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A Novel Approach to Measuring Physiologic Changes during Ambulation for a Patient with Post Infarct VSD Supported on Femoral IABP and VA ECMO

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Abstract
Post-infarct ventricular septal defect (PIVSD) is a rare, life-threatening complication following acute myocardial infarction (MI), associated with high overall mortality. Interventions include medical management, percutaneous closure, and/or surgical closure. Of these, delayed surgical closure is associated with the highest survivorship at 30 days and 1 year, necessitating early medical stabilization for an optimal surgical outcome. Consequently, patients with PIVSD often require mechanical circulatory support (MCS), namely intra-aortic balloon pump (IABP) and/or veno-arterial extra-corporeal membrane oxygenation (VA ECMO) and are likely faced with prolonged preoperative phases with associated immobility. Available case reports document length of stays between 19 days to 8 weeks, associated with complications related to immobilization. There is a dearth of evidence that supports the mobilization of patients with PIVSD while supported on MCS. Accordingly, we present a novel case of a critically ill 61-year-old male with a 2.72 cm PIVSD, supported with femoral IABP and femoral VA ECMO, that safely and successfully participated in physical therapy (PT), including ambulation (mean 109 ft.) during 10 sessions over 18 days while awaiting surgical repair. In addition, we discuss the use of transthoracic echocardiography (TTE) at rest and during exercise demonstrating improvement in all measures of RV systolic function (RVOT VTI, RV Free Wall S', TAPSE) as well as a reduction in shunt ratio (Qp:Qs) with exertion. This experience detailing early PT intervention/ambulation with TTE measures of RV function provides one model for the safe management of patients with PIVSD supported on MCS devices awaiting surgical intervention.

Extracorporeal membrane oxygenation in diabetic ketoacidosis

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Abstract
Purpose: Diabetic ketoacidosis (DKA) is a common illness in the United States. Some patients develop severe shock and/or respiratory failure, and extracorporeal membrane oxygenation (ECMO) may be considered. This series describes the clinical presentation and outcomes of patients with DKA managed with ECMO.

Materials and Methods: We conducted a retrospective review of 15 patients with DKA who required ECMO at our institution. Demographics and ECMO-specific data was collected. Additional variables included ICU length of stay, acute kidney injury, use of dialysis, disposition, and mortality.

Results: All ECMO cannulations were performed by intensive care physicians. The majority of patients were female (73%) with a median age of 27 (IQR=21.5-45) years. A diagnosis of diabetes mellitus (DM) prior to ECMO was present in 11 (73%) patients. Veno-arterial ECMO was the initial mode used in 11 (73%) patients. The median duration of ECMO support was 7 (IQR=6-14) days. The median ICU length of stay was 12 (IQR=8.5-20.5) days, and the median hospital length of stay was 21 (IQR=11-36.5) days. Eight patients had cardiac arrest and underwent extracorporeal cardiopulmonary resuscitation (ECPR) of which four (50%) patients survived to discharge. Overall, 10 (66.7%) patients were successfully weaned from ECMO and survived to discharge.

Conclusions: This is the largest case series regarding the use of ECMO for patients with refractory shock, cardiac arrest, or respiratory failure related to DKA. The findings suggest that ECMO is a viable support strategy for these patients. Further research is needed to identify optimal patient selection criteria and management strategies.
Obesity is Associated with Increased Mortality in Patients Undergoing Venoarterial Extracorporeal Membrane Oxygenation
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Abstract
Background: Venoarterial Extracorporeal Membrane Oxygenation (VA-ECMO) is used to support patients with cardiac and respiratory failure. The relationship between obesity and VA-ECMO outcomes is unknown.

Objectives: To determine the relationship between all-cause mortality and morbidity in patients treated with VA-ECMO, and to further assess whether this relationship is mediated via patient factors, complications, or treatments.

Methods: Using the ELSO Registry, VA-ECMO runs from 2015 to 2021 were retrospectively analyzed. The patient demographics, ECMO indication and complications for survivors and decedents were univariately compared. Logistic regression with fractional polynomials was then used to elucidate the relationship between body mass index (BMI) of VA-ECMO patients to both mortality and complications.

Results: 22,825 VA-ECMO runs met inclusion criteria for analysis. The mean BMI for survivors is 28.4 +/- 6.5 kg/m2. The mean BMI for decedents is 29.5 +/- 6.9 kg/m2. BMI was significantly associated with mortality (P <.001), with the odds of mortality increasing with increasing BMI. 47% of underweight patients died, progressing to 50% for normal range, to 53%, 56%, 58%, and 65% for preobese, Class-1, Class-2, and Class-3 obese patients respectively. Relative to a BMI of 25, a BMI of 35 had mortality increased as BMI increased. Results for other BMI categories are shown in Table 1. BMI was significantly associated with increased mechanical, cardiovascular, pulmonary and renal complications.

Conclusions: In patients undergoing VA-ECMO, increasing BMI was associated with increasing all-cause mortality and complications. The odds of mortality increased as BMI increased.

Mechanical circulatory support for cardiogenic shock: a network meta-analysis of randomised controlled trials and propensity score matched studies.
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Abstract
Background: Cardiogenic shock is associated with high mortality. In refractory shock, it is unclear if mechanical circulatory support (MCS) devices improve survival. We conducted a systematic review and network meta-analysis to determine the impact of using various MCS devices in this population.

Methods: We searched four databases through 1 March 2023 for eligible randomised controlled trials (RCTs) and propensity-score matched studies (PSMs). We conducted frequentist network meta-analysis, investigating mortality as the primary outcome. We assessed risk of bias using the Cochrane risk of bias 2.0 tool or Newcastle Ottawa Scale, and evaluated certainty in pooled estimates using the GRADE approach. As a sensitivity analysis, we reconstructed survival data from published survival curves, and conducted one-stage unadjusted IPD meta-analysis using a stratified Cox model.

Results: We included 36 studies (48,297 patients), most reporting on patients with Society for Cardiovascular Angiography and Intervention shock stage (SCAI) C-E cardiogenic shock. Compared with no MCS, extracorporeal membrane oxygenation (ECMO) with intra-aortic balloon pump (ECMO-IABP; odds ratio [OR]: 0.60, 95%- confidence interval (CI): 0.37-0.98, moderate certainty) may be associated with lower mortality. There were no important differences in mortality using ECMO alone, microaxial ventricular assist device (mVAD) alone, IABP alone, centrifugal VAD alone, ECMO-mVAD, or mVAD-IABP (all very low certainty). One-stage IPD meta-analysis found only ECMO-IABP was associated with lower mortality (HR: 0.54, 95%-CI: 0.44-0.66).

Conclusions: In patients with cardiogenic shock, ECMO-IABP may reduce mortality. Nonetheless, results for other MCS devices are based on very low to low certainty and require further confirmation from RCTs.
Takotsubo Syndrome and Severe Cardiogenic Shock secondary to Plastic Surgery treated with VA-ECMO. Case Series
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Abstract
The Takotsubo Syndrome (TTS) is a cardiomyopathy induced by emotional or physical stress with secondary sympathetic hyperstimulation and catecholamine release. The diagnosis is showed through an image-tool evidencing its classical left ventricular apical ballooning or any of its multiple morphological presentations.
Surgery has been documented as a physical triggering factor. Although its physiopathology is not completely understood, some factors during aesthetic procedures seem to have a relation with the manifestation of this disease. Most takotsubo cases are self-limited to its reversible natural history of the illness. However, some patients can rapidly worsen, where the actual medical treatment appears to be controversial and sometimes insufficient.
Few case reports have documented TTS as a complication of plastic surgery. We describe 4 cases of young women, ages 28, 27, 31 and 34, who underwent plastic surgery (1.- Liposculpture and Mammoplasty 2.- Mammoplasty 3.- Liposculpture, Rhinoplasty, Abdominoplasty and Mastopexy 4. Mammoplasty + Liposuction). None had a history known related to the possible development of this cardiomyopathy. During the surgery, tachycardia, electrocardiographic abnormalities and hypotension were identified. Diagnosis of TTS was confirmed by transesophageal echocardiography with rapidly progression to severe CS. VA ECMO therapy was utilized. 1 patient was canulated under ECPR strategy after 25 minutes of low flow cardiopulmonary reanimation. We registered circulatory assistence of 1-4 days, main hospitalization stay of 5.5 days and 100 % survival.
It should be contemplated nowadays that plastic surgery is a potential trigger of this syndrome, which can become catastrophic. For complicated cases, ECMO is a must consideration.

Sex-based differences in the extracorporeal cardiopulmonary resuscitation population for out-of-hospital cardiac arrest in the Minneapolis metro area
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Abstract
Background: Women constitute nearly 40% out-of-hospital cardiac arrests (OHCA), receive less post-arrest evidence-based interventions. Aims: To identify presence of sex-based differences in utilization of extracorporeal cardiopulmonary resuscitation (ECPR) for refractory OHCA in the Minneapolis (MSP) metro area. Methods: Patients eligible for the Minnesota Resuscitation Consortium (MRC) ECPR protocol between 2013-2021 were identified in the Cardiac Arrest Registry to Enhance Survival (CARES) registry. Patients who presented to the University of Minnesota (UMN) and were eligible for the MRC protocol between 2014-2022 were identified. Arrest data, patient characteristics and mortality were compared between the sexes in both populations. Results: We identified 2790 OHCA patients through CARES of whom 685 (24.6%) were women. There were 443 referrals to UMN for ECPR, of whom 87 (19.6%) were women. Significantly more eligible women arrested than were referred for ECPR (p =0.02). In MSP, women were more likely to suffer cardiac arrest at home (59% vs 66%,p<0.01), less likely to receive bystander CPR (42% vs 35%,p<0.01) and have greater time to professional CPR (6.3 vs 5.4 mins,p<0.01). Among referrals for MRC protocol, there were no differences in arrest characteristics between the sexes. Multivariate analysis for neurologically favorable survival showed female sex was associated with decreased survival in the community (p=0.03) but trended towards increased survival in the UMN cohort (p=0.08). Conclusion: Women suffering from cardiac arrest have higher mortality in the community, are less likely to be referred for ECPR, however, have equal survival after ECPR. Fewer referral of women for ECPR warrants further investigation.
Distinction of characteristics associated with successful venoarterial extracorporeal membrane oxygenation decannulation in extracorporeal cardiopulmonary resuscitation for out-of-hospital cardiac arrest

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Abstract

Background: Assessment for readiness for decannulation from venoarterial extracorporeal membranous oxygenation (VA ECMO) is largely based on anecdotal data and provider experience with relatively high failure rates of 30-70% reported in literature. Compared to patients cannulated for cardiogenic shock, in-hospital cardiac arrest and post-cardiotomy, patients cannulated for out-of-hospital cardiac arrest (OHCA) extracorporeal cardiopulmonary resuscitation (ECPR) represent a unique population.

Aims: We sought to identify parameters impacting decannulation success among OHCA patients treated with ECMO-facilitated resuscitation.

Methods: Consecutive OHCA patients treated with previously described Minnesota Resuscitation Consortium ECPR protocol from 2015 to 2022 were eligible for inclusion. Hemodynamics, patient characteristics, mechanical circulatory support, and echocardiographic data were compared among patients with successful versus failed decannulations, defined as death due to cardiac causes or recannulation on VA ECMO within the same hospitalization.

Results: Among 390 ECPR protocol patients, 125 (32%) were deemed ready for decannulation with 88% successful (n=110) and 12% failed decannulations (n=15). Feature importance analysis was performed by leveraging multiple models, to identify strength of variables associated with successful decannulation. Multivariable logistic regression showed left ventricular ejection fraction (coefficient 0.14), pressors (coefficient -0.12), pulsatility (coefficient 0.08) and VA ECMO flow prior to decannulation played a role in success. The ROC-AUC for LVEF alone was 0.57, however, incorporation of additional variables improved the predictive power with an ROC-AUC of 0.857 (Figure 1).

Conclusion: Our findings accurately predict decannulation success and emphasize considering multiple factors. Prospective validation of a composite score combining these variables is warranted.

Figure 1: The Logistic Regression Model: Summary of Ranked Coefficients:

Utilization of Impella as a Weaning Platform from ECMO is Associated with Increased Survival in Cardiogenic Shock Patients

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Abstract

Background: Although extracorporeal membrane oxygenation (ECMO) is an integral part of a robust cardiogenic shock program, it is associated with high mortality. The optimal strategy for weaning from ECMO is unknown. We undertook this study to better understand the use of ECMO for acute cardiogenic shock.

Methods: We conducted a retrospective review of all cardiogenic shock patients at our facility from 2021-2023. Patients with mixed cardiogenic shock were included. The primary outcome was survival to discharge.

Results: From 2021-2023, 284 shock patients were treated by our shock team. A total of 91 (32.16%) patients were treated medically while 192 (67.84%) were treated with temporary mechanical circulatory support (tMCS), including 65 (22.89%) patients who were treated with ECMO. Of those treated with ECMO, 33 (50.77%) had another form of tMCS prior to ECMO cannulation, 43 (67.19%) utilized tMCS as a left ventricular vent while one ECMO, and 34 (53.97%) utilized Impella as a weaning platform for ECMO decannulation. Cardiogenic shock patients requiring ECMO support had lower survival compared to those who did not (35.38% vs. 65.30%, p<0.001) and this survival was unaffected by left ventricular venting (39.53% vs. 28.57%, p=0.39). However, patients utilizing Impella as a weaning platform from ECMO had significantly improved survival (55.88% vs. 13.79%, p=0.001) compared to those who did not wean to tMCS.

Implications: Although the need for ECMO is associated with an increased mortality in cardiogenic shock, the utilization of Impella as a weaning platform may mitigate some of the risks. Further investigation is warranted.
ECMO as an Indirect Bridge to Durable Left Ventricular Assist Device Implantation

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Abstract

Introduction: The need for preoperative extracorporeal membrane oxygenation (ECMO) support prior to left ventricular assist device (LVAD) therapy has been associated with increased mortality. Our study investigated the impact of de-escalating from ECMO to Impella prior to implantation.

Methods: We conducted a retrospective review of all LVAD implantations from 2017-2023. We stratified patients into 4 groups: those requiring ECMO at the time of LVAD; those requiring ECMO who were de-escalated to Impella only support; those requiring Impella support who never required ECMO; and those who did not require temporary mechanical circulatory support (tMCS). The primary outcome was Kaplan-Meier survival.

Results: From 2017-2023, 146 of our patients underwent LVAD implantation. Preoperative mechanical support included ECMO (4, 2.74%), ECMO then Impella only (11, 7.53%), Impella only (46, 31.51%), and no tMCS (85, 58.22%). Overall operative mortality was 8.22% with a 1-year survival of 85.40%. When stratified by the need for preoperative tMCS, the need for preoperative ECMO support was associated with significantly decreased 1-year survival (50.00%) compared to ECMO de-escalated to Impella only (80.81%), Impella only (80.88%), and no tMCS (89.91%, p=0.02). Notably, patients who initially required ECMO support but were subsequently de-escalated to Impella only had clinically and statistically similar survival compared to those requiring Impella only (p=0.92) or those who did not require tMCS (p=0.36).

Conclusions: Indirectly bridging from ECMO to LVAD by de-escalating to Impella only prior to LVAD implantation may mitigate the increased risk associated with using ECMO as a direct bridge to LVAD therapy.

Acquired blood stream infections during extracorporeal membrane oxygenation in adults: risk factors and outcomes.

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Abstract

Infection is one of the most frequent complications in the management of ECMO patients. Although there are several studies demonstrating the role of ECMO in patients with pre-existing sepsis, there are only a few studies with relatively small size on new-onset blood stream infection (BSI) during ECMO. Our study aimed to determine the clinical impact of new-onset BSI in ECMO. This was a retrospective, single-center and observational study. A total of 852 consecutive patients underwent ECMO at our institution between January 2014 and June 2020. Excluding patients with documented infections before ECMO, 639 patients were enrolled for analysis. In the multivariable analysis, ECMO weaning failure was associated with BSI (P = 0.005), continuous renal replacement therapy (P = 0.001), and lactate level at 24 h after ECMO (P = 0.004). Overall mortality was independently associated with BSI (P = 0.008). BSI was identified in 110 patients (17.2%), and these patients experienced more concomitant infections (78.2% vs. 38.8%; P < 0.001), red blood cell transfusions (17.0 [10.0, 30.0] vs. 9.0 [4.0, 17.0] units; P < 0.001), limb ischemia (12.7% vs. 5.3%; P = 0.008) and gastrointestinal bleeding (17.3% vs. 3.4%; P < 0.001) than patients without BSI. In conclusion, newly developed BSI during ECMO is significantly associated with poor clinical outcome. Pre-emptive management of patients with high risk of BSI may improve both ECMO weaning success rate and overall survival.
Association between prophylactic distal perfusion catheter insertion and survival at discharge in patients with out-of-hospital cardiac arrest who underwent ECPR; secondary analysis of the SAVE-J2 study

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Abstract
Background: Currently, the effect of prophylactic distal perfusion catheter insertion after extracorporeal cardiopulmonary resuscitation (ECPR) in patients with out-of-hospital cardiac arrest (OHCA) remains unclear. Therefore, we aimed to clarify the association between prophylactic distal perfusion catheter insertion and prognosis in patients with OHCA undergoing ECPR.

Methods: A secondary analysis of the Study of Advanced Life Support for Ventricular Fibrillation with Extracorporeal Circulation in Japan (SAVE-J II) database was performed to compare the groups with or without prophylactic distal perfusion catheter. A multivariable analysis of survival at discharge was performed using factors that were significant in the two-arm comparison.

Results: A total of 2,044 patients were included in the analysis after excluding those who adjusted the exclusion criteria. Survival at discharge was observed in 548 patients (26.9%). One hundred patients (4.9%) developed lower extremity ischemia, and 14 patients (0.7%) required therapeutic intervention for lower extremity ischemia. There was no significant association between survival at discharge and prophylactic distal perfusion catheter insertion (odds ratio [95% confidence interval]: 0.90 [0.65–1.24], p = 0.509).

Conclusion: The implementation of prophylactic distal perfusion catheter insertion after ECPR for patients with OHCA may not contribute to the survival at discharge. A further study is needed to determine in which cases prophylactic distal perfusion catheter insertion is useful.

Device Strategy in Non-Cardiac Procedures

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Abstract
Background: Invasive non-cardiac procedures (NCPs) are often required while patients receive tMCS due to CS. The purpose of this study is to analyze patients listed for OHT, undergoing NCPs with tMCS devices and their safety to undergo transplantation.

Methods: Records for patients listed for OHT from January 2015 to January 2023 were reviewed identifying patients receiving tMCS due to CS and performance of NCPs under support.

Results: A total of 152 patients were identified as supported by tMCS due to CS, with a total of 246 devices used as therapeutic approach. The cohort was predominantly male, with an average age of 57±12.4 years. Table 1 summarizes all characteristics and outcomes of CS patients under tMCS. Overall, 39% of patients underwent NCPs under tMCS. Figures 1 and 2 summarizes both trajectories of tMCS support towards OHT, and trajectories of tMCS undergoing NCPs. There is a significant difference in the number of performed transplants when single NCPs are conducted with single tMCS devices (p=0.0277). In the context of NCP performance, there is a significant difference in the number of performed transplants when comparing single to multiple NCPs, regardless of the number of tMCS devices (p=0.0326) (Table 2).

Conclusions: This study suggests that NCPs under tMCS are feasible regardless of the type of intervention, or number of support devices. Larger prospective studies are needed to determine a higher power of analysis to determine safety of technique and survival rates.
Algorithmic Approach to Early Extubation in V-V ECMO Patients

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Abstract

Background: Extubation while receiving V-V ECMO is being considered earlier for patients with respiratory failure. This can facilitate early mobilization, participation in physical therapy, and reduce the potential consequences of prolonged mechanical ventilation and analgesedation. When confronted with the decision of extubation vs tracheostomy in a V-V ECMO patient, there is a paucity of evidence to fully support one decision over the other. Our institution has created an algorithmic approach when faced with this conflict to help guide our management. We discuss three cases that highlight the use of this approach.

Methods: Three patients were selected to discuss the potential benefit of utilizing an algorithmic approach to extubation.

Results: All three patients would have met criteria for extubation. One patient had a tracheostomy performed instead of extubation, which resulted in excessive positive pressure and worsening bronchopleural fistulas, ultimately requiring re-cannulation and initiation on V-V ECMO. The other two had improved clinical outcomes, despite similar pathophysiology and clinical pictures.

Discussion

We often find ourselves in conflict when patients are showing improvement and we are faced with the decision to decannulate, extubate, or perform a tracheostomy. There is evidence supporting lack of orotracheal intubation in these patients, but minimal evidence to support tracheostomy over extubation. As we have implemented an algorithm in our decisions, based on respiratory mechanics, we are finding that some patients may certainly benefit from the removal of positive pressure to allow for parenchymal healing. Further studies are needed to validate and explore this approach.
Venting the Left Ventricle from the Atrium: A Case Series of transeptal LA Vent VA-ECMO

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Abstract

Introduction: In cardiogenic shock, peripheral veno-arterial extracorporeal membrane oxygenation (VA-ECMO) can provide hemodynamic support, however this results in adverse left ventricular afterload. Left ventricle (LV) venting (unloading) has favorable effects on myocardial remodeling and hemodynamics. The preferred approach at our institution is by adding left atrial drainage via trans-septal puncture, resulting in Bi-Atrial VV-A (BAVVA) ECMO. An advantage of BAVVA-ECMO is that it avoids the need for additional large bore arterial access. Here, we present our single center case-series on BAVVA-ECMO.

Methods: Adults cannulated for BAVVA-ECMO in our institution from 2011 – 2023. Baseline demographics including age, sex, race and BMI were examined. The primary outcome of interest was survival to recovery or transplant. Other outcomes of interest include bleeding, limb complications, renal replacement therapy and duration of ECMO support.

Results: There were 56 patients who underwent transeptal puncture for LA vent decompression at our institution. Baseline characteristics include a mean age of 53.1 ± 16.6, 37 (66.1%) male and a mean BMI 31.3 ± 5.7 (table 1). Patients were supported for a median of 10.6 [4.91, 15.9] days. Regarding complications 2 (3.6%) developed limb complications, 21 (37.5) required renal replacement therapy, and 13 (23.2%) experienced major bleeding. Regarding the primary outcome of interest, 28 (50%) survived to recovery or transplant.

Conclusion: LA transeptal venting for VA-ECMO is an alternative approach to left ventricular venting in cardiogenic shock that does not involve additional large bore arterial access. Further studies are needed to directly compare BAVVA-ECMO to other approaches in LV venting.
Predictors of Survival Outcomes and Discharge Location following VA-ECMO
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Abstract
Background: Mortality and complication rates remain high with VA-ECMO. Understanding risk factors for mortality and post-ECMO functional status may aid conversations about prognosis.

