat*).ti,ab. , 9,683

23 , (extracorp* adj ((cardiopulmon* adj resuscitat*) or CPR)).ti,ab. , 1,851

24 , ECPR.ti. , 352

25 , (Biomedicus adj pump*).ti,ab. , 50

26 , (Maquet* adj rotaflow*).ti,ab. , 31

27 , (jostra adj (pump* or rotaflow*)).ti,ab. , 16

28 , (levitronix adj (centrimag* or pump* or system* or oxygen*)).ti,ab. , 150

29 , (Medos adj (Hilite* or oxygen*)).ti,ab. , 44

30 , left ventricle assist device.ti,ab. , 217

31 , or/18-30 , 96,434

32 , 17 and 31 , 5,350

33 , Nonhuman/ not Human/ , 5,532,522

34 , 32 not 33 , 5,275

35 , limit 34 to letter/ or (letter or editorial).pt. , 2,165,352

36 , 34 not 35 , 4,904

37 , limit 36 to dc=20130331-20240930 , 3,599

38 , limit 37 to english language , 3,481

39 , (conference abstract* or conference review or conference paper or conference proceeding).db,pt,su. , 6,020,541

40 , 38 not 39 , 2,101

Cochrane Library (CDSR) search strategy

#1 MeSH descriptor: [Heart Failure] explode all trees and with qualifier(s): [therapy - TH] 2591

#2 MeSH descriptor: [Acute Disease] explode all trees and with qualifier(s): [therapy - TH] 118

#3 #1 and #2 0

#4 MeSH descriptor: [Cardiomyopathies] explode all trees and with qualifier(s): [therapy - TH] 248

#5 MeSH descriptor: [Shock, Cardiogenic] explode all trees and with qualifier(s): [therapy - TH] 177

#6 MeSH descriptor: [Myocardial Stunning] explode all trees and with qualifier(s): [therapy - TH] 3

#7 MeSH descriptor: [Myocarditis] explode all trees and with qualifier(s): [therapy - TH] 13

#8 MeSH descriptor: [Myocardial Infarction] explode all trees and with qualifier(s): [therapy - TH] 3337

#9 MeSH descriptor: [Primary Graft Dysfunction] explode all trees and with qualifier(s): [therapy - TH] 3

#10 MeSH descriptor: [Out-of-Hospital Cardiac Arrest] explode all trees and with qualifier(s): [therapy - TH] 539

#11 ((acute* or server*) near/1 (heart* or cardiac* or myocard* or cardio* or ventric*) near/1 (failur* or decompensation* or insufficient* or dysfunct* or stand* or still* or fault* or shock*)) 2663

#12 Myocardit* 1421

#13 (Postpartum* or post-partum* or peripartum* or peri-partum*) near/1 cardiomyopath* 47

#14 PPCM 39

#15 (myocard* near/1 (stun* or hibernat* or infract*)) 342

#16 (primary* near/1 graft* near dysfunct*) 146

#17 #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #168646

#18 MeSH descriptor: [Cardiopulmonary Resuscitation] this term only 1688

#19 MeSH descriptor: [Extracorporeal Membrane Oxygenation] this term only 361

#20 ECMO 1101

#21 MeSH descriptor: [Extracorporeal Circulation] this term only and with qualifier(s): [methods - MT] 120

#22 (extracorp* near/1 circulat*) 1423

#23 (extracorp* near/1 ((cardiopulmon* near resuscitat*) or CPR)) 71

#24 ECPR 112

#25 (Biomedicus near/1 pump*) 3

#26 (Maquet* rotaflow*) 3

#27 jostra near/1 (pump* or rotaflow*) 1

#28 (levitronix near/1 (centrimag* or pump* or system* or oxygen*)) 0

#29 Medos near/1 (Hilite* or oxygen*) 0

#30 left ventricle assist device 219

#31 #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #304577

#32 #17 AND #31 494

#33 "conference":pt or (clinicaltrials or trialsearch):so 777352

#34 #32 NOT #33 with Cochrane Library publication date Between Mar 2013 and Sep 2024, in Cochrane Reviews 13

Cochrane Library CENTRAL search strategy

#1 MeSH descriptor: [Heart Failure] explode all trees and with qualifier(s): [therapy - TH] 2591

#2 MeSH descriptor: [Acute Disease] explode all trees and with qualifier(s): [therapy - TH] 118

#3 #1 and #2 0

#4 MeSH descriptor: [Cardiomyopathies] explode all trees and with qualifier(s): [therapy - TH] 248

#5 MeSH descriptor: [Shock, Cardiogenic] explode all trees and with qualifier(s): [therapy - TH] 177

#6 MeSH descriptor: [Myocardial Stunning] explode all trees and with qualifier(s): [therapy - TH] 3

#7 MeSH descriptor: [Myocarditis] explode all trees and with qualifier(s): [therapy - TH] 13

#8 MeSH descriptor: [Myocardial Infarction] explode all trees and with qualifier(s): [therapy - TH] 3337

#9 MeSH descriptor: [Primary Graft Dysfunction] explode all trees and with qualifier(s): [therapy - TH] 3

#10 MeSH descriptor: [Out-of-Hospital Cardiac Arrest] explode all trees and with qualifier(s): [therapy - TH] 539

#11 ((acute* or server*) near/1 (heart* or cardiac* or myocard* or cardio* or ventric*) near/1 (failur* or decompensation* or insufficient* or dysfunct* or stand* or still* or fault* or shock*)) 2663

#12 Myocardit* 1421

#13 (Postpartum* or post-partum* or peripartum* or peri-partum*) near/1 cardiomyopath* 47

#14 PPCM 39

#15 (myocard* near/1 (stun* or hibernat* or infract*)) 342

#16 (primary* near/1 graft* near dysfunct*) 146

#17 #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #168646

#18 MeSH descriptor: [Cardiopulmonary Resuscitation] this term only 1688

#19 MeSH descriptor: [Extracorporeal Membrane Oxygenation] this term only 361

#20 ECMO 1101

#21 MeSH descriptor: [Extracorporeal Circulation] this term only and with qualifier(s): [methods - MT] 120

#22 (extracorp* near/1 circulat*) 1423

#23 (extracorp* near/1 ((cardiopulmon* near resuscitat*) or CPR)) 71

#24 ECPR 112

#25 (Biomedicus near/1 pump*) 3

#26 (Maquet* rotaflow*) 3

#27 jostra near/1 (pump* or rotaflow*) 1

#28 (levitronix near/1 (centrimag* or pump* or system* or oxygen*)) 0

#29 Medos near/1 (Hilite* or oxygen*) 0

#30 left ventricle assist device 219

#31 #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #304577

#32 #17 AND #31 494

#33 "conference":pt or (clinicaltrials or trialsearch):so 777352

#34 #32 NOT #33 with Cochrane Library publication date Between Mar 2013 and Sep 2024, in Trials 410

INAHTA HTA Database search strategy

1 , "Heart Failure"[mh] , 252

2 , "Acute Disease"[mh] , 46

3 , #2 AND #1 , 2

4 , "Cardiomyopathies"[mh] , 21

5 , "Shock, Cardiogenic"[mh] , 11

6 , "Myocardial Stunning"[mh] , 1

7 , "Myocarditis"[mh] , 1

8 , "Myocardial Infarction"[mh] , 123

9 , "Out-of-Hospital Cardiac Arrest"[mh] , 10

10 , ((acute* or server*) and (heart* or cardiac* or myocard* or cardio* or ventric*) and (failur* or decompensation* or insufficient* or dysfunct* or stand* or still* or fault* or shock*)). , 149

11 , Myocardit* , 5

12 , ((Postpartum* or post-parttum* or peripartum* or peri-partum*) AND cardiomyopath*) , 1

13 , PPCM , 0

14 , (myocard* and (stun* or hibernat* or infract*)) , 2

15 , "Primary Graft Dysfunction"[mh] , 0

16 , (primary* AND graft* AND dysfunct*). , 3

17 , #16 OR #15 OR #14 OR #13 OR #12 OR #11 OR #10 OR #9 OR #8 OR #7 OR #6 OR #5 OR #4 OR #3 , 291

18 , "Cardiopulmonary Resuscitation"[mh] , 23

19 , "Extracorporeal Membrane Oxygenation"[mh] , 29

20 , ECMO , 31

21 , "Extracorporeal Circulation"[mh] , 9

22 , (extracorp* AND circulat*). , 13

23 , (extracorp* AND ((cardiopulmon* AND resuscitat*) or CPR)) , 8

24 , ECPR , 4

25 , (Biomedicus AND pump*). , 0

26 , Maquet* and rotaflow*) , 0

27 , (jostra and (pump* or rotaflow*)). , 0

28 , (levitronix AND (centrimag* or pump* or system* or oxygen*)). , 0

29 , (Medos AND (Hilite* or oxygen*)). , 0

30 , left ventricle assist device , 3

31 , #30 OR #29 OR #28 OR #27 OR #26 OR #25 OR #24 OR #23 OR #22 OR #21 OR #20 OR #19 OR #18 , 74

32 , #31 AND #17 , 24

Search strategy history – update search strategy June 2026

This version of the search was modified to include 2 additional indications and searched from March 2013 to latest update.

