In-hospital outcome of post-cardiotomy extracorporeal life support in adult patients: the 2007–2017 Maastricht experience

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ABSTRACT

Objectives: The use of post-cardiotomy extracorporeal life support (PC-ECLS) has increased worldwide over the past years but a concurrent decrease in survival to hospital discharge has also been observed. We analysed use and outcome of PC-ECLS at the Maastricht University Medical Center.

Design: A retrospective study of a single-centre PC-ECLS cohort. Patient characteristics and in-hospital outcomes were evaluated.

Setting: Patients who underwent PC-ECLS due to intra- or peri-operative cardiogenic shock or cardiac arrest were included. Descriptive statistics were analysed and frequency analysis and testing of group differences were performed.

Participants: Eighty-six patients who received PC-ECLS between October 2007 and June 2017 were included. The mean age of the population was 65 years (range, 31–86 years), and 65% were men.

Main outcome measures: Survival rates were calculated and PC-ECLS management data and complications were assessed.

Results: Pre-ECLS procedures were isolated coronary artery bypass grafting (CABG) (22%), isolated valve surgery (16%), thoracic aorta surgery (4%), a combination of CABG and valve surgery (21%) or other surgery (24%). PC-ECLS was achieved via central cannulation in 17%, peripheral cannulation in 65%, or by a combination in 17%. The median duration of PC-ECLS was 5.0 days (IQR, 6.0 days). Weaning was achieved in 49% of patients, and 37% survived to discharge. Post-operative bleeding (overall rate, 42%) showed a trend towards a reduced rate over more recent years.

Conclusions: Our experience confirms an increased use of PC-ECLS during the last 10 years and shows that, by carefully addressing patient management and complications, survival rate may be satisfactory, and improved outcome may be achieved in such a challenging ECLS setting.

Crit Care Resusc 2017; 19 (Suppl 1): 53-61

The prevalence of post-cardiotomy extracorporeal life support (PC-ECLS) reported in the literature varies between 0.6% and 2.6% of all cardiac surgical cases.[1,2] Indications for PC-ECLS usually include intra-operative failure to wean from cardiopulmonary bypass due to left, right or biventricular dysfunction, or refractory cardiogenic shock or cardiac arrest in the post-operative period.[1-6]

Recently, the Extracorporeal Life Support Organization (ELSO) registry and other national surveys reported a remarkable increase in the use of ECLS as a supportive therapy after cardiac surgery.[3,7,8] However, a disappointing trend was observed relating to the in-hospital survival rate.[3] Further, despite this increase in use of ECLS and new technological developments in this area, only a few comprehensive, dedicated reports about PC-ECLS have been presented.[1,2,4,5] PC-ECLS, however, has represented the main indication for ECLS use,[7,8] and is characterised by specific aspects (duration and type of underlying disease, severity of comorbidities, indication and type of surgical procedure, modality of access and timing of implantation, and complication types and rates) when compared with other indications for ECLS. Often these aspects are exacerbated when there is limited experience in these procedures, particularly in centres without well-established ECLS programs. All these factors may potentially influence ECLS management and final outcomes in patients after undergoing cardiotomy, and make this particular setting one in which there are higher risks for unfavourable results.[3] Careful evaluation of patient features, complication rates and management, and in-hospital outcomes, according to accumulated experience, should provide meaningful information to assess centre performance. Analysis of overall outcomes and trends in outcomes may also indicate further areas for improvement in ECLS results.

For these reasons, we reviewed the PC-ECLS series in our centre to elucidate patient characteristics and outcome over the last 10 years of experience.

Methods

Patients from a single institution (Maastricht University Medical Centre [MUMC], Maastricht, The Netherlands) who received venoarterial ECLS after cardiac surgery between

October 2007 and June 2017 were included in our study. Data were retrospectively collected from hospital records including surgery reports and intensive care unit data. Informed consent was waived due to the retrospective design of the study and to the emergent procedure carried out in all patients.

Inclusion criteria were age ≥ 18 years and cardiac surgery before ECLS. Indications for ECLS consisted of intra-operative failure to wean from cardiopulmonary bypass due to right, left or biventricular failure, and post-operative refractory cardiogenic shock or cardiac arrest during the hospitalisation after the surgical procedure. Patients with pre-operative ECLS were excluded from the analysis.