Methods: ELSO Registry data for adults supported with VA-ECMO from 2018-2022 were used to calculate proportions of three outcomes: death after ECMO withdrawal, death after ECMO liberation, and survival to hospital discharge. For patients liberated, we calculated proportions of: discharge home, discharge to facility, or death. We used generalized linear mixed models to measure associations between predictors and different outcomes, using random intercepts to account for within-site correlation.

Results: 24,530 patients were supported with VA-ECMO (33% female, 61% white, mean age 55.6 years). ECMO withdrawal occurred in 43.4%, 12.4% were liberated but died prior to discharge, and 44.2% survived to discharge. Within-site, higher odds of withdrawal versus survival were observed in older age (1.03 per year, p<0.001), pre-ECLS arrest (1.36, p<0.001), higher flow at 24 hours (1.11, p<0.001), and renal replacement therapy (2.14, p<0.001). Findings were similar for death following liberation versus survival. Higher odds of discharge home versus facility were observed for those who were mobile (1.56, p<0.001), and lower odds for those with major complications (0.39, p<0.001). Findings were similar for discharge home vs death.

Conclusion: Markers of illness severity at ECMO initiation were associated with withdrawal of ECMO and death following liberation. Discharge to a facility was more common than discharge home, however the odds of discharge home were higher for those who had minor or no complications and were mobile while receiving ECMO.

Concomitant Use of VA-ECMO and Impella Support for Cardiogenic Shock
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Abstract
Background: VA-ECMO with concomitant Impella support (ECpella) is an emerging treatment modality for cardiogenic shock (CS). Survival outcomes by CS etiology with ECpella support have not been well-described.

Methods: This study was a retrospective, single-center analysis of patients with cardiogenic shock due to acute myocardial infarction (AMI-CS) or decompensated heart failure (ADHF-CS) supported with ECpella from December 2020 to January 2023. Primary outcomes included 90-day survival post-discharge and destination after support. Secondary outcomes included complications post-ECpella support.

Results: A total of 44 patients were included (AMI-CS, n = 20, and ADHF-CS, n = 24). Patients with AMI-CS and ADHF-CS had similar survival 90 days post-discharge (p=.267) with similar destinations after ECpella support (p =.220). Limb ischemia and acute kidney injury occurred more frequently in patients presenting with AMI-CS (p=.013; p =.030). Patients with initial Impella support were more likely to survive ECpella support and be bridged to transplant (p=.033) and less likely to have a cerebrovascular accident (p=.016). Sub-analysis of ADHF-CS patients into acute-on-chronic decompensated heart failure and de novo heart failure demonstrated no difference in survival or destination.

Conclusion: ECpella can be used to successfully manage patients with CS. There is no difference in survival or destination for AMI-CS and ADHF-CS in patients with ECpella support. Patients with initial Impella support are more likely to survive ECpella support and bridge to transplant. Future multicenter studies are required to fully analyze the differences between AMI-CS and ADHF-CS with ECpella support.
Outcomes in Obese Are Comparable to Non-Obese Patients: A Propensity Matched Cohort Study

**Peter Barrett**, William Ballard, Benjamin DeMoss, Charles Ross, Stephanie Bass, Jeffery Wang; **Piedmont Atlanta Hospital, Atlanta, USA**

**Abstract**

**Introduction:** Obesity, defined as a body mass index ≥ 40 kg/m², was considered a relative contraindication to cannulation for extra-corporeal membrane oxygenation (ECMO) during the coronavirus pandemic. While body habitus can create technical challenges to cannulation, there is emerging evidence to support that with appropriate patient selection, obesity should not be the sole criteria for exclusion from consideration for ECMO. Here we perform a retrospective propensity score matched (PSM) cohort study examining outcomes in obese compared to non-obese individuals.

**Methods:** Adults cannulated for ECMO in our institution from 2011 – 2023. Obesity was defined as a BMI ≥ 40 kg/m² at time of cannulation. Propensity score matching (2:1) was performed using optimal matching on variables: age, sex, Race and ECMO configuration. The outcomes of interest was recovery/transplant and limb complications. Statistics were performed using MatchIt (V4.5.1) in R (V4.2.1).

**Results:** The matched cohort consisted of 191 obese patients and 382 non-obese patients. After matching, there were no significant differences in age, sex, race, and mode of support (Table 1). When comparing obese to non-obese patients, there were no differences in limb complications (9 [4.7%] 27 [7.1%], p=0.36) and survival to recovery/transplant (100 [52.4%] vs 212 [55.5%], p=0.33).

**Conclusion:** In appropriately selected populations, clinically meaningful outcomes are comparable between obese and non-obese patients.

<table>
<thead>
<tr>
<th>Obese Patients (n=133)</th>
<th>Non-Obese Patients (n=266)</th>
<th>P-Value</th>
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<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td>0.91</td>
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<td>49.6 ± 14.2</td>
<td>49.8 ± 15.5</td>
<td></td>
</tr>
<tr>
<td><strong>Male Sex</strong></td>
<td></td>
<td>0.79</td>
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<tr>
<td>104 (54.5%)</td>
<td>214 (56%)</td>
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<tr>
<td><strong>Race</strong></td>
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<tr>
<td>96 (50.3%)</td>
<td>199 (52%)</td>
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<tr>
<td><strong>White</strong></td>
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<tr>
<td>80 (41.9%)</td>
<td>155 (40.6%)</td>
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<tr>
<td><strong>Black</strong></td>
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<tr>
<td>15 (7.9%)</td>
<td>28 (7.3%)</td>
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<tr>
<td><strong>BMI</strong></td>
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<td>&lt; 0.001</td>
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<td>45.1 (42.7–49.5)</td>
<td>29.5 (26.0–33.5)</td>
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<tr>
<td><strong>Mode</strong></td>
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<tr>
<td>VV</td>
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<tr>
<td>82 (42.9%)</td>
<td>153 (40.1%)</td>
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<td>VA</td>
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<tr>
<td>102 (53.4%)</td>
<td>261 (56.8%)</td>
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<td><strong>Conversion</strong></td>
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<tr>
<td>5 (2.6%)</td>
<td>8 (2.1%)</td>
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<tr>
<td><strong>ECMO-CPR</strong></td>
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<td>29 (15.2%)</td>
<td>56 (14.7%)</td>
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<td><strong>Limb Complications</strong></td>
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<td>9 (4.7%)</td>
<td>27 (7.1%)</td>
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<tr>
<td><strong>Survival to Recovery or Transplant</strong></td>
<td>100 (52.4%)</td>
<td>212 (35.5%)</td>
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</tbody>
</table>

Levosimendan in extracorporeal membrane oxygenation in refractory cardiac arrest

**Rasha Kaddoura**, Bassant Orabi, Mohamed Izhom Mohamed Ibrahim, Ahmed Shehatta, Sumaya Alsaadi Alyafei, Amr Omar; Hamad Medical Corporation, Doha, Qatar. Qatar University, Doha, Qatar

**Abstract**

**Background:** Veno-arterial extracorporeal membrane oxygenation (VA-ECMO) can re-establish tissue perfusion in refractory cardiac arrest requiring cardiopulmonary resuscitation (CPR). Levosimendan showed potential benefit in VA-ECMO weaning and mortality but was not studied in extracorporeal CPR (ECPR). This study examined levosimendan effect on in-hospital survival with good neurological outcomes in ECPR.

**Methods:** A retrospective cohort study recruited patients receiving ECPR between January 2015 and March 2021. Neurological outcome was expressed by cerebral performance category.

**Results:** Eighty-seven patients were included with mean age of 45.4 years and 86.2% males. Eighteen (20.7%) patients received levosimendan. Baseline characteristics were similar between groups except dopamine use was significantly higher in comparator group (odds ratio = 0.134; 95% CI: 0.024-0.752, p=0.022). ~70% of patients in either group suffered in-hospital cardiac arrest and 70% had asystole. In > 50% of them, myocardial infarction was the cardiac arrest etiology. Overall, ~ 50% of patients received electrical shocks (Table 1). In levosimendan group, duration of CPR prior to VA-ECMO was numerically longer, lactate levels between second and fourth days after ECPR were higher (p=0.047) and VA-ECMO support was longer (p=0.019) (Table 2). Survival to decannulation (27.8% vs 26.1%) or hospital discharge (27.8% vs 24.6%) did not differ between groups. Almost all survived patients (n=22) had good neurological outcome. Four and three patients died in levosimendan and comparator groups (p=0.281), respectively, within 6 months post discharge. Length of ICU and hospital stays were similar. (Table 2).

**Conclusions:** Levosimendan did not improve survival in ECPR. Well-designed trials are needed in this population.
A safe and effective method for percutaneous, awake, bedside decannulation of peripheral VA ECMO using vascular closure devices: a case series.
Adam Betz, Daniel Hopkins, Judith Muskrat, Brooke Weaver, Elizabeth Gillum, Adel Barkat; Oklahoma Heart Institute, Tulsa, USA

Abstract
Decannulation of patients on peripheral veno-arterial extracorporeal membrane oxygenation (VA ECMO) typically involves femoral arterial cutdown and surgical arteriotomy closure in an operating room under general anesthesia. However, this requires exposure of the still-fragile ECMO patient to the risks of transport from the intensive care unit (ICU), the depressive cardiovascular effects of general anesthesia, and often of re-induction and intubation of a patient who passed their ECMO wean while awake and extubated. We describe a case series in which a novel technique for percutaneous closure of peripheral, percutaneously placed veno-arterial ECMO sites has allowed for safe and reliable closure is achieved in awake, extubated patients, at bedside in the ICU. Common femoral arterial (CFA) sites are closed by accessing the arterial cannula with an 18ga needle, introducing a wire into the CFA over which the arterial cannula is removed and the site subsequently closed with a Teleflex MANTA Closure Device and the superficial femoral artery reperfusion site with a Mynx Vascular Closure Device. In our ten-patient series, complications were minimal, with none developing limb ischemia requiring procedural intervention, failed hemostasis, conversion to cutdown, or requiring intubation or conversion to general anesthesia. In one case, wire access to the artery was lost prematurely but hemostasis was maintained with manual pressure and no further intervention was required. Percutaneous bedside closure of peripheral VA ECMO sites appears feasible and safe. Further study would help hone technique as well as elucidate complication rates and cost saving compared with traditional techniques.
Prognostic Significance of Ischemia-Reperfusion Intestine Injury in Patients with Refractory Cardiac Arrest

Jana Smalcova, Ondrej Franek, Michal Huptych, Petra Kavalkova, Ondrej Smid, Daniel Rob, Jan Pudil, Milan Dusik, Jan Belohlavek; 2nd Department of Internal Cardiovascular Medicine, General University Hospital in Prague, First Faculty of Medicine, Charles University in Prague, Prague, Czech Republic. 1Emergency Medical Service in Prague, Prague, Czech Republic. 3Emergency Medical Service in Prague, Prague, Czech Republic. 4Czech Institute of Informatics, Robotics and Cybernetics (CIIRC), Prague, Prague, Czech Republic

Abstract

Introduction: The duration of cardiac arrest (CA) and the quality of cardiopulmonary resuscitation (CPR) affect the severity of ischemia-reperfusion (IR) injury following resuscitation. It may manifest as an intestinal IR injury, possibly affecting the post-resuscitation course.

Hypothesis: We hypothesized that IR intestinal injury reflects the severity of reperfusion injury and is a significant negative prognostic marker in patients with refractory CA.

Methods: In a post-hoc analysis of a randomized, prospective Prague OHCA study comparing invasive strategies (intra-arrest transport, extracorporeal CPR (ECPR)) vs. standard on-site CPR in refractory CA, we assessed intestinal IR injury (profuse diarrhea, higher nasogastric tube waste) in the early phase after CPR. We correlated its occurrence with neurologically unfavorable survival at 180 days.

Results: Out of 256 patients enrolled in the original study, data on intestinal IR injury was recorded in 61 patients who survived more than 1 hour after admission: 46 (51%) of 89 patients treated with ECPR and 15 (16%) of 92 patients treated with standard CPR. The adverse neurological outcome was observed in 41 (89%) out of 46 patients in the ECPR group with IR injury (OR 4.39 (95% CI (1.43–13.47)) and 9 (60%) out of 15 patients in the CPR group (OR 1.8 (95% CI (0.58–5.55)). The manifestation of intestinal IR injury was significantly associated with a poor neurological outcome.

Conclusions: The incidence of intestinal IR injury in patients with refractory CA treated with ECPR is significantly associated with adverse neurological outcomes.
Transfer Learning Boosts Performance Of Deep Learning Model Prediction of In-Hospital Mortality In Patients Treated With Extracorporeal Membrane Oxygenation

Adeel Abbasi1, Isaac Sears1, George Zerveas2, Neel Sodha3, Corey Ventetuolo1,2, Carsten Eickhoff2,4; 1Warren Alpert School of Medicine at Brown University, Providence, USA. 2Brown University, Providence, USA. 3Brown School of Public Health, Providence, USA. 4University of Tübingen, Tübingen, Germany

Abstract

Background: The application of deep learning – a powerful but data-intensive subset of machine learning – to smaller cohorts including extracorporeal membrane oxygenation (ECMO) datasets is challenging. Transfer learning can boost the performance of deep learning models trained on smaller datasets.

Methods: We applied deep learning to routinely collected electronic health record data within the Medical Information Mart for Intensive Care IV database to predict in-hospital mortality in a small cohort of subjects treated with ECMO, 24 hours prior to death. Model performance was assessed with and without pre-training on data for subjects not treated with ECMO.

Results: The study dataset included 27,192 subjects admitted to one of six intensive care unit (ICUs) at a single medical center between 2008 and 2019. Seventy five (0.3%) subjects were treated with ECMO, including 58 (77%) treated with veno-arterial ECMO. In-hospital mortality in subjects treated with ECMO, 24 hours prior to death. Model performance was assessed with and without pre-training on data for subjects not treated with ECMO.

Pre-training on smaller cohorts of subjects not treated with ECMO resulted in similar strong performances.

Conclusions: A deep learning model performed well at predicting in-hospital mortality in a small cohort of patients treated with ECMO after first pre-training on data from patients not treated with ECMO. Transfer learning allows pre-trained deep learning models to be applied to smaller clinical datasets, including datasets of patients undergoing highly specialized treatments, resulting in better overall performance.

Evaluating the Impact of Undergoing Fasciotomy or Lower Extremity Amputation while on Venoarterial Extracorporeal Membrane Oxygenation

Benjamin Usry1, Maxwell Kilcoyne1, Cora Bisbee1, Sanford Zeigler1, Arman Kilic1, Zubair Hashmi2; 1Medical University of South Carolina, Charleston, USA. 2Virginia Commonwealth University, Richmond, USA

Abstract

Objectives: Lower extremity vascular complications are a major source of morbidity for patients on venoarterial extracorporeal membrane oxygenation (VA-ECMO) that may require fasciotomy or amputation. The objective of this study is to examine how fasciotomies and amputations affect VA-ECMO outcomes.

Methods: A retrospective review of all patients who underwent VA-ECMO at our institution from January 2018 to September 2022 was performed and clinical data was extracted from the electronic medical record. Patients who underwent a lower extremity fasciotomy or amputation (FA) while on VA-ECMO were compared with those who did not (non-FA).

Results: One hundred and forty-six patients met our inclusion criteria. Fasciotomy or amputation was performed on 8.2% (12) of patients. There were no significant differences in baseline demographics or VA-ECMO configuration between the FA and non-FA groups including BSA (2.03 vs. 2.13, p=0.64) or arterial cannula size (19.0 vs. 19.0 Fr., p=0.75). Most FA and non-FA patients had distal reperfusion cannulas ipsilateral to their femoral arterial cannula (75.0% (9) vs 67.9% (91), p=0.753). The FA group did have a significantly longer period of VA-ECMO support (7.5 vs 5 days, P=0.018) but no significant difference in survival to hospital discharge (25.0% (3) vs 38.3% (51), p=0.494) or median post-ECMO survival (281.5 vs 201.5 days, p=0.253).

Conclusions: Our study found no significant differences in survival outcomes for FA patients but this may be secondary to our limited sample size. The length of VA-ECMO support was significantly longer in the FA group, which emphasizes the importance of consistent neurovascular checks.
Characteristics of Elderly Patients Supported by Extracorporeal Membrane Oxygenation (ECMO)

Weiting Chen1, Valentina Obreja1, Taline Marcarian2, Vadim Gudzenko2, Peyman Benharash1; 1Ronald Reagan UCLA Medical Center, Los Angeles, USA. 2Ronald Reagan UCLA Medical Center, Los Angeles, USA

Abstract

Background: A few ECMO data are reported for the geriatric population.

Objective

To analyze the characteristics of elderly patients supported by ECMO from the ECMO support type, the reason for the ECMO therapy, survival at discharge, the highest level of mobility at seven days and during ECLS, as well as complications (stroke, acute kidney injury, bleeding, limb ischemia).

Methods: A retrospective chart review was performed on patients 65 and older from January 1st, 2018, to December 31st, 2022. Continuous variables were expressed as the mean ± SD. Categorical variables were expressed as numbers and percentages. Logistic regression was used. A P-value <0.05 was considered statistically significant. The Institutional Review Board approved this study. All data records were de-identified and analyzed anonymously.

Results: Among 709 ECMO patients (5 subjects were excluded given missing data), there are 127 patients: 34 female (29 VA, 5 VV) and 93 males (88 VA, 5 VV) for the youngest-old group ages 65-74, with survival at discharge 77 (61%). For the middle-old, those between ages 75 and 84 years, there are 26 patients, 12 female (11 VA) and 14 male (13 VA), with a survival at discharge of 50%. The oldest-old are those aged over 85 years – two females and one male on VA ECMO, survival at discharge 100%.

Conclusion: This single-center report analyzes the characteristics of ECMO patients aged 65 and older and the predictor factors for ECMO survival. Older age was not found to be an independent risk factor for mortality among VA ECMO patients.

Predictors of weaning failure in VA ECMO after cardiac surgery

Jae Hoon Kim, Pil-Je Kang, Jun Young Kim; Asan Medical Center, Seoul, Korea

Abstract

Background: Recently, the use of venoarterial (VA) extracorporeal membrane oxygenation (ECMO) for cardiogenic shock after cardiac surgery is increasing. Several factors are known for the success of VA ECMO weaning, but limited data are available regarding the predictor for weaning failure. The aim of this study was to identify the factors that may help predict failure during VA ECMO weaning.

Methods: From January 2005 to December 2021, patients who underwent VA ECMO support after cardiac surgery were retrospectively reviewed.

Results: Among 337 patients included in the study, 171 (50.7%) patients had weaning success and 166 (49.2%) patients had weaning failure. According to univariable analysis, age, BMI, hypertension, chronic kidney disease, lactate level before ECMO support were risk factor for ECMO weaning failure. On the other hand, there was no significant difference according to the type of surgery. As the length of VA ECMO support increased, the proportion of patients who weaned ECMO decreased, falling from 58.6% after 10 days to about 17.3% after 20 days. The cut off threshold for VA ECMO support period was 6.9 days. When VA ECMO was maintained for more than 6.9 days, ECMO weaning failure showed OR=2.22, CI [1.35-3.64], p=0.0017.

Conclusion: For VA ECMO weaning, establishing a treatment plan to ECMO weaning within 7 days help reduce weaning failure and patients with more than 7 days, it is better to consider heart transplantation or LVAD. More attention should be paid when ECMO weaning, patient with old age, HTN, CKD, high lactate level.
Safety and Effectiveness of the Lifemotion® ECMO Applied to Adults in Long-Term Cardiopulmonary Support

Jiajia Li1, Xiaoxiu Luo2, Yu Lei2, Hongyang Xu2, Jia Huang3, Yijiang Li4, Xiaobo Huang1

1Department of ICU, Sichuan Provincial People’s Hospital, University of Electronic Science and Technology of China, Chengdu, China. 2The Affiliated Wuxi People’s Hospital of Nanjing Medical University, Wuxi People’s Hospital, Wuxi Medical Center, Nanjing Medical University, Wuxi, China. 3National Clinical Research Center for Infectious Diseases, Third People’s Hospital of Shenzhen, Shenzhen, China. 4Guangdong Organ Support Engineering Technology Research Center, Shenzhen, China

Abstract

Objective: To assess the safety and efficacy of Lifemotion® ECMO (ChinaBridge Shenzhen Medical Technology Co., Ltd.) for providing long-term (≥seven days) cardiopulmonary support in adult patients.

Methods: A multicenter cross-sectional study was performed with patients who received Lifemotion® ECMO as an adjunctive therapy for ≥ seven days. Descriptive statistics were used to analyze the following variables: the incidence of serious adverse events and device-related adverse events during ECMO use, the rate of successful weaning from ECMO, discharge survival rate, and 28-day survival rate.

Results: Nine eligible patients from four centers who were enrolled between April 24 and August 1, 2022. The patients included six males (66.7%), with a mean age of 60.0 ± 20.2 years and a mean BMI of 23.9 ± 4.2 kg/m². The indications for ECMO were cardiogenic shock (n=4, 44.5%), high-risk PCI (n=3, 33.3%), and acute hypoxic respiratory failure (n=2, 22.2%). The mean duration of ECMO support was 8.6 ± 2.0 days, with VV ECMO in two patients (22.2%) and VA ECMO in seven patients (77.8%). Three patients experienced a total of four serious adverse events (left ventricular distension, right brachial artery thrombosis, cardiogenic shock, and ventricular fibrillation), all of which were related to primary disease. No device-related adverse events occurred during ECMO use. All patients were successfully weaned from ECMO and survived to discharge. Six patients (66.7%) survived to 28 days.

Conclusion: This study demonstrated for the first time the safety and efficacy of Lifemotion® ECMO for long-term cardiopulmonary support in adult patients.

Developing and Sustaining an Extracorporeal Cardiopulmonary Resuscitation (ECPR) Program for Out of Hospital Cardiac Arrest

Deborah Miller, RN, Crescens Pellecchia, DO, Naseem Hashmani, RN, Whitney Hooper, RN, Mark Gamber, MD; Medical City, Plano, USA

Abstract

Introduction: ECPR may improve outcomes in selected patients with refractory out-of-hospital cardiac arrest (OHCA). Our key findings in establishing and sustaining an out-of-hospital ECPR program were: (1) Identifying and assessing institution’s resources, (2) partnership with key EMS teams, (3) protocols and criteria that are clear to members of the team and, (4) training drills and team dynamics.

Methods: Development of an OHCA ECPR team consisted identifying key multidisciplinary personnel. If patients meet selection criteria (Table 1), they are brought to our institution by EMS. The patients are cannulated in the Catheterization Laboratory if no “hard-stop” criteria are met (Table 1). Every cannulated patient undergoes coronary angiogram and other interventions as necessary.