MEDLINE ALL search strategy

1, Heart Failure/th [Therapy], 31,048

2, Acute Disease/th [Therapy], 1,222

3, 1 and 2, 11

4, *Cardiomyopathies/th, 1,952

5, *Shock, Cardiogenic/th, 2,922

6, Myocardial Stunning/th [Therapy], 155

7, Myocarditis/th [Therapy], 1,333

8, *Myocardial infarction/th [Therapy], 19,394

9, Out-of-Hospital Cardiac Arrest/th [Therapy], 6,031

10, ((acute* or severe* or refract*) adj (heart* or cardiac* or myocard* or cardio* or ventric*) adj (failur* or decompensation* or insufficient* or dysfunct* or stand* or still* or fault* or shock* or arrest* or stunn*)).tw., 18,262

11, (cardiogen* adj shock).tw., 17,331

12, Myocardit*.tw., 22,410

13, ((Postpartum* or post-partum* or peripartum* or peri-partum*) adj cardiomyopath*).tw., 1,811

14, (postcardiotomy or Post-cardiotomy).tw., 1,230

15, PPCM.tw., 717

16, (myocard* adj (stun* or hibernat* or infarct*)).tw., 241,791

17, Primary Graft Dysfunction/th [Therapy], 109

18, (primary* adj graft* adj dysfunct*).tw., 1,543

19, or/3-18, 301,507

20, *Cardiopulmonary Resuscitation/mt [Methods], 5,700

21, *Extracorporeal Membrane Oxygenation/, 14,654

22, ECMO.tw., 14,889

23, *Extracorporeal Circulation/mt, 1,259

24, (extracorp* adj circulat*).tw., 8,706

25, (extracorp* adj ((cardiopulmon* adj resuscitat*) or CPR)).tw., 1,377

26, ECPR.ti,ab., 1,006

27, (Biomedicus adj pump*).tw., 45

28, (Maquet* adj rotaflow*).tw., 12

29, (jostra adj (pump* or rotaflow*)).tw., 5

30, (levitronix adj (centrimag* or pump* or system* or oxygen*)).tw., 54

31, (Medos adj (Hilite* or oxygen*)).tw., 22

32, (left adj ventricle adj assist adj device).tw., 107

33, or/20-32, 35,941

34, 19 and 33, 6,390

35, animals/ not humans/, 5,314,500

36, 34 not 35, 6,296

37, (exp child/ or exp pediatrics/ or exp infant/ or exp adolescent/) not (exp adult/ or exp middle age/ or exp aged/), 2,281,857

38, 36 not 37, 5,768

39, limit 38 to english language, 5,398

40, limit 39 to ed=20130901-20250630, 3,883

41, limit 39 to dt=20130901-20250630, 4,610

42, 40 or 41, 4,707

EMBASE search strategy

1, heart failure/th [Therapy], 15,823

2, acute disease/th [Therapy], 2,430

3, 1 and 2, 10

4, *cardiomyopathy/th [Therapy], 1,155

5, *cardiogenic shock/th [Therapy], 2,198

6, stunned heart muscle/th [Therapy], 53

7, myocarditis/th [Therapy], 874

8, *heart infarction/th [Therapy], 9,266

9, "out of hospital cardiac arrest"/th [Therapy], 3,990

10, ((acute* or severe* or refract*) adj (heart* or cardiac* or myocard* or cardio* or ventric*) adj (failur* or decompensation* or insufficient* or dysfunct* or stand* or still* or fault* or shock* or arrest* or stunn*)).tw., 32,685

11, (cardiogen* adj shock).tw., 33,626

12, Myocardit*.tw., 33,287

13, ((Postpartum* or post-partum* or peripartum* or peri-partum*) adj cardiomyopath*).tw., 3,113

14, (postcardiotomy or Post-cardiotomy).tw., 2,079

15, PPCM.tw., 1,382

16, (myocard* adj (stun* or hibernat* or infarct*)).tw., 360,780

17, primary graft dysfunction/th [Therapy], 94

18, (primary* adj graft* adj dysfunct*).tw., 3,390

19, or/3-18, 448,325

20, *resuscitation/, 62,739

21, *extracorporeal oxygenation/, 18,275

22, ECMO.tw., 32,585

23, *extracorporeal circulation/, 9,325

24, (extracorp* adj circulat*).tw., 10,199

25, (extracorp* adj ((cardiopulmon* adj resuscitat*) or CPR)).tw., 2,110

26, ECPR.tw., 2,050

27, (Biomedicus adj pump*).tw., 50

28, (Maquet* adj rotaflow*).tw., 33

29, (jostra adj (pump* or rotaflow*)).tw., 17

30, (levitronix adj (centrimag* or pump* or system* or oxygen*)).tw., 154

31, (Medos adj (Hilite* or oxygen*)).tw., 46

32, (left adj ventricle adj assist adj device).tw., 230

33, or/20-32, 115,373

34, 19 and 33, 15,247

35, Nonhuman/ not Human/, 5,720,207

36, 34 not 35, 14,988

37, (conference abstract* or conference review or conference paper or conference proceeding).db,pt,su., 6,294,375

38, 36 not 37, 6,986

39, (exp child/ or exp pediatrics/ or exp adolescent/) not exp adult/, 2,766,023

40, 38 not 39, 6,431

41, limit 40 to english language, 5,795

42, limit 41 to dd=20130901-20250630, 4,668

43, limit 41 to dc=20130901-20250630, 4,655

44, 42 or 43, 4,669

45, Clinical trial.pt., 533,511

46, 44 not 45, 4,461

Cochrane Library (CDSR) search strategy

#1 MeSH descriptor: [Heart Failure] this term only and with qualifier(s): [therapy - TH] 2567

#2 MeSH descriptor: [Acute Disease] this term only and with qualifier(s): [therapy - TH] 115

#3 #1 and #2 0

#4 MeSH descriptor: [Cardiomyopathies] this term only and with qualifier(s): [therapy - TH] 86

#5 MeSH descriptor: [Shock, Cardiogenic] this term only and with qualifier(s): [therapy - TH] 194

#6 MeSH descriptor: [Myocardial Stunning] this term only and with qualifier(s): [therapy - TH] 3

#7 MeSH descriptor: [Myocarditis] this term only and with qualifier(s): [therapy - TH] 13

#8 MeSH descriptor: [Myocardial Infarction] this term only and with qualifier(s): [therapy - TH] 2729

#9 MeSH descriptor: [Out-of-Hospital Cardiac Arrest] this term only and with qualifier(s): [therapy - TH] 568

#10 ((acute* or severe*or refract*) next (heart* or cardiac* or myocard* or cardio* or ventric*) next (failur* or decompensation* or insufficient* or dysfunct* or stand* or still* or fault* or shock* or arrest* or stunn*)) 2872

#11 (cardiogen* next shock) 1767

#12 Myocardit* 1473

#13 ((Postpartum* or post-partum* or peripartum* or peri-partum*) next cardiomyopath*) 50

#14 (postcardiotomy or Post-cardiotomy) 48

#15 PPCM 41

#16 (myocard* next (stun* or hibernat* or infarct*)) 39538

#17 MeSH descriptor: [Primary Graft Dysfunction] this term only and with qualifier(s): [therapy - TH] 3