Statistical analysis

We compared in-hospital survivors and non-survivors and used the Shapiro–Wilk test for testing of normality of continuous variables. All variables were analysed with descriptive and frequency analysis. Variables with missing data in more than 5% of the patients were excluded from analysis. The χ^2 and Fisher exact tests were used to compare group differences for categorical variables. Continuous variables were analysed using the Mann–Whitney *U* test and were reported as means with standard deviations (SDs) or as medians with interquartile ranges (IQRs). $P < 0.05$ was considered a significant difference between the groups. The Storey–Tibshirani multiple testing correction was used.[9] Variables that achieved $P < 0.2$ in the univariate analysis were examined by using multivariate analysis with forward stepwise logistic regression to evaluate independent risk factors for hospital mortality. The *R* package *q* value was applied. All statistical tests were performed with SPSS, version 23.0 (IBM).

Results

During the study period, 86 patients received PC-ECLS. The mean age was 65 years (range, 31–86 years; 28 patients were aged 70–80 years; five patients were aged > 80 years), and most patients were men (65%). All pre-operative patient characteristics and details about cardiac disease are shown in Tables 1 and 2, respectively.

The most common cardiac disease in this patient cohort was coronary artery disease, followed by aortic valve disease and mitral valve disease. No differences between survivors and non-survivors were found for pre-operative comorbidities or for pre-operative left or right ventricular dysfunction, cardiogenic shock or cardiac arrest.

Operative procedures before ECLS are shown in Table 3. Previous cardiac surgery was reported for 20% of the patients, and most patients received elective surgery before ECLS cannulation. Only the combination of coronary artery bypass grafting with mitral valve surgery showed a significant difference ($P < 0.033$) for in-hospital mortality. Type-A aortic dissection was not considered a contraindication for PC-ECLS. However, no in-hospital survivors were observed in this patient subgroup. Cardiopulmonary bypass and aortic cross-clamping times were not significantly different between survivors and non-survivors.

ECLS implant and weaning details are shown in Table 4. The most frequent indication for ECLS in this cohort was failure to wean from cardiopulmonary bypass. Most ECLS runs were commenced in the operating room directly after surgery, with the remaining cases started in the ICU. Most ECLS catheter access was by peripheral cannulation, followed by central cannulation or a combination of central arterial and peripheral venous cannulation, at similar rates. Cannulation strategy did not appear to influence survival in this patient cohort, as summarised in Table 4. The additional support to ECLS with intra-aortic balloon pump (IABP) was used in 25% of the patients to favour left ventricular unloading and opening of the aortic valve, as well as to increase coronary flow.

Patients were kept on ECLS for a median duration of 5.0 days (IQR, 6 days). For in-hospital survivors, this was 6 days (IQR, 5 days) and for in-hospital non-survivors, this was 4 days (IQR, 6 days). This difference proved not to be significant.

The use of PC-ECLS was associated with several complications (Table 5). Post-operative cardiac arrhythmias and re-thoracotomy for bleeding, followed by acute renal injury, right ventricular dysfunction, sepsis and major neurological impairment, were the most common complications. Interestingly, the re-thoracotomy rate for bleeding decreased in the second period of our experience (Figure 1) after some changes in patient management. Major neurological impairment was seen in 20% of cases. Post-operative vasoplegic syndrome was a frequent event with a significant difference between survivors and non-survivors (Table 5).

Overall, successful ECMO weaning was possible in 49.4% of cases, but survival to hospital discharge was achieved in 37% of cases. The main reason for death was a cardiac event, followed by multiorgan failure and neurological complications. In-hospital survival rates during the study period are shown in Figure 2. On multiple logistic regression analysis, age > 65 years and post-operative arrhythmia were independent risk factors for mortality (Table 6).

Discussion

Our 10-year experience shows that:

- Use of PC-ECLS is markedly increasing and can be widely used in all post-cardiotomy scenarios.
- The results of this temporary support can be improved with increasing case volume and centre expertise.