Results: From October 2022 to June 2023, EMS activated our ECPR team 31 times. Of the 31, 23 met criteria to proceed with VA ECMO cannulation. Per our protocol, patient must have a shockable rhythm on presentation or anytime throughout the arrest event. Various check-points are ensured completion by the ECPR Lead, such as: (1) Airway, (2) No Pulse Checks/Continuous LUCAS, (3) Roles Identified, and (4) First stick arterial for POC sample. EMS agency protocols were adapted for this select patient population. 15 patients survived to hospital discharge with good neurologic function (65%). 12 of the 15 received some type of cardiovascular intervention (PCI, thrombectomy, AICD placement) (80%).

Conclusions: with extensive resource allocation and partnership with EMS agencies, ECPR is a feasible. We have found, adherence to criteria and time to ECMO support, as important factors.
Impact of Coding Changes on Medicare Payment for Extracorporeal Membrane Oxygenation (ECMO)

Angelica Oyugi1, Jennifer Williams1, Kevin Kennedy2, Lianna Weissblum3; 1Medtronic, Mounds View, USA. 2Medtronic, Washington, USA. 3Medtronic, Minneapolis, USA

Abstract

Background: Since 2018, ECMO has evolved from a single inpatient code to multiple iterations resulting in changes to coding and payment. There is great interest in understanding how these changes impacted Medicare MS-DRG assignment and payment.

Methods: We conducted a retrospective analysis of patients undergoing ECMO between October 01, 2017, to September 30, 2022, using Medicare claims data. Patients were included in the study if they underwent an ECMO procedure based on ICD-10 PCS procedure codes.

Results: Effective October 01, 2018 (CMS FY2019), ECMO inpatient coding was updated to reflect central or peripheral access site. The following year, coding changes were implemented to specify ECMO duration as continuous or intraoperative. Since then, peripheral ECMO comprises approximately 78% of ECMO claims.

Prior to these changes, ECMO procedures were billed with a single code and superseded other procedures to group to MS-DRG 003, one of Medicare’s highest-paying MS-DRGs. During CMS FY2019, central ECMO continued to be assigned to MS-DRG 003; however, peripheral ECMO was paid via MS-DRGs for the primary procedure.

Considering resource utilization for ECMO regardless of access, Medicare responded to comments regarding resource consumption and refined its payment logic based on the ECMO updated codes that specify duration. Since then, 90+% of continuous ECMO, regardless of access site, is paid under MS-DRG 003.

Conclusion: The ECMO coding changes and subsequent revisions demonstrated the importance of considering resource utilization in MS-DRG assignments. The current ECMO codes continue to show the appropriate MS-DRG assignment of ECMO procedures based on resource utilization.

Outcomes Associated with the Use of Bilateral Distal Perfusion Catheters in Patients Undergoing Vena-Arterial Extracorporeal Membrane Oxygenation and Impella CP® (ECPELLA)

Otoniel Espinoza, CCRN1, Omar O. Hernandez, CCRN2, Lauren Plucinski, CCRN2, Carli Mooney, RN2, Drew Lupton, MD2, Srinivas Yallapragada, MD2, James Hayhurst, MD2, Marc Salhanick, MD2, Juan C. MacHannaford, MD2; 1Medical City Heart Hospital, Dallas, USA. 2Medical City Healthcare, Dallas, USA. 3Medical City Fort Worth Hospital, Fort Worth, USA

Abstract

Background: The use of femoral percutaneous microaxial flow pump Impella CP®, in addition to, VA-ECMO (ECPELLA) is an emerging option to overcome left ventricle overload and distension. Patients requiring ECPELLA who receive femoral cannulation have a risk of lower-limb hypoperfusion and ischemia of the contralateral, non ECMO, leg. Limited research is available on the use of bilateral distal reperfusion catheters (DPC) in ECPELLA patients who develop hypoperfusion of the lower extremities. Here we present our experience.

Methods: A retrospective review of patients with bilateral DPC while undergoing ECMO with Impella CP® was conducted between January 2021 and June 2023.

Results: Patient characteristics and outcomes are shown in table 1. During the study period, 41 out of 93 patients had simultaneous use of Impella CP® and VA-ECMO (ECPELLA) configuration. Of these patients, 25 (61%) had single DPC to ECMO extremity and no DPC to Impella CP® extremity. While 16 (39%) patients had bilateral DPCs to the ECMO and Impella extremities. In the single DPC group, 3 (12%) reported lower extremity complications in the Impella CP® limb. Two patients developed lower extremity compartment syndrome requiring fasciotomy and one patient developed lower extremity mottling that was resolved without surgical intervention. In the bilateral DPC group, no lower extremity complications were reported.

Conclusion: Bilateral DPCs may be a viable strategy for preventing lower extremity ischemia in patients who receive percutaneous femoral VA-ECMO with Impella CP®.
Impella 5.5® as a Bridge to Recovery in Patients with Acute Cardiogenic Shock Receiving Veno-Arterial Extracorporeal Membrane Oxygenation and IMPELLA CP®

Omar O. Hernandez, CCRN1, Otoniel Espinoza, CCRN2, Carolyn Soza, CCRN2, Merlita Mendoza, RN1, Jeremy Miller, RT1, Drew Lupton, MD1, Juan C. MacHannaford, MD1; 1Medical City Healthcare, Dallas, USA. 2Medical City Heart Hospital, Dallas, USA

Abstract

Background: Acute cardiogenic shock refractory to conservative treatment requires mechanical circulatory support (MCS). The concomitant use of veno-arterial extracorporeal membrane oxygenation (VA-ECMO) and percutaneous micro-axial flow pump ventricular assist device Impella CP® support is well documented. However, there is limited data on the use of Impella 5.5 as a bridge to recovery and separation from VA-ECMO and Impella CP. These are our associated outcomes.

Methods: A retrospective review of patients who were bridged from VA-ECMO and Impella CP® to Impella 5.5® was conducted from January 2019 to June 2023.

Results: Patient characteristics and outcomes are shown in Table 1. A total of 34 VA-ECMO cases with concomitant use of Impella CP® were performed during the study period. 23 (67.6 %) patients were separated from VA-ECMO but maintained Impella CP. There were 11 (32.4 %) patients who were bridged from VA-ECMO and Impella CP to Impella 5.5. Survival to discharge for patients who were weaned from VA-ECMO to Impella CP® was 16 (47.8%). Survival to discharge for patients who were transitioned to Impella 5.5® was 10 (90.9%). There was an increased ICU and Hospital length of stay for patients who transitioned to Impella 5.5.

Conclusion: Our institution’s experience when transitioning from VA-ECMO and Impella CP to Impella 5.5® has been positive with favorable outcomes. This strategy allows more time for residual myocardial recovery, progressive mobility, and functional rehabilitation.

Protective effects of Levosimendan in postcardiotomy V-A ECMO patients. Results of 6,456 ECMO runs.

Benjamin Friedrichson, Thomas Jasny, Michael Nordine, Oliver Old, Kai Zacharowski, Jan Kloka; Goethe University Frankfurt, University Hospital, Department of Anaesthesiology, Intensive Care Medicine and Pain Therapy, Frankfurt, Germany

Abstract

Background: Postcardiotomy patients on veno-arterial extracorporeal membrane oxygenation (V-A ECMO) often struggle with weaning due to cardiac dysfunction. Levosimendan, a calcium sensitizer with positive inotropic effects, shows potential for improving cardiac function and facilitating ECMO weaning in several retrospective studies.

Objective

The objective of this study was to determine the impact of levosimendan use on the hospital survival rates among postcardiotomy V-A ECMO patients at a national level in Germany.

Methods: This nationwide retrospective study is based on adult post-cardiotomy patients requiring V-A ECMO therapy from all German hospitals from 2012 to 2021, provided by the German Federal Statistical Office. A multiple logistic regression model for ECMO patients was used to adjust for predefined patient characteristics and complications.

Results: Of the 6,456 patients enrolled, 1,439 received levosimendan. Hospital mortality was 69.6% (n=1,001) in the levosimendan cohort and 77.8% (n=3,905) in the non-levosimendan cohort. The median age in the levosimendan cohort was 66 years (IQR: 57-74), significantly younger than in the non-levosimendan cohort (median: 67, IQR: 58-75, p=0.005). The odds ratio (OR) for mortality with levosimendan use was 0.561 (95% CI: 0.487-0.645). Age OR 1.037 (95% CI: 1.032-1.042), Elixhauser Comorbidity Index OR 1.004 (95% CI: 1.032-1.042), and female gender OR 1.245 (95% CI: 1.090-1.422) were associated with increased mortality.

Conclusions: This is the first nationwide cohort study to demonstrate a significant reduction in hospital mortality in postcardiotomy shock patients on V-A ECMO treated with levosimendan. However, the mortality rates in both groups exceed those reported in previous studies.
Nosocomial Infections in Adult Patients Undergoing Veno-arterial Extracorporeal Membrane Oxygenation for Acute Coronary Syndrome: Incidence, Risk Factors, and Clinical Outcomes

Hae In Ko1, Min Cheol Kim1, Yongwhan Lim1, Hwa Jin Cho1, Seong Eun Kim1, Do Wan Kim1, In Seok Jeong1, Hae In Ko1, Min Cheol Kim1, Yongwhan Lim1, Hwa Jin Cho1, Seong Eun Kim1, Do Wan Kim1, In Seok Jeong1; 1Chonnam National University Hospital and Medical School, Gwangju, Korea, Republic of.

Abstract

Introduction: Extracorporeal membrane oxygenation (ECMO) is an essential therapy for severe cardiopulmonary failure. However, the risk factors and impact of nosocomial infections (NI) during ECMO on prognosis have yet to be adequately studied. In this study, we aimed to evaluate the incidence and effects of NI, including multidrug-resistant infections, on clinical outcomes in adult patients undergoing venoarterial (VA) ECMO following acute coronary syndrome (ACS).

Methods: We conducted a retrospective analysis of medical records from January 2016 to December 2022 involving 172 adult patients who underwent VA ECMO for ACS-induced cardiogenic shock. These patients were categorized into the NI group and the non-NI group. Risk factors for NI were analyzed, and clinical outcomes were compared between the two groups.

Results: The median age of the patients was 69 years, with 23.8% being women. The incidence of NI was 21.31 cases per 1,000 ECMO-day. Multivariate analysis revealed that younger age, lower Glasgow Coma Scale, utilization of intra-ECMO renal replacement treatment (RRT), and absence of multidisciplinary care were significant risk factors for NI (Fig. 1). And the two groups had no significant difference in survival rate at discharge (p=0.103) (Fig. 2).

Conclusion: We found that a longer duration of ECMO and RRT was associated with an increased risk of NI. Additionally, we identified that multidisciplinary care plays a crucial role in reducing the occurrence of NI.

Outcomes of high-risk PCI supported by venoarterial extracorporeal membrane oxygenation

Shanshan Zhou1, Yundai Chen1, Yijiang Li2, Feng Tian1; 1The Chinese PLA General Hospital, Beijing, China. 2Guangdong Life and Organ Support Engineering Technology Research Center, Shenzhen, China

Abstract

This study aimed to investigate the short-term outcomes of high-risk percutaneous coronary intervention (PCI) with venoarterial extracorporeal membrane oxygenation (VA-ECMO) support in patients with complex coronary artery disease who were not feasible for surgical revascularization. The study was conducted retrospectively in a multi-center trial using Lifemotion ECMO system, and the short-term outcome was defined as the incidence of major adverse cardiac events (MACE) during the hospital stay and within 28 days after discharge. Between March 2022 and November 2022, 19 patients underwent high-risk PCI with ECMO support. The majority of the patients were male (84.21%), with a mean age of 63.25±10.28 years. The mean duration of the ECMO run was 66.82±78.74 hours. Successful revascularization was achieved in 100 patients (100%), and procedural success was achieved in 19 patients (100.00%). No MACE during hospital stay occurred, and one case of MACE occurred within 28 days after discharge (5.26%).

In conclusion, high-risk PCI with VA-ECMO support is a feasible treatment option for patients with complex coronary artery disease who are not feasible for surgical revascularization. However, larger and prospective studies are needed to confirm the benefits of ECMO support in elective high-risk PCI compared to other mechanical circulatory support devices.
A comparison of ECMO center policies and protocols across the United States
Jenna Lizzo1, Justin Clapp2, Jacqueline Kruser3, Rachel Hadler4; 1University of Iowa, Iowa City, USA. 2University of Pennsylvania, Philadelphia, USA. 3University of Wisconsin, Madison, USA. 4Emory University, Atlanta, USA

Abstract
Introduction: As use of extracorporeal membrane oxygenation (ECMO) has become more widespread, researchers, clinicians, and organizations have sought to refine and disseminate standardized utilization criteria. However, little is known about how individual institutions deploy this information in patient selection.

Methods: We used the Extracorporeal Life Support Organization (ELSO) Center Directory to identify adult ECMO centers across the United States and invited center leadership to share documents describing their policies and protocols informing ECMO use. Four investigators performed qualitative content analysis of the shared documents.

Results: 284 centers were contacted. Of the 91 (32.0%) that responded, 47 (16.5%) provided documents. All centers (47/47) referenced ELSO guidelines. The most frequently cited indications for venoarterial (VA) ECMO were specific diagnoses, including post-cardiotomy shock (25/47), cardiogenic shock (22/47), and pulmonary embolism (19/47). Clinical parameters such as urine output (11/47) and cardiac index (9/47) also guided initiation. Indications for venovenous ECMO were more heterogeneous but centered on physiologic criteria such as hypoxemia (34/47), respiratory acidosis (15/47), and hypercapnia (15/47). In contrast to VA ECMO documents, specific diagnoses were less frequently described. Commonly referenced contraindications for both modalities of support included: neurological dysfunction (36/47), age (35/47), obesity (24/47), and malignancy (24/47). Do-not-resuscitate status was described as a contraindication at 6/47 centers. Many protocols left substantial leeway for clinicians to determine poor candidacy based on subjective assessment of big-picture issues like recoverability or quality of life.

Conclusion: Although ECMO selection criteria are frequently described as being based in available clinical evidence, institutional selection criteria vary significantly.

Utilization of ECMO in liver transplant patients: Pre-emptive vs rescue strategy, jury is still out!
Pramod Guru, Pablo Moreno Franco, Anirban Bhattacharyya, Anek Jena, Rhoda Tawk, Sean Kiley, Devang Sanghavi, Philip Lowman, Juan Canabal, Ryan Chadha, Stephen Aniskevich, Martin Archer, Mathew Thomas, Kevin Landolfo, Burcin Taner, Basar Sareyyupoglu, Si Pham, Sanjay Chaudhary; Mayo Clinic, Jacksonville, USA

Abstract
Background: The growing body of evidence supports the utilization of ECMO in perioperative period in liver transplant patients. Controversies and challenges exist for the type (VV vs VA vs combination) and timing (preemptive cannulation vs rescue strategy) of ECMO support in these patients. We present our case series utilizing ECMO during perioperative period in liver transplant patients.

Methods: We retrospectively reviewed our experience with utilization of ECMO in the liver transplant patients from January 2017 till June 2023.

Results: Total of 7 out of 1002 patients (0.007%) undergoing liver transplantation were found to have received ECMO support. The mean age was 60 years and 70% were female. The mean MELD score prior to transplant was 27, and all patients had NASH as the primary liver disease. Of the 7 patients, pre-emptive peripheral VA cannulation prior to transplant was performed in 1 patient, 4 required emergent VAECMO support intra-operatively, and 2 patients were supported by VVECMO in post-transplantation period for ARDS. Mean duration of ECMO was 5 days, and the 30-day hospital survival rate was 57%.

Conclusion: ECMO should be considered in carefully selected patients undergoing liver transplantation, pre-emptively to overcome the risk of peri-operative cardiorespiratory decompensation as well as in other severe and potentially reversible causes of respiratory and/or cardiovascular collapse.
Optimal Early ECMO Sweep Flow and Cerebral Autoregulation in Swine ECPR
Hannah Rando, Jin Kook Kang, Jose Porras, Ifeanyi Chinedozi, Zachary Darby, Glenn Whitman, Steven Keller, Sung Min Cho; Johns Hopkins Hospital, Baltimore, USA

Abstract
Background: In the immediate peri-cannulation period of ECPR, clinicians may increase sweep to correct acidosis and hypercapnia. Given CO2 is a potent vasodilator and cerebral autoregulation regulator, we hypothesized that rapid CO2 removal with high sweep could impair cerebral autoregulation.

Methods: In our ECPR swine model, animals were assigned to rapid sweep (200%), slow sweep (25%), or control sweep (100%) flow. Bilateral femoral access was obtained for ECPR. An intracranial pressure (ICP) monitor was placed via burr-hole craniotomy and fibrillatory arrest was induced to avoid confounding, vasoactive medications and chest compression were not given. At 15 minutes post-arrest, ECMO flow was initiated at 50-60 mL/kg/minute. After five minutes of ECMO, defibrillation was performed. ECMO was maintained for five minutes post-ROSC. ABG data was collected at baseline (T0), after ECMO initiation (T1), after ROSC (T2), and before euthanasia (T3). ICP and MAP data were collected continuously and used to calculate the pressure reactivity index (Prix) at T0 and T3.

Results: Six animals were included, with two in each treatment group. ABG data did not differ between groups at T0 or T1. Rapid sweep yielded a higher pH and lower PaCO2 at T2 and T3. Prix at T0 was negative in all groups at T0 and positive in the rapid sweep group at T3, but the correlation index was close to zero, indicating intact autoregulation.

Conclusion: In this hyperacute swine ECPR model, rapid sweep flow did not alter cerebral autoregulation function. Further research with a structural brain assessment is necessary.

Factors Associated with Small Arterial Return Cannula among Adults Receiving VA-ECMO: An ELSO Registry Analysis
Laura Aguilar-Franco, Alvaro A. Delgado, Kevin Kennedy, A. Reshad Garan, E. Wilson Grandin; Beth Israel Deaconess Medical Center, Boston, MA, USA

Abstract
Introduction: Observational studies suggest similar outcomes among adults receiving VA-ECMO supported with a small versus larger arterial return cannula. The factors associated with the use of a small arterial cannula (SAC) and the variability of SAC use across ECMO centers are not well described.

Methods: We analyzed adult VA-ECMO cases from the ELSO registry (2017-2022), categorizing patients into small (<16 Fr) and large (>16 Fr) arterial cannula sizes. Excluding central cannulation and multiple ECMO runs. We used multivariable logistic regression modeling (MVM) to investigate factors associated with SAC use. After restricting to centers performing >20 VA-ECMO cases, the SAC rate was defined as the number of patients with SAC divided by the total number of VA-ECMO patients supported at that center.

Results: Among 10,130 adults receiving VA-ECMO, 1802 (17.8%) received a SAC. SAC recipients were more often female, had lower BSA, were less likely to be Caucasian, had lower rates of post-cardiotomy shock or acute myocardial infarction, lower rates of >2 vasopressor use, and decreased incidence of pre-ECMO organ failures (Table 1) MVM factors most strongly associated with SAC use were female gender, Asian race, smaller BSA, the absence of organ failures, primary diagnoses of heart transplant, pulmonary arterial hypertension, and congestive heart failure (Figure 1). There was wide variability in SAC use with 25% of centers never using a SAC (Figure 2).

Conclusions: Clinical factors strongly associated with SAC use include gender, body size, and concomitant organ failures. SAC utilization is low with significant variation across ECMO centers.
Impact of a Multidisciplinary C-Shock Team on the Survival of Patients Undergoing VA ECMO in an Academic Quaternary Hospital Center.

LeeAndra Schnell, Ioana Dumitru; Tampa General Hospital, Tampa, USA

Abstract

Background: Veno-arterial Extracorporeal membrane oxygenation (VA ECMO) is an advanced form of temporary mechanical circulatory support (tMCS) used for patients with SCAI D/E cardiogenic shock. Overall survival to hospital discharge is at best 50% according to the ELSO Registry Report.

Hypothesis: We aimed to analyze whether using a multidisciplinary C-Shock team (Heart Failure Cardiologist, Cardiac Surgeon, Interventional Cardiologist, Critical Care physician, MCS Coordinator) in-de-escalating support for patients on VA ECMO is superior to a no team approach when survival is concerned.

Methods: We conducted a single center retrospective review of all patients who were initiated on VA ECMO for cardiogenic shock between March 1, 2022- June 1, 2023, and were alive at the time of VA ECMO decannulation. Survival of patients decannulated via C-Shock alert for de-escalation was compared to patients having no C-Shock activation prior to VA ECMO decannulation.

Results: Of a total of 42 patients, 13/42(31%) had a C-Shock alert for de-escalation and 29/42 (69%) did not. 9/13(69%) of pts de-escalated via team activation were alive at discharge. 16/29 (55%) pts decannulated without a C-Shock call were alive at discharge.

Conclusion: C-Shock team activation for de-escalation of therapy of VA ECMO has proven to have superior survival when compared to non-team decision making and to current published ELSO registry survival data (69% vs 55%). Further larger database analysis should be conducted.

