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MAIN TEXT

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Post-cardiotomy extracorporeal life support: A cohort of cannulation in the general ward

Gabor Bari[1,2] | Silvia Mariani[2,3] | Bas C. T. van Bussel[2] | Justine Ravaux[2] | Michele Di Mauro[2] | Anne Schaefer[4] | Jawad Khalil[5] | Matteo Pozzi[6] | Luca Botta[7] | Davide Pacini[7] | Udo Boeken[8] | Robertas Samalavicius[9] | Karl Bounader[10] | Xiaotong Hou[11] | Jeroen J. H. Bunge[12] | Hergen Buscher[13] | Leonardo Salazar[14] | Bart Meyns[15] | Michael Mazeffi[16] | Sacha Matteucci[17] | Sandro Sponga[18] | Graeme MacLaren[19] | Claudio Russo[20] | Francesco Formica[3,21] | Pranya Sakiyalak[22] | Antonio Fiore[23] | Daniele Camboni[24] | Giuseppe Maria Raffa[25] | Rodrigo Diaz[26] | I-wen Wang[27] | Jae-Seung Jung[28] | Jan Belohlavek[29] | Vin Pellegrino[30] | Giacomo Bianchi[31] | Matteo Pettinari[32] | Alessandro Barbone[33] | José P. Garcia[34] | Kiran Shekar[35] | Glenn Whitman[36] | Roberto Lorusso[2] | the PELS Investigators

Correspondence
Gabor Bari, Clinic of Internal Medicine, Department of Cardiac Surgery, University of Szeged, Semmelweis str. 8., Szeged 6726, Hungary.
Email: drbarigabor@gmail.com

Abstract

Objectives: Post-cardiotomy extracorporeal life support (ECLS) cannulation might occur in a general post-operative ward due to emergent conditions. Its characteristics have been poorly reported and investigated This study investigates the characteristics and outcomes of adult patients receiving ECLS cannulation in a general post-operative cardiac ward.

Methods: The Post-cardiotomy Extracorporeal Life Support (PELS) is a retrospective (2000–2020), multicenter (34 centers), observational study including adult patients who required ECLS for post-cardiotomy shock. This PELS sub-analysis analyzed patients´ characteristics, in-hospital outcomes, and long-term survival in patients cannulated for veno-arterial ECLS in the general ward, and further compared in-hospital survivors and non-survivors.

Results: The PELS study included 2058 patients of whom 39 (1.9%) were cannulated in the general ward. Most patients underwent isolated coronary bypass grafting (CABG, $n=15$, 38.5%) or isolated non-CABG operations ($n=20$, 51.3%).

Complete affiliations and list of all PELS Investigators in Supplemental Materials.

Gabor Bari and Silvia Mariani contributed equally.

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For affiliations refer to page 9.

The main indications to initiate ECLS included cardiac arrest (n = 17, 44.7%) and cardiogenic shock (n = 14, 35.9%). ECLS cannulation occurred after a median time of 4 (2–7) days post-operatively. Most patients' courses were complicated by acute kidney injury (n = 23, 59%), arrhythmias (n = 19, 48.7%), and postoperative bleeding (n = 20, 51.3%). In-hospital mortality was 84.6% (n = 33) with persistent heart failure (n = 11, 28.2%) as the most common cause of death. No peculiar differences were observed between in-hospital survivors and nonsurvivors.

Conclusions: This study demonstrates that ECLS cannulation due to post-cardiotomy emergent adverse events in the general ward is rare, mainly occurring in preoperative low-risk patients and after a postoperative cardiac arrest. High complication rates and low in-hospital survival require further investigations to identify patients at risk for such a complication, optimize resources, enhance intervention, and improve outcomes.

KEYWORDS

cardiac arrest, cardiac surgery, complications, extracorporeal life support, shock, ward

1 | INTRODUCTION

Postcardiotomy extracorporeal life support (PC–ECLS) is usually used in cardiac surgery patients after unsuccessful weaning from cardiopulmonary bypass (CPB) or in the postoperative period to restore and maintain compromised end-organ perfusion.[1] PC–ECLS is most often deployed in the operating theater or the intensive care unit (ICU).[2] Nevertheless, rapid development of postoperative cardiogenic shock or cardiac arrest may demand emergent cannulation and PC–ECLS start even in the general ward. For example, in case of cardiac arrest, despite emergency re-sternotomy and cardiopulmonary resuscitation, ECLS implantation might be required in the normal ward.[3–5] Such events, however, demand a high expertise in the management of cardiac emergencies through ECLS, like a dedicated team able to reach the patient in a few minutes, a stand-by ECLS machine with an available circuit, and professionals trained to cannulate a patient in an unfavorable setting.[6] Indeed, normal wards are usually not equipped with invasive monitoring systems and, sometimes, not even with re-sternotomy surgical kits or sterile sets to be used in the cannulation process. Moreover, spaces are usually tighter than those of an ICU, and the logistics are more complicated. All these limitations may influence the success of ECLS application in such an environment and conditions.