#18 (primary* next graft* next dysfunct*) 150

#19 #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18 44787

#20 MeSH descriptor: [Cardiopulmonary Resuscitation] this term only and with qualifier(s): [methods - MT] 761

#21 MeSH descriptor: [Extracorporeal Membrane Oxygenation] this term only and with qualifier(s): [methods - MT] 103

#22 ECMO 1170

#23 MeSH descriptor: [Extracorporeal Circulation] this term only and with qualifier(s): [methods - MT] 123

#24 (extracorp* next circulat*) 1423

#25 (extracorp* next ((cardiopulmon* next resuscitat*) or CPR)) 80

#26 ECPR 127

#27 (Biomedicus next pump*) 2

#28 (Maquet* next rotaflow*) 2

#29 (jostra next (pump* or rotaflow*)) 0

#30 (levitronix next (centrimag* or pump* or system* or oxygen*)) 0

#31 (Medos next (Hilite* or oxygen*)) 0

#32 (left next ventricle next assist next device) 1

#33 #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 or #31 or #32 3455

#34 #19 AND #33 with Cochrane Library publication date Between Sep 2013 and Jun 2025, in Cochrane Reviews 30

#35 conference:pt or (clinicaltrials or trialsearch or clinicaltrials.gov or www.who.int) 861611

#36 #34 not #35 0

Cochrane Central (CDSR) search strategy

#1 MeSH descriptor: [Heart Failure] this term only and with qualifier(s): [therapy - TH] 2567

#2 MeSH descriptor: [Acute Disease] this term only and with qualifier(s): [therapy - TH] 115

#3 #1 and #2 0

#4 MeSH descriptor: [Cardiomyopathies] this term only and with qualifier(s): [therapy - TH] 86

#5 MeSH descriptor: [Shock, Cardiogenic] this term only and with qualifier(s): [therapy - TH] 194

#6 MeSH descriptor: [Myocardial Stunning] this term only and with qualifier(s): [therapy - TH] 3

#7 MeSH descriptor: [Myocarditis] this term only and with qualifier(s): [therapy - TH] 13

#8 MeSH descriptor: [Myocardial Infarction] this term only and with qualifier(s): [therapy - TH] 2729

#9 MeSH descriptor: [Out-of-Hospital Cardiac Arrest] this term only and with qualifier(s): [therapy - TH] 568

#10 ((acute* or severe*or refract*) next (heart* or cardiac* or myocard* or cardio* or ventric*) next (failur* or decompensation* or insufficient* or dysfunct* or stand* or still* or fault* or shock* or arrest* or stunn*)) 2872

#11 (cardiogen* next shock) 1767

#12 Myocardit* 1473

#13 ((Postpartum* or post-partum* or peripartum* or peri-partum*) next cardiomyopath*) 50

#14 (postcardiotomy or Post-cardiotomy) 48

#15 PPCM 41

#16 (myocard* next (stun* or hibernat* or infarct*)) 39538

#17 MeSH descriptor: [Primary Graft Dysfunction] this term only and with qualifier(s): [therapy - TH] 3

#18 (primary* next graft* next dysfunct*) 150

#19 #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18 44787

#20 MeSH descriptor: [Cardiopulmonary Resuscitation] this term only and with qualifier(s): [methods - MT] 761

#21 MeSH descriptor: [Extracorporeal Membrane Oxygenation] this term only and with qualifier(s): [methods - MT] 103

#22 ECMO 1170 #23 MeSH descriptor: [Extracorporeal Circulation] this term only and with qualifier(s): [methods - MT] 123

#24 (extracorp* next circulat*) 1423

#25 (extracorp* next ((cardiopulmon* next resuscitat*) or CPR)) 80

#26 ECPR 127

#27 (Biomedicus next pump*) 2

#28 (Maquet* next rotaflow*) 2

#29 (jostra next (pump* or rotaflow*)) 0

#30 (levitronix next (centrimag* or pump* or system* or oxygen*)) 0

#31 (Medos next (Hilite* or oxygen*)) 0

#32 (left next ventricle next assist next device) 1

#33 #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 or #31 or #32 3455

#34 #19 AND #33 with Cochrane Library publication date Between Sep 2013 and Jun 2025, in Trials 499

#35 conference:pt or (clinicaltrials or trialsearch or clinicaltrials.gov or www.who.int) 861611 #36 #34 not #35 295

INHTA HTA Database search strategy

1 , "Heart Failure"[mh] , 271

2 , "Acute Disease"[mh] , 44

3 , #2 AND #1 , 2

4 , "Cardiomyopathies"[mh] , 25

5 , "Shock, Cardiogenic"[mh] , 11

6 , "Myocardial Stunning"[mh] , 1

7 , "Myocarditis"[mh] , 2

8 , "Myocardial Infarction"[mh] , 122

9 , "Out-of-Hospital Cardiac Arrest"[mh] , 11

10 , ((acute* or severe* or refract*) AND (heart* or cardiac* or myocard* or cardio* or ventric*) AND (failur* or decompensation* or insufficient* or dysfunct* or stand* or still* or fault* or shock* or arrest* or stunn*) , 268

11 , (cardiogen* AND shock) , 19

12 , Myocardit* , 5

13 , ((Postpartum* or post-partum* or peripartum* or peri-partum*) AND cardiomyopath*) , 1

14 , (postcardiotomy or Post-cardiotomy) , 0

15 , PPCM , 0

16 , (myocard* AND (stun* or hibernat* or infarct*)) , 236

17 , "Primary Graft Dysfunction"[mh] , 0

18 , (primary* AND graft* AND dysfunct*) , 3

19 , #18 OR #17 OR #16 OR #15 OR #14 OR #13 OR #12 OR #11 OR #10 OR #9 OR #8 OR #7 OR #6 OR #5 OR #4 OR #3 , 523

20 , "Cardiopulmonary Resuscitation"[mh] , 23

21 , "Extracorporeal Membrane Oxygenation"[mh] , 28

22 , ECMO , 30

23 , "Extracorporeal Circulation"[mh] , 8

24 , (extracorp* AND circulat*) , 13

25 , (extracorp* AND ((cardiopulmon* AND resuscitat*) or CPR)): , 8

26 , ECPR , 4

27 , (Biomedicus AND pump*) , 0

28 , (Maquet* AND rotaflow*) , 0

29 , (jostra AND (pump* or rotaflow*)) , 0

30 , (levitronix AND (centrimag* or pump* or system* or oxygen*)) , 0

31 , (Medos AND (Hilite* or oxygen*)) , 0

32 , (Left AND ventricle AND assist AND device) , 3

33 , #32 OR #31 OR #30 OR #29 OR #28 OR #27 OR #26 OR #25 OR #24 OR #23 OR #22 OR #21 OR #20 , 72

34 , #33 AND #19 , 29

Inclusion criteria

The following inclusion criteria were applied to the abstracts identified by the literature search.

- Publication type: clinical studies were included with emphasis on identifying good quality studies. Abstracts were excluded if they did not report clinical outcomes. Reviews, editorials, and laboratory or animal studies, were also excluded and so were conference abstracts, because of the difficulty of appraising study methodology, unless they reported specific adverse events not available in the published literature.
- Population: adults with postcardiotomy cardiogenic shock.
- Intervention or test: VA ECMO.
- Outcome: articles were retrieved if the abstract contained information relevant to the safety, efficacy, or both.

If selection criteria could not be determined from the abstracts the full paper was retrieved.

Potentially relevant studies not included in the main evidence summary are listed in Appendix B: Other relevant studies.

Find out more about how NICE selects the evidence for the committee.

Appendix B: Other relevant studies

Other potentially relevant studies that were not included in the main evidence summary (table 2 and table 3) are listed in table 5 below.

Case studies and observational studies with fewer than 100 people were excluded unless they included outcomes that were not frequently reported.