Table 1. Pre-operative variables

Variable	Total (*n* = 86)	In-hospital survivors (*n* = 32)	In-hospital non-survivors (*n* = 54)	*P* (exact, 2-sided)*
Mean age, years (SD)	65.0 (11.2)	62.6 (12.5)	66.5 (10.3)	0.171
Female (%)	34.9%	31.3%	37.0%	0.645
Mean BSA, m^2 (SD)	1.91 (0.18)	1.91 (0.19)	1.92 (0.18)	0.963
Median BMI, kg/m^2 (IQR)	26.6 (5.35)	25.9 (6.00)	26.7 (5.78)	0.785
Medical history (%)				
Hypertension	94.0%	90.3%	96.2%	0.357
Smoking	15.1%	17.9%	13.3%	0.739
Hypercholesterolaemia	96.3%	93.5%	98.0%	0.554
Diabetes	17.1%	9.7%	21.6%	0.230
Diabetes with insulin use	7.4%	3.3%	9.8%	0.405
COPD	12.5%	6.7%	16.0%	0.306
Chronic renal failure	4.9%	0	7.8%	0.291
Dialysis	1.2%	0	2.0%	1.000
Stroke	9.9%	6.7%	11.8%	0.703
TIA	14.8%	25%	13.3%	0.345
Carotid stenosis	3.8%	6.7%	2.0%	0.553
Peripheral vascular disease	18.5%	16.7%	19.6%	0.778
Pulmonary hypertension	7.6%	3.3%	10.2%	0.399
LVEF < 35% (%)	19.5%	16.7%	21.3%	0.771
Preoperative condition (%)				
AF	26.5%	12.9%	34.6%	0.037
Pacemaker/ICD	9.6%	9.7%	9.6%	1.000
Prior cardiac surgery	20.9%	21.9%	20.4%	1.000
AMI	32.1%	31.3%	32.7%	1.000
AMI < 30 days	19.0%	21.3%	17.3%	0.776
PCI	9.6%	3.1%	13.7%	0.144
VSD	2.4%	3.1%	1.9%	1.000
Cardiogenic shock	16.5%	12.5%	18.9%	0.554
Cardiac arrest	10.5%	6.3%	13.0%	0.474
Pulmonary oedema	9.5%	3.1%	13.5%	0.147
RV dysfunction	4.8%	6.3%	3.8%	0.633
Vasopressors	10.6%	3.1%	15.1%	0.144
Intubation	13.4%	12.5%	14.0%	1.000
IABP	10.5%	15.6%	7.4%	0.283
Mean Euroscore II (IQR)	6.55 (9.87)	5.65 (4.62)	9.83 (12.11)	0.111

SD = standard deviation. BSA = body surface area. BMI = body mass index. IQR = interquartile range. COPD = chronic obstructive pulmonary disease. TIA = transient ischaemic attack. LVEF = left ventricular ejection fraction. AF = atrial fibrillation. ICD = implantable cardiac defibrillator. AMI = acute myocardial infarction. PCI = percutaneous coronary intervention. VSD = ventricular septal defect. RV = right ventricle. IABP = intra-aortic balloon pump. * P represents comparison between in hospital survivors and non-survivors.

- Underlying cardiac disease and modality of cardiac procedure do not influence the hospital mortality, except from ECLS in acute type-A aortic dissection.
- The ECLS configuration (central v peripheral cannulation) and the use of IABP do not appear to influence survival.
- PC-ECLS is still accompanied by a high mortality, although with an acceptable weaning rate (nearly 50%) in patients with an otherwise unfavourable prognosis.

Post-cardiotomy shock is a catastrophic entity. The reported definition includes the inability to wean from

Table 2. Proportions of patients with pre-operative cardiac disease

Condition (%)	Total (*n* = 86)	In-hospital survivors (*n* = 32)	In-hospital non-survivors (*n* = 54)	*P* (exact, 2-sided)*
Coronary artery disease	57.0%	65.6%	51.9%	0.263
3-vessel disease	22.1%	15.6%	25.9%	0.297
Aortic valve disease	43.0%	43.8%	42.6%	1.000
Mitral valve disease	37.2%	34.4%	38.9%	0.818
Tricuspid valve disease	4.7%	3.1%	5.6%	1.000
Thoracic aorta aneurysm	10.5%	3.1%	14.8%	0.145
Type-A dissection	11.6%	0%	18.5%	0.011
Type-B dissection	1.2%	3.1%	0%	0.372
Pulmonary embolism	1.2%	3.1%	0%	0.372
Bacterial endocarditis	9.3%	12.5%	7.4%	0.463
Cardiac tumour	2.3%	3.1%	1.9%	1.000
Other cardiac disease	7.0%	9.4%	5.6%	0.666

* *P* represents comparison between in-hospital survivors and non-survivors.