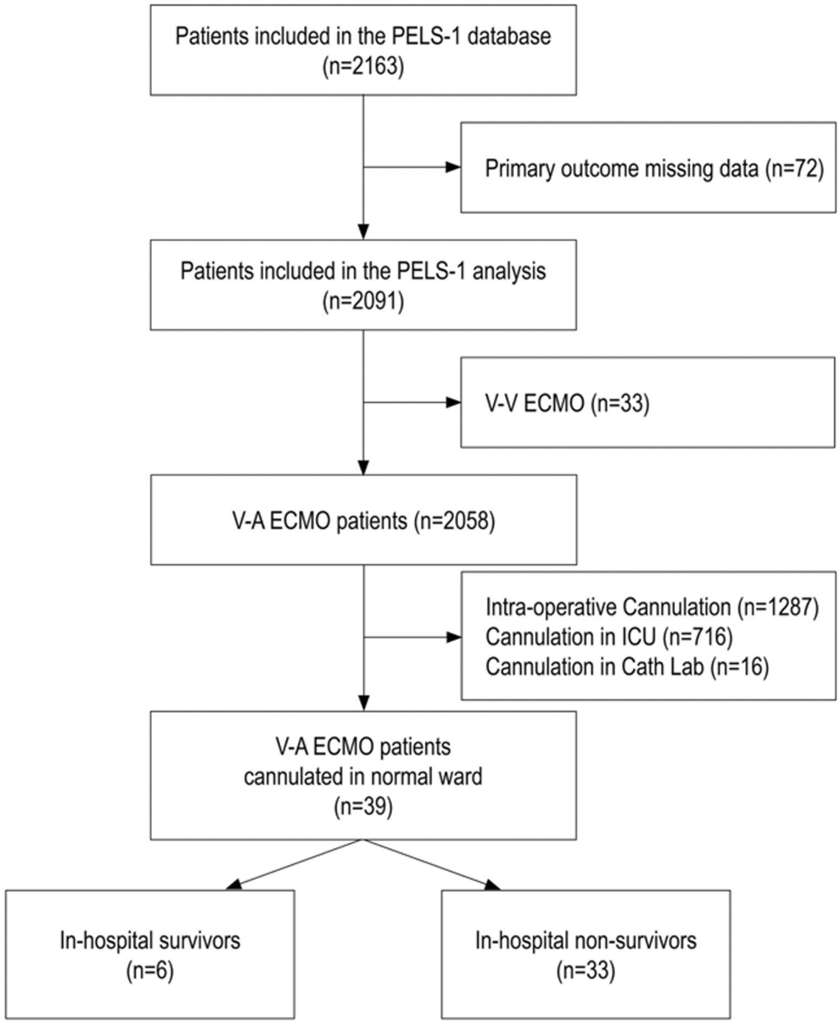
While results of PC–ECLS for in-hospital cardiac arrest or shock have been recently described,[7–9] little is known about the outcomes of PC–ECLS application in a normal ward to support patients experiencing post-cardiotomy complications. It can be hypothesized that the unfavorable setting of a normal ward might lead to worse outcomes compared to the typical post-cardiotomy ECLS cases or the noncardiac surgery patients requiring ECLS outside the ICU. Therefore, this study sough to describe the clinical characteristics and outcomes of patients who received ECLS cannulation in the normal ward based on a multicenter, international database specifically addressing PC–ECLS application. A further analysis investigated the features of in-hospital survivors and non-survivors within this patients' group.

2 | METHODS

This analysis included patients selected from the PELS (Postcardiotomy Extracorporeal Life Support) database, which was built from a multicenter (34 centers, 16 countries), retrospective observational study that enrolled patients supported with ECLS after cardiac surgery (ClinicalTrials.gov:NCT03857217).[6–9] For the present analysis, characteristics and outcomes of patients receiving a veno-arterial ECLS implantation in the general ward was investigated (Figure 1).

The study was conducted in accordance with the Declaration of Helsinki. Institutional Review Board was acquired at the coordinating center (MUMC+, METC-2018-0788) and in all participant hospitals. Data were collected centrally according to data-sharing agreements. The need for informed consent was waived due to the observational character of the registry, the emergency of the performed procedure, and the de-identification of shared data.

FIGURE 1 Patient flow-chart.



2.1 | Data collection and outcomes

Demographics, preoperative variables, procedural characteristics, ECLS details, and outcomes were collected according to a pre-defined protocol, with specific variable definitions, as extensively described elsewhere.[2,8–10] The primary outcome of interest was all-cause in-hospital mortality. Secondary outcomes included in-hospital complications and mortality at follow-up for in-hospital survivors.

2.2 | Statistical analysis

Data were merged and analyzed using SPSS 26.0 (IBM, New York, USA), and R 4.1.2 (R Foundation for Statistical Computing, Vienna, Austria).