---

**TABLE 1 Baseline Characteristics of Adults Supported With VA-ECMO Stratified by Canoule Size**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total (n=42)</th>
<th>Cannula size 12 to 15 (n=30)</th>
<th>Cannula size 16 to 20 (n=12)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>55.19 ± 14.42</td>
<td>54.54 ± 15.70</td>
<td>55.28 ± 14.13</td>
<td>0.048</td>
</tr>
<tr>
<td>Race</td>
<td>68.22 (67.3%)</td>
<td>93.01 (91.9%)</td>
<td>58.66 (70.7%)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>BSA</td>
<td>2.61 ± 0.30</td>
<td>1.87 ± 0.22</td>
<td>2.04 ± 0.30</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Race</td>
<td>5722 (66.5%)</td>
<td>909 (44.9%)</td>
<td>4919 (99.0%)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Asian</td>
<td>1368 (31.5%)</td>
<td>403 (25.1%)</td>
<td>915 (11.5%)</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>1075 (10.6%)</td>
<td>153 (8.6%)</td>
<td>922 (11.1%)</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>612 (6.0%)</td>
<td>114 (6.3%)</td>
<td>498 (6.0%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>1333 (13.4%)</td>
<td>273 (15.1%)</td>
<td>1060 (13.0%)</td>
<td></td>
</tr>
<tr>
<td>Primary diagnosis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postcardiomy</td>
<td>1984 (19.6%)</td>
<td>332 (17.9%)</td>
<td>1652 (20.0%)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Acute Myocardial Infarction</td>
<td>2279 (22.0%)</td>
<td>319 (17.7%)</td>
<td>1910 (22.9%)</td>
<td></td>
</tr>
<tr>
<td>Chronic Heart Failure</td>
<td>1762 (17.4%)</td>
<td>364 (16.1%)</td>
<td>1418 (17.0%)</td>
<td></td>
</tr>
<tr>
<td>VVTM</td>
<td>497 (4.9%)</td>
<td>82 (4.9%)</td>
<td>415 (5.3%)</td>
<td></td>
</tr>
<tr>
<td>Heart Transplant</td>
<td>269 (2.6%)</td>
<td>60 (3.2%)</td>
<td>199 (2.3%)</td>
<td></td>
</tr>
<tr>
<td>Myocarditis</td>
<td>466 (4.6%)</td>
<td>120 (6.4%)</td>
<td>346 (4.4%)</td>
<td></td>
</tr>
<tr>
<td>Pulmonary Embolism</td>
<td>428 (4.2%)</td>
<td>80 (4.4%)</td>
<td>348 (4.2%)</td>
<td></td>
</tr>
<tr>
<td>Pulmonary Hypertension</td>
<td>90 (9.0%)</td>
<td>29 (1.6%)</td>
<td>61 (7.7%)</td>
<td></td>
</tr>
</tbody>
</table>

Concomitant Organ Failure

- Respiratory
- Renal
- Liver
- Pre-ECMO Arrai
- DCM
- RV Fx
- Heart Failure
- PVF
- Pre-ECMO pH
- Vasoconstrictor drugs
- 2-3

Time on ECMO, h

146.42 ± 153.88

*The data is limited to cardiac support. Values are mean ± SD or median (IQR). ECMO= Extracorporeal Membrane Oxygenation; ECP= Extracorporeal Hemolymphatic Resuscitation; MAP= Mean Arterial Pressure; VA-ECMO= Veno-Arterial Extracorporeal Membrane Oxygenation; VVTM= Ventricular Tachycardia/Ventricular Fibrillation; DSA= Body Surface Area; IAP= Intra-Aortic Balloon Pump; pVAD= Perfusion Ventricular Assist Device.*
Single Arterial Access for ECMO and Impella Support - SAECPELLA
Rene Aleman, Federico Napoli, David Baran, Cedric Sheffield, Jose Nava, Nicolas Brozzi; Cleveland Clinic Florida, Weston, USA

Abstract

Background: The application of temporary mechanical circulatory support (TMCS) for cardiogenic shock (CS) continues to evolve with increasing recognition of the value of left ventricular venting. Dual application of Impella 5.5 and veno-arterial extracorporeal membrane oxygenation (VA-ECMO) provides the most robust platform for patients with severe CS. Single axillary arterial access is intended to facilitate rehabilitation of patients receiving dual TMCS.

Methods: Description of surgical strategy and technical pitfalls. Retrospective chart review of CS patients receiving dual TMCS with single axillary arterial access for Impella 5.5 and VA-ECMO (SAECPELLA), including management strategies, clinical trajectory, requirement of heart replacement, development of major complications, and hospital survival.

Results: A total of 5 patients presenting CS received SAECPELLA support. All patients were male, with a mean age of 58.6±5.9-years. Table 1 summarizes all general demographics and clinical characteristics, and Table 2 summarizes SAECPELLA characteristics and clinical trajectory of patients. Hospital survival was 80% (4 patients) with 1 patient weaned-off support due to myocardial recovery (N=1) and 3 patients bridged to heart transplant. Figure 1 summarizes the trajectory of patients with CS supported with ECPPELLA. Following support, a significant difference was observed on ejection fraction (p=0.0076) and fibrinogen levels (p=0.0001). Two device-related complications were reported, and a single mortality occurred while on-support.

Conclusions: SAECPELLA configuration is a feasible approach for TMCS in patients with CS, providing promising outcomes via a robust preemptive intervention in face of biventricular failure. Further studies are needed to determine the long-term outcomes of the implementation of this technique.

Table 1

<table>
<thead>
<tr>
<th>General Demographics</th>
<th>Mean±SD or N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>5</td>
</tr>
<tr>
<td>Age (years)</td>
<td>58.6±5.9</td>
</tr>
<tr>
<td>Gender (M)</td>
<td>5 (100)</td>
</tr>
<tr>
<td>OSH patients</td>
<td>2 (40)</td>
</tr>
</tbody>
</table>

Table 2

<table>
<thead>
<tr>
<th>ECPPELLA Characteristics</th>
<th>Mean±SD or AVG (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>5</td>
</tr>
<tr>
<td>LOS (days)</td>
<td>30.4±20.8</td>
</tr>
<tr>
<td>LOS post-ECPPELLA</td>
<td>14.6±15.2</td>
</tr>
<tr>
<td>Right axillary artery cannulation</td>
<td>5 (100)</td>
</tr>
<tr>
<td>Sodium bicarbonate line purge</td>
<td>5 (100)</td>
</tr>
<tr>
<td>Time on support (days)</td>
<td>13.2±10.9</td>
</tr>
<tr>
<td>ECPPELLA complications</td>
<td></td>
</tr>
<tr>
<td>CVA</td>
<td>1 (20)</td>
</tr>
<tr>
<td>Clogging</td>
<td>1 (20)</td>
</tr>
<tr>
<td>Circuit exchange</td>
<td>1 (20)</td>
</tr>
<tr>
<td>Successful decannulation</td>
<td>4 (80)</td>
</tr>
<tr>
<td>Bridge to Transplant</td>
<td>3 (60)</td>
</tr>
<tr>
<td>ECPPELLA to OHT listing (days)</td>
<td>6.0±5.3</td>
</tr>
<tr>
<td>ECPPELLA to OHT (days)</td>
<td>14.3±12.0</td>
</tr>
<tr>
<td>Type of transplant</td>
<td></td>
</tr>
<tr>
<td>Heart</td>
<td>2 (40)</td>
</tr>
<tr>
<td>Heart &amp; Kidney</td>
<td>1 (20)</td>
</tr>
<tr>
<td>Anticoagulation post ECPPELLA</td>
<td></td>
</tr>
<tr>
<td>Heparin</td>
<td>5 (100)</td>
</tr>
</tbody>
</table>

Maternal and fetal outcomes in peripartum extracorporeal membrane oxygenation
Benjamin Seadler, James Zelten, Adhitya Ramamurthi, Adam Ubert, Lucian Durham; Medical College of Wisconsin, Milwaukee, USA

Abstract

Introduction: Management of peripartum cardiogenic shock and respiratory failure affects both mother and fetus. Initiation of extracorporeal membrane oxygenation (ECMO) may be delayed out of concerns for the effects of anticoagulation on fetus and eventual delivery.

Methods: A single-center retrospective analysis of all patients with peripartum cardiogenic shock or respiratory failure necessitating ECMO support between 2016 and 2023.

Results: 15 patients met criteria, 8 antepartum and 7 postpartum. Maternal age was 34 ± 7.2 years (mean ± SD) and gestational age on admission was 26 ± 4.0 weeks. Indications were respiratory failure in 13 patients (7 COVID related), and 2 post-partum cardiomyopathies. ECMO configuration was V-V in 7 patients, V-PA in 6, and V-A in 2. Of the 8 antepartum mothers, 6 delivered on ECMO via cesarean section and all fetuses survived to discharge. Gestational age at delivery was 30 ± 2.6 weeks. The most common complication was bleeding requiring reoperation in 50%. All antepartum mothers were alive 1 year after discharge. Of the 7 postpartum mothers, 5 survived to discharge and were alive at 1 year, with 2 mortalities related to intracranial hemorrhage.

Conclusion: ECMO provided a mean increase of 4 weeks gestational age in this cohort. There were no anticoagulation-related adverse events in mother or fetus prior to delivery. Peripartum ECMO is a viable strategy for the treatment of refractory cardiogenic shock or respiratory failure.

Percutaneous RVAD for acute right heart dysfunction: indications and outcomes
Benjamin Seadler¹, Brian Butterfield¹, James Zelten¹, Lyle Joyce¹, Adam Ubert¹, David Joyce², Lucian Durham¹; ¹Medical College of Wisconsin, Milwaukee, USA. ²Eastern Idaho Falls Regional Medical Center, Idaho Falls, USA

Abstract

Introduction: Outcomes regarding percutaneous right ventricular assist device (pRVAD) placement with and without an oxygenator vary greatly with the pathology necessitating support. Patient selection and the timing of the initiation of therapy continue to be debated.

Methods: A single-center retrospective analysis of all adult patients that required pRVAD support from March 2021 to May 2023.

Results: 106 patients required pRVAD support; the mean age was 55 years and 70% were male. 18% had no oxygenator while 72% required an oxygenator. Indications were respiratory failure (40%), cardiogenic shock (30%), post-cardiotomy cardiogenic shock (PCCS) (22%), post-left ventricular assist device insertion (7%), and trauma (1%). Survival to discharge was 67% for respiratory failure, 65% for cardiogenic shock, and 47% for PCCS. Among survivors, the mean length of stay was 58 days for cardiogenic shock, 28 days for PCCS, and 64 days for respiratory failure. Complications included Acute Kidney Injury (AKI) with 50% receiving continuous renal replacement therapy (CRRT) during RVAD support; 19% of survivors were discharged on dialysis. Bleeding issues included gastrointestinal (6%), diffuse alveolar hemorrhage (3%), intracranial hemorrhage (4%) and pericardial effusion (1%). Device migration below the pulmonic valve required repositioning in 7%.

Conclusions: Acute right heart failure with or without respiratory failure is a highly morbid condition with heterogeneous outcomes based on the indication for support. Further research on earlier identification of right heart dysfunction and initiation of pRVAD support is warranted to impact the complication profile.
Post-closure percutaneous decannulation of femoral veno-arterial extracorporeal membrane oxygenation (VA ECMO)
Naseem Hashmani, BSN, RN, CCRN, Deborah Miller, BSN, RN, CCRN, Crescens Pellecchia, MD, Rikesh Patel, MD, FACC, Drew Lupton, MD; Medical City Plano, Plano, USA

Abstract
Background: Femoral VA ECMO decannulation is traditionally performed in the operating room by vascular or cardiothoracic surgery and requires femoral cutdown to repair the arteriotomy. The logistical and surgical nature of this technique poses challenges such as: operating room availability, surgeon availability, significant blood loss, additional anesthesia, and risk of infection. To circumvent these challenges, we collaborated with our interventional cardiology colleagues to percutaneously decannulate patients from VA ECMO in the cardiac catheterization lab utilizing perclose sutures.

Methods: In this single-center retrospective chart review, we collected data on all patients that were decannulated from VA ECMO support between 01/01/2023 to 05/01/2023.

Results: Twelve patients were decannulated from VA ECMO. Of the twelve, two were decannulated percutaneously and the remainder underwent open surgical repair of the arteriotomy. Both percutaneously decannulated patients were also percutaneously cannulated in an extracorporeal cardiopulmonary resuscitation (ECPR) setting with similar cannulation techniques (Table 1). Neither patient had significant peripheral vascular disease, limb ischemia, or skin breakdown around cannulation sites. Length of VA ECMO support was 6 days for both patients. Estimated blood loss during percutaneous decannulation was between 40 to 50 mL. There were no reported events after percutaneous decannulation of lower extremity complications, major bleeding, or infection related to decannulation and closure. One patient was discharged from the hospital and the other was discharged to hospice care.

Discussion: Post-closure percutaneous decannulation of VA ECMO appears to be a viable option for certain patient populations and when the risks of traditional open surgical repair outweigh the benefits.

The outcome of extracorporeal membrane oxygenation in adult patients with septic shock: a systematic review and meta-analysis
Hwa Jin Cho1, Kollengode Ramanathan2, Do Wan Kim3, In Seok Jeong1, 2 Chonnam National University Children’s Hospital and Medical School, Gwangju, Korea, Republic of. 3 National University of Singapore, Singapore, Singapore. 1 Chonnam National University Hospital and Medical School, Gwangju, Korea, Republic of

Abstract
Objective: Several studies have suggested that extracorporeal membrane oxygenation (ECMO) support may enhance the possibility of survival in adult patients with septic shock. Nonetheless, the clinical results are still inconsistent.

Methods: We systematically searched PubMed, Embase, Scopus, and Cochrane databases up to December 2022, and included all relevant studies reporting on > 10 adult patients requiring ECMO for septic shock. A meta-analysis was performed to accomplish 3 objectives: firstly, to evaluate the overall survival rate in patients with septic shock; secondly, to compare the survival rates between patients receiving ECMO and those not receiving ECMO; and thirdly, to assess the disparities in survival rates between venoarterial (VA)-ECMO and venovenous (VV)-ECMO.

Results: Seventeen observational studies were included in the analysis with a total of 664 ECMO patients. The pooled survival rate in this population was 42.9% (95% Confidence interval (CI): 0.32-0.55%) (Fig. 1) and when analyzing the trend of survival rates based on the years of inclusion studies, the survival rate did not increase (Fig. 2). After including 3 studies (VA-ECMO: 1, VV-ECMO: 2) for adult septic shock, ECMO group demonstrated significant improvement in survival compared to non-ECMO treatment (Fig. 3) (OR = 2.90, 95% CI = 1.14–7.38, P=0.03). VA-ECMO showed no survival enhancement as compared to VV-ECMO (N = 6, OR = 0.61, 95% CI = 0.25-1.47, P=0.27).

Conclusions: More than 40% of septic shock patients treated with ECMO support survive. Use of ECMO may increase survival rates compared to conservative treatment.
Arterial Cannula Size and the Need for Delayed Left Ventricular Mechanical Unloading in Adults Supported with VA-ECMO: An ELSO Registry Analysis

Alvaro A. Delgado, Laura Aguilar-Franco, Kevin Kennedy, A. Reshad Garan, E. Wilson Grandin; Beth Israel Deaconnes Medical Center, Boston, USA

Abstract

Introduction: VA-ECMO is commonly used with left ventricular mechanical unloading (LVMU), including intra-aortic balloon pump (IABP) or percutaneous left ventricular assist device (pVAD). The impact of arterial cannula size on the need for a delayed LVMU is unknown.

Methods: We queried the ELSO Registry from 2017-2022 for adults undergoing VA-ECMO and stratified them by small (<16 Fr) versus large (≥16 Fr) arterial cannula. We excluded those with concomitant LVMU, central cannulation and multiple runs. The primary outcome was the need for delayed LVMU, defined as IABP or pVAD placed >3 hours after ECMO initiation, and the influence of arterial cannula size was examined using multivariate logistic regression modeling.

Results: Among 6216 adults supported with VA-ECMO who met study criteria, 1230 (19.8%) patients received a small arterial cannula (SAC). Patients with a SAC were less likely to be male, had smaller BSA, a lower incidence of pre-ECMO arrest, a lower incidence of pre-ECMO organ failures, and were less likely to be on >2 vasopressors (Table 1). Among 341 (5.5%) patients who underwent delayed LVMU, those with a small arterial cannula were more likely to receive IABP whereas patients with larger arterial cannula were more likely to receive a pVAD (Figure A). In multivariable modeling, the use of a small arterial cannula was not associated with the need for a delayed LVMU device (Figure B).

Conclusions: In adults supported with VA-ECMO, there was no difference in the need for a delayed LVMU device among patients receiving a small versus larger arterial cannula.
Complex and Hybrid Extracorporeal Membrane Oxygenation Implementation: Outcomes from a High Volume ECLS Center
Mario A Padilla, MSN, APRN, AGACNP-BC, CCRN, FCCS, Karina Reyes, MSN, AGACNP-BC, CCRN, Trenton Raff, APRN, AGACNP-BC, Nicole Reagan, BSN, RN, Kaitlyn Lingle, BSN, RN, CCRN-CSC, Kara A Monday, MD, Britton A Blough, MD, Dan M Meyer, MD, Gary S Schwartz, MD, Michael Foreman, MD; Baylor University Medical Center, Dallas, USA

Abstract
Introduction: While standard veno-venous (V-V) and veno-arterial (V-A) extracorporeal life support (ECLS) configurations are most utilized, some patients require more complex or hybrid configurations tailored to their specific pathophysiology. This may include additional venous drainage and/or return cannulation, utilization of dual lumen cannulas for additional drainage and/or return, multiple circuits in parallel, as well as variable central cannulation models. Limited data exists regarding the decision-making process for upgrading, downgrading, or selecting the appropriate hybrid model.

Methods: A retrospective analysis was conducted at a high volume ECLS center to assess patients undergoing complex cannulation strategies. The primary endpoint was weaning from ECLS and survival to discharge. Secondary endpoints were identification of common pathologies necessitating hybrid ECLS support, outlining reconfiguration plans, and defining alternative exit strategies.

Results: From 2018 to 2023, 782 patients were supported in one of the standard configurations, with 60 requiring reconfigurations to a hybrid mode. The initial and hybrid configurations of these patients are listed in Table 1. Patients were predominantly male (42/60, 70%). The most common reconfiguration was veno-arteriovenous (V-AV, 42%). Four patients required left atrial drainage due to left ventricular distention and/or thrombus. Successful weaning occurred in 29/60 (48%), with 22/29 (76%) surviving to discharge neurologically intact.

Conclusion: Standard ECLS configurations may not adequately support critically ill patients, necessitating the use of hybrid configurations tailored to individual pathophysiology. Consensus-based guidelines are needed to aid decision-making. The study proposes an algorithm (Figure 1 & 2) to guide the selection and reconfiguration of hybrid ECLS models.
Adult Cardiac

Early versus late extracorporeal cardiopulmonary resuscitation for in-hospital cardiac arrest (RAPID): a target-trial emulation of the ELSO registry.
Ryan Ruiyang Ling1, Tianyuan Gu1, Bee Choo Tai1, Jae Seung Jung1, Marc Anders3, Kiran Shekar4, Daniel Brodie5, Graeme MacLaren5, Kollengode Ramanathan6; 1National University of Singapore, Singapore, Singapore. 2Korea University, Seoul, Korea, Republic of. 3Texas Children’s Hospital, Texas, USA. 4The Prince Charles Hospital, Queensland, Australia. 5The Johns Hopkins Hospital, Maryland, USA. 6National University Hospital, Singapore, Singapore

Abstract
Background: Recent landmark randomised controlled trials (RCTs) suggest that extracorporeal cardiopulmonary resuscitation (ECPR) may improve survival in cardiac arrest. While the European Resuscitation Council and Extracorporeal Life Support Organization (ELSO) suggest initiating ECPR within 60 minutes, there are no studies in adults which compare early vs late ECPR to substantiate this recommendation.

Methods: We conducted a target trial emulation using the ELSO registry. We included adults (≥18 years) who received ECPR for witnessed in-hospital cardiac arrest between 1/1/2020, and 31/5/2022. We used marginal structural models and inverse probability weighting to compare the adherence-adjusted survival of patients who received early and late ECPR (defined as 60 minutes in our primary analysis, and 20-70 minutes in our secondary analysis), and estimated the 95%-confidence intervals based on 100 bootstrapped samples.

Findings: We included 804 patients in the analysis, and present preliminary findings of the primary outcomes. The adherence-adjusted survival was 40.1% (95%-CI: 34.8%-43.7%) for patients receiving early ECPR, and 17.5% (95%-CI: 8.4%-25.9%) for patients receiving late ECPR. Early ECPR within 60 minutes of arrest was associated with significant reductions in mortality (risk difference: 22.6%, 95%-CI: 6.6%-28.5%; NNT: 4.42, 95%-CI: 3.50-15.2, HR: 0.59, 95%-CI: 0.43-0.81).

Interpretation: In patients with witnessed in-hospital cardiac arrest, initiating ECPR within 60 minutes was associated with lower mortality. This supports putting the necessary infrastructure in place to accelerate cannulation and reduce low flow time. Centers providing ECPR for patients with in-hospital cardiac arrest, and studies evaluating its efficacy should target to initiate ECPR within that timeframe.

ECPR with cardiac recovery and subsequent pulmonary support
Kyle McCullough, Kara Monday, Britton Blough, Katherine Vandervest, Mario Padilla, Kaitlyn Lingle, Jillian Roberts, Katharina Fetten, Aldo Rafael, Dan Meyer, Gary Schwartz; Baylor University Medical Center, Dallas, USA

Abstract
Introduction: While the majority of cardiac arrest (CA) patients have isolated cardiac dysfunction, some develop concomitant or resultant pulmonary dysfunction. When extracorporeal cardiopulmonary resuscitation (ECPR) is utilized, cardiac pathology typically recovers prior to pulmonary recovery, requiring transition to other extracorporeal membrane oxygenation (ECMO) configurations, including veno-arteriovenous (V-AV), veno-venous (VV), and veno-pulmonary (V-P). We sought to determine the incidence and outcome of ECPR patients requiring reconfiguration for pulmonary support.

Methods: A retrospective review was performed for patients undergoing ECPR at a high volume ECMO center from 2018-2023. Patients that were not separated directly from veno-arterial (VA) support were included. Primary end point was survival to discharge neurologically intact. Secondary end points were reconfiguration configuration, indication, and days on mechanical support.

Results: Approximately 12% of eCPR patients required reconfiguration for pulmonary support. These patients were far more likely to have had in hospital CA. Seven transitioned to V-AV, 6 to V-V, and 8 to Veno-pulmonary ECMO. Those converted to VV or V-AV were more likely to have a pulmonary cause of CA than those converted to Venopulmonary support. The latter group included three post-heart transplant patients and two LVAD patients, illustrating their cardiac complexity that necessitated venopulmonary support and contributed to this group’s higher mortality.

Discussion: A significant proportion of patients suffering cardiac arrest requiring ECPR require further pulmonary mechanical support after cardiac recovery. Cannulation strategy is influenced by underlying medical pathology, and prompt recognition of the need for reconfiguration can increase survival to discharge in this complex population.
Pre-embolectomy Low-flow Peripheral Venoarterial ECMO in Massive Pulmonary Embolism: A Case Series.
Adam Betz, Daniel Hopkins, Elizabeth Gillum, Judith Muskrat, Brooke Weaver, Adel Barkat; Oklahoma Heart Institute, Tulsa, USA

Abstract
Massive pulmonary embolism (PE) with features of shock carries an associated early mortality of 30-50% with the highest rate of mortality occurring in the first two hours. Early catheter directed therapy such as suction embolectomy are becoming more common in the management of massive pulmonary embolism. However, in a patient whose right ventricle (RV) is on the brink of failure, the placement of a large-bore embolectomy catheter across the pulmonic valve for an extended time can be the additional RV afterload that results in intraprocedural hemodynamic collapse. eCPR for these patients requires large cannulas and high initial flows in addition to end organ damage sustained during CPR. We describe the safe use of preprocedural, low-flow peripheral VA ECMO that allows expedited restoration of cardiac output, improved hemodynamic stability intraoperatively, and can be decannulated percutaneously post procedure following successful wean from ECMO. The controlled, preprocedural nature of the cannulation allows for smaller cannula sizes, lower ecmo flows and, often, time to preclose the arterial insertion site. In our initial series of 10 patients, we report no instances of stroke, limb-ischemia requiring more than an antegrade reperfusion catheter, vascular injury, or hemorrhagic complication. 90% survived to discharge and those who survived typically were decannulated within 24 hours. The one non-surviving patient died secondary to a massive PE that proved repeatedly inoperable and unresponsive to TPA while being ruled out as a transplant candidate.
Utilizing Extracorporeal Membrane Oxygenation to successfully bridge to secure a definite airway in a patient with head and neck malignancy
Michael Gale, Spandan Patel, Joaquim Tavares, Robert Wills, Daisyrose Lopez, Timothy Hamilton, Ashraf Osman, Liawaty Ho; Sunrise Hospital and Medical Center, Las Vegas, USA

Abstract

Introduction: Head and neck tumors can cause central airway obstruction, and prove to be very dangerous oncological emergencies.