Table 3. Surgical procedures

Procedure	Total (*n* = 86)	In-hospital survivors (*n* = 32)	In-hospital non-survivors (*n* = 54)	*P* (exact, 2-sided)*
Emergency surgery (%)	38.4%	34.4%	40.7%	0.649
Reoperation (%)	19.8%	18.8%	20.4%	1.000
Off pump surgery (%)	3.5%	6.3%	1.9%	0.553
Median aortic cross clamp time, minutes (IQR)	104 (90)	108 (97)	98 (92)	0.754
Median CPB time, minutes (IQR)	197 (207)	181 (103)	229 (245)	0.087
Normothermia (%)	34.9%	34.4%	35.2%	1.000
CABG (%)	22.1%	25.0%	20.4%	0.789
AV surgery (%)	8.1%	12.5%	5.6%	0.416
MV surgery (%)	4.7%	0%	7.4%	0.292
Thoracic aorta surgery (%)	3.5%	0%	5.6%	0.291
CABG + AV surgery (%)	9.3%	15.6%	5.6%	0.142
CABG + MV surgery (%)	11.6%	21.9%	5.6%	0.033
CABG + thoracic aorta surgery (%)	1.2%	0%	1.9%	1.000
AV + MV surgery (%)	3.5%	6.3%	1.9%	0.553
AV + thoracic aorta surgery (%)	9.3%	3.1%	13.0%	0.249
MV + thoracic aorta surgery (%)	2.3%	0	3.7%	0.527
Other surgery (%)	24.4%	15.6%	29.6%	0.196

IQR = interquartile range. CPB = cardiopulmonary bypass. CABG = coronary artery bypass graft. AV = aortic valve. MV = mitral valve.
* *P* represents comparison between in-hospital survivors and non-survivors.

cardiopulmonary bypass, requiring a mechanical circulatory support system, the need for mechanical circulatory support within 48 hours or earlier after the index procedure, and the use of a mechanical circulatory support at any point during the initial hospital stay.[6] Patients with post-cardiotomy shock are typically characterised by high pre-operative creatinine blood levels, previous myocardial infarction, presence of left-main disease, left ventricle (LV) dysfunction, prolonged history of coronary artery disease, redo operations, recent operation, unstable clinical status, and emergency.[4]

Trend and mortality

PC-ECLS has been shown to be the most frequent indication for catheter implantation in the United States until 2011.[7] In a retrospective analysis of ECLS as therapy for post-cardiotomy shock in the US between 2002 and 2012, McCarthy and colleagues[8] found a significant increase in ECLS application in this setting. The reported mortality of 60% in the study was the highest mortality for all ECMO indications reported. These results have been

Table 4. Extracorporeal life support data (setting, implant and weaning)

Procedure	Total (*n* = 86)	In-hospital survivors (*n* = 2)	In-hospital non-survivors (*n* = 54)	*P* (exact, 2-sided)*
Weaning CPB with ECLS (%)	53.5%	46.9%	57.4%	0.378
Weaning CPB with IABP (%)	9.3%	12.5%	7.4%	0.463
ECLS placed during OR (%)	55.8%	50.0%	59.3%	0.501
ECLS placed in ICU (%)	44.2%	50.0%	40.7%	0.501
ECLS implanted central (%)	17.4%	15.6%	18.5%	0.779
ECLS implanted peripheral (%)	65.1%	65.6%	64.8%	1.000
ECLS implanted arterial central, venous peripheral (%)	17.4%	18.8%	16.7%	1.000
ECLS indication, failure to wean (%)	52.3%	43.8%	57.4%	0.267
ECLS indication, post-cardiotomy cardiogenic shock (%)	47.7%	56.3%	42.6%	0.267
Resuscitation between CPB and ECLS implantation (%)	24.4%	31.3%	20.4%	0.304
Perioperative low cardiac output syndrome (%)	50.0%	43.8%	53.7%	0.504
Post-operative IABP (%)	27.1%	32.3%	24.1%	0.454
Median ECLS duration, days (IQR)	5.0 (6.0)	6.0 (5.0)	4.0 (6.0)	0.219

CPB = cardiopulmonary bypass. ECLS = extracorporeal life support. IABP = intra-aortic balloon pump. OR = odds ratio. ICU = intensive care unit. IQR = interquartile range. * *P* represents comparison between in hospital survivors and non-survivors.

