ORIGINAL ARTICLE

ECMO POST-CARDIOTOMY, A SINGLE CENTRE EXPERIENCE

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Abstract

Objectives: *Our objective was to examine the results of ECMO post cardiotomy in Centro Hospitalar Universitário S. João (CHUSJ).*

Methods: *Between 2011 and 2019, 13 patients were cannulated for refractory cardiogenic shock post-cardiotomy; 8 (61,5%) male and 5 (38,5%) female. Patients under 18 years old were excluded.*

Data was collected from hospital archives concerning preoperative comorbidities, open-heart surgery procedure, dates of ECMO cannulation and decannulation, postoperative complications, hospital mortality and cause of death. Follow-up was obtained by review of the last outpatient observation.

The outcomes investigated were hospital mortality and survival at 12, 36 and 60 months.

Results: *After a median ECMO-VA therapy of 6 days (1-16 days), 7 (53,8%) patients were successfully decannulated; from these 2 succumbed from stroke and septic shock, one is still in intermediate care convalescing steadily and 4 were discharged. Overall 8 (61,5%) patients died. 5 (38,5%) survived, 4 were discharged home and 1 is still in intermediate care. Survival (after discharge) at 12, 36 and 60 months was respectively 25%, 16,7% and 8,3%.*

Regarding postoperative complications, reoperation for bleeding was necessary in 5 (38.5%), stroke was diagnosed in 2 (15,4%), dialysis in 6 (46,2%), leg ischemia affected 5 (38,5%) and mediastinitis occurred in 1 (7,7%).

Conclusions: *VA ECMO saves a life in each three patients suffering from refractory cardiogenic shock after cardiac surgery. Despite risks associated with advanced cardiopulmonary support, survivors maintain good health condition.*

INTRODUCTION

In selected patients in cardiogenic shock after heart surgery, venoarterial extracorporeal membrane oxygenation (VA ECMO) offers the possibility for heart recovery or a bridge to investigate other treatments.[1]

OBJECTIVE

Our objective was to examine the results of post cardiotomy ECMO in Centro Hospitalar Universitário S. João (CHUSJ) in Oporto, Portugal, from 2011 to 2019.

MATERIAL AND METHODS

We searched our registries for all adult patients treated with ECMO after open heart surgery. Therefore, between 2011 and 2019, 13 patients were cannulated for refractory post-cardiotomy cardiogenic shock: 8 (61,5%) males and 5 (38,5%) females.

Data was collected from hospital archives concerning preoperative comorbidities, open-heart surgery procedure, dates of ECMO cannulation and decannulation, postoperative complications, hospital mortality and cause of death. Follow-up was obtained by review of the last outpatient observation.

Facing intraoperative failure to wean from cardiopulmonary bypass, eligibility for ECMO was decided by a multidisciplinary team, headed by the main surgeon and the ECMO expert on call. We emphasize that these difficult decisions are unsubstantiated by trials, information is scarce and consequently, absolute contraindications are not established. Type of cannulation was left at surgeon discretion; nonetheless peripheral cannulation was favoured, alongside distal perfusion catheter insertion.

After initial post-operative stabilization in the cardiothoracic unit, specially related to bleeding control in patients with central ECMO, according to the hospital policy all patients were transferred to a dedicated ECMO unit. In addition to regular ICU check-up, ECMO patients had head and peripheral tissue oxygenation near-infrared spectroscopy (NIRS) monitoring to detect ischemia. Moreover, right arm arterial pressure and oxygenation were mandatory to diagnose Harlequin syndrome. The

entire circuit was inspected daily for kinks, damage of tubes and presence of clots. Moreover, transmembrane pressure gradient (ΔP) trends and blood gas exchange analysis denoted oxygenator usability. Concerning anticoagulation, after complete heparin reversal with protamine, heparin was only initiated after the bleeding resolved and administered to maintain an activated prothrombin time (aPTT) 1,8-2 times normal. The objective in all patients was bridge to recovery.