Table 5 additional studies identified

Study	Number of people and follow up	Direction of conclusions	Reason study was not included in main evidence summary
Baldan BU, Hegeman, RR, Bos NM et al. (2024) Comparative analysis of therapeutic strategies in post-cardiotomy cardiogenic shock: insight into a high-volume cardiac surgery center. Journal of Clinical Medicine 13: 2118	Retrospective cohort n=125 (73 ECMO)	In people who had ECMO (n=73), the in-hospital mortality was 60%, compared to an in-hospital mortality of 85% for those who had conservative management (n=52). In 18 (25%) people who had ECMO, the plasma lactate level normalised within 48 hours, compared to 2 (4%) in the non-ECMO group. The morbidity in the non-ECMO group compared to ECMO included a need for dialysis (42% versus 60%), myocardial infarction (19% versus 27%), and cerebrovascular accident (17% versus 12%).	Larger studies are included.
Baran C, Ozcinar E, Kayan A et al. (2024) Comparison of ECMO,	Retrospective cohort	The weaning rate from VA ECMO was significantly higher in	Studies with more people or longer

IABP and ECMO + IABP in the postoperative period in patients with postcardiotomy shock. Journal of Cardiovascular Development and Disease 11: 283	n=255 (98 IABP, 103 VA ECMO, and 54 both VA ECMO and IABP) Follow-up: 1 year	the combined VA ECMO and IABP group (81%) compared with the other groups (p=0.004). One-year survival was also higher in the combined group (76%) (p=0.002). Complications or renal function did not differ significantly among the groups.	follow-up are included.
Biancari F, Makikallio T, L'Acqua C et al. (2025) How long should patients be treated with postcardiotomy venoarterial extracorporeal membrane oxygenation? Individual Patient Data Pooled Analysis. Critical Care Medicine 53: e908	Systematic review and individual patient data pooled analysis n=1,267 (10 studies)	In-hospital mortality was lowest among those treated 3 to 6 days with VA ECMO. Multilevel mixed-effects logistic regression considering the cluster effect of the participating hospitals adjusted for individual patient's risk profile and operative variables showed that the risk in-hospital mortality did not significantly increase in people treated more than 6 days up to 20 days.	Review focuses on duration of treatment.
Biancari F, Kaserer A, Perrotti A et al. (2024) Hyperlactatemia and poor outcome After postcardiotomy veno-arterial extracorporeal membrane oxygenation: An individual patient data meta-Analysis. Perfusion 39: 956-965	Systematic review and individual patient data meta-analysis n=1,269 (10 studies)	Arterial lactate level at VA ECMO initiation was increased in those who died during the index hospitalisation compared to those who survived (9.3 versus 6.6 mmol/litre, p<0.0001). Accordingly, in-hospital mortality increased along quintiles of pre-VA ECMO arterial lactate level (quintiles: 1, 55%; 2, 55%; 3, 67%; 4, 74%; 5, 82%, p<0.0001). The best	Review focuses on prognostic impact of arterial lactate level before starting VA ECMO.

		cut-off for arterial lactate was 6.8 mmol/litre (in-hospital mortality, 77% versus 56%, p<0.0001).	
Biancari F, Makikallio T, Loforte A et al. (2024) Inter-institutional analysis of the outcome after postcardiotomy veno-arterial extracorporeal membrane oxygenation. The International Journal of Artificial Organs 47: 25-34	Systematic review and individual patient data meta-analysis n=1,269 (10 studies)	In-hospital mortality was 67%. Observed versus expected in-hospital mortality ratio showed that 4 hospitals were outliers with significantly increased mortality rates, and 1 hospital had significantly lower in-hospital mortality rate.	Review focuses on comparison of outcomes from different institutions.
Biancari F, Kaserer A, Perrotti A et al. (2022) Central versus peripheral postcardiotomy veno-arterial extracorporeal membrane oxygenation: systematic review and individual patient data meta-analysis. Journal of Clinical Medicine 11: 7406	Systematic review and individual patient data meta-analysis n=1,269 (10 studies)	Crude rates of in-hospital mortality after central versus peripheral arterial cannulation for VA ECMO were 71% versus 64%, respectively (adjusted OR 1.38, 95% CI 1.08 to 1.75). Among propensity score matched cohorts, central arterial cannulation VA ECMO was associated with statistically significantly higher in-hospital mortality compared to peripheral arterial cannulation VA ECMO (64% versus 71%, p=0.027).	Review focuses on central versus peripheral cannulation.
Biancari F, Dalen M, Fiore A et al. (2022) Gender and the outcome of postcardiotomy veno-arterial extracorporeal membrane oxygenation. Journal of Cardiothoracic	Retrospective, propensity score-matched analysis of an international registry n=358	Among 94 propensity score-matched pairs, women had a higher hospital mortality (70% versus 56%, p=0.049) compared with men. Logistic regression	Small study focusing on the effect of gender on outcomes.

and Vascular Anesthesia 36: 1678–85		analysis showed that women (OR 1.87; 95% CI 1.10 to 3.16), age (OR 1.06; 95% CI 1.04 to 1.08) and pre-ECMO arterial lactate (OR 1.09; 95% CI 1.04 to 1.16) were independent predictors of hospital mortality. Among propensity score-matched pairs, 1-, 3-, and 5-year mortality were 61%, 65%, and 65% among men, and 71%, 71%, and 74% among women, respectively (p=0.110, adjusted HR 1.27; 95% CI 0.96 to 1.66).	
Biancari F, Saeed D, Fiore A et al. (2019) Postcardiotomy venoarterial extracorporeal membrane oxygenation in patients aged 70 years or older. The Annals of Thoracic Surgery 108: 1257-1264	Retrospective multicentre study and meta-analysis of other studies n=781	Hospital mortality in the overall series was 64%. In the 255 people who were 70 years or older (33%), hospital mortality was statistically significantly higher than in younger patients (76% versus 59%; adjusted OR 2.20; 95% CI 1.54 to 3.15). Arterial lactate level greater than 6 mmol/litre before starting VA ECMO was the only predictor of hospital mortality among older people in univariate analysis (83% versus 70%; p=0.029). Meta-analysis of current and previous studies showed that early mortality after postcardiotomy VA ECMO was statistically	Studies with more people or longer follow-up are included.

		significantly higher in people aged 70 years or older compared with younger people (OR 2.09; 95% CI 1.59 to 2.75; 5 studies including 1,547 people; I^2=6%). The pooled early mortality rate among people aged 70 years or older was 79% (95% CI 74.1 to 83.5; 6 studies including 617 people; I^2=42%). Two studies reported 1-year mortality (including hospital mortality) of 80% and 76%, respectively, in people aged 70 years or older.	
Biancari F, Fiore A, Jonsson K et al. (2019) Prognostic significance of arterial lactate levels at weaning from postcardiotomy venoarterial extracorporeal membrane oxygenation. Journal of Clinical Medicine 8: 2218	Multicentre retrospective study (PC-ECMO registry) n=338	Arterial lactate levels at weaning from VA ECMO (adjusted OR 1.43, 95% CI 1.16 to 1.76) was an independent predictor of hospital mortality, and its best cutoff values was 1.6 mmol/litre (less than 1.6 mmol/litre=26% versus 45% for 1.6 mmol/litre or above; adjusted OR 2.49, 95% CI 1.37 to 4.50). Among 87 propensity score-matched pairs, hospital mortality was statistically significantly higher in those with arterial lactate 1.4 mmol/litre or above (39% versus 23%, p=0.029) compared to those with lower arterial lactate.	The main results from the study are published in Biancari (2020).

Bunge JJH, Mariani S, Meuwese C et al. (2024) characteristics and outcomes of prolonged venoarterial extracorporeal membrane oxygenation after cardiac surgery: the post-cardiotomy extracorporeal life support (pels-1) cohort study. Critical Care Medicine 52: e490–502	Retrospective multicentre cohort (PELS-1) n=2,021	Duration of post cardiotomy ECMO was 0 to 3 days in 649 people (32%), 4 to 7 days in 776 (38%), 8 to 10 days in 263 (13%), and more than 10 days in 333 (16%) people. In-hospital mortality increased after 7 days of support, especially in people having valvular and complex surgery, or who had complications, although the long-term post-discharge prognosis was comparable to PC ECMO with shorter support duration.	Study focuses on duration of ECMO. There were other indications for post-cardiotomy VA ECMO as well as cardiogenic shock.
Carroll BJ, Shah RV, Murthy V et al. (2015) Clinical features and outcomes in adults with cardiogenic shock supported by extracorporeal membrane oxygenation. The American Journal of Cardiology 116(10): 1624-30	Single centre retrospective study, US n=123 (26 postcardiotomy [21%]) Follow-up: In-hospital	Overall, 69 people (56%) were weaned from ECMO, with 48 patients (39%) surviving to discharge. People with postcardiotomy shock had the poorest overall survival after ECMO.	Included in Kowalewski (2020) SLR.
Chiarini G, Mariani S, Schaefer A-K et al. (2024) Neurologic complications in patients receiving aortic versus subclavian versus femoral arterial cannulation for post-cardiotomy extracorporeal life support: results of the PELS observational multicenter study. Critical Care 28: 265	Retrospective multicentre cohort n=1,897	Subclavian or axillary cannulation was associated with higher rates of major neurological complications and seizures. In-hospital mortality was higher after aortic cannulation, despite no statistically significant differences in incidence of neurological cause of death in these people.	Study focuses on the association between cannulation site and neurological complications.