Method: A 24 year old female with high grade undifferentiated sarcoma, originating from her right neck with dysphagia. She developed rapid respiratory compromise. All front-of-neck airway techniques were excluded due to the location of the obstruction. The patient’s condition deteriorated with worsening hypoxia and an arrest. Peripheral VAECMO was initiated. Once on ECMO, a definitive airway was secured over a bronchoscope with nasal intubation. ECMO was weaned off and the patient was decannulated. The patient was transferred for debulking surgery and oncologic management.

Results: Practice patterns for the use of ECMO during high-risk airways vary, and data is limited. J.W. Stokes et al conducted retrospective cohort study of adults where 9 patients had venovenous ECMO to facilitate high-risk airway interventions and determined its use safe and feasible. Another study, Malpas et al, conducted a systemic review, which discussed the use of ECMO for the management of airway obstruction. All cases reported a favorable outcome. Initiating ECMO prior to airway interventions may reduce adverse events associated with respiratory failure and airway compromise. Placing small catheters for vascular access without completing cannulation is a strategy that may expedite ECMO initiation and reduce risks of cannulation if ECMO is urgently needed.

Conclusion: The use of ECMO should be considered in patients with severe airway obstruction. This approach can provide oxygenation while attempts to secure a definitive airway are carried out in a controlled environment.

Venovenous Extracorporeal Membrane Oxygenation for Severe Acute Respiratory Distress Syndrome in Metastatic Choriocarcinoma During Systemic Chemotherapy: Case Report
Jared Cappelli1, Amber Edwards2, Jonathan Emling2; 1UTHSC, Nashville, USA. 2Ascension St. Thomas West, Nashville, USA

Abstract

Gestational trophoblastic neoplasms (GTN) are rare and include multiple different types of tumors such as hydatidiform moles, placental site trophoblastic tumors, and choriocarcinoma (CC). Metastatic CC is well described with an excellent prognosis when treated appropriately with chemotherapy. The most common location for metastatic disease is the lungs which can unfortunately lead to severe acute respiratory distress syndrome (ARDS) in the most severe cases. Metastatic cancer has historically been a contraindication for the use of extracorporeal life support (including extracorporeal membrane oxygenation or ECMO). With advancing technology and medicine, this contraindication has been called into question. Prior case reports describe the use of ECMO in complicated cases of metastatic cancer and even choriocarcinoma with lung metastasis and refractory ARDS. To date, no case report has described a patient with choriocarcinoma in viable pregnancy who developed lung metastasis and ARDS that was managed with venovenous ECMO successfully. We describe such a case where a patient was cannulated for 14 days with subsequent full pulmonary recovery. This helps providers understand the broad utility of ECMO and the need to assess candidacy for this therapy on a case by case basis.
Prevalence and survival of prolonged venovenous ECMO for ARDS: an analysis of the Extracorporeal Life Support Organization Registry
Craig Rackley, Abhimanyu Chandel, Kimberly Fabyan, Sandra Mendelsohn, Nitin Puri, Emily Damuth, Steven Conrad, Christopher King, Adam Green, 1Duke University Health System, Durham, USA. 2Walter Reed National Medical Center, Bethesda, USA. 3Cooper University Health Care, Camden, USA. 4Cooper Medical School of Rowan University, Camden, USA. 5Louisiana State University Health Sciences Center, Shreveport, USA. 6Inova Fairfax Hospital, Falls Church, USA
Abstract
Rationale: Although prolonged support of patients with ARDS with venovenous extracorporeal membrane oxygenation (VV ECMO) is increasingly common, outcomes of prolonged VV ECMO support remains poorly defined.
Objectives: To examine trends in utilization and outcomes among patients with ARDS requiring prolonged VV ECMO support.
Methods: Adult patients in the Extracorporeal Life Support Organization (ELSO) registry supported with VV ECMO for ARDS between January 2012 and December 2022 were identified. Mortality while supported with VV ECMO and survival to hospital discharge based on ECMO duration was examined utilizing multivariable logistic regression.
Measurements and Main Results: Among the 13,681 patients supported with VV ECMO, 4,040 (29.5%) were supported for ≥21 days and 975 (7.1%) for ≥50 days. Patients supported with prolonged VV ECMO were less likely to be discharged alive from the hospital compared to those with short duration of support (46.5 vs. 59.7; p<0.001). However, among patients supported with VV ECMO ≥21 days, duration of ECLS was not significantly associated with mortality (HR: 0.99; 95% CI: 0.98-1.01, P=0.869, adjusted HR: 0.99; 95% CI: 0.96-1.01, P=0.246). Even in those supported with VV ECMO for at least 120 days (N=113), 52 (46.0%) of these patients were ultimately discharged alive from the hospital.
Conclusions: Prolonged VV ECMO support of ARDS has increased and accounts for a substantial portion of cases. Among patients that survive for ≥21 days while receiving VV ECMO support, duration is not predictive of survival to hospital discharge and lung recovery may occur even after very prolonged VV ECMO support.

Improving education on the use of echocardiograms in diagnosing Right Ventricular Dysfunction in VV-ECMO patients: A Retrospective Study.
Ashley Williams, Brent Pierce; University of Kentucky, Lexington, USA
Abstract
Background: Right ventricular (RV) dysfunction is a common complication associated with patients who experience acute respiratory distress syndrome (ARDS). In hemodynamically unstable patients, pulmonary hypertension develops increasing the afterload in the right ventricle. This occurs in 22-50% of patients who experience ARDS. Patients who develop RV dysfunction have a longer hospital stay and mortality rate of up to 68%. This review investigates the use of echocardiograms in identifying right ventricular dysfunction in VV-ECMO patients.
Methods and results: In this single center retrospective chart review, we analyzed the outcomes of 125 adult VV-ECMO patients from June 2021- December 2022. Out of 125 patients, 18% had RV dysfunction prior to ECMO cannulation and 37% developed RV dysfunction during their ECMO run, making the total number of patients with RV dysfunction 55%. Twenty two percent of patients did not develop RV dysfunction during their ECMO run. Out of the 55% who had RV dysfunction, 90% received epoprostenol, 41% received milrinone, and 32% were placed on an OxyRVAD. Twelve percent of patients were unknown due to poor visualization or no documented ECHO.
Conclusion: Patients who were placed on VV-ECMO were twice as likely to develop RV dysfunction indicating the need for routine monitoring using echocardiograms. Echocardiograms have the potential to play a fundamental role in the diagnosis and recovery of VV-ECMO patients with RV dysfunction, but published literature remains scarce. There is a need for further evaluation of echocardiograms in VV-ECMO patients to reduce patient mortality and increase outcomes.
OxyRVAD for COVID-19 Acute Respiratory Distress Syndrome: Not Just for the Failing Right Ventricle
Jon Greenberg, John Grotberg, Mary Sullivan, Kunal Kotkar, Amit Pawale, Muhammad Masood; Washington University in St Louis, St. Louis, USA

Abstract
Background: Certain patients with severe COVID-19 acute respiratory distress syndrome (ARDS) require extracorporeal life support. Acute cor pulmonale is prevalent in severe ARDS and is associated with increased mortality (1,2). Percutaneous right ventricular assist device with a membrane oxygenator (oxyRVAD) supports the RV, decreases recirculation, and may improve outcomes (3–6).

Methods: A retrospective analysis of patients with COVID-19 ARDS who underwent oxyRVAD configuration was performed. Patients were grouped by indication: 1) right ventricular failure, 2) “refractory hypoxemia,” and 3) “recurrent suck-down events (SDE).” Pre and post-reconfiguration vasoactive inotropic scores (VIS) were reported for group 1, fraction of inspired oxygen (FIO2) for group 2, and resolution of SDE for group 3. 90-day mortality was computed for all groups.

Results: 47 patients underwent oxyRVAD configuration, 18 in group 1, 16 in group 2 and 8 in group 3. 3 patients had oxyRVAD empirically placed, and 2 were reconfigured prior to transfer. Overall 90-day mortality was 66% and 77.8%, 81.3% and 37.5% for groups 1, 2 and 3 respectively. Mean VIS decreased in group 1 24 hours after reconfiguration (8.3 vs 2.9, p=0.005), mean FIO2 decreased in group 2 24 hours after reconfiguration and sustained at 72 hours (82.5% vs 52.5% at 24 hours and 47.5% at 72 hours, p<0.001). 6 of 8 patients had SDE resolve after reconfiguration.

Conclusion: OxyRVAD configuration in COVID-19 ARDS improves hemodynamics in RV failure, oxygenation in refractory hypoxemia, and decreases SDE. Further studies assessing generalizability to non-COVID-19 ARDS and whether oxyRVAD configuration improves mortality are warranted.

Safety and Efficacy of Metoprolol Use to Improve Oxygenation in COVID-19 Patients on Venovenous Extracorporeal Membrane Oxygenation
Abby Krupnik, Jasdeep Dhaliwal, Kevin Hatton, Aaron Harris, Alexandra White, Aric Schadler, Ayesha Ather; UK HealthCare, Lexington, USA

Abstract
Background: Beta-blockers may improve oxygenation in patients on venovenous extracorporeal membrane oxygenation (VV-ECMO) by reducing intrapulmonary shunt through a decrease in cardiac output (CO).

Methods: This single-center, retrospective study evaluated the safety and efficacy of metoprolol in COVID-19 patients requiring VV-ECMO from 01/01/2021 to 07/31/2022. The primary outcome was a composite endpoint of bradycardia or hypotension, need for cardiopulmonary resuscitation, or a rise in serum lactate. The secondary outcome was a 10% increase in SaO2 compared to baseline after 6, 12, and 24 hours of beta-blocker use. Outcomes before and after metoprolol administration were compared.

Results: Among the 42 patients in this study, 46 adverse events occurred in 20 patients (47.6%). Out of the 20 patients, metoprolol was discontinued in 12 patients (60%) due to 37 sustained hypotensive events. In addition, 3 patients (15%) experienced a significant increase in serum lactate and 1 patient (5%) experienced bradycardia. There was only a non-significant increase in SaO2 at 6 and 12 hours, from 93% to 95% and 94%, respectively, and no change was observed at 24 hours.

Conclusions: The use of metoprolol in COVID-19 patients on VV-ECMO did not improve oxygenation, was frequently discontinued and required rescue therapies in some cases. Because CO was not continuously measured, it is not known whether a significant decrease in CO was achieved resulting in increased arterial oxygen content. Additional research is needed to verify these findings in a larger pool of patients, directly measuring CO, to evaluate the impact of metoprolol in VV-ECMO patients.
Safety and Feasibility of Anticoagulation-Free ECMO for Post-traumatic ARDS.
Changsung Han¹, Seunghwan Song², Seon Hee Kim³; ¹Department of Thoracic and Cardiovascular Surgery, Pusan National University Hospital, Busan, Korea, Republic of; ²Department of Thoracic and Cardiovascular Surgery and Biomedical Research Institute, Pusan National University Hospital, Busan, Korea, Republic of; ³Department of Trauma Surgery, Pusan National University Trauma Center, Pusan National University School of Medicine, Biomedical Research Institute, Pusan National University Hospital, Busan, Korea, Republic of

Abstract
Despite the development of ECMO circuit coating technology, the use of anticoagulants is still essential for ECMO treatment. It is often difficult to use anticoagulants in severe trauma patients with bleeding problems, and the outcomes of ECMO treatment in these patients were investigated and analyzed. Among the severe trauma patients who visited our level 1 trauma center from January 2016 to December 2022, 34 patients who underwent veno-venous ECMO treatment for respiratory distress syndrome were enrolled. The study was divided into two groups: one group in which anticoagulation treatment was continued without interruption (anticoagulation group, 25 patients) and another group in which anticoagulation treatment was discontinued for more than 48 hours (anticoagulation free group, 9 patients). The average ECMO running time was 8.9 days, and there was no difference between the two groups. There was also no statistical difference in mortality between the two groups. There was also no statistical difference in mortality between the two groups (anticoagulation group n=6, 24% vs anticoagulation free group n=4, 44.4%, p=0.467). The most common cause of anticoagulant discontinuation was intracranial hemorrhage, followed by intraabdominal hemorrhage. For this reason, patients in the anticoagulation free group had significantly lower GCS and TRISS (11.96±3.67 versus 7.33±4.61, p=0.019, 0.75±0.256 versus 0.45±0.28, p=0.014). There was no difference between the two groups in events such as thrombo-embolic complications or emergency circuit change due to anticoagulant discontinuation (n=6, 24%, versus n=2, 22.2%, p=0.648). In conclusion, even in trauma patients with bleeding problems, ECMO treatment could be performed safely and effectively by adjusting anticoagulant administration.

Parallel dual-circuit configuration for management of refractory hypoxemia on veno-venous ECMO
Sage Whitmore, Meghan Breed, Jamie Jarzembowski, Joshua Lamb, Timothy Abbott, Robert Castiglia, Owen Stell, Elliott Cohen; TriStar Centennial Medical Center, Nashville, USA

Abstract
Veno-venous extracorporeal membrane oxygenation (VV-ECMO) is an effective treatment for severe hypoxic respiratory failure. On VV-ECMO, arterial oxygenation (PaO2) depends on ECMO blood flow and oxygenator performance in relation to native cardiac output and pulmonary shunt fraction. With near-total pulmonary shunt and elevated cardiac output, even a maximally efficient single VV-ECMO circuit may not result in adequate PaO2. Previous case series have reported the addition of a second circuit in parallel in this situation. Here we report a retrospective review of our experience with parallel circuits for refractory hypoxemia in thirteen patients treated with VV-ECMO from January 1, 2021 to June 1, 2023. All initial cannulations were percutaneous femoral-internal jugular. For severe hypoxemia despite maximal ECMO flow, red cell transfusion, and neuromuscular blockade, a second VV-ECMO circuit was added contralaterally. Patients were mostly male (12/13), average age 35.2 years (standard deviation 28.7-41.7) and body mass index of 45.3 (25-65.6). Nine had COVID-19 and four had other causes of respiratory failure. After addition of the second circuit, total flow increased from 5.9L/min (5.5-6.4) to 7.3L/min (6.0-8.0) [p<0.001], and PaO2 improved from 45.4mmHg (35.6-61.1) to 76.2mmHg (55.8-96.5) [p<0.0001]. Eleven patients survived to decannulation after an average of 19.8 days (7-32.6) on parallel circuits and 52.4 (18.8-86) total ECMO days. There was one accidental decannulation, four patients developed deep vein thromboses, and five developed bacteremia. Nine patients survived to discharge (61.5%), either to home or inpatient rehabilitation. Parallel, dual VV-ECMO circuit configuration appears to correct refractory hypoxemia with good survival and functional status.
Objective: VV ECMO is a standard therapy for patients with respiratory failure who have failed conventional therapy. Careful evaluation is necessary to determine candidacy due to limited resources. Few studies have examined outcomes of patients evaluated for VV ECMO, but rejected for cannulation. The objective of this study was to examine outcomes of patients rejected for VV ECMO cannulation.

Methods: We conducted a retrospective review of patients evaluated but rejected for VV ECMO cannulation at a tertiary academic medical center between January 2020 and March 2023. Demographics, PMH, acute characteristics, and outcomes were collected.

Results: 112 patients were identified. Patients were divided into two groups: those who survived and those who expired. There was no difference in ARDS therapies pre-ECMO evaluation. There was no difference in PaO2/FiO2 ratio. Overall 61.26% (95% CI: 52%, 70%) died.

Those rejected due to improvement with medical management had lowest mortality, 39.7% (95% CI: 27.7%, 52.6%). Patients rejected due to multi-organ failure had higher mortality, 81.5% (95% CI: 63.6%, 92.9%). Other reasons for rejection with associated mortality were: age (83.3%), concerning neurological status (100%), prolonged mechanical ventilation (73.7%), chronic organ failure (76.2%), obesity (62.5%).

Conclusions: Patients with severe ARDS rejected for ECMO cannulation due to improvement with medical management have a high survival rate. Patients with severe ARDS and contra-indications to ECMO have a high mortality if not offered ECMO support. It is unknown if mortality would differ if VV ECMO was offered. Research investigating ideal candidates for VV ECMO should be pursued.

Imaging of recirculation with a dual lumen cannula and venovenous ECMO with cannula venography
Dale Mueller1,2, Ruggero Ruggero Bruzzone2; 1Cardiothoracic and Vascular Surgery Associates, Jacksonville, USA. 2HCA Florida Memorial Hospital, Jacksonville, USA

Abstract
33 year old female with no prior medical problems who presented from an outside hospital with Covid pneumonia and hypoxic and hypercarbic refractory respiratory failure. She was paralyzed and prone and despite these maneuvers hypoxia persisted. She underwent ECMO with a Crescent dual lumen cannula via the right internal jugular vein with TEE and fluoroscopic guidance. After three days of ECMO with systemic saturations of 90% or better she had an abrupt decline in saturation to 75% with a rapid rise in venous saturations. A transthoracic and transesophageal echocardiogram was unable to definitively determine the position of the outflow cannula. The patient underwent fluoroscopy and clockwise rotation of the Crescent dual lumen cannula. Despite this maneuver systemic oxygen saturations remained low. Approximately 20 cc of intravenous contrast was injected into the outflow port. The venogram demonstrated recirculation in the inferior vena cava into the inflow cannula (Figure 1). The cannula was withdrawn and an additional injection demonstrated flow sequential flow into the right atrium, right ventricle, and pulmonary arteries.
Reconfiguration rate and flow dynamics in ECMO supported patients with ARDS

Meaghan Flatley1, Joshua Fuller2, Cara Agerstrand1, Richa Asija3, Alexey Abramov2, Dana Mullin1, James Beck2, Daniel Brodie2, Joshua Sonett2, Philippe Lemaitre2; 1Brooke Army Medical Center, San Antonio, USA. 2Columbia University, New York, USA. 3Community Memorial Health Systems, Ventura, USA

Abstract

Background: The extracorporeal membrane oxygenation (ECMO) flow rate needed to adequately support patients with acute respiratory distress syndrome (ARDS) is variable. Meeting the oxygen delivery needs of these patients occasionally requires higher than average flow thus necessitating the insertion of an additional drainage cannula. This study addresses the frequency with which ARDS patients on ECMO require an additional drainage cannula and whether this need is related to initial cannula selection. Flow dynamics before and after reconfiguration are analyzed.

Methods: Retrospective chart review was performed on patients cannulated to venovenous (VV) ECMO at a high volume ECMO center from March 1, 2020 to January 1, 2022. Incidence of reconfiguration from VV to veno-venovenous (VVV) ECMO as well as flow dynamics before and after reconfiguration were analyzed. A Fischer exact test was used to compare the reconfiguration rates and a nonlinear mixed effects model with autoregression correlation was used to compare the pre and post-cannulation states

Results: A higher proportion of patients who received a cannula less than 29Fr in size required reconfiguration when compared to patients who received 29Fr cannula (23.26% vs. 6.25%, p=0.259). Mean flow after reconfiguration was higher than before reconfiguration by 0.335 L/min (p<0.00001). Mean negative drainage pressure was less negative after reconfiguration than before by 18.474 mmHg (p<0.00001).

Conclusions: Cannulation with the largest available drainage cannula is the most optimal cannulation strategy to avoid impaired oxygen delivery requiring reconfiguration.
114-day ECMO Bridge to Recovery for ARDS

Meaghan Flatley², Richa Asija², Philippe Lemaitre³, Cara Agerstrand³, ¹Brooke Army Medical Center, San Antonio, USA. ²Community Memorial Health Systems, Ventura, USA. ³Columbia University, New York, USA

Abstract

Prolonged venovenous extracorporeal membrane oxygenation (ECMO) for acute respiratory distress syndrome (ARDS) has been described in the wake of the coronavirus disease (COVID) 2019 pandemic. Given the severity of fibrosis exhibited by these patients, most extended ECMO runs culminate with lung transplantation. We describe the successful use of prolonged VV-ECMO (114 days) as a bridge to recovery for ARDS. We describe the case of a 33 year-old who progressed to hypoxemic respiratory failure 24 days after COVID diagnosis. Her condition worsened despite aggressive ventilator management, paralysis, and proning. She was cannulated to VV-ECMO and transferred to an ECMO center. The patient’s course was complicated by sepsis secondary to predominantly respiratory infections and she was on antibiotics for the majority of her ECMO run. When the patient was not in septic shock, she was well-supported on ECMO and was extubated for some of her course. However, despite minimizing further ventilator induced lung injury, the patient’s compliance remained poor and she developed multiple pneumothoraces requiring chest tubes. Attempts at weaning ECMO support were made, but the degree of fibrosis seemed to portend an incredibly poor prognosis and the transplant team was consulted. The patient refused lung transplantation. Over time her compliance improved. She was decannulated on March 25, 2022 on ECMO day 114. She was discharged home 224 days after initial presentation and is currently leading an active life without the need for continuous oxygen support. This case provides evidence for lung recovery after an unprecedentedly prolonged VV ECMO run.

The Role of Respiratory Phenotype in Outcomes of ARDS Patients Supported with ECMO

Hannah Rando, Bo Soo Kim, Glenn Whitman, Sung Min Cho, Steven Keller; Johns Hopkins Hospital, Baltimore, USA

Abstract

Background: Due to differences in gas transportation in the blood, ECMO can completely eliminate CO2 across a range of blood flow rates, but is limited in oxygen delivery by the fraction of total venous return entrained. We hypothesized that ECMO would restore homeostasis in hypercapnic respiratory failure and lead to improved outcomes when compared to hypoxic failure.