The investigated outcomes were hospital mortality and survival at 12, 36 and 60 months.

STATISTICAL ANALYSIS

Descriptive analysis was performed for the entire cohort and data presented as percentage (%), mean and standard deviation, median, range or interquartile ranges (IQRs), according to its distribution. Intergroup analyses were conducted using chi-square tests or Fisher exact test for categorical variables and Student t-tests or Mann-Whitney for continuous variables, according to the dimension and distribution of the samples, respectively. Linear correlations were tested with the Pearson's test. A stepwise logistic regression was conducted for the multivariate analysis of hospital mortality. The survival data was described with Kaplan Meyer curves and time related comparisons between groups using the log-rank test. The results were considered statistically significant if $p < 0,05$ was computed.

RESULTS

The number of ECMO expanded with the absolute number of surgeries in our department (Fig.1) due to increased experience with the technique.

A total of 13 patients unable to wean from cardiopulmonary bypass were treated with VA-ECMO for a median of 6 days (1-16 days). Seven (53.8%) patients were successfully decannulated; from these 2 succumbed from stroke and septic shock, 4 were discharged and 1 was convalescing steadily at the time of writing. Overall, 8 (61,5%) patients died and 5 (38,5%) survived. Survival (after discharge) at 12, 36 and 60 months was respectively 25%, 16,7% and 8,3% (Fig. 2). Survivors remained in NYHA class I or II in follow-up appointment.

Regarding postoperative complications, reoperation for bleeding was necessary in 5 (38.5%), stroke was diagnosed in 2 (15,4%), dialysis in 6 (46,2%), leg ischemia in 5 (38,5%) and mediastinitis occurred in 1 (7,7%). (Table. 2)

DISCUSSION

The ECMO program was implemented in our hospital in 2010 through a dedicated team to address the H1N1 pandemic. Over the years experience grew, gradually encompassing sicker patients, namely the post cardiotomy refractory cardiogenic shock ones. Although this group of patients is widely recognized as the ones having the worst outcomes with this technique, initial enthusiasm faded as the first patient died and the technique for post cardiotomy shock was interrupted until 2017. However, as experience thrived with respiratory and non-respiratory ECMO, this technique was used more frequently and over time, initial worrisome results improved.

Refractory shock after cardiac surgery is more usual after technically challenging and lengthy operations, where the surgical team has put all its best, making the decision to use ECMO difficult. This difficulty is often increased by the emotional link between surgeon, patient