Distelmaier K, Wiedemann D, Binder C et al. (2018) Duration of extracorporeal membrane oxygenation support and survival in cardiovascular surgery patients. Journal of Thoracic and Cardiovascular Surgery 155(6): 2471-2476	Single centre retrospective study, Austria n=354 Follow-up: median 45 months (IQR: 20 to 81 months)	Through a median follow-up period of 45 months, 245 people (69%) died. An association between increased duration of ECMO support and mortality was observed in people who survived ECMO support with a crude hazard ratio of 1.96 (95% CI 1.40 to 2.74; p<0.001) for 2 year mortality compared with the third tertile and the second tertile of ECMO duration.	Included in Kowalewski (2020) SLR.
Djordjevic I, Eghbalzadeh K, Sabashnikov A et al. (2020) Central vs peripheral venoarterial ECMO in postcardiotomy cardiogenic shock. Journal of Cardiac Surgery 35(5): 1037-1042	Single centre retrospective study, Germany n=156 Follow-up: 30 days	30-day mortality was comparable with nearly 70% in both cohorts (cECMO 39 [70%] vs pECMO 69 [69%]; p=0.93). ECMO complications occurred significantly more frequently in people treated with cECMO (cECMO 44 [79%] vs pECMO 54 [54%]; p<0.01).	Outcomes not reported as overall population, but by subgroup: central or peripheral VA ECMO.
Flecher E, Anselmi A, Corbineau H et al. (2014) Current aspects of extracorporeal membrane oxygenation in a tertiary referral centre: determinants of survival at follow-up. European journal of cardio-thoracic surgery : official journal of the European Association for Cardio-thoracic Surgery 46(4): 665-671	Single centre retrospective study, France n=325 (postcardiotomy 29%) Follow-up: mean 84 days (SD: 86)	Overall in the VA group, weaning rates were 59%, survival after 30 days was 44% and survival at the end of the follow-up was 41%.	More recent studies with outcomes split by aetiologies were included.

Fux T, Holm M, Corbascio M et al. (2018) Venoarterial extracorporeal membrane oxygenation for postcardiotomy shock: Risk factors for mortality. The Journal of Thoracic and Cardiovascular Surgery 156(5): 1894-1902e3	Single centre retrospective study, Sweden n=105 Follow-up: 90 days	The 90-day overall mortality was 57%, and in-hospital mortality was 56%. Forty-seven percent of patients died on venoarterial extracorporeal membrane oxygenation, 51% of patients were successfully weaned, 1% of patients were bridged to heart transplantation, and 1%of patients were bridged to left ventricular assist device.	Included in Alba (2021) SLR.
Hanuna M, Herz G, Stanzl AL et al. (2024) Mid-Term Outcome after Extracorporeal Life Support in Postcardiotomy Cardiogenic Shock: Recovery and Quality of Life. Journal of Clinical Medicine 13: 2254	Retrospective cohort n=142 Follow-up: 2.2 years	Estimated survival rates at 3, 12, 24 and 36 months were 47%, 46%, 43% and 43% (SE: 4%). Multivariable Cox Proportional Hazard regression analysis revealed preoperative EuroSCORE II (p=0.013), impaired renal function (p=0.010), cardiopulmonary bypass duration (p = 0.015) and pre-ECLS lactate levels (p=0.004) as independent predictors of mid-term mortality. At the time of follow-up, 83% of the survivors were free of moderate to severe disability (mRS less than 3). SF-36 analysis showed a physical component summary of 45.5 and a mental	Studies with more people or longer follow-up are included.

		component summary of 50.6.	
Hess NR, Wang Y, Kilic A (2021) Utilization and outcomes of postcardiotomy mechanical circulatory support. Journal of Cardiac Surgery 36: 4030–37	Retrospective single-centre cohort study n=533 (115 ECMO) Median follow-up=2.3 years	442 (83%) of people were supported with intra-aortic balloon pump counterpulsation, 23 (4%) with an Impella device, and 115 (22%) with ECMO. Three people had an unplanned ventricular assist device placed. Operative mortality was 30%. Longitudinal survival was 56% and 43% at 1 and 5 years, respectively. Survival was lowest in those supported with ECMO and highest with those supported with an Impella (p<0.001). Freedom from readmission was 61% at 5 years. Postoperative ECMO was an independent predictor of mortality (HR 5.1, 95% CI 2.0 to 12.9, p<0.001), but none of the MCS types predicted long-term hospital readmission after risk adjustment.	Only a small proportion of people had ECMO.
Heuts S, Mariani S, van Bussel BCT et al. (2023) The Relation Between Obesity and Mortality in Postcardiotomy Venoarterial Membrane Oxygenation. The Annals of Thoracic Surgery 116: 147–54	Retrospective multicentre cohort (PELS-1) n=2,046	In-hospital mortality was 60%, without statistically significant differences among BMI classes for in-hospital mortality (p=0.225) or major adverse events (p=0.126). The crude association between BMI and in-hospital mortality was not statistically significant	Study focuses on the effect of obesity on outcomes. There were other indications for post-cardiotomy VA ECMO as well as

		after adjustment for comorbidities and intraoperative variables (class 1: OR 1.21; 95% CI 0.88 to 1.65; class 2: OR 1.45; 95% CI 0.86 to 2.45; class 3: OR 1.43; 95% CI 0.62 to 3.33), which was confirmed in multiple sensitivity analyses.	cardiogenic shock.
Hohri Y, Zhao Y, Takayama H et al. (2025) Relationship between indexed surgery and postcardiotomy extracorporeal life support outcomes. Perfusion 40: 915–22	Retrospective single centre cohort study n=149	Major cardiac surgery included aortic surgery (n=35, 24%), CABG alone (n=29, 20%), valve surgery alone (n=59, 40%), and concomitant CABG and valve surgery (n=26, 17%). In-hospital mortality was worst in the CABG and valve surgery group (p<0.01), and the incidence of acute kidney injury was highest in the aortic surgery group (p=0.03). In multivariable logistic regression, CABG and valve surgery (OR 4.20, 95% CI 1.30 to 13.6, p=0.02) and lactate level at ECLS initiation (OR 1.17; 95% CI 1.06 to 1.29; p<0.01) were independently associated with mortality.	Studies with more people or longer follow-up are included.
Hou D, Wang H, Yang F et al. (2021) Neurologic Complications in Adult Post-cardiotomy Cardiogenic Shock	Retrospective single centre cohort study n=415	Neurological complications happened in 87 people (21%), including cerebral infarction in	Studies with more people or longer

Patients Receiving Venoarterial Extracorporeal Membrane Oxygenation: A Cohort Study. Frontiers in Medicine 8: 721774		33 (8%), brain death in 30 (7%), seizures in 14 (3%), and intracranial haemorrhage in 11 (3%) people. In-hospital mortality in those with neurological complications was 91%, compared to 52% in controls (p<0.001). In a multivariable model, the lowest systolic blood pressure (SBP) level before ECMO (OR 0.89; 95% CI 0.86 to 0.93) and aortic surgery combined with coronary artery bypass grafting (OR 9.22; 95% CI 2.10 to 40.55) were associated with overall neurological complications. Age (OR 1.06; 95% CI 1.01 to 1.12) and lowest SBP (OR 0.81; 95% CI 0.76 to 0.87) were correlative factors of brain death. Coagulation disorders (OR 9.75; 95% CI 1.83 to 51.89) and atrial fibrillation (OR 12.19; 95% CI 1.22 to 121.61) were associated independently with intracranial haemorrhage, whereas atrial fibrillation (OR 8.15; 95% CI 1.31 to 50.62) was also associated with cerebral infarction.	follow-up are included.
Ivanov B, Krasivskyi I, Gerfer S et al. (2022) Impact of Initial Operative Urgency on Short-Term	Retrospective single centre cohort study	The direct comparison between patients divided into groups based on urgency	Studies with more people or longer