The total cohort was investigated, and a subsequent analysis was conducted to compare in-hospital survivors and non-survivors. Demographic and clinical variables were expressed as numbers (valid percent on available data, excluding missing values) for categorical variables and median (IQR, interquartile range) for continuous variables after evaluation of normality. Categorical data were compared between groups with Pearson's Chi-Square or Fisher's exact test, as appropriate. Continuous variables were analyzed using the Mann–Whitney *U* test. Stacked bar plots were done to represent the distributions of levels within each categorical variable to compare them between study groups. Survival was investigated with the Kaplan–Meier method. A two-sided *p*-value of <0.05 was considered statistically significant.

3 | RESULTS

3.1 | Baseline, surgical, and ECLS characteristics

Out of the 2058 patients who received a veno-arterial PC–ECLS within the PELS study, 39 (1.9%) were cannulated in the general ward and were included in the current analysis (Figure 1). Their geographical distribution comprised 11 hospitals and 9 countries. The population included 14 (35.9%) females and 25 (64.1%) males with a median age of 66 years (IQR:52–72 years). The most common comorbidities were hypertension (n=32, 82.1%), diabetes mellitus (n=18, 46.2%), previous myocardial infarction (n=12, 30.8%) and peripheral artery disease (n=9, 23.1%, Table 1). Frequent pre-operative diagnoses included coronary artery disease (n=22, 56.4%), aortic valve disease (n=15, 38.5%), and mitral valve disease (n=8, 20.5%). Urgent and emergency surgery were performed in 9 (23.1%) and 7 (17.9%) patients, respectively.

The studied patients most commonly underwent isolated non-CABG operations in 20 (51.3%) patients followed by coronary artery bypass grafting, either associated with other procedures or as isolated procedure (n=15, 38.5%). Aortic valve (n=15, 38.5%) and mitral valve (n=7, 17.9%) operations were also common (Table 2).

Cannulation occurred at a median time of 4[2–7] days after surgery in both survivors (median: 4, IQR:1–15 days) and non-survivors (median:4, IQR:2–7 days). Indication for PC-ECLS start in the general ward (Figure 2), included mainly cardiac arrest (n=17, 44.7%) and cardiogenic shock (n=14, 35.9%). Nine (26.5%) patients underwent central aortic cannulation, but most patients were cannulated at the femoral site (n=21, 61.8%). Data on chest status were lacking in 17 patients (43.6%), but chest was left open in 11 (50.0%) of patients with available data (n=22). Left ventricle unloading strategy was used in 9 (33.3%) patients. The median duration of the ECLS runs was 110 (21.3–190.5) hours (Table 3).

3.2 | In-hospital outcomes and follow-up survival

Patients who were cannulated in the general ward, mostly suffered acute kidney injury (n=23, 59%), arrhythmias (n=19, 48.7%), and postoperative bleeding (n=20, 51.3%), 11 (28.2%) of whom required re-thoracotomy (Table 4). In-hospital mortality was 84.6% (n=33), with 17 (43.6%) patients deceased on ECLS and 16 (41.0%) patients deceased after ECLS weaning (Figure 3). Persistent heart failure (n=11, 28.2%) was the most common cause of death in these patients.

No specific differences were observed between in-hospital survivors and nonsurvivors. Overall survival at follow-up was 11.1% (n=4, Figure 4) with one more patient who died after discharge and one patient lost to follow-up.

4 | DISCUSSION

To our knowledge, this is the first study specifically addressing PC–ECLS initiation after cardiac surgery in the general ward. This study demonstrates that PC–ECLS cannulation in the general ward is possible while characterized by a dismal prognosis compared to the reported mortality for the PC–ELCS population overall. This study has five main findings. First, patients with ECLS cannulated in the general ward represent 2% of the overall PC–ECLS population. This is substantial and indicates that more attention to cannulation in the general ward is needed in the field of PC–ECLS. Second, most of these events happen in patients typically classified as preoperative low-risk patients who underwent isolated non-CABG (51%) or isolated CABG (39%) operations. Third, most PC–ECLS cannulations in the general ward occur for cardiac arrest (45%) or cardiogenic shock (36%) 4 days after surgery. Fourth, up to 60% of patients received a peripheral cannulation, and 14% of patients underwent ECLS without anticoagulation. Fifth, acute kidney injury (n=23, 59%), bleeding and arrhythmias occurred in 59%, 51%, and 49% of patients with an overall in-hospital mortality of 85%.

PC–ECLS is a term that comprises a huge variety of clinical situations, from intra-operative cannulation for CPB weaning failure to rescue cannulation for a cardiac arrest days after surgery. All these different clinical pictures are characterized by specific patients' profiles and outcomes.[8] It is, thus, necessary to differentiate each of these entities, to adequately address outcomes, to interpret results and related details, and set-up focused therapeutic strategies to prevent or lower complications and ultimate patient outcomes.

ECLS cannulation in the general ward is one of the multiple facets of the PC-ECLS. Typically, and in contrast to other ECLS, cannulation in the general ward is performed in hostile emergency conditions and in unfavorable settings where the facilities of an operating theater or of an intensive care environment are not available and with several other shortcomings (untrained personnel, lack of specific instruments, etc). Based on the intrinsic difficulties of this practice, cannulation in the general ward is not performed routinely in all cardiac surgery centers or, most likely, not reported. Nevertheless, this study showed that 2% of all PC–ECLS included in the PELS study were initiated in the general ward. Moreover, these cases were performed in 11 hospitals and 9 countries, indicating that this practice was not clustered in few centers only.