Methods: We conducted a retrospective view of ARDS patients on VV-ECMO in the ELSO database (2010-19). Using pre-cannulation blood gases to define patient groups, we compared hypercapnic (pH < 7.25 and PaCO2>60 mmHg) to hypoxic failure (PaO2:FiO2<100) while excluding those who met neither or both criteria. Baseline characteristics, ABG data, and outcomes were compared using chi-squared, student t-tests, or Wilcoxon rank-sum tests. Logistic regression was performed for the primary outcome of in-hospital mortality.

Results: 7,632 patients were included, with 6,798 (89%) defined as hypoxic and 834 (11%) as hypercapnic. Hypercapnic patients were more likely to achieve systemic homeostasis (pH>7.35 and PaO2>65 mmHg) within 24-hours (60.4% vs 51.4%, p<0.001). ECMO duration was similar between groups (211 vs 213 hours, p=0.39). Hypercapnic patients had a lower incidence of limb ischemia (0.4% vs 1.3%, p=0.023), and renal failure (26.1% vs 32.8%, p<0.001), but had higher mortality (43.2% vs 35.5%, p<0.001). After adjusting for age, ECMO duration, comorbidities, baseline lung disease, and stroke, hypercapnic patients had 1.35 times greater odds of in-hospital mortality (CI 1.02-1.80).

Conclusion: ECMO was more efficacious in addressing the physiologic derangements of hypercapnic respiratory failure, but this did not translate into a mortality benefit.

Table 1: Baseline characteristics and outcomes of VV-ECMO patients stratified by respiratory phenotype

<table>
<thead>
<tr>
<th>Respiratory Phenotype</th>
<th>Hypoxic (n=7,632)</th>
<th>Hypercapnic (n=834)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yrs</td>
<td>67 (36.8-68.2)</td>
<td>67 (33.9-68)</td>
<td>0.71</td>
</tr>
<tr>
<td>Body-mass index, kg/m²</td>
<td>28.4 (24.8-35.9)</td>
<td>27.5 (25.8-35.3)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Male</td>
<td>4067 (60.1)</td>
<td>482 (57.4)</td>
<td>0.15</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>3869 (56.4)</td>
<td>500 (60.1)</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>730 (10.4)</td>
<td>112 (13.4)</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>435 (6.6)</td>
<td>50 (6.0)</td>
<td></td>
</tr>
<tr>
<td>Asian</td>
<td>1073 (15.1)</td>
<td>87 (10.4)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>793 (10.9)</td>
<td>85 (10.2)</td>
<td></td>
</tr>
<tr>
<td>El-Shaer Comorbidity Index</td>
<td></td>
<td></td>
<td>0.046*</td>
</tr>
<tr>
<td>0</td>
<td>2195 (79.7)</td>
<td>159 (69.1)</td>
<td></td>
</tr>
<tr>
<td>1-3</td>
<td>585 (20.3)</td>
<td>59 (20.5)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>67 (2.2)</td>
<td>7 (1.3)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>29 (0.7)</td>
<td>3 (1.0)</td>
<td></td>
</tr>
<tr>
<td>Chronic pulmonary disease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asthma</td>
<td>288 (2.8)</td>
<td>40 (4.8)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Cystic fibrosis</td>
<td>28 (0.4)</td>
<td>99 (11.3)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>COPD</td>
<td>276 (2.6)</td>
<td>33 (3.0)</td>
<td>0.001*</td>
</tr>
<tr>
<td>Pre-ECMO Arrest</td>
<td>40 (1.5)</td>
<td>61 (7.4)</td>
<td>0.08</td>
</tr>
<tr>
<td>24-hour ABG</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.78 (7.09)</td>
<td>7.98 (7.08)</td>
<td>0.65</td>
</tr>
<tr>
<td>PaO2</td>
<td>92 (85.4-46)</td>
<td>115 (89.9-115.5)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>PaCO2</td>
<td>25 (15.6)</td>
<td>26.4 (15-7)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>HCO3</td>
<td>21.9 (15-24)</td>
<td>21.9 (15-24)</td>
<td>0.9</td>
</tr>
<tr>
<td>24-hour systemic homeostasis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECO2 duration, hours</td>
<td>216 (120-353)</td>
<td>211 (120-353)</td>
<td>0.39</td>
</tr>
<tr>
<td>Complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulmonary hemorrhage</td>
<td>304 (4.5)</td>
<td>27 (3.5)</td>
<td>0.19</td>
</tr>
<tr>
<td>Surgical bleeding</td>
<td>390 (5.7)</td>
<td>48 (5.8)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>GI bleeding</td>
<td>413 (6.0)</td>
<td>58 (7.0)</td>
<td>0.30</td>
</tr>
<tr>
<td>Intracranial hemorrhage</td>
<td>34 (0.5)</td>
<td>5 (0.6)</td>
<td>0.70</td>
</tr>
<tr>
<td>Intracranial ischemia</td>
<td>94 (1.4)</td>
<td>8 (1.0)</td>
<td>0.31</td>
</tr>
<tr>
<td>Limb ischemia</td>
<td>81 (1.0)</td>
<td>3 (0.4)</td>
<td>0.023*</td>
</tr>
<tr>
<td>Renal failure</td>
<td>322 (35.3)</td>
<td>238 (28.6)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>Mortality</td>
<td>2464 (34.5)</td>
<td>380 (43.9)</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>

Data are presented as mean (standard deviation), median (interquartile range) or n (%) . Patients were categorized as hypoxic if pre-cannulation PaO2:FiO2<100 and hypercapnic if pre-cannulation pH<7.25 and PaCO2>60. Systemic homeostasis was defined as pH>7.35 and PaO2>65 mmHg after 24-hours of ECMO support.
Everyone Should Get a Chance: Successful vs. Unsuccessful ECMO Bridge to Lung Transplant
Richa Asija1,2, Joshua Fuller1, Harpreet Grewal1, Luke Benvenuto1, Gabriela Magda1, Lori Shah1, Angela Dimango1, Hilary Robbins1, Erika B. Rosenzweig1, Dana Mullin1, James Beck1, Cara Agerstrand1, Darryl Abrams1, Natalie Yip1, Purnema Madahar1, Madhavi Parekh1, Kate Melville1, Briana Short1, Jennifer Cunningham1, Joseph Costa1, Bryan Payne Stanifer1, Joshua Sonett1, Frank D’Ovidio1, Selim Arcasoy1, Philippe Lemaitre1; 1Columbia University Medical Center, New York, USA. 2Community Memorial Health Systems, Ventura, USA

Abstract
Background: Extracorporeal membrane oxygenation (ECMO) as a bridge to transplantation (BTT) is an effective strategy for lung transplant candidates failing maximized medical management. A significant proportion of patients are unsuccessfully bridged and undergo withdrawal of life-support. This study compares successfully and unsuccessfully bridged patients at a high-volume lung transplant center.

Methods: All patients BTT on ECMO at Columbia University Medical Center (CUMC) between 01/2012 and 04/2023 were identified. Retrospective chart review was performed to collect patient characteristics and BTT outcomes. Multiple variable logistic regression was used to analyze the effect of different variables on the likelihood of a successful bridge.

Results: Of 152 patients, 93 (61%) patients were successful BTT and 59 (39%) patients were unsuccessful BTT. One hundred-five patients were bridged using venoarterial (VA) ECMO and 47 patients were bridged using venovenous (VV) ECMO. Sixty-two of 105 (59%) patients on VA ECMO and 31/47 (66%) patients on VV ECMO were successful BTT (p=0.474). No significant statistical differences existed when comparing patient characteristics in successful or unsuccessful BTT. Reasons for unsuccessful BTT were most commonly multi-system organ failure (61%), cardiopulmonary arrest (7%) and debilitation (5%). In patients with group one and three pulmonary hypertension (PH), 52/84 patients (62%) on VA ECMO and 23/35 (66%) patients on VV ECMO were successful BTT (p=0.858).

Conclusion: This study demonstrates there is no significant difference in characteristics, support mode and ECMO duration when comparing successful to unsuccessful ECMO BTT. Our data suggests most patients selected for lung transplantation are appropriate candidates for ECMO BTT.

Prolonged HFNC use for COVID-19 related ARDS prior to VV-ECMO: Single center case series
Daniel Rowan, Leon Eydelman, Debjit Saha, Axel Joob, Alex Cedeno-Rodriguez; Advocate Lutheran General Hospital, Park Ridge, USA

Abstract
The COVID-19 pandemic presented a health crisis due to the large influx of patients hospitalized with respiratory failure, leading to widespread adoption of high flow nasal cannula (HFNC) for severe symptoms, often for extended courses. Little is known regarding the outcomes of patients requiring VV ECMO following prolonged use of HFNC and failure of mechanical ventilation, posing a challenge to the traditional consideration of ventilatory support duration as an exclusion criteria. Herein we report on the outcomes of patients at our center necessitating ECMO following a minimum of 7 days of HFNC and failed mechanical ventilation. A total of 10 patients within our cohort met this criterion. The mean age was 42.7, 6 were male, with average length of symptoms, hospitalization, and HFNC support of 20, 13.5, and 10.9 days, respectively. Prior to ECMO, combined HFNC and mechanical ventilation days averaged 14.0. Notable peri-ECMO variables included a mean duration of intubation of 3.1 days, ventilator FiO2 of 91%, PEEP of 11, P/F ratio of 80, and plateau pressure of 33.6.

All patients were ventilated with 6 cc/kg or less tidal volume, sedated, paralyzed, received trials of prone positioning, with extracorporeal support decision-making guided by EOLIA criteria. The survival in this cohort was 7/10 patients, with 1 patient requiring lung transplantation, and an average ECMO duration of 59.8 days. Prolonged combined duration of HFNC and mechanical ventilation prior to ECLS may not represent a strict exclusion criterion. Further study is required to identify patients of highest likelihood to benefit.
Evaluation of Selective Factor Xa Inhibition for Artificial Surface Induced Coagulation in an Ovine Venovenous ECMO Model

Umar Nasim1, Yeahwa Hong1,2, Helen Scala1, Suji Shin1, Kelly Strong1, Patrick Iyasele1, Abigail Gredell1, Rachel Shockley1, Konstantinos Bogiantzis1, Keith Cook1; 1Biomedical Engineering, Carnegie Mellon University, Pittsburgh, USA. 2Surgery, University of Pittsburgh Medical Center, Pittsburgh, USA

Abstract

Introduction: Wearable respiratory support technologies are under development as an alternative therapy for patients with advanced lung disease. Heparin and warfarin are the clinical standard anticoagulants for blood-contacting medical devices, but both require frequent anticoagulation monitoring. Direct oral anticoagulants (DOAC) are currently approved at a fixed dose without any monitoring. The present study evaluates the feasibility of rivaroxaban to inhibit artificial surface-induced coagulation.

Methods: 12-hour ovine pharmacokinetics and pharmacodynamics of rivaroxaban were evaluated using activated clotting time (ACT), prothrombin time (PT), and plasma concentration using intravenous bolus doses of 0.25, 0.5, and 1mg/kg. The anticoagulation efficacy of these rivaroxaban doses was compared to heparin with an ACT target of 250-290s using a small-scale VV-ECMO circuit. The primary outcome was device failure, defined as a blood flow resistance increase to 20 times the baseline value.

Results: Initial experiments demonstrated dose-dependent pharmacodynamics of rivaroxaban, as measured by ACT and PT (n=2, each). However, sheep expressed a higher volume of distribution (2.2+/-0.4L/kg), shorter half-life (1.8+/-0.3hr), and faster clearance (73+/-21L/hr) than humans. Small-scale ECMO experiments (n=4, each) demonstrated dose-dependent device survival with a mean survival of 58+/-26min (heparin), 31+/-9min (0.25mg/kg), 51+/-17min (0.5mg/kg), and 104+/-33min (1mg/kg) (p<0.01), where heparin and 0.5 mg/kg had comparable survival (p=0.59) (Figure).

Conclusion: The results demonstrate that sheep are an appropriate model of rivaroxaban activity in humans, and a 0.5 mg/kg rivaroxaban dose provides artificial surface anticoagulation comparable to heparin. Our next step is to evaluate the long-term efficacy of rivaroxaban in 10-day full-scale VV-ECMO experiments in sheep.

Blood prime and circuit interplay does not potentiate inflammation in Extracorporeal Membrane Oxygenation

Swosti Joshi1,2, Htay Aung3, Michelle Mejia2, Ta’teanna Revels2, Vilmaris Quinones Cardona1,2, Ogechukwu Menkiti1,2; 1Drexel University College of Medicine, Philadelphia, USA. 2St Christopher’s Hospital for Children, Philadelphia, USA

Abstract

Introduction: Initiation of pediatric extracorporeal membrane oxygenation (ECMO) is often complicated by systemic inflammatory response syndrome (SIRS). Blood products utilized in circuit prime may augment the inflammatory response induced by ECMO initiation. We hypothesize that donor blood products contain inflammatory proteins which are activated on exposure to the ECMO circuit.

Materials and Methods: Single-center prospective study of an ex-vivo ECMO circuit model utilizing reconstituted or whole blood. Samples were collected and stored at regular intervals following ECMO initiation. Luminex © Cytokine Storm 65-Plex Panel I and MILLIPLEX® Multiplex for Luminex® (Human Complement Expanded Panel 1 and 2) were used for analysis.

Results: Twelve ECMO circuits were included. Whole blood and reconstituted blood were used at 67% and 33% respectively. Ten circuits (83%) had platelets and six (50%) plasma included in prime (Table 1). Of the sixty-five analytes, pro-inflammatory cytokines implicated in cytokine storm were negligible. Detectable levels of MCP-1, CXCL13 (BLC), soluble receptors and VEGF-A were present without significant variation over time (Figure 1). Of twelve complements, high levels of Complements C2, C5 and factor I were detected (Figure 2).

Conclusion: This ex-vivo study shows inflammatory proteins are present in donor blood products in variable degrees but were not potentiated by exposure to the ECMO circuit. While donor blood product-circuit interplay did not significantly alter these proteins, their presence may provide valuable insight into key interactions responsible for ECMO-SIRS once the host is involved. Next steps include determining mean concentrations and types of inflammatory proteins present in donor blood products.
Ultrasound Use for Assessment of Muscle Changes in Critically Ill Patients on ECMO with Clinical Outcomes

Melissa Poindexter1,2, Ashley Mullins1,3, Leah Wilson1,3, Maria Paula Moran1,2, Pinar Robles1,3, Tammi Wade1; 1Baylor University Medical Center, Dallas, USA. 2Aramark Healthcare Plus, Dallas, USA. 3Aramark Healthcare Plus, Dallas, USA

Abstract

Background: Patients on extracorporeal membrane oxygenation (ECMO) experience prolonged hospital stays contributing to debilitation, muscle mass loss, and malnutrition, which are associated with greater risk of mortality. This study investigated muscle loss of the quadricep to evaluate differences between malnourished and nourished patients as well as differences between those fed adequately or inadequately on ECMO.

Design: This retrospective study included 10 adult patients on ECMO and receiving nutrition support between November 2022 and January 2023 at Baylor University Medical Center. Ultrasound measurements of the quadricep muscle were obtained using validated methods within 72 hours of cannulation and repeated every 7-10 days for three measurements. Net muscle loss was calculated as the third measurement minus the first measurement and is represented in centimeters. Nutritional adequacy was expressed as meeting greater than 80% of needs prescribed.

Results: Two patients were diagnosed with malnutrition and six patients were adequately fed. There was no association between quadricep muscle thickness change for those who were malnourished compared to nourished (-0.26 vs -1.21 p=0.38). There was a trend of greater thickness loss in patients fed inadequately (-1.33 vs -.014 p=0.22), but was not statistically significant.

Conclusion: Adequate protein and energy intake may contribute to rates of muscle wasting for critically ill patients on ECMO. These result are limited due to a small sample and unequal size in groups compared. High rates of edema were also suspected to influence quality and accuracy of ultrasound imaging, which warrants further study to validate use of ultrasound in this population.
The Viscoelastic Coagulation Monitor (VCM) as a novel means for coagulation monitoring and adjustment in ECMO patients receiving bivalrudin: Initial results compared to the TEG 5000.

Zachary Stotz¹, Jorden Harrity¹, Mauro Panigada³, Heidi Dalton²; ¹INOVA, Falls Church, USA. ²INOVA, Falls Church, USA. ³Fondazione IRCCS Ca Granda Ospedale Maggiore Policlinico, Milan, Italy

Abstract

Viscoelastic testing is becoming more frequent to monitor/adjust anticoagulation during ECMO. The TEG 5000 (Haemonetics) is commonly used with samples collected and transported to lab in citrated tubes (1.7 cc whole blood) where kaolin is added to perform testing. The VCM (Entegrior Inc) is a new, simple device which requires minimal training, uses 300 microliters of fresh whole blood, no reagents (glass slides in the device initiate clotting) and is performed at the site of care.

Methods: We compared results from the TEG 5000 to the VCM for ECMO patients receiving bivalirudin for anticoagulation.

Results: 39 time points were assessed. Bivalirudin demonstrated an effect on VCM coagulation initiation (the CT), with a median range of 8.4 min (7.1-10, normal 5.2-8.7). Differences between clot initiation found TEG R time (clot initiation) 1.3 minutes longer than VCM CT under bivalirudin. TEG R time and aPTT had poor correlation (spearmans rho 0.13, p=0.42) while VCM CT and aPTT correlated moderately well (spearmans rho 0.45, p=0.005) Maximum clot formation (MCF, VCM) had moderate correlation to platelet count while TEG MA was poor.

Conclusions: The VCM may represent a new paradigm in anticoagulation monitoring, using less blood and personnel time to perform while providing real-time results. As no sample manipulation for collection or processing is needed, errors in these aspects may be reduced and results may be more consistent with native clotting processes. Correlation with tests such as aPTT or platelet count may represent ways to reduce lab testing and phlebotomy. Further evaluation needed.
Circuit And Equipment

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Tilting the Recovery Tides, the Impact of a High Tilt Angle Capable Bed for Passive Early Mobility to Maintain Function and Enhance Convalescence in Peripherally Cannulated Extracorporeal Life Support Patients

Samuel Daddow, Kevin Floyd, Laura Kenny, Stephanie Mateev, Salvador Sanchez; UC Davis Medical Center, Sacramento, USA

Abstract
Extracorporeal Life Support (ECLS) patients have traditionally been excluded from early mobility interventions due to sedation requirements and safety concerns. However, recent evidence suggests that implementing early mobility interventions in ECLS patients is safe and can lead to improved patient outcomes and reduced length of stay.

An interprofessional UC Davis Medical Center team investigated early mobility interventions in ECLS patients. One innovative intervention was the VitalGo Total Lift Bed (VGTLB), capable of an 82° upright tilt angle. With scant literature evidence supporting its use, a 5-patient trial was authorized to assess safety and outcomes. We developed a progressive tilt bed protocol for passive mobility in accordance with the Society of Critical Care Medicine’s comprehensive four-phase mobility guidance. Nursing and rehabilitation staff received training on the VGTLB’s operation.

Five patients participated in the passive early mobility intervention using the VGTLB. Four patients progressed to Level II (Tilt >45°), and three patients to Level III (Full 82° tilt) of the mobility protocol. No patients reached Level IV (ambulation). Compared to a retrospective cohort, the early mobility group experienced a 22.5% reduction in median ECLS run hours (502 to 402 hours), improved ECLS survival (63% to 75%), and decreased hospital mortality (50% to 25%). Median ICU and hospital stays were shortened by approximately seven days. No adverse safety events occurred with VGTLB use.

Our early passive mobility trial in ECLS patients using the VGTLB yielded positive outcomes, suggesting that further investigation into progressive tilting as an early mobility intervention is warranted.

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Better Secure Than Sorry: Developing Evidence Based Best Practice Guidelines for ECMO Cannula Securement

Brian Asermily1, Karen Smith2, Lisa Owen2, Igor Gosev2, Ryan Magnuson2; 1University Of Rochester Medical Center, Rochester, USA. 2University of Rochester Medical Center, Rochester, USA

Abstract
Cannula dislodgement is one of the gravest complications of Extracorporeal Membrane Oxygenation (ECMO) that can easily be prevented. After experiencing three near-miss events over a two-year period, we acknowledged the need for change and utilized a rapid review approach to develop and implement a new securement policy to prevent future occurrences. We conducted a comprehensive literature search and found insufficient evidence to support best practice guidelines for the prevention of cannula complications. The barrier of "more research is needed on this topic" led us to take a closer look at the data we’ve collected on over 200 patients on mechanical circulatory support and develop our own best practice guidelines.

Our new policy requires several anchor points using 3-5 #5 ethibond sutures as well as one catheter securement device per cannula/circuit tubing. Securement integrity is assessed daily along with every ECMO cannula dressing change to confirm securement at the insertion site is intact at the skin and the cannula/circuit tubing. Cannula position is assessed daily with x-ray and all suture securement is replaced at 30 days on ECMO, or sooner if any sutures are found to no longer be intact. With this new protocol we have not experienced any near misses related to cannula dislodgement.

We went on to build a survey that was sent to 60 ELSO platinum and gold centers of excellence within the United States and look forward to presenting our findings at ELSO with the goal of stimulating discussion on ECMO cannula securement.
Preliminary Data on the Safety and Performance of a Novel Extracorporeal Membrane Oxygenation Device in a Long-term Ovine Model

Yongchao Li1, Hongbin Gao1, Zhongqiang Huang1, Lei Cai1, Yalun Guan1, Yunfeng Li1, Shuhua Liu1, Xia Tian Li2, Ge Li1, Yijiang Li2, Yu Zhang3; 1Guangdong Laboratory Animals Monitoring Institute, Guangzhou, China. 2Guangdong Organ Support Engineering Technology Research Center, Shenzhen, China

Abstract
A novel portable extracorporeal membrane oxygenation (ECMO) device (Lifemotion®) has been developed. The aim of this study is to assess the safety and performance of this ECMO device with small tailed Han sheep. Sheep were supported using Lifemotion® (Chinabridge, China)(Figure 1) and Novalung Xlung kit 230 (as Control) with VV-ECMO and VA-ECMO modes. Tracheal intubation, arteriovenous access and ECMO support were performed. Vital signs and blood laboratory tests of the subjects were monitored and recorded. Main organs were examined pathologically at the end of day fourteen.

Fifteen sheep were survived until day fourteen, with ten in the Lifemotion® group (five VV-ECMO and five VA-ECMO) and five in the Control group (two VV-ECMO and three VA-ECMO). All sheep were successfully weaned from ECMO without transfusion or cannula complications. No significant differences were observed between the two groups in terms of vital signs, oxygenation, hemodynamic stability, and physiological function(Figure 2, Figure3). No obvious thrombosis and bleeding was observed at main organs, such as the brain, liver, and lung, etc. There were no serious adverse events and no disposable items replaced due to thrombosis during the monitor period. Both groups had satisfactory values in vital signs, blood gas, most blood cell count values, blood biochemistry during VV-ECMO and VA-ECMO.