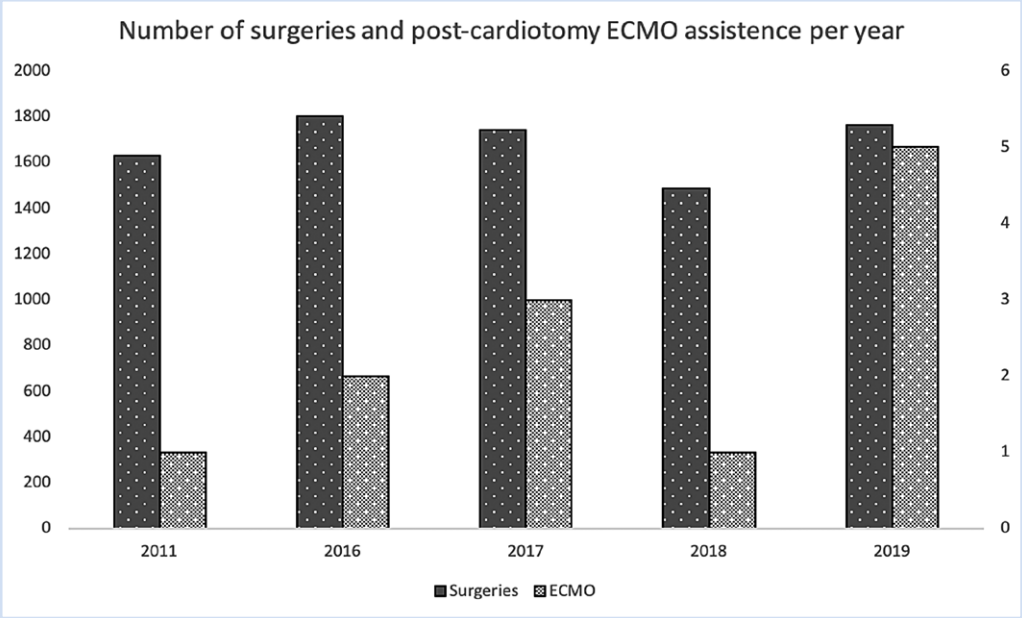

Figure 1 *Correlation of number of surgeries and ECMO per year.*

Table 1 Basic characteristics of the population

Covariates	Overall series (13 patients)
Age (median)	51 years (18-68)
Gender	Female 5 (38,5%) Male 8 (61,5%)
Serum creatinine (µmol/L)	84,9 (32,7-234,31)
PAD	0
COPD	1 (7,7%)
Active endocarditis	1 (7,7%)
Critical state	5 (38,5%)
Insulin-dependent diabetes	1 (7,7%)
NYHA	I – 2 (15,4%) II – 3 (23,1%) III - 2 (15,4%) IV – 6 (46,2%)
CCS IV	6 (46,2%)
LVEF	<21% - 3 (23,1%) 21-30% - 1 (7,7%) 31-50% - 6 (46,2%) >50% - 3 (23,1%)
Recent myocardial infarction	2 (15,4%)
SPAP	<31mmHg – 1 (7,7%) 31-55mmHg – 5 (38,5%) >55mmHg – 2 (15,4%) Unknown – 5 (38,5%)
Urgency	Elective – 7 (53,4%) Urgent – 4 (30,8%) Emergent – 2 (15,4%)
Aorta surgery	6 (46,2%)
Euroscore II (median)	8,7% (0,7-41,6)

PAD – pulmonary artery disease; COPD – chronic obstructive pulmonary disease; NYHA class – New York Heart Association classification; CCS-IV– Canadian cardiovascular society grade IV; LVEF – Left ventricle ejection fraction; SPAP – Systolic pulmonary artery pressure

and families, and by the surgical culture of success. Nonetheless, this decision demands good and objective clinical judgement. Scrutiny of factors identifying patients more likely to survive should warrant the establishment of guidelines.[2] However, until this moment no official recommendations about this topic were published, in particular contra-indications based in factors affecting survival or specific management strategies.

It is known that age is a decisive factor, since older patients have worse prognosis, particularly older than 70 years old.[3] Our oldest patient was 68 years old, nonetheless in this small series age per se did not affect survival (p=1,0). Unambiguously, two patients over sixty survived, likewise one in thirties, one in twenties and a 22-year-old woman is

Table 2 Operative characteristics of the population

Surgical procedure	Overall series (13 patients)
Congenital (anomalous origin of coronary arteries)	1 (7,7%)
Isolated CABG	2 (15,4%)
Isolated valve	2 (15,4%)
Combined valve	2 (15,4%)
Valve & CABG	2 (15,4%)
Heart transplantation	4 (30,8%)
Extracorporeal circulation time (min)	169 (105-451)
Aortic clamp time (min)	97 (0-221)

currently admitted in intermediate care, after chest reconstruction for mediastinitis.