Notwithstanding, PC–ECLS in general ward was not required for patients with highly complex preoperative characteristics but for patients who received isolated CABG or isolated non-CABG procedures. Our data showed that the median EuroSCORE II value of the included patients was 4.4, which can be considered a low margin value of the intermediate-risk patients (4%–8%).[11] As previously demonstrated, complex

TABLE 1 Preoperative characteristics.

	Overall population (*n* = 39)	Survivors (*n* = 6)	Non-survivors (*n* = 33)	*p*-value
Age (years)	66 (52–72)	68.77 (36–75.1)	66 (53–70)	0.835
Sex				0.434
Female	14 (35.9%)	3 (50%)	11 (33.3%)	
Male	25 (64.1%)	3 (50%)	22 (66.7%)	
Body mass index (kg/m^2)	26 (24.2–29.7)	27 (24.2–30.5)	26 (24.1–29.7)	0.106
Comorbidities				
Hypertension	32 (82.1%)	6 (100%)	26 (78.8%)	0.213
Dialysis	8 (20.5%)	2 (33.3%)	6 (18.2%)	0.398
Previous myocardial infarction	12 (30.8%)	2 (33.3%)	10 (30.3%)	0.882
Myocardial infarction (last 30 days)	6 (15.4%)	0 (0%)	6 (18.2%)	0.256
Smoking	7 (17.9%)	1 (16.7%)	6 (18.2%)	0.929
Previous stroke	5 (12.8%)	2 (33.3%)	3 (9.1%)	0.102
Atrial fibrillation	3 (7.7%)	1 (16.7%)	2 (6.1%)	0.370
Diabetes mellitus	18 (46.2%)	2 (33.3%)	16 (48.5%)	0.493
Implanted cardioverter defibrillator	1 (2.6%)	0 (0%)	1 (3%)	0.666
Previous percutaneous coronary intervention	6 (15.4%)	0 (0%)	6 (18.2%)	0.256
Chronic obstructive pulmonary disease	2 (5.1%)	0 (0%)	2 (6.1%)	0.536
Peripheral artery disease	9 (23.1%)	2 (33.3%)	7 (21.2%)	0.517
Pulmonary hypertension (>50 mm Hg)	4 (10.3%)	1 (16.7%)	3 (9.1%)	0.574
Previous cardiac surgery	6 (15.4%)	3 (50%)	3 (9.1%)	0.036
Left ventricular ejection fraction (%)	51 (40–60)	55 (45–61)	50 (40–58)	0.501
Euroscore II	4 (3.2–13.1)	13 (2.4–14.7)	4 (3.2–12.3)	0.723
Preoperative condition				
NYHA class				0.353
Class I	2 (5.3%)	0 (0%)	2 (6.3%)	
Class II	11 (28.9%)	3 (50%)	8 (25%)	
Class III	16 (42.1%)	3 (50%)	13 (40.6%)	
Class IV	9 (23.7%)	0 (0%)	9 (28.1%)	
Preoperative cardiogenic shock	7 (17.9%)	0 (0%)	7 (21.2%)	0.213
Preoperative intubation	2 (5.1%)	0 (0%)	2 (6.1%)	0.536
Preoperative vasopressors	5 (12.8%)	2 (33.3%)	3 (9.1%)	0.102
Emergency surgery	7 (17.9%)	0 (0%)	7 (21.2%)	0.213
Urgent surgery	9 (23.1%)	3 (50%)	6 (18.2%)	0.089
Diagnosis				
Coronary artery disease	22 (56.4%)	2 (33.3%)	20 (60.6%)	0.215
Aortic vessel disease	5 (12.8%)	1 (16.7%)	4 (12.1%)	0.759
Aortic valve disease	15 (38.5%)	3 (50%)	12 (36.4%)	0.528
Mitral valve disease	8 (20.5%)	3 (50%)	5 (15.2%)	0.052
Tricuspid valve disease	7 (17.9%)	3 (50%)	4 (12.1%)	0.059

Note: Data are reported as *n* (% as valid percentage excluding missing values) or median (interquartile range).

Abbreviation: NYHA, New York Heart Association.

patients preferentially receive PC–ECLS cannulation intra-operatively with good outcomes, while patients who undergo easier operations more often experience an unexpected complication requiring ECLS after surgery.[2] Thus, a level of vigilance and preparing the environment for such catastrophic events is necessary even

TABLE 2 Procedural characteristics.