Outcomes in Patients Treated with ECMO Due to Postcardiotomy Cardiogenic Shock. Life 12 (no. 11)	n=164 Follow-up=to hospital discharge	showed that in-hospital mortality rates were comparable between the groups.	follow-up are included.
Kakuturu J, Dhamija A, Chan E et al. (2023) Mortality and cost of post-cardiotomy extracorporeal support in the United States. Perfusion 38: 1468–77	US National Inpatient Sample database n=4,475	2,000 (45%) hospitalisations involved isolated valvular procedures, 1,700 (38%) isolated CABG, and 775 (17%) involved a combination of both. Overall, in-hospital mortality was 42% (n=1,880). Factors statistically significantly associated with in-hospital mortality included patients with multiple comorbidities (more than 7) and those having combination of valve and CABG procedures. Only 27% of those who survived to discharge, were discharged home independently.	Studies with more relevant outcomes are included.
Khorsandi M, Dougherty S, Bouamra O et al. (2017) Extra-corporeal membrane oxygenation for refractory cardiogenic shock after adult cardiac surgery: a systematic review and meta-analysis. Journal of cardiothoracic surgery 12(1): 55	Systematic review and meta-analysis n=1,926 24 studies Follow-up: In-hospital	Meta-analysis for overall survival rate to hospital discharge of 31% (95% CI 0.29 to 0.34, $p<0.01$, $I^2=60\%$).	More recent systematic reviews and meta-analyses included.
Kienlein RM, Trauzeddel RF et al. (2025) Outcome and complications in postcardiotomy cardiogenic shock treated with	Systematic review and meta-analysis 5 studies	Successful weaning from extracorporeal life support was accomplished in 53% (31% to 57%) and 31% were discharged alive	Only 5 studies were included.

extracorporeal life support - a systematic review and meta-analysis. BMC Anesthesiology 25: 29		(mortality of 25 to 56% after weaning). 95% of people had at least 1 complication. Diabetes mellitus and obesity seem to be independent risk factors for poor outcome.	
Kowalewski M, Raffa G, Zielinski K et al. (2020) Baseline surgical status and short-term mortality after extracorporeal membrane oxygenation for post-cardiotomy shock: a meta-analysis. Perfusion 35(3): 246-254	Systematic review and meta-analysis n=2,235 22 studies Follow-up: In-hospital, 30 day	Overall in-hospital or 30-day mortality event rate was 67% (95% CI 63 to 70%). There were no differences in in-hospital or 30-day mortality with respect to baseline surgical status in the subgroup analysis (test for subgroup differences; p=0.406).	Studies with more relevant outcomes were included.
Laimoud M, Hakami E, Machado P et al. (2024) Appropriate timing of veno-arterial extracorporeal membrane oxygenation initiation after cardiac surgery. Cardiothoracic Surgeon 32: 2	Retrospective cohort n=152	81 (53%) people were intra-operatively supported with VA ECMO while 71 (47%) people were postoperatively supported. Postponed postoperative ECMO insertion was associated with an increased risk of death (HR 1.628, 95% CI 1.102 to 2.403, p=0.014). Postponed ECMO insertion in critically sick people was associated with increased mortality after cardiac surgery. Early intraoperative initiation of post-cardiotomy ECMO may have the potential to improve outcomes after cardiac surgery.	Small study, focusing on the timing of VA ECMO.

Lorusso R, Whitman G, Milojevic M et al. (2021) 2020 EACTS/ELSO/STS/AATS expert consensus on post-cardiotomy extracorporeal life support in adult patients. European Journal of Cardio-thoracic surgery 59: 12–53	Consensus statement	Postcardiotomy extracorporeal life support represents a well-established and valuable tool to rescue people in refractory cardiocirculatory failure, with or without concomitant respiratory dysfunction, in various circumstances that otherwise would almost certainly lead to death.	Consensus statement
Mariani S, Perazzo A, De Piero ME et al. (2025) Postcardiotomy extracorporeal membrane oxygenation after elective, urgent, and emergency cardiac operations: Insights from the PELS observational study. JTCVS open 24: 280-310	Retrospective multicentre observational study (Post-cardiotomy Extracorporeal Life Support Study) n=2,036	One-quarter of postcardiotomy VA ECMOs were implemented after emergency operations. Despite more complications in emergency cases, in-hospital and 5-year survival were comparable between emergency, urgent, or elective operations.	Study describes characteristics and outcomes of people having cardiac operations and requiring VA ECMO, stratified by emergency, urgent, or elective operation. Another paper from the same study is included (Mariani 2023a).
Mariani S, Ravaux JM, van Bussel BCT et al. (2024) Features and outcomes of female and male patients requiring postcardiotomy extracorporeal life support. The Journal of Thoracic and Cardiovascular	Retrospective multicentre observational study n=1,823 Median overall follow-up time was 21 days, and median follow-	Females and males needing postcardiotomy ECLS have different preoperative characteristics and ECLS indications and complications, but comparable in-hospital and long-term survival.	Study focuses on outcomes for females versus males.

Surgery168: 1701-1711e30	up for hospital survivors was 730 days.		
Mariani S, Schaefer A-K, van Bussel BCT et al. (2023b) On-Support and Postweaning Mortality in Postcardiotomy Extracorporeal Membrane Oxygenation. Annals of Thoracic Surgery 116: 1079	Retrospective multicentre observational study (Post-cardiotomy Extracorporeal Life Support Study) n=2,058	Mortality during ECMO support was 37%, mostly associated with unstable preoperative haemodynamics. Another 23% of people died after weaning in association with severe complications. This underscores the importance of postweaning care for postcardiotomy VA ECMO patients.	Another paper from the same study is included (Mariani 2023a).
Mariani S, van Bussel BCT, Ravaux JM et al. (2023) Variables associated with in-hospital and postdischarge outcomes after postcardiotomy extracorporeal membrane oxygenation: Netherlands Heart Registration Cohort. Journal of Thoracic and Cardiovascular Surgery 165(3): 1127-1137e14	Retrospective Netherlands Heart Registry study n=406 Follow-up: In-hospital, 1 year	In-hospital mortality was 52%, with death occurring in a median of 5 days (IQR 2 to 14 days) after surgery. Hospital survivors (n=196) experienced considerable rates of pulmonary infections, respiratory failure, arrhythmias, and deep sternal wound infections during a hospitalisation of median 29 days (IQR 17 to 51 days).	Larger registry studies from broader regions included.
Mariani S, Wang I-W, van Bussel BCT et al. (2023c) The importance of timing in postcardiotomy venoarterial extracorporeal membrane oxygenation: A descriptive multicenter observational study. The Journal of Thoracic and Cardiovascular Surgery 166: 1670-1682e33	Retrospective multicentre observational study (Post-cardiotomy Extracorporeal Life Support-1 Study) n=2,003	Cardiogenic shock (45%), right ventricular failure (16%), and cardiac arrest (14%) were the main indications for postoperative ECMO initiation, with cannulation occurring after (median) 1 day (IQR, 1 to 3 days). Compared with intraoperative application, patients	Another paper from the same study is included (Mariani 2023a).