Table 5. Postoperative complications

Variable	Total (*n* = 86)	In-hospital survivors (*n* = 32)	In-hospital non-survivors (*n* = 54)	*P* (exact, 2-sided)*
Arrhythmia	47.1%	65.6%	35.8%	0.009
AF	20.0%	37.5%	9.4%	0.003
VT	7.1%	6.3%	7.5%	1.000
VF	17.6%	12.5%	20.8%	0.392
Other	9.4%	15.6%	5.7%	0.146
Pacemaker/ICD	3.6%	9.7%	0	0.047
Re-thoracotomy for bleeding	46.4%	50.0%	44.2%	0.657
Acute kidney injury	29.8%	18.8%	36.5%	0.093
Respiratory insufficiency	14.5%	12.9%	15.4%	1.000
TIA	0	0	0	na
Stroke	11.9%	18.8%	7.7%	0.170
Cerebral haemorrhage	0	0	0	na
Major neurological impairment	20.2%	15.6%	23.1%	0.577
Brain death	9.5%	0	15.4%	0.022
Sepsis	21.4%	18.8%	23.1%	0.786
Vasoplegic syndrome	13.1%	3.1%	19.2%	0.045
RV dysfunction	29.8%	36.5%	18.8%	0.093
Leg ischaemia	10.7%	18.8%	5.8%	0.078
Leg fasciotomy	4.8%	9.4%	1.9%	0.152
GI complications	14.3%	9.4%	17.3%	0.359
Bowel ischaemia	1.2%	0%	1.9%	1.000
Laparotomy required	4.8%	3.1%	5.8%	1.000
Pneumonia	10.7%	12.5%	9.6%	0.726
ARDS	0	0	0	na

AF = atrial fibrillation. VT = ventricular tachycardia. VF = ventricular fibrillation. ICD = implantable cardiac defibrillator. TIA = transient ischemic attack. RV = right ventricle. GI = gastrointestinal. ARDS = acute respiratory distress syndrome. na = not applicable. * *P* represents comparison between in hospital survivors and non-survivors.

Figure 1. Rates of re-thoracotomy for bleeding during the study period in patients receiving a post-cardiotomy extracorporeal life support implant

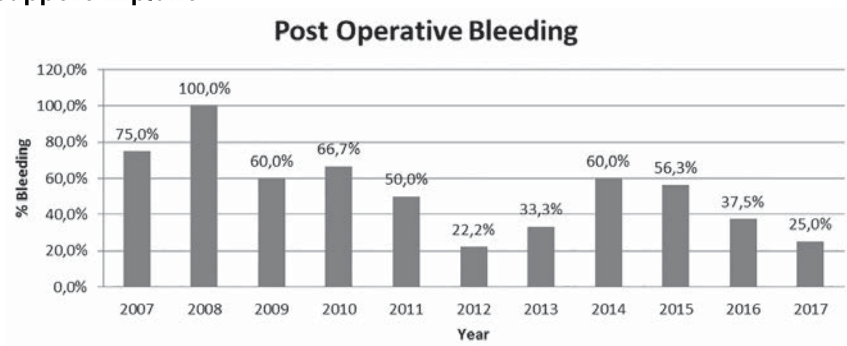
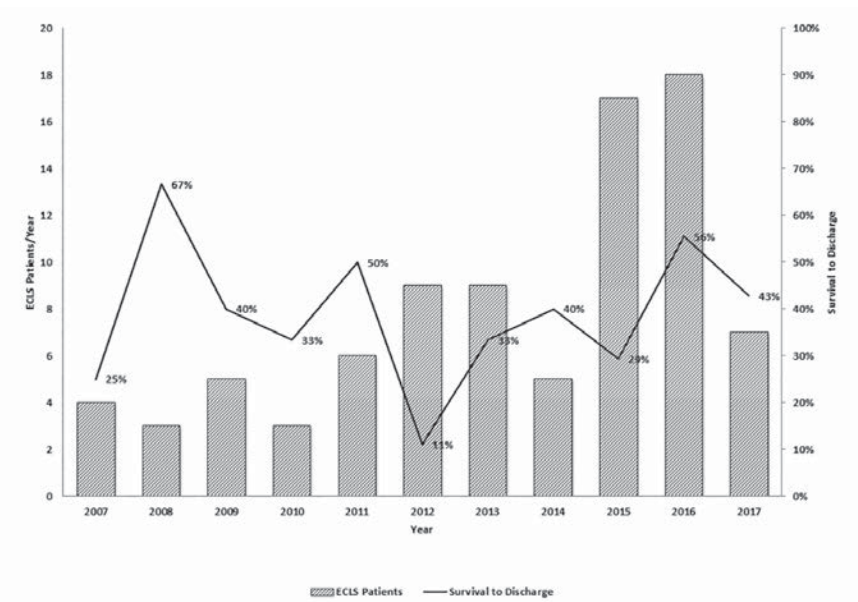