	Overall population ($n=39$)	Survivors ($n=6$)	Nonsurvivors ($n=33$)	*p*-value
Weight of surgery				0.081
Isolated CABG	15 (38.5%)	0 (0%)	15 (45.5%)	
Isolated non-CABG	20 (51.3%)	6 (100%)	14 (42.4%)	
2 procedures	1 (2.6%)	0 (0%)	1 (3%)	
2 or more procedures	3 (7.7%)	0 (0%)	3 (9.1%)	
Aortic valve surgery	15 (38.5%)	3 (50%)	12 (36.4%)	0.528
Mitral valve surgery	7 (17.9%)	3 (50%)	4 (12.1%)	0.059
Tricuspid valve surgery	3 (7.7%)	1 (16.7%)	2 (6.1%)	0.370
Aortic surgery	6 (15.4%)	1 (16.7%)	5 (15.2%)	0.925
Pulmonary endoarterecty	1 (0%)	0 (0%)	1 (3%)	0.666
Heart transplantation	3 (7.7%)	0 (0%)	3 (9.1%)	0.442
Off-pump surgery	4 (10.3%)	0 (0%)	4 (12.1%)	0.368
Cardiopulmonary bypass time (min)	124 (94–233)	173 (109–264)	123 (92–233)	0.479
Cross clamp time (min)	80 (59–117)	90 (84–151)	77 (58–117)	0.348

Note: Data are reported as *n* (% as valid percentage excluding missing values) or median (interquartile range).

Abbreviation: CABG, coronary artery bypass graft.

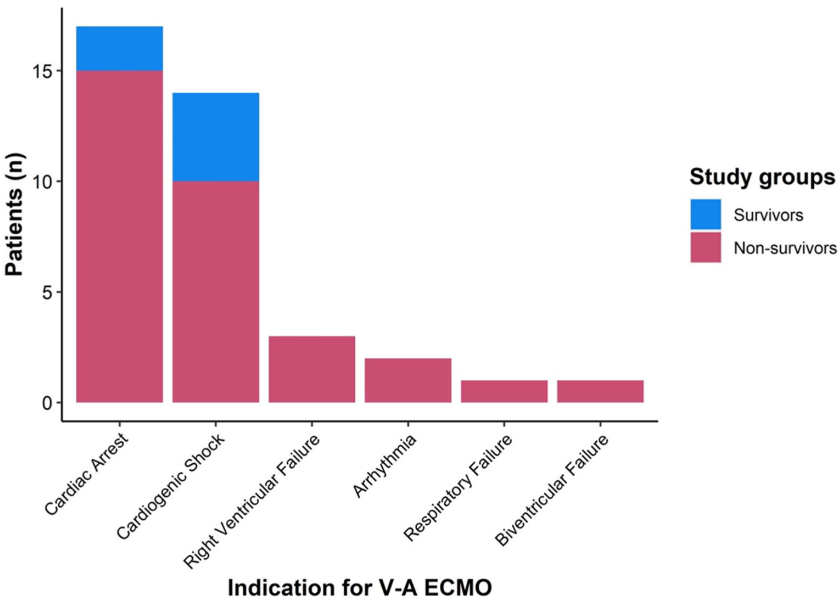


FIGURE 2 Indications for ECLS. Bar charts representing the number of patients cannulated for ECLS with different indications and their survival status.

in low-risk patients. Every sign of hemodynamic instability should be carefully evaluated to identify those patients who might necessitate unexpected and sudden hemodynamic deterioration with urgent/emergent PC–ECLS needs and activate adequate countermeasures even when the patient is already in the general ward, days after surgery.

The evidence discussed above suggests that each cardiac surgery center providing PC-ECLS should advisably be prepared to alert the ECLS team and have access to transportable as well as application of ECLS-based equipment for the event of cannulation outside the operating theater or ICU. The organization of a dedicated team able to perform PC–ECLS initiation elsewhere in the hospital should follow the guidelines for the management of emergencies after cardiac surgery[1,4,5] and extracorporeal cardiopulmonary resuscitation (ECPR).[3,12] These guidelines could help to deliver ECLS in difficult situations and manage postoperative cardiac arrest, which is the main indication for PC–ECLS in general ward, followed by cardiogenic shock. Cardiac surgery patients represent less than 10% of all in-hospital cardiac arrest cases, but they represent almost 50% of those cases approached with ECPR.[7,13] Moreover, cardiac surgical patients are 24 times more likely to be treated with ECPR compared to other patients.[13] However, when observing how patients

TABLE 3 Details on extracorporeal life support.

	Overall population ($n=39$)	Survivors ($n=6$)	Non-survivors ($n=33$)	*p*-value
Chest status				1.000
Chest closed	11 (50%)	1 (50%)	10 (50%)	
Chest open	11 (50%)	1 (50%)	10 (50%)	
Arterial cannulation				0.063
Aorta	9 (26.5%)	0 (0%)	9 (31.0%)	
Subclavian artery	4 (11.8%)	2 (40%)	2 (6.9%)	
Femoral artery	21 (61.8%)	3 (60%)	18 (62.1%)	
Distal femoral perfusion	12 (57.1%)	1 (50%)	11 (57.9%)	1.000
Left ventricular unloading	9 (33.3%)	1 (25%)	8 (34.8%)	0.702
Anticoagulation				
None	5 (13.9%)	1 (16.7%)	4 (13.3%)	0.805
Heparin	31 (86.1%)	5 (83.3%)	26 (86.7%)	0.829
ECMO duration (hours)	110 (21.3–190.5)	121 (84–156.8)	99 (13.5–216)	0.594