In this animal trial the novel ECMO device, Lifemotion®, demonstrated the safety and acceptable performance of the device by providing satisfactory oxygenation, stable hemodynamics and physiological function to the sheep. This study provides preliminary evidence for future clinical trials.

Figure 1 Image of the Lifemotion® ECMO device components and a sheep subject supported by the Lifemotion® ECMO. Top left panel: Lifemotion® ECMO console; bottom left panel: disposable Lifemotion® pump head and oxygenator. Right panel: sheep subject on the Lifemotion® ECMO.

Figure 2 Vital sign values were stable during ECMO support, including heart rate, mean arterial pressure, and arterial oxygen saturation. The three dotted lines in each plot represent the pre-surgical highest, average (red), and lowest values, respectively.

Figure 3 The oxygenation performance data during ECMO support showed that the oxygenators of the Lifemotion® group had comparable oxygenation efficacy to that of the control group. Abbreviations: Pao2, partial pressure of oxygen before the oxygenator; Svo2, oxygen saturation before the oxygenator; Paco2, partial pressure of carbon dioxide after the oxygenator; Pao2, partial pressure of oxygen after the oxygenator; Svo2, oxygen saturation after the oxygenator.
Mitigating Circuit Changes and Cannula Clotting in Neonatal and Pediatric ECLS: Iterative Optimization and Evaluation of the Cardiohelp System for Patients Under 15 Kilograms
Laura Kenny, Samuel Daddow, Stephanie Mateev; UC Davis Medical Center, Sacramento, USA

Abstract
UC Davis Medical Center’s Extracorporeal Life Support (ECLS) program, encompassing neonatal, pediatric, and adult care, transitioned from the Jostra Rotaflow/Quadrox combination the Cardiohelp system in 2019 for adults and in 2020 for neonatal and pediatric patients. As part of this shift, we recognized the necessity to modify our previously uniform circuit design to better serve our smaller patients. The primary objectives of the disposable circuit redesign were to reduce complications related to cannula clotting, mitigate the risk of cranial hemorrhages linked to swift CO2 decreases at the start of the procedure, lower the usage of Continuous Renal Replacement Therapy (CRRT) in patients with non-renal disease experiencing fluid overload, and minimize platelet consumption.

To evaluate the effectiveness of these changes, we performed a comparison of our patients weighing less than 15kg from 2018 and 2019 (23 ECLS Runs), who were treated with the old system, against those treated from 2020 onwards (53 ECLS) with the custom Cardiohelp circuits. Results reflect a 23% decrease in circuit changes between the old system and the new system despite the increased number of runs. With the switch to the new system, we noted an increase in clotted cannuulas to 8 incidences. This prompted a redesign of the shunt, change in practice of moving flow probes, and a tiered heparin bolus system. With that implementation there has been 1 clotted cannula.

A Newly Developed Maglev ECMO System BreathMo
Tingting Wu¹, Xiaotong Hou², Zhongtao Du², Chia Hao Hsu¹, Xianshan Qi¹, Polin Hsu¹; ¹magAssist Co., Ltd., Suzhou, China. ²Center for Cardiac Intensive Care, Beijing Anzhen Hospital, Capital Medical University, Beijing, China, Beijing, China

Abstract
Despite the importance of ECMO in heart failure and ARDS treatment, it faces challenges such as complications and component failures. To address these issues, innovative ECMO systems have been developed, focusing on improved hemocompatibility, compactness, and usability. MagAssist Co., Ltd has created BreathMo, a new ECMO system that enhances hemocompatibility and usability through innovative technologies. It utilizes maglev pump technology with a special fluid pathway and impeller design to reduce hemolysis and coagulation. The oxygenator has a high gas exchange efficiency, a heparin-based membrane coating, and a unique fluid pathway design that minimizes cross oxygenator pressure (<50mmHg @7L/min). A novel priming set enables fast priming in urgent clinical situations. The console platform is lightweight(<8kg) and supports both (extracorporeal)Extra-VAD and ECMO functions. The portable cart is user-friendly for intrahospital and interhospital transport.

The system’s safety and efficacy have been validated in a 14-day in-vivo study on 10 samples of sheep, with five Venous-Arterial(VA) and five Venous-Venous(VV) cannulation configurations. The system demonstrated its oxygenation efficacy, as the PO2 remained stable (>300mHg) throughout the trial for all the samples. No device malfunctions, organ dysfunction, hemolysis, or device-related thrombus formation occurred. All adverse events found (infection, catheterization, alkalosis) were analyzed and concluded to not be associated with the device.

The system is currently undergoing a multi-center, single-arm clinical trial validation across 7 large medical centers in China. Twenty-one cases have been enrolled, with 17 VA-ECMO and 4 VV-ECMO configurations. Further clinical trial results will be reported upon completion.
Pilot Efficacy and Hemocompatibility Comparison of CardioHELP HLS 7.0 and XLUNG during 72 Hours ECLS in Swine

Teryn R Roberts, Daniel S Wendorff, George T Harea, Brendan M Reiley, Yanyi Zang, Antoine Persello, Andriy I Batchinsky; Autonomous Reanimation and Evacuation Research Program, The Geneva Foundation, San Antonio, USA

Abstract

Introduction: Clinical evaluation of extracorporeal lung support (ECLS) device safety and efficacy across manufacturers is challenging due to center specific management practices and underlying patient conditions. In our translational research laboratory, we performed a cross-study comparison of CardioHELP HLS Advanced 7.0 system (Maquet/Getinge; Rastatt, Germany) versus the XLUNG system (Fresenius; Bad Homburg, Germany) in uninjured swine utilizing the same experimental conditions regarding anticoagulation and subject management. The objective of the study was to assess device specific differences in performance and hemocompatibility.

Methods: Swine (50-60 kg) were anesthetized (TIVA), mechanically ventilated, and placed on ECLS with either the HLS 7.0 (n=6) or XLUNG (n=2) system for 72-hours. Flow rates were initiated at 1.5 L/min blood flow and 3 L/min sweep gas flow. Heparin (UFH) was administered to target ACT of 150% baseline value. Systemic blood samples were collected for arterial blood gas and coagulation assessment. Additionally, pre- and post-membrane oxygenator samples were collected for blood gas analysis. Statistical analyses were two-sided with p<0.05 for significance.

Results: No difference in pre- and post-membrane oxygenator pO₂ and pCO₂ values were detected over time between devices (Figure 1). Systemic arterial blood pH, pO₂, pCO₂, lactate, base excess, bicarbonate, and hemoglobin levels were not different between groups. No group difference in aPTT, INR, platelet count and plasma free hemoglobin was observed (Figure 2).

Conclusions: In this pilot assessment we did not observe a difference in gas exchange efficiency or hemocompatibility between the HLS 7.0 and XLUNG systems. Data collection is ongoing.

Centrifugal or Roller Blood Pumps for Neonatal VV-ECMO: Extracorporeal Life Support Organization Database Comparison of Mortality and Morbidity Using a Multivariable Logistic Regression Model

Akif Undar¹, Allen Kunselman¹, Ryan Barbaro², Peta Alexander³, Krishna Patel¹, Neal Thomas¹; ¹Penn State College of Medicine, Hershey, USA. ²University of Michigan, Ann Arbor, USA. ³Boston Children’s Hospital, Boston, USA. ⁴Penn Satette College of Medicine, Hershey, USA

Abstract

Objective: This study investigates the association between the use of centrifugal and roller pumps and outcomes of neonatal patients supported with venovenous extracorporeal membrane oxygenation (VV-ECMO) using the Extracorporeal Life Support Organization (ELSO) Registry data between 2016-2020.

Methods: Data from all neonates (≤ 28 days) supported with VV-ECMO and cannulated via right internal jugular vein using dual-lumen VV cannulas and polymethyl-pentene (PMP) membrane-oxgenators from all ECMO centers reporting to the ELSO-Registry between 2016 and 2020 were collected. In order to generate a homogenous dataset for analysis, only those cannulated via right-internal-jugular-venous-vein using dual-lumen VV-cannulas and-polymethyl-pentene (pmp) membrane-oxgenators are included in this study.

Results: A total of 612 neonates (centrifugal, n = 340; conventional roller, n = 272) were included in-the-analysis. Using a multivariable-logistic-regression-model, centrifugal-pump use – as opposed to roller-pump use – was associated with lesser-odds-of-survival, OR 0.53 [95%CI 0.33 to 0.84], p < 0.008. Thrombosis and clots in the circuit components were also associated with lesser-odds-of-survival, OR 0.28 [95%CI 0.16 to 0.60], p <0.001. We failed to show that hemolysis was an independent variable for survival, OR 0.60 [95%CI 0.31 to 1.19], p = 0.14. The primary-diagnosis of neonatal aspiration/meconium-aspiration is associated with more than 7-fold greater odds-of-survival; OR 7.57 [95%CI 4.02 to 15.74], p < 0.001.

Conclusions: Contrary to our hypotheses, conventional roller pump use was associated with greater-odds-of-survival. While thrombosis and clots in circuit components were independent variables for lesser-odds-of-survival, further research is needed better to understand the use of centrifugal pumps in neonatal practice.

Table 1: Multivariable Logistic Regression Results Utilizing Centrifugal vs. Roller Pumps

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio [95% CI]</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centrifugal vs Roller</td>
<td>0.53 (0.33, 0.84)</td>
<td>0.008</td>
</tr>
<tr>
<td>Mechanical: Thrombosis/Clot: circuit component YES vs NO</td>
<td>0.28 (0.16, 0.50)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mechanical Clot: low NO YES vs NO</td>
<td>0.57 (0.32, 0.94)</td>
<td>0.27</td>
</tr>
<tr>
<td>Hemorrhagic: Hemolysis (hgb &gt; 40 mg/dL) YES vs NO</td>
<td>0.60 (0.31, 1.19)</td>
<td>0.14</td>
</tr>
<tr>
<td>Primary Diagnosis: Neonatal aspiration/meconium aspiration YES vs NO</td>
<td>7.57 (4.02, 15.74)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

* Results based on logistic regression using Firth’s Penalized Likelihood approach.
**Circuit And Equipment**

**Trial of new Infant and Pediatric Oxygenator for Surgical Neonates on ECMO**
Kyle Weinberger, James Connelly, Elizabeth Malick; Children’s Hospital of Philadelphia, Philadelphia, USA

**Abstract**

**Introduction/Background:** At Children’s Hospital of Philadelphia a portion of the patients on Extracorporeal Membrane Oxygenation (ECMO) require surgical procedures while on the ECMO circuit. In order to control patient bleeding, Amicar (an inhibitor of fibrinolysis), and low dose heparin are used during the procedures, often resulting in component and circuit changes. CHOP has implemented a new oxygenator distributed by Abbott that was used for these circuits and was evaluated on function and need for change out post procedure.

**Aim:** Evaluate infant and pediatric Abbott oxygenators in ECMO circuits at CHOP that have had Amicar and low doses of heparin utilized on the circuit for surgical repair.

**Methods:** A quantitative study was conducted on the pediatric/infant Abbott and Pediatric Quadrox oxygenators in ECMO circuits for potential surgical patients (CDH, CCAM/CPAM, tracheal rings), of which a percentage had been introduced to Amicar and low dose heparin in the neonatal ECMO population.

**Results:** From July 2022 through June 2023, five ECMO runs used Abbott oxygenators on surgical neonates in the Neonatal Intensive Care Unit (NICU), two of which utilized Amicar and low dose heparin in the neonatal ECMO population.

**Conclusion:** The Abbott oxygenator is a safe and reliable replacement as compared to the Pediatric Quadrox oxygenator and can withstand the introduction of Amicar and low dose heparin.

**Reducing Post Cannulation Events with a Multidisciplinary Huddle**
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**Abstract**

**Background:** Pediatric patients who have refractory severe cardiorespiratory failure can be rescued with Extracorporeal Membrane Oxygenation (ECMO) while the underlying disease process is being managed. The deployment of Pediatric ECMO is a resource intensive process. Despite this, many institutions do not have in-house 24-hour coverage by pediatric surgeons, requiring calling the team in when ECMO is needed. In addition, surgeons must sometimes return to the hospital within 6 hours of ECMO cannulation because of issues arising from cannula malposition, bleeding post cannulation, inadequate ECMO flows or unacceptably high ECMO pump RPMs to achieve sufficient flow.

**Objective:** This quality improvement initiative was intended to decrease the number of post cannulation events. This would result in improved quality of care for the patients and overall improvement in resource utilization.

**Design and Setting:** Single-center prospective quality improvement project

**Methods and Main Results:** The process is driven by a post cannulation huddle involving the multidisciplinary team consisting of the Pediatric Intensivist, Pediatric Cardiothoracic Surgeon, ECMO nurse specialist, perfusionist and Pediatric Intensive Care bedside nurse. The huddle focuses on assessing the adequacy of cannula position, assessing achievable ECMO flow rates with corresponding RPMs, evaluating adequate oxygenation post cannulation, and discussing anticoagulation strategy and goals prior to the team dispersing. In the year following implementation of the post cannulation huddle, events requiring the ECMO team to return to the bedside related to cannula positioning, insufficient ECMO flow or unacceptably high RPMs to achieve sufficient flow, and bleeding requiring surgical exploration decreased by approximately 50%.
A prescriptively designed, human factors focused, emergency ECMO Cart for cannulation or circuit exchange
Salim Olia PhD1, Catherine Francis MSN2, Gina Terranova CRNP2, Helen Chacko MSN2, Waqas Akhtar BMBCh3, Daniel France PhD, MPH4, Scott Tilton DNP2. 1University of Pennsylvania, Division of Cardiac Surgery, Philadelphia, USA. 2Penn Presbyterian, Department of Nursing, Heart and Vascular Intensive Care Unit, Philadelphia, USA. 3Royal Brompton and Harefield Hospitals, Harefield, United Kingdom. 4Vanderbilt University, Department of Biomedical Engineering, Nashville, USA
Abstract
Background: Amidst a chaotic ECMO initiation or circuit exchange, even when centralized to a single location, timely acquisition of the required supplies may be challenging. We sought to create a comprehensive emergency ECMO Cart following a prescriptive and human factors design approach to minimize time for appropriate item retrieval.
Methods: The principle design rules were defined as: 1) the cart must securely contain all required disposable items for cannulation or exchange; 2) supplies should be intuitively grouped; 3) avoid stacking of similar items; 3) support two procedures without restocking; and 4) drawer contents readily identifiable by all end users. End users were defined as HVICU RNs, APPs, perfusionists, cardiac surgery residents, and cannulating physicians.
Results: Disposables (e.g. wires/kits, cannulas, etc) included were based on historical usage and expert feedback. Iterative mock layout optimization, led to the selection of a customized cart (Flexline, InterMetro Industries, Pa) with specified drawer depths and a “bronchoscope cabinet” for the oversized venous cannulas. Lastly, vinyl decals were designed with extensive user-feedback for each drawer handle and face.
Discussion: The resultant cart was well received and has become the primary supply resource for all ECMO procedures (Fig.1-Left). Handle numbering matches the utilization sequence, while the pastel palette visually organizes without predisposition. Large content lists and pictograms support rapid identification of the desired drawer. Easily maneuverable, the flat top allows for sterile supply staging and opening. In transatlantic collaboration, this design has since been successfully implemented at the NHS Harefield Hospital UK as well (Fig.1-Right).

Evaluation of the Calibrated Automated Thrombogram in Swine during 72-hour Veno-Venous Extracorporeal Life Support
Eric Bigon1,2, Pamela Villalobos1,2, Antoine Persello1,2, Andriy Batchinsky1,2, Teryn Roberts1,2, 1Autonomous Reanimation and Evacuation Research Program, The Geneva Foundation, San Antonio, USA. 2Department of Translational Medicine, University of the Incarnate Word School of Osteopathic Medicine, San Antonio, USA
Abstract
Introduction: The Calibrated Automated Thrombogram (CAT) is a method to assess thrombin generation via lag-time (duration required for the initial amounts of thrombin to form), peak height (highest concentration of thrombin reached), and endogenous thrombin potential (overall quantity of thrombin that the tested plasma can generate). Objective: investigate thrombin generation by CAT and carry out standard methods prothrombin time [PT] and activated partial thromboplastin time [aPTT] during 72-hour veno-venous extracorporeal CO2 removal (vv-ECCO2R) in swine. We hypothesized that thrombin generation metrics by CAT correlate with PT and aPTT.
Methods: Mechanically ventilated, anesthetized swine (n=11; 50-60kg) were cannulated (23-Fr dual-lumen cannula) in the right jugular vein for vv-ECCO2R (1.5L/min blood flow, 3L/min sweep gas) using the CardioHELP system (Maquet/Getinge, Germany). Blood was collected at baseline (BL), post-ECLS, (pECLS) and 6, 24, 48 and 72-hours for CAT (Diagnostica Stago; France) thrombin generation and PT, aPTT analyses. CAT data were compared to PT/aPTT via Spearman correlation.
Results: Lag-time, peak height and endogenous thrombin potential increased from 24-72-hours (Figure). PT increased significantly from BL (14.0±0.2 sec) to 72-h (16.3±1.8 sec) (p=0.03). aPTT did not change, BL (28±1 sec),72-h (27±3 sec). No correlation between PT/aPTT and CAT was found.
Conclusions: CAT did not correlate with PT and aPTT in this study. Future research on the utilization of CAT to yield clinically meaningful insights into thrombin generation compared to PT/aPTT should be continued, and is ongoing in our laboratory to include models with injury.

Figure: Data normalized to hematocrit levels. Changes over time were compared to BL and assessed using a mixed model. All comparisons were two-sided, p<0.05 for statistical significance.
Chlorhexidine cleaning of the exposed ECLS circuit is associated with reduced blood stream infections

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Abstract

Background: Blood stream infection (BSI) is an important complication of ECLS. Chlorhexidine gluconate (CHG) cleaning of the exposed ECLS circuit has been reported to reduce infections.

Methods: We adopted the practice of cleaning of the exposed ECLS circuit with 2% CHG impregnated wipes coinciding with daily CHG patient skin baths in mid-year 2022. Our institution BSI quality database was cross-referenced with our ECLS patient log from 2018 through February 2023 to identify all ECLS patients with a culture-proven BSI while on ECLS or within 72-hours of decannulation. ECLS associated BSI (E-BSI) events were defined by the subset of BSI without an antecedent infection or clear primary or alternative source, in which case the infection was suspected due to ECLS or another endovascular device. BSI and E-BSI incidence were measured pre and post intervention to gauge impact.

Results: The ECLS database identified 98 distinct cases for 875 days in the pre-CHG, and 48 cases for 405 days in the post-implementation period. The pre-CHG BSI rate was 13.4% or 16.7 BSI per 1000 ECLS days compared to the post-CHG BSI incidence of 4.2% (p=0.07) or 5.0 BSI per 1000 ECLS days (p=0.08). Pre- and post-CHG E-BSI rate was 11.3% and 2.1%; Difference of 9.1% (p<0.05) or 14.1 vs 2.5 E-BSI per 1000 ECLS days (p=0.05).

Conclusion: Our single center experience recognized an association of daily CHG disinfection of exposed ECLS circuits with reduced BSI and E-BSI. This intervention warrants investigation in a controlled trial.

Quality Improvement: Stabilizing Cannula Placements – A Multidisciplinary Team Approach

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Abstract

Introduction: Cannula problems or complications are defined as “reposition or exchange for misplacement, dislodgement, replacement due to clots mechanical failure or inappropriate position”. In 2019, our ECMO program utilized care bundles to improve quality of care and promote evidence-based practices to prevent accidental decannulation. Reviewing ArborMetrix, we recognized an opportunity to decrease cannula complications in comparison to other ELSO Centers. Identifying opportunities for change in our practice to decrease cannula migration.

Methods: Quarter 1 2021 our program moved from recognizing how to stabilize cannula and tubing to x-ray review, understanding cannula placement, configurations, and functionality. In collaboration with our surgical teams we reviewed cannula and configurations available for our patients. Bedside audits, reeducation, and the ECMO quality board supplied data. The components of the cannula stabilization bundle include cannula secured to the patient, tubing secured in two places, cannula placement reviewed at handover, skin protectant in place and documentation of cannula placement.

Results: In Q1 2021 our cannula complication rate, as defined by ELSO Registry Standards, was at 50% by Q2 2021 we had an improvement to 28%. With each subsequent quarter improvement continued and by Q4 2022 our complication rate is at 8%.

Conclusions: ECMO cannula stabilization bundle implementation, standardized expectations of cannula management, understanding configurations and cannula placements lead to a 40 % decrease in cannula complications and less risk to patients. ECMO Specialist education has led to team awareness of cannula complications and prevention strategies. We continue to evaluate our process and educate as new opportunities are recognized.
Multicenter Assessment of a Novel ECMO Cannulation Simulator Using a Standardized Procedural Checklist
Lovkesh Arora1, Dawda Jawara2, Erin Evans1, Erick Przybylski2, Dan McCarthy2; 1University of Iowa, Iowa City, USA. 2University of Wisconsin, Madison, USA

Abstract
Background: Venoarterial extracorporeal membrane oxygenation (VA ECMO) is an emergency procedure performed across various specialties. These conditions present barriers to education and assessment of competency. Checklists and simulation may be useful supplements to cannulation training. The objective of this study was to develop a checklist for VA ECMO cannulation and assess performance using a novel high-fidelity cannulation simulator.

Methods: Using a modified Delphi technique, six experienced cannulators created a femoral VA ECMO cannulation checklist. In a video monitored setting, fellows and attending physicians underwent a simulation training at two academic institutions in Wisconsin and Iowa. Cannulation videos were scored on a 23-item checklist with a maximum of 34 points. Pre- and post-cannulation surveys were completed by the participants.

Results: The simulation was completed by 10 participants. The mean and median scores of the participants were 31.8 (SD 2.2) and 32.5 (IQR 1.8), respectively. The most commonly missed items on the checklist was related to wire confirmation in the vessels. Additionally, 75% of the participants felt the simulator provided a “suitably realistic experience with cannulation”.

Conclusions: The cannulation checklist and simulator resulted in reproducible performance assessments and consistently positive participant feedback, suggesting these tools may be a useful addition to a cannulation curriculum. Performance assessments can be used to improve training curricula and to document proficiency prior to independent practice. Further research is necessary to validate whether this tool can discriminate between experienced and novice operators.