Figure 2. Post-cardiotomy patients receiving extra-corporeal life support at Maastricht University Medical Centre, and survival to hospital discharge



ECLS = extracorporeal life support.

also confirmed in a recent 15-year analysis of the ELSO database.[3] This report has shown that, although ECLS use has increased exponentially in that time, it appears that survival rates to discharge have decreased up to 15% in the most recent period. There are several potential explanations for this observation, including the learning curve of the centres using this treatment, to more complex patient profiles, or even to the more liberal use of PC-ECLS and this technique often being applied as a "last resort" in moribund patients.

Our results showed an overall survival comparable to those reported in the literature.[1,3,6,8] However, by observing the survival rates of PC-ECLS patients during the time in our experience, we did see a decline in survival in the initial phase of our experience followed by an improved in-hospital outcome during the last 5 years. We believe that this most likely reflects the increase in volume and centre experience, as well as enhanced complication prevention and management.

Technical considerations

There is still much debate about which cannulation site (central v peripheral) should be used to achieve the best recovery and easier management in PC-ECLS.[10] In the largest single-centre series, Rastan and colleagues[2] reported on 517 patients (1.2% of the total cardiac surgery cases) who required PC-ECLS. In their study, no advantages were seen by using different cannulation sites. In fact, percutaneous femoral vein drainage was associated with a worse prognosis, and may be a surrogate of suboptimal venous drainage and compromised ECLS flow. By contrast, Loforte and colleagues showed that central cannulation in PC-ECLS resulted in increased bleeding and continuous venovenous haemofiltration rates compared with peripheral access (62.7% v 48.4%, and 56.8% v 43.6%, respectively).[11]

During the central configuration of ECLS, LV venting, either directly or indirectly, is usually more frequently adopted, but its role and potential benefits are still controversial.[12] The role of IABP placement in aiding recovery is also controversial. The beneficial effects of adding IABP

Table 6. Multivariate logistic analysis model*

Variable	OR	SE	*P*
Postoperative arrhythmia	0.283	0.576	0.028
Age > 65 years	4.348	0.614	0.017

OR = odds ratio. SE = standard error. * The following variables were included in the analysis: pre-operative atrial fibrillation, pre-operative percutaneous coronary intervention, acute pulmonary oedema, pre-operative vasopressors, pre-operative EURO-score, type-A aortic dissection, cardiopulmonary bypass time, aortic cross-clamping time, pre-operative arrhythmia, post-operative vasoplegic syndrome, post-operative right ventricular dysfunction, post-operative left ventricular dysfunction, post-operative leg ischaemia, combo-operation (coronary artery bypass grafting plus aortic valve/mitral valve/thoracic aorta or aortic valve plus mitral valve or thoracic aortic plus mitral valve), age > 65 years.

support to ECLS have been well demonstrated in a recent single-centre experience which showed reduced lung stasis in patients with ECLS and IABP association.[13] However, other investigators have shown no difference between patients supported with ECLS, with or without concomitant IABP.[14] Further studies are therefore warranted to ascertain advantages and to elucidate mode, effects and results of IABP or other modes of LV unloading during ECLS.