Note: Data are reported as *n* (% as valid percentage excluding missing values) or median (interquartile range).
Abbreviations: ECMO, extracorporeal membrane oxygenation; LV, left ventricular; VA, veno-arterial; VV, veno-venous.

are treated for in-hospital cardiac arrest based on their location, those who arrest in the general inpatient environment are more likely treated with conventional cardiopulmonary resuscitation.[13] A peculiarity of the treatment algorithm for post-cardiotomy arrest is the inclusion of emergency re-sternotomy that should occur within 5 min to facilitate internal cardiac massage or defibrillation.[4,5,12] This occurs in up to 50% of postoperative cardiac arrests or in 2.7% of all patients undergoing cardiac surgery.[4,12] Our data shows that, for all these reasons, a ready-to-use re-sternotomy kit should be available in each cardiac surgery ward. Re-sternotomy also offers the chance to perform a central cannulation or solve a hemodynamically compromising pericardial effusion. However, the current study showed that cannulation of the aorta was performed in a quarter of the included patients, while the femoral artery was the chosen approach in 62% of patients and 80% (data not shown) of cardiac arrests. This finding might be explained by the need of continuing the chest compression as advanced life support while the surgeons perform the peripheral cannulation for ECLS initiation. Moreover, the chest was left open in about 50% of cases, and a major percentage of patients did not receive any anticoagulation. None of these practices showed clear advantages in terms of survival. However, they indicate the high complexity of these patients when compared to the general PC–ECLS population, as previously described in other PELS studies.[2,8,9]

The higher complexity is also reflected by the greater number of complications and by the high mortality, reaching 85%. This high mortality was mainly due to the deaths within the cardiac arrest group, where the 88% ($n=15/17$) of patients did not survive to discharge. These values are much higher compared to the expected ~60% mortality previously described.[8,9,14,15] None of the patients cannulated for right ventricular failure survived to discharge. This information indicates that patients experiencing right ventricular failure perioperatively should even receive higher surveillance due to such potential adverse events.

Cardiac arrest is a strong determinant against survival[8,16,17] and the current study demonstrates that when an ECPR is required in the general ward after cardiac surgery, the mortality risk is even higher. The question therefore arises as to whether such a situation should be considered as a relative contraindication to starting ECLS, while in contrast studies are needed to understand whether a trained and ready team or the rapid execution of sternotomy in these situations can improve outcomes.

4.1 | Strengths and limitations

The small sample size limited the statistical power to detect differences in survivors and nonsurvivors. However, this study is, so far, the largest report on the practice of PC–ECLS in the general ward. Moreover, this study is observational by nature, preventing causal inferences. An in-depth analysis of hemodynamic parameters, serial arterial lactate concentrations before and during ECMO support, anesthesiologic practices, and cardiopulmonary resuscitation details was not possible. Finally, we cannot exclude partial overlapping with previously reported series.[18,19]

TABLE 4 Postoperative outcomes.

	Overall population ($n=39$)	Survivors ($n=6$)	Non-survivors ($n=33$)	p-value
Intensive care unit stay (days)	7 (3.5–12.5)	12 (4–27)	7 (3–12)	0.422
Hospital stay (days)	16.5 (8–36)	87 (36–88)	13 (7–31)	<0.001
Postoperative bleeding	20 (51.3%)	2 (33.3%)	18 (54.5%)	0.339
Requiring rethoracotomy	11 (28.2%)	1 (16.7%)	10 (30.3%)	0.495
Cannulation site bleeding	5 (12.8%)	0 (0%)	5 (15.2%)	0.307
Diffuse no-surgical related bleeding	8 (20.5%)	2 (33.3%)	6 (18.2%)	0.398
Neurological complications				
Brain edema	3 (7.7%)	0 (0%)	3 (9.1%)	0.442
Cerebral hemorrhage	4 (10.3%)	0 (0%)	4 (12.1%)	0.368
Stroke	4 (10.3%)	0 (0%)	4 (12.1%)	0.368
Arrhythmia	19 (48.7%)	2 (33.3%)	17 (51.5%)	0.412
Leg ischemia	5 (12.8%)	1 (16.7%)	4 (12.1%)	0.759
Right ventricular failure	6 (15.4%)	1 (16.7%)	5 (15.2%)	0.925
Acute kidney injury	23 (59%)	4 (66.7%)	19 (57.6%)	0.677
Pneumonia	2 (5.1%)	0 (0%)	2 (6.1%)	0.536
Septic shock	10 (25.6%)	2 (33.3%)	8 (24.2%)	0.639
Distributive shock syndrome	3 (7.7%)	1 (16.7%)	2 (6.1%)	0.370
Acute respiratory distress syndrome	2 (5.1%)	0 (0%)	2 (6.1%)	0.536
Postoperative procedures				
Cardiac surgery	12 (30.8%)	2 (33.3%)	10 (30.3%)	0.882
Abdominal surgery	5 (12.8%)	2 (33.3%)	3 (9.1%)	0.102
Vascular surgery	5 (12.8%)	2 (33.3%)	3 (9.1%)	0.102
In-hospital mortality				N.A.
Deceased on ECLS			17 (43.6%)	
Deceased after weaning			16 (41%)	
Main cause of death				N.A.
Multiorgan failure			7 (17.9%)	
Sepsis			3 (7.7%)	
Persistent heart failure			11 (28.2%)	
Vasoplegia			2 (5.1%)	
Bleeding			1 (2.6%)	
Neurological injury			6 (15.4%)	
Other			1 (2.6%)	

Note: Data are reported as *n* (% as valid percentage excluding missing values) or median (interquartile range).