In addition to patient selection, other factors may influence outcomes, namely cannulation strategy. Despite easy conversion of cardiopulmonary bypass to central VA ECMO, since 2017 we favor peripheral cannulation, due to the excessive risk of bleeding and infection with the first. In our study, two out of three patients with central cannulation succumbed from septic shock and multiorgan failure. Recently a meta-analysis corroborated a positive association between central cannulation and hospital mortality in post-cardiotomy VA ECMO.[4]

Peripheral cannulation may be complicated with suboptimal venous drainage and unloading of the left ventricle. These difficulties may be surpassed by simple measures as flow diminution, inotropes or insertion of an IABP.[5] If preliminary measures fail, the preferred and most efficacious technique that has been utilized is atrial septostomy with a trans-atrial cannula placement as an additional inflow cannula to the system;[6] another valuable although more expensive option is Impella heart pump.[7] Surgical techniques have the drawback of invasiveness but permit insertion of large bore catheters to unload the left ventricle and rapidly reverse pulmonary edema. We point out that

Table 3 Postoperative complications

Covariates	Overall series (13 patients)
Reoperation for bleeding	5 (38,5%)
Stroke	2 (15,4%)
Dialysis	6 (46,2%)
Leg ischaemia	5 (38,5%)
Mediastinitis	1 (7,7%)

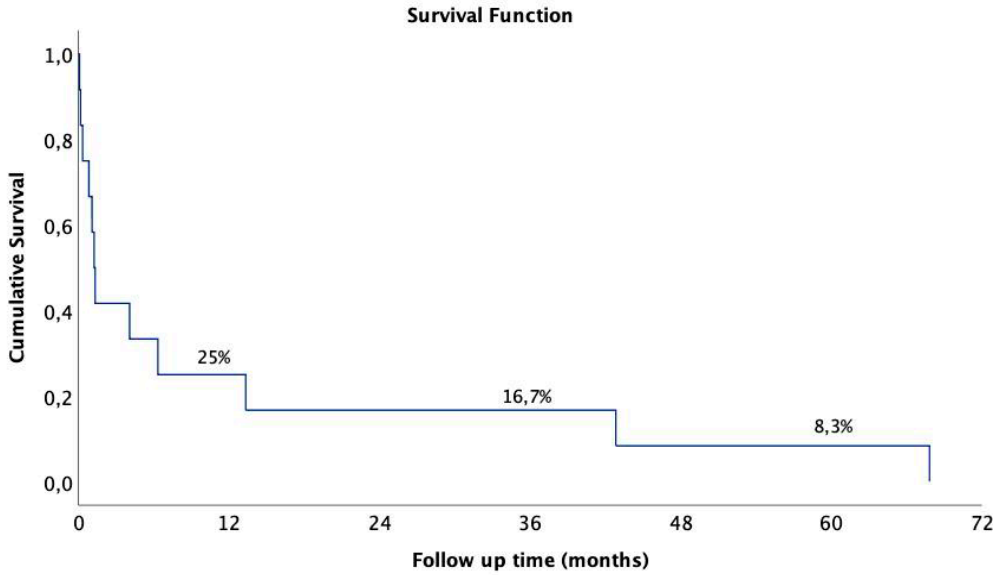

Figure 2 *Survival after postcardiotomy ECMO.*

patients with lowest ejection fraction often need efficient unloading to avoid irreversible damage.

Left ventricle unloading is controversial. In our study 3 (23,0%) patients had an IABP inserted before VA ECMO, which remained for purposes of left ventricle unloading. In the other nine patients, there was no evidence of severe left ventricle distension in the echocardiogram despite the adoption of conservative measures (no unloading). However, a recent meta-analysis demonstrated any unloading strategy in VA ECMO patients was associated with lower mortality as compared to no-unloading.[8] However, the role of residual left ventricular function remains elusive in these studies, as patients with better residual LV function will probably survive more and depend less on the strategy of unloading.

Four (33,3%) patients already discharged were in NYHA class I-II. In accordance with scientific literature, despite perioperative care improvement, hospital survival remains stable around 30%.[9] We emphasise that, despite this ominous results, VA ECMO salvages a third of patients in post cardiotomy refractory cardiogenic shock and survivors can maintain a good health condition.[10] As expected, survival reduces over time as 25%, 16,7% and 8,3% patients are alive 12, 36 and 60 months after surgery.