Complications in patients on ECLS are frequent and strongly affect the final outcome.[2,3] The duration of ECLS varies in the literature on PC-ECLS and, although this does not seem to affect the weaning rate, a shorter duration of ECLS has been linked to better survival rates, mainly due to reduction of complication rates.[2,15] Re-thoracotomy for bleeding, gastrointestinal bleeding, kidney failure, limb ischaemia, and neurological injury are well reported complications of ECLS, and our experience is consistent with the literature. Bleeding is a major problem in PC-ECLS care, with rates as high as 90%.[15-18] Reasons for excessive bleeding in these patients include surgical trauma, thrombocytopenia, activation of leucocytes, and anticoagulation treatment. In our experience, we observed a high rate of bleeding complications in the initial phase, with subsequent improvement after having carefully addressed potential determinants. Proper haemostasis for patients supported with ECMO after cardiac surgery, with a closed chest if feasible, is our main goal in PC-ECLS patients. Protamine administration and delayed anticoagulation treatment (by at least 24 hours or later) are further recommended strategies to reduce bleeding risk.

In the presence of peripheral vascular disease, a switch from central to peripheral ECMO with heparin-coated circuits may also be applied to reduce the incidence of limb ischaemia and related complications. However, distal perfusion of the cannulated limb for arterial perfusion is critical to reduce or prevent such an adverse event[4] and is routinely adopted in our program.

Our data on other complication types and rates accord with published literature.[2-4] Notably, data on patients receiving venoarterial ECLS, from the ELSO registry, have shown that neurological complications occur in 15% of the cases, leading to almost 90% mortality.[19] This complication rate may be slightly higher in PC-ECLS patients, as shown in our and other investigators' findings.[2,4] Currently, however, there is no consistent action recommended or advisable to reduce such adverse events. It is hoped that additional refinement in ECLS technology, improved and reliable brain monitoring systems, and enhanced anticoagulation management will affect the understanding, detection and prevention of cerebral insult and injury, leading to improvements in this area.

Age is a controversial issue in PC-ECLS but is a well known risk factor for hospital mortality in PC-ECLS support,[2,5] and our findings were consistent with that. Recently, the influence of age in ECLS was investigated from the ELSO registry in patients supported for refractory cardiogenic shock.[20] More than 700 patients older than 70 years were analysed, and the 30.5% survival rate to hospital discharge in these patients encourages further evaluation of this. It appeared to indicate that age should not be considered an absolute parameter for ECLS indication.

Based on these factors, we recently adopted a "patient-tailored concept" for post-cardiotomy ECLS configuration and management, includign the following:

- The ECLS mode must account for the patient's pre-operative status (general condition, function of right and left ventricle), particularly in elderly patients, underlying disease (chronic v acute) and intra-operative status and requirement, avoiding a repetitive and fixed ECLS configuration.
- Sternal closure must be achieved, also in the central configuration, to reduce perioperative bleeding.
- Prevention or reduction of LV distension, by cannulation of the pulmonary artery used as additional drainage or using other LV venting techniques and devices, is recommended.
- IABP is highly recommended (sheathless implant) to favour LV unloading and opening of the aortic valve, thus enhancing LV unloading and reducing the risk of left cardiac chamber thrombosis.
- Use of distal limb perfusion is recommended in the case of femoral artery cannulation, to reduce limb ischaemia.

Study limitations

This was a single-centre series of consecutive patients, retrospectively reviewed. In addition, although there was no difference in age between survivors and non-survivors, 19 deaths occurred in patients between 70 and 80 years, and three deaths occurred in patients > 80 years. The true influence of age on events after PC-ECLS warrants further investigation. Further, the study population showed a heterogeneity in procedures and cannulation strategy and management. Finally, for some patients, data were missing (eg, haemodynamic and laboratory test parameters) and this is an additional limitation.

Conclusions

Use of ECLS after cardiac surgery is increasing, but is still limited by high mortality rates and resource consumption, despite all efforts and advancements in technology. Our experience confirms the data already reported, but highlights that careful patient management and increased expertise may lead to a gradual reduction of complication rates, particularly for bleeding episodes.

Alternative configurations and cannulation strategies tailored specifically to the status of the patient, as well as a dedicated program, increased expertise and a multidisciplinary approach can improve knowledge in the field and, we hope, ultimately benefit patients undergoing PC-ECLS. Finally, this article must be seen in the context of a dedicated issue that explores multiple aspects of extracorporeal life support in the critically ill.[21-24]

Competing interests

None declared.

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