Abbreviation: ECLS, extracorporeal life support.

5 | CONCLUSIONS

PC–ECLS can be required also in the general ward days after the operation. This, so far, neglected population represents 2% of all patients with PC–ECLS, which is substantial. Thus, cannulation in the general ward requires more attention in studies reporting on postcardiotomy support or in-hospital cardiac arrest. Although hampered by acute setting and low-prevalence cannulation in the ward, strategies to improve patients' outcomes should be investigated since the current in-hospital mortality reaches 85%. Moreover, the present results suggest that the unfavorable outcome is due to cannulation in the general ward, as low preoperative risk patients make selection by confounding indication less likely. This suggests that optimization of care may have benefits instead of considering cannulation in the general ward a practice for futile patients. Finally, based on the rareness of this practice, collaboration in multicenter studies

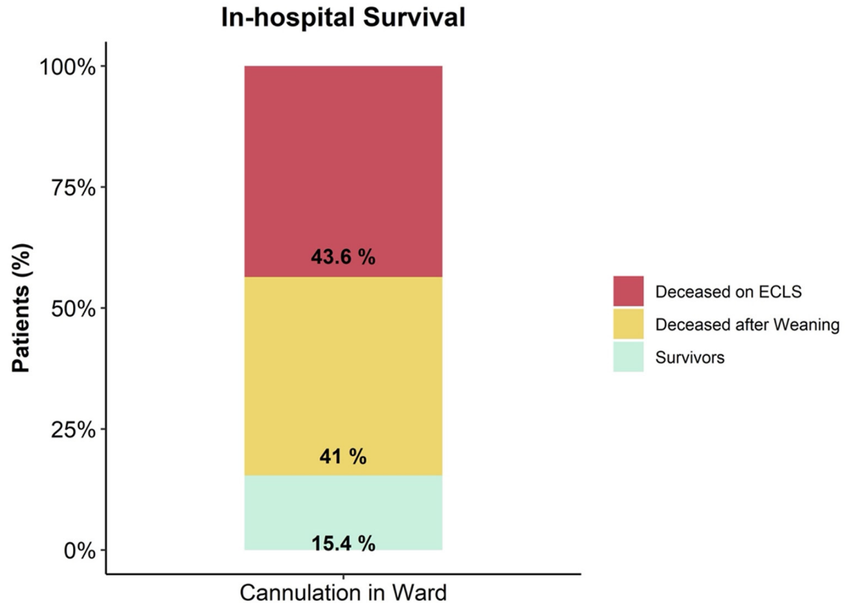


FIGURE 3 In-hospital survival. Bar chart representing the hospital survival outcome of patients requiring extracorporeal life support (ECLS) cannulation in the general ward in the total investigated population. (Red: Deceased on ECLS, Yellow: Deceased after weaning, Green: Survivors).

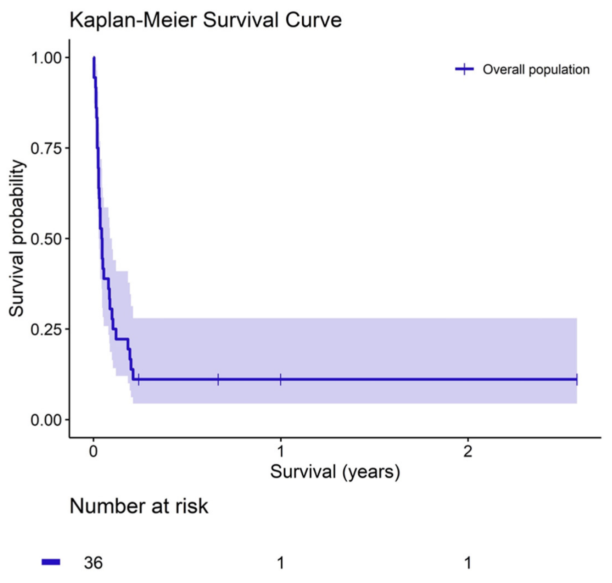


FIGURE 4 Kaplan–Meier survival curve with 95% confidence intervals.

on this topic is to be encouraged to provide larger cohorts and a more detailed insight into possible strategies to improve these patients' outcomes.

AUTHOR CONTRIBUTIONS

Gabor Bari, Silvia Mariani, Bas C. T. van Bussel, Roberto Lorusso conceived and designed the study. Gabor Bari, Silvia Mariani, Bas C. T. van Bussel conceived and performed the analysis. Gabor Bari, Silvia Mariani, and Roberto Lorusso drafted the manuscript. All authors interpreted the results, critically edited the manuscript, approved the final work, and agreed to be accountable for the accuracy and integrity of the work.