Frequent complications ensue in patients requiring VA ECMO after heart surgery. We highlight the extended surgical extracorporeal circulation times, triggering coagulation disorders and bleeding, requiring transfusion with associated morbidity and mortality.

In this series, excessive haemorrhage was strongly associated with death, causing the demise of five (38,5%) patients. A meta-analysis showed comparable high rates of reoperation for bleeding (between 32,0-68,0%) in VA ECMO patients.[11] A recent observational study demonstrated association of low haemoglobin (< 9g/dL), fibrinogen (<2g/L), pH (<7,12) and BMI (<25) with early major bleeding events.[12] Taking into account these findings, cannulation of severely acidotic or anemic patients may be futile, unless amenable to a speedy correction.

Peripheral cannulation may diminish leg perfusion, particularly in hemodynamically unstable patients with large arterial cannulas. Other factors related to ischemia are small femoral arteries, peripheral vascular disease, difficult cannulation[1] and vasoactive infusions.[13] We routinely monitor oxygenated blood in peripheral extremities, aiming for a perfusion pressure above 50mmHg and we perfuse the superficial femoral artery with a 5-7 Fr catheter, according to the patient's size.

In our small series, leg ischemia was a lethal complication, with only one survival of the five (38,5%) patients diagnosed. Wang et al reported an incidence of leg ischemia between 10,0-20,0%[11], however parallelism of these results is challenging because of our small sample.

In our study, no patient suffered from peripheral artery disease; however vasoactive infusions were universally administered in these coagulopathic patients after long extracorporeal circulation runs.

Ischemic stroke and intracranial bleeding are major complication of VA ECMO. Ischemic stroke has no specific risk factors and does not appear to increase mortality, as opposed to intracranial bleeding, which is linked to female sex, central cannulation, thrombocytopenia and rapid CO2 clearance.[14] In our analysis 2 (15,4%) patients succumbed to extensive ischemic stroke, but no case of brain hemorrhage was detected. This proportion is in line with recent studies.[11] Unsurprisingly, no case of Harlequin syndrome was diagnosed as in postcardiotomy VA ECMO patients it is uncommon that heart recovery happens before lung recovery.

Advanced circulatory support was maintained during a median of 6 days (1-16 days), without significant disparity between survivors and victims. Survivors were in

VA ECMO for 4-7 days besides a patient still admitted for mediastinitis who was decannulated at 16th day after surgery. Two patients died after more than 10 days of VA ECMO for aortic dissection and refractory right ventricle failure, which may be related to the diagnosis itself. One patient died of ischemic stroke after 10 days of VA ECMO, but one cannot ascertain if it was a complication directly related to ECMO. Biancari *et al* demonstrated prolonged VA ECMO therapy may achieve good results,[15] but Di Mauro recognized duration of circulatory support between 4-7 days achieves the best results.[16] In absence of recovery allowing weaning from ECMO, a patient deemed not having an irreversible clinical condition should maintain longer periods of circulatory support.

In these challenging patients, selection and optimization of perioperative care are vital to achieve good results. We hypothesize that the concentration of postcardiotomy patients in a single Department might improve the expertise and save more lives. As stated by Biancari *et all*, centers that treat more than 50 patients with postcardiotomy venoarterial extracorporeal membrane oxygenation have a significantly lower hospital mortality than lower volume centers.[15]

Despite the small number of this series, its results are in line with others reported[15,11] We understand better patient selection and improved perioperative care, namely improved hemostasis and less transfusions, will ultimately increase survival in our Department.

CONCLUSION

VA ECMO saves a life in each three patients suffering from refractory cardiogenic shock after cardiac surgery. Despite risks associated with advanced cardiopulmonary support, survivors maintain good health condition.

Further studies in the field are required to better select and treat patients.

STUDY LIMITATIONS

This study has limitations. It is a retrospective analysis of a very small sample of patients.

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