		who had postoperative ECMO showed more complications, cardiac reoperations (intraoperative: 20%; postoperative: 25%, p=0.011), percutaneous coronary interventions (intraoperative: 2%; postoperative: 4%, p=0.026), and had greater in-hospital mortality (intraoperative: 58%; postoperative: 64%, p=0.002).	
Mariscalco G, El-Dean Z, Yusuff H et al. (2021) Duration of Venoarterial Extracorporeal Membrane Oxygenation and Mortality in Postcardiotomy Cardiogenic Shock. Journal of Cardiothoracic and Vascular Anesthesia 35: 2662–68	Retrospective multicentre registry (PC-ECMO) n=725	The mean duration of VA ECMO was 7.1 days (range 0 to 39). Multivariate logistic regression showed that prolonged duration of VA ECMO therapy (4 to 7 days: adjusted rate 54%, OR 0.28, 95% CI 0.18 to 0.44; 8 to 10 days: adjusted rate 61%, OR 0.51, 95% CI 0.29 to 0.87; and more than 10 days: adjusted rate 59%, OR 0.49, 95% CI 0.31 to 0.81) was associated with lower risk of mortality compared with VA ECMO lasting 3 days or less (adjusted rate 78%). Patients needing VA ECMO therapy for 8 to 10 days (OR 1.96, 95% CI 1.15 to 3.33) and more than 10 days (OR 1.85, 95% CI 1.14 to 3.02) had statistically significantly higher mortality	Study focuses on association between duration of VA ECMO and mortality.

		compared with those on VA ECMO for 4 to 7 days.	
Mariscalco G, Salsano A, Fiore A et al. (2020) Peripheral versus central extracorporeal membrane oxygenation for postcardiotomy shock: Multicenter registry, systematic review, and meta-analysis. Journal of Thoracic and Cardiovascular Surgery 160: 1207-1216.e44	Registry data and systematic review and meta-analysis n=781 (registry) n=2,491 (systematic review)	Pooled prevalence of in-hospital and 30-day mortality in overall patient population was 67% (95% CI 64.7 to 68.4%), and pooled unadjusted risk ratio analysis confirmed that people having peripheral VA ECMO had a lower in-hospital and 30-day mortality than those who had central cannulation (risk ratio, 0.92; 95% CI 0.87 to 0.98).	Study focuses on cannulation strategy.
Menon PR, Flo Forner A, Marin-Cuartas M et al. (2021) 30-Day perioperative mortality following venoarterial extracorporeal membrane oxygenation for postcardiotomy cardiogenic shock in patients with normal preoperative ejection fraction. Interactive Cardiovascular and Thoracic Surgery 32: 817-824	Retrospective single-centre cohort study n=173 Follow-up=30 days	71 (41%) people presented PCCS caused by coronary malperfusion and in 102 (59%) no evident cause was found for PCCS. Median duration of VA ECMO support was 5 days. 135 (78%) people presented VA ECMO related complications, and the overall 30-day perioperative mortality was 58%. Independent predictors of mortality were lactate level just before VA ECMO implantation (OR 1.27; p<0.001), major bleeding during VA ECMO (OR 3.76; p=0.001), prolonged cardiopulmonary bypass time (OR 1.01; p<0.001) and female gender (OR 4.87; p<0.001).	Small study, focusing on outcomes in people with normal preoperative ejection fraction.

Melehy A, Ning Y, Kurlansky P et al. (2022) Bleeding and thrombotic events during extracorporeal membrane oxygenation for postcardiotomy shock. The Annals of Thoracic Surgery 113(1): 131-137	Single centre retrospective study, USA n=141 Follow-up: In-hospital	Of the 152 patients who received ECMO for postcardiotomy shock, 33 (23%) had 40 thrombotic events and 64 (45%) had 86 bleeding events.	Studies with more relevant outcomes were included.
Mihu MR, El Banayosy AM, Harper MD et al. (2024) Comparing outcomes of post-cardiotomy cardiogenic shock patients: on-site cannulation vs. retrieval for V-A ECMO support. Journal of Clinical Medicine 13(11): 3265	Single centre retrospective study, USA n=121 Follow-up: In-hospital	The overall mortality rate was 52%. Of the patients who died (n=63), 50 experienced on-ECMO mortalities, and 13 had post-weaning mortalities. The ECLS weaning rate was 55% (n=34) in the retrieved group and 63% (n=37) in the on-site group (p=0.38).	Outcomes not reported as overall population, but by subgroup: cannulation on or off site.
Papadopoulos N, Marinos S, El-Sayed Ahmad A et al. (2015) Risk factors associated with adverse outcome following extracorporeal life support: Analysis from 360 consecutive patients. Perfusion 30(4): 284-290	Single centre retrospective study, Germany n=360 Follow-up: In-hospital, 5 years	ECLS weaning was successful in 58% and 30% could be discharged from hospital. The main cause of death was sepsis (69%). Overall, major cerebrovascular events occurred in 12% (bleeding 3%, embolic 9%), limb ischaemia in 13%, GI complications in 16% and RRT in 61%. Kaplan Meier estimates for long-term survival were 26% at one year and 22% at 5 years.	Included in Kowalewski (2020), Biancari (2018), Alba (2021) SLRs.
Provaznik Z, Philipp A, Zeman F et al. (2021) Extracorporeal life support in postcardiotomy cardiogenic shock: a view on scenario, outcome,	Single centre retrospective study, Germany n=261	Overall mortality on ECLS was 39%. Overall follow-up survival was 24%.	Larger studies with longer follow-up included.

and risk factors in 261 patients. The Thoracic and Cardiovascular Surgeon 69(3): 271-278	Follow-up: median 3.2 years		
Qi J, Yan W, Liu G et al. (2023) Evaluation of Acute Kidney Injury in Postcardiotomy Cardiogenic Shock Patients Supported by Extracorporeal Membrane Oxygenation. Reviews in Cardiovascular Medicine 24: a36	Retrospective single-centre observational study n=136	The incidence of acute kidney injury (AKI) 3 or higher was 59%. People with AKI 3 or higher needed significantly longer mechanical ventilation and hospital stay. Intraoperative implantation VA ECMO was associated with a decreased incidence of AKI 3 or higher.	Small study, focusing on acute kidney injury.
Radwan M, Baghdadi K, Popov AF et al. (2023) Right Axillary Artery Cannulation for Veno-Arterial Extracorporeal Membrane Oxygenation in Postcardiotomy Patients: A Single-Center Experience. Medicina 59 (no. 11)	Retrospective single-centre observational study n=179 Follow-up=1 year	Successful weaning=49% In-hospital survival=35% 46 (26%) people were alive after 1-year follow-up. In people with acute LV dysfunction after cardiothoracic surgery who cannot be weaned from cardiopulmonary bypass, right axillary artery cannulation is a safe and reliable method for VA ECMO support with an acceptable complication rate.	Small study, focusing on right axillary artery cannulation for VA ECMO.
Raffa GM, Kowalewski M, Brodie D, Ogino M et al. (2019) Meta-Analysis of Peripheral or Central Extracorporeal Membrane Oxygenation in Postcardiotomy and Non-Postcardiotomy Shock.	Systematic review and meta-analysis n=1,691 (17 studies)	The peripheral approach was more commonly used (58%) than the central one. There was no difference in the analysis between the 2 techniques regarding all-cause mortality RR	More recent systematic reviews are included.

The Annals of Thoracic Surgery 107: 311-321		(1.00, 95% CI 0.94 to 1.08, I^2=0%, p=0.92). Peripheral cannulation was associated with a statistically significant reduction in the risk of bleeding (p=0.02), continuous venovenous hemofiltration (p=0.03), transfusion of red blood cells units (p<0.00001), fresh frozen plasma units (p=0.0002), and platelet units (p<0.00001).	
Saha A, Kurlansky P, Ning Y et al. (2021) Early venoarterial extracorporeal membrane oxygenation improves outcomes in post-cardiotomy shock. Journal of Artificial Organs 24: 7-14	Retrospective cohort n=156	Overall, outcomes of ECMO for post-cardiotomy shock improved over the study period. The survival benefit appears to be associated with earlier ECMO initiation before prolonged hypoperfusion occurs.	Studies with more people or longer follow-up are included.
Sahli SD, Kaserer A, Braun J et al. (2022) Predictors associated with mortality of extracorporeal life support therapy for acute heart failure: single-center experience with 679 patients. Journal of Thoracic Disease 14(6): 1960-1971	Single centre retrospective study, Switzerland n=679 (postcardiotomy n=215) Follow-up: In-hospital	In-hospital mortality significantly varied between ECLS indications: 71% (152/215) for postcardiotomy, 68% (108/159) for cardiopulmonary resuscitation, 47% (110/234) for refractory cardiogenic shock, and 10% (7/71) for lung transplantation and expansive thoracic surgery (p<0.001).	Larger studies split by cardiogenic shock aetiology were included.
Schaefer A-K, Latus M, Riebandt J et al. (2023) Bleeding and thrombotic events in post-cardiotomy	Retrospective single-centre cohort	196 people (39%) had 235 bleeding events. Overall mortality was higher in people with	Retrospective study focused on bleeding and