AFFILIATIONS

[1]Clinic of Internal Medicine, Department of Cardiac Surgery, University of Szeged, Szeged, Hungary
[2]Maastricht University Medical Center, Cardio-Thoracic Surgery Department and Cardiovascular Research Institute Maastricht, Maastricht, The Netherlands
[3]Department of Medicine and Surgery, Cardiac Surgery Clinic, San Gerardo Hospital, Monza, Italy
[4]Division of Cardiac Surgery, Medical University of Vienna, Vienna, Austria
[5]Department of Cardiac Surgery, Leipzig Heart Center, Leipzig, Germany
[6]Department of Cardiac Surgery, Louis Pradel Cardiologic Hospital, Lyon, France
[7]Division of Cardiac Surgery, IRCCS Azienda Ospedaliero-Universitaria di Bologna, Bologna, Italy
[8]Department of Cardiac Surgery, Heinrich Heine University, Duesseldorf, Germany
[9]Department of Anesthesiology, Centre of Anesthesia, Intensive Care and Pain management, Vilnius University Hospital Santariskiu Klinikos, Vilnius, Lithuania
[10]Division of Cardiothoracic and Vascular Surgery, Pontchaillou University Hospital, Rennes, France
[11]Center for Cardiac Intensive Care, Beijing Institute of Heart, Lung, and Blood Vessels Diseases, Beijing Anzhen Hospital, Beijing, China
[12]Department of Intensive Care Adults, and Department of Cardiology, Erasmus MC, Rotterdam, The Netherlands
[13]Department of Intensive Care Medicine, Center of Applied Medical Research, St Vincent's Hospital, Darlinghurst, New South Wales, Australia
[14]Department of Cardiology, Fundación Cardiovascular de Colombia, Bucaramanga, Colombia
[15]Department of Cardiac Surgery, University Hospitals Leuven, Leuven, Belgium
[16]Departments of Medicine and Surgery, University of Maryland, Baltimore, Maryland, USA
[17]SOD Cardiochirurgia, Ospedali Riuniti 'Umberto I - Lancisi-Salesi', Ancona, Italy
[18]Division of Cardiac Surgery, Cardiothoracic Department, University Hospital of Udine, Udine, Italy

[19]Cardiothoracic Intensive Care Unit, National University Hospital, Singapore, Singapore
[20]Cardiac Thoracic and Vascular Department, Niguarda Hospital, Milan, Italy
[21]Department of Medicine and Surgery, University of Parma, Parma, Italy
[22]Division of Cardiovascular and Thoracic Surgery, Department of Surgery, Siriraj Hospital, Bangkok, Thailand
[23]Department of Cardio-Thoracic Surgery, University Hospital Henri-Mondor, Créteil, France
[24]Department of Cardiothoracic Surgery, University Medical Center Regensburg, Regensburg, Germany
[25]Department for the Treatment and Study of Cardiothoracic Diseases and Cardiothoracic Transplantation, Istituto Mediterraneo per i Trapianti e Terapie ad Alta Specializzazione, Palermo, Italy
[26]ECLS Unit, Departamento de Anestesia, Clínica Las Condes, Santiago, Chile
[27]Division of Cardiac Surgery, Memorial Healthcare System, Hollywood, Florida, USA
[28]Department of Thoracic and Cardiovascular Surgery, Korea University Anam Hospital, Seoul, South Korea
[29]2nd Department of Cardiovascular Surgery, Cardiovascular Medicine, General Teaching Hospital, Prague, Czech Republic
[30]Intensive Care Unit, The Alfred Hospital, Melbourne, Victoria, Australia
[31]Department of Cardiac Surgery, Ospedale del Cuore Fondazione Toscana "G. Monasterio", Massa, Italy
[32]Department of Cardiovascular Surgery, Ziekenhuis Oost-Limburg, Genk, Belgium
[33]Cardiac Surgery Unit, IRCCS Humanitas Research Hospital, Rozzano, Italy
[34]Memorial Cardiac and Vascular Institute, Indiana University Methodist Hospital, Indianapolis, Indiana, USA
[35]Adult Intensive Care Service, The Prince Charles Hospital, Brisbane, Queensland, Australia
[36]Division of Cardiac Surgery, Johns Hopkins Hospital, Baltimore, Maryland, USA

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DATA AVAILABILITY STATEMENT
Data will be shared on reasonable request to the corresponding author with the permission of all PELS participating centers.

ORCID
Gabor Bari https://orcid.org/0000-0003-4167-5736
Silvia Mariani https://orcid.org/0000-0002-2238-1399
Matteo Pozzi https://orcid.org/0000-0001-6550-0872
Robertas Samalavicius https://orcid.org/0000-0001-7854-2211
Francesco Formica https://orcid.org/0000-0003-3989-6134
I-wen Wang https://orcid.org/0009-0006-3044-1300
Alessandro Barbone https://orcid.org/0000-0002-5120-5802

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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