extracorporeal life support. European Journal of Cardio-thoracic Surgery 63 (no. 4)	n=504	major bleeding complications than in those without bleeding complications (p<0.0001). 246 people (49%) had at least 1 haemocompatibility-related adverse event.	thrombotic events.
Schaefer A-K, Distelmaier K, Riebandt J et al. (2022) Access site complications of postcardiotomy extracorporeal life support. The Journal of Thoracic and Cardiovascular Surgery 164: 1546-1558e8	Retrospective single-centre cohort n=436	Although survival did not differ, surgeons should be aware of access-site-specific complications when choosing peripheral PC-ECLS access. Although lower rates of limb ischaemia and the advantage of antegrade flow seem beneficial for axillary cannulation, the high incidence of right hemispheric strokes in axillary artery cannulation should be considered.	Retrospective study focused on assessing the influence of primary arterial access.
Schaefer A-K, Riebandt J, Bernardi MH et al. (2022) Fate of patients weaned from post-cardiotomy extracorporeal life support. European Journal of Cardio-thoracic Surgery 61: 1178-1185	Retrospective single-centre cohort n=478	358 patients were successfully separated from ECLS and survived for more than 24 hours (352 weaned from ECLS, 3 transitioned to durable left ventricular assist device and 3 transitioned to a heart transplant). A total of 36% of patients who were successfully weaned from ECLS did not survive until hospital discharge. In-hospital deaths of the whole cohort were 52%. For those who survived to discharge (n=231), survival was	Retrospective study focused on the outcomes for people who were weaned from post-cardiotomy ECLS.

		87% after 1 year and 69% after 5 years. Longer ECLS duration, older age, female gender and lower preoperative glomerular filtration rate were independently associated with in-hospital death after successful ECLS weaning.	
Shao J, Shao C, Wang Y et al. (2023) The low hemoglobin levels were associated with mortality in post-cardiotomy patients undergoing venoarterial extracorporeal membrane oxygenation Perfusion DOI: 10.1177/ 02676591231193987	Retrospective cohort n=116	Survival=45%. Those who survived were younger than those who died (58 versus 63, p=0.023). Low haemoglobin levels at day 1 were independently associated with in-hospital mortality.	Small retrospective study focusing on the impact of low haemoglobin levels.
Shao C, Wang L, Yang F et al. (2022) Quality of life and mid-term survival in patients receiving extracorporeal membrane oxygenation after cardiac surgery. ASAIO Journal 68(3): 349-355	Single centre retrospective study, China n=102 Follow-up: 5 years	The SF-36 scores in general health and vitality were significantly lower among the ECMO survivors ($p<0.05$). After discharge, ECMO versus non-ECMO survival (93% versus 82%; p=0.013).	Studies with more relevant outcomes were included.
Tantway TM, Arafat AA, Albabtain MA et al. (2023) Sepsis in postcardiotomy cardiogenic shock patients supported with veno- arterial extracorporeal membrane oxygenation.	Retrospective single-centre cohort n=103	High body mass index and CABG were associated with sepsis. Preoperative dialysis and IABP predicted sepsis. Patients with ECMO-associated sepsis tended to have a higher blood transfusion after surgery, with a trend of	Small retrospective study assessing predictors of sepsis and its effect on outcomes after ECMO.

The International Journal of Artificial Organs 46: 153-161		a higher rate of re-exploration.	
Terrazas JA, Stadlbauer AC, Li J et al. (2024) Age-Related Quality of Life in Cardiac Surgical Patients with Extracorporeal Life Support. The Thoracic and Cardiovascular Surgeon 72: 530–38	Retrospective cohort n=200 (113 in younger group aged 70 or less and 87 older than 70) Follow-up: at least 6 months	Overall survival-to-discharge was 32% (n=63), with better survival in the younger group (young=39%; old=22%, p=0.01). 42 people (66%) responded to the QoL survey after a median follow-up of 4.3 years. Older people reported more problems with mobility (young=52%; old=88%, p=0.02) and self-care (young=24%; old=76%, p=0.01). However, the self-rated health status using the Visual Analogue Scale showed no differences (70% for both, p=0.38). Likewise, the comparison with an age-adjusted German reference population showed similar QoL indices.	Studies with more people or longer follow-up are included.
Tian X, Wang L, Li C et al. (2024) Combining the vasoactive-inotropic score with lactate levels to predict mortality in post-cardiotomy patients supported with venoarterial extracorporeal membrane oxygenation. European Journal of Cardio-thoracic Surgery 66 (no. 3)	Retrospective single centre cohort n=222	139 people (62%) were weaned from VA ECMO, and 104 (47%) survived to hospital discharge. Among patients with PCS needing VA ECMO, the initiation before reaching a vasoactive-inotropic score (VIS) above 24.3 and lactate levels higher than 6.85 mmol/litre was associated with improved in-hospital and 30-day outcomes,	Small retrospective study determining the predictive role of the combined assessment of the vasoactive-inotropic score (VIS) and lactate levels.

		suggesting that the combined assessment of the VIS and lactate levels may be instructive for determining the initiation of VA ECMO.	
Toivonen F, Biancari F, Dalen M et al. (2021) Neurologic Injury in Patients Treated With Extracorporeal Membrane Oxygenation for Postcardiotomy Cardiogenic Shock. Journal of Cardiothoracic and Vascular Anesthesia 35: 2669-2680	Retrospective multicentre registry (PC-ECMO) n=781	Overall, neurological injury occurred in 19% of people in the overall series, but the proportion ranged from 0% to 65% among the centres. Ischaemic stroke occurred in 84 people and haemorrhagic stroke in 47 people. Emergency procedure was the sole independent predictor of neurological injury. In-hospital mortality was higher in those with neurological injury than those without (79% versus 61%, p<0.001). The 1-year survival was lower in the neurological injury group (17% versus 37%). Long-term survival did not differ between people with ischaemic stroke and those with haemorrhagic stroke.	Main outcomes from the registry are included in a separate paper (Biancari 2020).
Xie H, Yang F, Hou D et al. (2020) Risk factors of in-hospital mortality in adult postcardiotomy cardiogenic shock patients successfully weaned from venoarterial extracorporeal membrane oxygenation. Perfusion 35(5): 417-426	Single centre retrospective study, China n=363 Follow-up: In-hospital	In total, 212 (58%) of 363 postcardiotomy cardiogenic shock patients were successfully weaned from venoarterial extracorporeal membrane oxygenation.	Studies with more relevant outcomes and larger studies with longer follow-up were included.

Yang F, Hou D, Wang J et al. (2018) Vascular complications in adult postcardiotomy cardiogenic shock patients receiving venoarterial extracorporeal membrane oxygenation. Annals of Intensive Care 8: 72	Prospective single centre study n=432 Follow-up: to discharge	252 people (58%) were weaned off VA ECMO and 153 (35%) survived to discharge. Major vascular complications were seen in 72 patients (17%), including bleeding or haematoma in the cannulation site (9%), limb ischaemia needing fasciotomy (9%), femoral artery embolism (1%), and retroperitoneal bleeding (1%). The rate of survival to discharge was 17% and 39% in people with or without major vascular complications, respectively (p<0.001).	Studies with more people or longer follow-up are included.
Zhigalov K, Sa MPBO, Safonov D et al. (2020) Clinical outcomes of venoarterial extracorporeal life support in 462 patients: Single-center experience. Artificial Organs 44(6): 620-627	Single centre retrospective study, Germany n=462 (postcardiotomy n=357) Follow-up: In-hospital	Overall, the in-hospital survival rate was 26%. There was no statistically significant difference between the groups: 26% for PCS and 25% for non-PCS, respectively. Weaning from VA-ECLS was possible in 44% for PCS and in 30% for non-PCS (p=0.004).	Larger studies split by CS aetiology were included.