Assessment of Plasma Free Hemoglobin in Swine During 72-hour Veno-Venous Extracorporeal CO2 Removal: HemoCue® versus HemCheck
Kara Jones1,2, Antoine Persello2, Teryn Roberts2, Andriy Batchinsky2; 1University of the Incarnate Word School of Osteopathic Medicine, San Antonio, USA. 2The Geneva Foundation, San Antonio, USA

Abstract
Introduction: Post injury pfHb is associated with outcomes in trauma patients. The HemCheck (HemCheck Sweden AB, Karlstad, Sweden) is a CE-marked simplified point-of-care hemolysis testing device. Using Bland- Altman analysis, we evaluated the HemCheck versus the FDA-approved HemoCue® Plasma/Low Hb System (HemoCue, Angelholm, Sweden) reference device for measurement of pfHb in swine with ARDS due to smoke inhalation injury and 40% total body surface area burns managed with or without extracorporeal CO2 removal.

Methods: EDTA plasma from anesthetized, mechanically ventilated, Female Yorkshire swine (n=20) subjected to injury (smoke inhalation and burn), with or without ECLS (750-1000 ml/min blood flow) for 72-h was analyzed. Samples for assessment of pfHb were collected at baseline, post-injury, post-ECLS, then 6, 24, 48 and at 72-hours. The HemoCue® was used per manufacturer guidelines. For HemCheck, 0.1 ml of plasma was added to a HemCheck s-Test. Bland-Altman was performed to compare HemCheck against HemoCue.

Results: See Figure. HemoCue values were systematically higher than HemCheck. No agreement was found between the two devices for the measure of pfHb when considering all data points overall due to skewness of data in the above 300mg/dL range of values. pfHb values in the 0-300mg/dL range showed good agreement HemCheck and HemoCue.

Conclusions: In this cohort of animals with smoke inhalation injury and burns managed with and without VV ECO2R, HemCheck showed good agreement with HemoCue values in the pfHb range of 0-300mg/dL. More research is needed for accurate assessment of pfHb in subjects with different injury patterns.

Figure: Bland-Altman analysis of HemCheck (test device) versus HemoCue (reference device) for pfHb (mg/dL) value ranges: 0-500+ (A); 0-49 (B); 50-99 (C); 100-199 (D); 200-299 (E); 300-500 (F); and 500+ (G). Mean difference, standard deviation and confidence intervals are listed.
Circuit And Equipment

Going Against the Flow: One Center's Experience with Returning Blood to the Patient During ECMO Decannulation.
Elisabeth McHale, MD, Cassandra Schoborg, MD, Beth Heather, RN, MSN, Matthew Prekker, MD, MPH; Hennepin County Medical Center, Minneapolis, USA

Abstract
Background: Conserving blood during ECMO decannulation may preserve oxygen content. We describe our practice of routinely returning circuit blood (~600 mL) to patients undergoing decannulation. We compare hemoglobin after decannulation vs. circuit change, where circuit blood is discarded.

Methods: We analyzed consecutive ECMO patients who underwent VV or peripheral VA ECMO decannulation or circuit change over 7 years at 1 adult center. During decannulation, a nurse specialist accessed the Cardiohelp HLS membrane oxygenator using the emergency prime line; circuit blood was flushed back to the patient using crystalloid boluses via both circuit limbs. Investigators reviewed the electronic health record and hemoglobin data are summarized using means ± standard deviations.

Results: A total of 119 patients underwent 130 procedures involving separation from an ECMO circuit (110 decannulations [68 VV, 42 VA] and 20 circuit changes). Circuit blood was returned in 107 decannulations (return group) and discarded in 23 procedures including 3 decannulations (discard group). In the return group, hemoglobin before vs. after decannulation without RBC transfusion was 8.5 ± 0.9 vs. 8.8 ± 1.0 g/dL among 57 VV decannulations and 9.5 ± 1.6 vs. 9.0 ± 1.4 g/dL among 34 VA decannulations. In the discard group, hemoglobin before vs. after 17 circuit changes without RBC transfusion was 9.1 ± 0.7 vs. 8.4 ± 0.9 g/dL.

Conclusions: The standard practice of flushing blood back to the patient during VV and peripheral VA ECMO decannulation appeared to preserve the hemoglobin concentration as compared to circuit changes where the circuit blood is discarded.

Cessation of the Better Bladder and the Transitional Process of Our ECMO Program
Monika Collins, Erin Glikes, Jordan Andrews, Alicha Gibbs, Kumi McCool, Elizabeth Fournier; The Medical University of South Carolina, Charleston, USA

Abstract
Identification: The Better Bladder (BB) venous reservoir was introduced to the ECLS community August 1998 and quickly became a tool for facilitating venous line compliance and noninvasive pressure monitoring. Since that time, it became an integral component within our circuit configuration and its utilization deemed essential for patients <10kg on rollerpumps receiving ECMO support. In the fall of 2022, a recall was issued, impacting all current BB and delaying production of all future BB. We immediately initiated a proactive strategy to ensure uninterrupted care for our identified ECMO patients.

Methods: A proactive, multi-phasic approach was taken: Phase #1 Program Preplanning began prior to exhaustion of internal supply. Potential circuit reconfigurations and water lab testing examined vulnerable areas for hemolysis/shunt requirements. Phase #2 Physician Stakeholders were consulted regarding the proposed circuit schematics and impact upon patient populations Phase #3 Weekly Communication of Supply Level was initiated for bidirectional information sharing Phase #4 Implementation of BB Free circuity on first patient

Results: Eight patients were analyzed over a 6-month period. Primary metrics included weight, cannula size(s), venous line pressure(s), volume administration, and plasma free Hbg (PFHb) levels. Venous line pressures did not exceed ~44 despite cannula size/ location/ flow and PFHb found statistically insignificant.

Conclusion: Pediatric patients <10kg can safely receive support on rollerpump sans venous line reservoir. Tight parameters, servo-regulation, and staff hypervigilance assist with the delivery of ECLS without increased hemolysis risk. Maintaining a low threshold for hemolysis is essential in the successful application of this strategy.
Centrifugal versus roller pumps in pediatric extracorporeal membrane oxygenation: experiences from a community hospital

Brian Gao1, Allen Dang1, Thomas Lindsey2, Rebecca Denna1, Naruhito Watanabe1,2, Teimour Nasirov1,2,1 California Northstate University College of Medicine, Elk Grove, USA. 1 Sutter Medical Center, Sacramento, USA. 2 Stanford University School of Medicine, Department of Cardiothoracic Surgery, Palo Alto, USA

Abstract

Purpose: To compare the clinical outcomes of centrifugal pumps to roller pumps in nurse-managed pediatric extracorporeal membrane oxygenation (ECMO) at a community hospital.

Methods: A retrospective single-center study was conducted on all patients between 4-weeks old and 18-years old who received ECMO support in the PICU between December 1997 and March 2023. 41 ECMO runs were performed, of which 20 used centrifugal pumps (PediMag/CentriMag) and 21 used roller pumps (Stockert). The endpoints investigated include survival to discharge, ECMO duration, and ECMO complications. Analyses were performed using Fisher’s exact tests and two-tailed unpaired t-tests.

Results: There were no statistically significant differences in survival to discharge when comparing centrifugal pumps to roller pumps in elective pulmonary support (p=0.619), elective cardiac support (p=0.608), and extracorporeal cardiopulmonary resuscitation (ECPR) (p=0.999). There were no significant differences in average ECMO duration for elective pulmonary support (206 vs. 226 hours, p=0.849), elective cardiac support (137 vs. 132 hours, p=0.885), and ECPR (94.3 vs. 98.1 hours, p=0.952). There were no significant differences in the average incidence of mechanical, hemorrhagic, neurologic, renal, cardiovascular, pulmonary, infectious, metabolic, and limb complications per patient; however, of the complications that arose, centrifugal pumps had a significantly higher rate of major complications (defined by ELSO guidelines) compared to roller pumps (32.8% vs. 4.26%, p=0.00478).

Conclusion: Both centrifugal and roller pumps yielded similar patient outcomes; however, centrifugal pumps were associated with a higher rate of developing major complications. The results of this study encourage further exploration by larger-scale clinical investigations.

Awake, Ambulatory Bridge to Lung Transplant Utilizing Extracorporeal Carbon Dioxide Removal (ECCO2R)

Katherine Vandervest, Mario Padilla, Kaitlyn Lingle, Kara Monday, Britton Blough, Dan Meyer, Michael Foreman, Todd Grazia, Gary Schwartz; Baylor University Medical Center, Dallas, USA

Abstract

Introduction: Bridge to lung transplantation using extracorporeal support is well accepted, ideally in an awake and ambulatory configuration. Few reports exist on the utilization of ECCO2R as a bridge to lung transplantation.

Clinical Summary: A 61-year-old male with interstitial lung disease was evaluated and approved for lung transplantation. He was admitted urgently to the ICU with hypercapnic respiratory failure and a PaCO2 of 110mmHg. Oxygenation was sufficiently supplemented with nasal cannula, but titration to continuous non-invasive-ventilation (NIV) occurred which was prohibitive to nutrition and conditioning. A multidisciplinary decision was made to proceed with ECCO2R bridge. Utilizing local anesthetic and ultrasound-guidance, the right common femoral vein was percutaneously cannulated with a Hemolung® 15.5-French catheter after administration of 2500units of intravenous heparin. Initial settings of 450mL/min flow, 1300rpm, and sweep of 8L/min (CO2 removal of 108ml/min), corrected the PCO2 from 107mmHg to 77.7mmHg. Over the next ten days, average parameters included: 520ml/min flow, 1350rpm, sweep 10L/min, approximate CO2 removal 88ml/min, and serum CO2 level ~63mmHg (Table 1). Nocturnal NIV and 2-4L oxygen supplementation enabled ambulation >900ft. Subcutaneous heparin (5000units q8hours) was utilized without hemorrhagic or thrombotic complication. On day 11 of extracorporeal support, bilateral lung transplantation was performed with catheter decannulation and discharge occurred 22 days post-operatively.

Discussion: Awake, ambulatory ECCO2R can be safely and effectively utilized as a bridge to lung transplantation in predominantly hypercapnic respiratory failure. Exercise tolerance can be achieved with low flow and via femoral cannulation. Therapeutic anticoagulation was avoided which possibly mitigated bleeding risk without circuit thrombosis.
A Comparative Review of ECMO Systems and Their Features

Yijiang Li, Guangdong Organ Support Engineering Technology Research Center, Shenzhen, China

Abstract
As ECMO patients and centers increase, knowledge of available (and coming) systems for patients is needed. We compared 5 systems including the newly manufactured LifeMotion (ChinaBridge Inc).

Conclusions: Given current supply chain issues, knowledge of current and new equipment that is arising is valuable to clinicians and centers.

Table 1. Product Specification Comparison

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<th>Medtronic</th>
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</table>
Neonatal

The use of high-fidelity simulation to orient neonatal intensive care nurses to bedside care of ECMO patients

Micheal Heard¹, Erika Hamden¹, Esther Taylor¹, Sarah Keene¹; ¹Children’s Healthcare of Atlanta, Atlanta, USA. ²Emory University, Atlanta, USA

Abstract

Introduction: At Children’s Healthcare of Atlanta, bedside Neonatal Intensive Care (NICU) nurses are trained to care for ECMO patients as an advanced competency. The nurses are required to take a 4-hour class including didactic and high fidelity simulation followed by bedside orientation. Low staffing levels as well as decreased numbers of NICU ECMO patients have made it difficult to complete orientation, with some nurses waiting months to do so.

Discussion: We developed a novel simulation to accomplish the objectives that are part of the orientation shift, and included situations that may never occur on a specific shift. We planned an eight-hour high fidelity simulation. Objectives included admission of candidate progressing to ECMO; cannulation and initiation of ECMO; basic nursing care, management of off bypass emergency, weaning, trial off, decannulation and post ECMO care.

An important part of this simulation was the inclusion of a Respiratory Therapist and a Neonatology Fellow to increase the fidelity of the simulation. Each had their own objectives to accomplish. Additionally, a content expert was an embedded participant for each discipline.

Results: Three NICU nurses, a respiratory therapist and fellow participated in six scenarios. Pre and post surveys demonstrated that all gained knowledge and confidence through simulation. A NICU ECMO patient was admitted one week later and two nurses and the fellow were able to provide care. Their surveys showed both confidence and knowledge in their care.

Conclusion: Simulation adequately or more than adequately prepared nurses and a physician for actual bedside patient care.

Neonatal Systemic Hypertension In Patients On Extra Corporeal Membrane Oxygenation (ECMO) Across the Pediatric Health Information System (PHIS) database

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Abstract

Background: Normal blood pressure ranges in critically ill neonates have not been well established leading to variability in diagnosis, and management of systemic hypertension (HTN). ECMO increases afterload, and therefore contributes to HTN. We aim to describe incidence of HTN in ECMO patients in the Pediatric Health Information System (PHIS) database.

Methods: Retrospective cohort of neonates requiring ECMO from January 1, 2010, to December 31, 2020, across the PHIS database using ICD 9/10 codes to ascertain the diagnosis of HTN. We excluded patients with incomplete data, and those with congenital heart disease (CHD). The distributions of categorical variables were summarized with frequencies and percentages. Median and inter-quartile ranges were used for quantitative variables.

Results: A total of 437,014 admissions met criteria, with 4805 (1.1%) required ECMO, of which 200 (4.2%) had a diagnosis of HTN. Of those, 148 (148/200=74%) received an antihypertensive medication by 28 days of life. Vasodilators were most commonly used, with hydralazine being the most prescribed agent. More than half (55.4%) received multiple agents. Half (74/148= 50.0%) received one class of drugs, 51 (34.4%) received two, 19(12.8%) received three, 2(1.4%) received four, and 2(1.4%) received five classes of agents.

Conclusion: There is variability in antihypertensive medication exposure in neonates with systemic hypertension receiving ECMO therapy. A consensus guideline may be beneficial to reduce practice variations.
"It's so expensive and isn't any better! Or is it?" A Financial, Hemorrhagic, and Survival Analysis of Bivalirudin vs Heparin in Neonates on ECMO

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Abstract
Background: Bivalirudin use in neonatal ECMO is less well studied than heparin and has a higher production cost. Centers are cautious about changing to a newer, more expensive agent. Some safety and efficacy data exist for neonates, but there are few, if any, cost analyses between heparin and bivalirudin.

Methods: A single center, retrospective study was conducted for neonates on ECMO receiving heparin or bivalirudin. We evaluated the dollar cost per ECMO hour, incidence of intracranial hemorrhage (ICH), and survival rates. Data from 68 patients was collected (demographics, anticoagulation type and cost, ECMO duration, number and cost of component changes, anticoagulation lab costs and frequency, ICH occurrence, and survival outcome). Total cost per ECMO hour was calculated. Drug costs were calculated utilizing average wholesale price (AWP). Two-tailed t-tests and chi-squared analyses were used to evaluate data.

Results: 39 patients received heparin and 29 received bivalirudin. No significant difference was found in cost per ECMO hour between bivalirudin ($54.14) and heparin ($58.27). There was a trend towards significance in survival for patients treated with bivalirudin, and a significant decrease in ICH seen with bivalirudin (p < 0.05).

Conclusion: The cost difference per hour of ECMO between heparin and bivalirudin is negligible. Examination with center specific contract pricing, rather than AWP, revealed even greater cost savings with bivalirudin. A clinically and statistically significant reduction in ICH was seen using bivalirudin. Data did not show a statistically significant difference in survival, but did trend towards significance. Wider study across the ECMO community is warranted.

Single Center Experience with Percutaneous Cannulation in Neonatal Veno-Venous ECMO

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Abstract
Background: The landscape of ECMO for respiratory failure has changed over the past years, primarily because of unavailable equipment. OriGen catheters were recalled in 2019 compelling centers to opt for veno-arterial (VA) ECMO given technical complexity and reported complications of Avalon bicaval catheter placement. We describe our experience with percutaneous veno-venous (VV) ECMO cannulation and short-term neonatal outcomes in our institution.

Methods: Retrospective cohort review of VV ECMO patients from 2019 to 2023 in a level IV referral NICU. Multiple process changes were sequentially implemented in 2019 to ensure training and safety of percutaneous cannulation, and cannula position during the ECMO run (Figure 1). Patient and ECMO characteristics as well as complications, imaging studies and short-term outcomes were collected.

Results: Ten neonatal patients were cannulated onto VV ECMO, 7 via percutaneous approach and 3 open (Table 1). Of the open cannulations, 1 was surgeon preference, 1 patient instability and 1 catheter malposition requiring conversion to VA ECMO. All open cannulations involved vessel ligation at decannulation. Complications of percutaneous cannulation included catheter malposition (n=4) and post decannulation vessel thrombosis (n=4) requiring systemic anticoagulation (n=3). There were no life-threatening complications such as vessel or cardiac perforation. Imaging studies for cannula placement and position monitoring varied (Table 2).

Conclusions: A multidisciplinary practice change involving education, simulation training, and standardized protocol changes led to the successful percutaneous neonatal VV ECMO cannulation in a referral ECMO center without life-threatening complications. Next steps include process improvements to safely decrease imaging burden for cannula position monitoring.
Neonatal Hemostatic Complications During Neonatal Extracorporeal Membrane Oxygenation: Roller Pump and Centrifugal Pump Driven Circuits

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Abstract

Recently three different neonatal extracorporeal membrane oxygenation (ECMO) circuits have been employed in our clinic. These circuits were compared for clotting and bleeding complications. Initially we used an ECMO circuit containing a roller pump and venous bladder without severe complications. Manufacturing of circuit components was discontinued, necessitating the replacement of this circuit by a circuit with a centrifugal pump with 3/8 inch in- and outlet. Acute increase of oxygenator resistance requiring emergency changeout became unexpectedly a regularly occurring complication. The increase in resistance was suspected to be caused by oxygenator clotting, although oxygenator function was preserved. To prevent this complication we changed to a levitating centrifugal pump with 1/4 inch in- and outlet, after which no oxygenator malfunction has been observed. Macroscopic and electron microscopic analysis demonstrates that small clots are formed within the circuit, presumably in or near the centrifugal pump, which are transported to the oxygenator and clog up the hollow fiber layer at the inlet side, barely penetrating the oxygenator beyond this first layer. Our results suggest that low blood velocities accompanied with recirculation of blood within or near the centrifugal pump and/or heat generation within the pump could contribute to the formation of these clots.
Neonatal

Risk of intracranial hemorrhage or death during ECMO in neonates with hypoxic ischemic encephalopathy
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Abstract
Introduction
Newborns receiving therapeutic hypothermia (TH) for perinatal hypoxic ischemic encephalopathy (HIE) are thought to have an increased risk of intracranial hemorrhage (ICH). A proportion of infants with HIE will require ECMO therapy for respiratory and/or circulatory failure. This retrospective study examines whether neonates with HIE receiving ECMO are at an increased risk for significant ICH or death when compared to neonates without HIE.

Study design
A single-center retrospective chart review of all neonates who required ECMO over a 10-year period (2013-2022). Rates of significant ICH (Grade III or IV) or death before discharge were compared between infants with HIE and those without HIE. As TH is the standard of care for moderate to severe HIE, we defined infants with HIE as those who received TH.

Results: A total of 82 neonates were included in the study; 30 received TH for HIE and 52 did not. Among those with HIE, 30% developed significant ICH compared to 11.5% of neonates without HIE (9/30 vs. 6/52, p=0.06). Death before discharge occurred in 16.6% of neonates with HIE vs. 11.5% of neonates without HIE (5/30 vs. 6/52, p=0.5).

Conclusion: Neonates with HIE who received ECMO therapy did not have a statistically significant increased risk of severe ICH or death before discharge when compared to those receiving ECMO without HIE. Additional detailed analysis including a logistical regression of clinical risk factors for ICH or death is pending completion.

Factors and Outcomes Associated with Circuit Change in the Neonatal and Pediatric ECLS populations: An Analysis of the ELSO Registry
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Abstract
Objectives: Circuit change is one of the most common circuit complications in neonatal and pediatric ECMO. Single-center studies have reported multiple factors associated with circuit change, but no multicenter data reporting the prevalence, factors and outcomes associated with these events exists.

Methods: We conducted a multicenter retrospective cohort analysis of 14,185 patients less than 18 years of age in the ELSO international registry who were supported on ECMO from January 2018 to December 2021. A Cox proportional hazards model with center random effect was fit to determine demographic, pre-ECLS, and ECLS variables associated with the risk of circuit change. We also evaluated whether circuit change is associated with other ECLS complications and in-hospital mortality.

Results: The primary outcome was time to first circuit change. Factors associated with increased risk of circuit change included neonatal age, center volume ≥ 26 runs/yr, ECLS in 2019/2020, bridge to transplant and mechanical cardiac support prior to ECMO. Weight in the 2nd and 3rd quartiles, Asian race and therapeutic hypothermia were associated with decreased risk of circuit change. Significant associations of circuit changes were observed with bleeding, hemolysis and renal replacement therapy. The secondary outcome was odds of in-hospital mortality. Both neonatal and pediatric patients who underwent a circuit change had an increased likelihood of in-hospital mortality when adjusting for ECMO indication.

Conclusions: Circuit change is an important clinical marker that is associated with ECLS complications and in-hospital mortality.

Key Words: Circuit change, extracorporeal membrane oxygenation, neonates, pediatrics
Epinephrine dosing during pediatric extracorporeal cardiopulmonary resuscitation (ECPR): A single center retrospective study assessing adherence to resuscitation guidelines.

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Abstract
Purpose: Guidelines for cardiac arrest in children suggest epinephrine administration at fixed duration intervals (every 3-5 minutes) and do not provide guidance for epinephrine dosing during ECPR. Limited evidence suggests an association between epinephrine dosing and survival in pediatric ECPR. We sought to establish our own institutional practice and adherence to resuscitation guidelines for epinephrine dosing.

Methods: Retrospective case-notes review was performed from 2019-2022 for 20 children who received ECPR.

Results: We analyzed 123 Epinephrine doses in the 20 children. 66% (n=81) of epinephrine doses were administered appropriately (3-5 minute interval), of which 7 were < 3 mins and 35 were > 5 min intervals. The median (IQR) number of epinephrine doses administered was 6.5 (5 - 9) with a median ECPR duration of 51 (44-63) minutes. The time interval between successive doses of epinephrine doses remained consistent with a median of 4-5 minutes for all dosing intervals (Graph 1).

The median time interval between the final epinephrine dose and the initiation of ECLS was 10 minutes (IQR 3.5-30 minutes), with this time interval being > 30 minutes in 25% of children.

Conclusions: When administered, time intervals between successive doses of epinephrine during ECPR showed good adherence to resuscitation guidelines. In some children, the duration between the final epinephrine dose and initiation of flows suggests a decision was made to cease the administration of epinephrine during ECPR. More evidence is needed to link epinephrine dosing in ECPR to patient outcomes.

Graph 1 – A chart to illustrate the time interval between successive doses of Epinephrine (y axis) with boxplot (median and interquartile range) and dose numbers for each child (x axis).

Negative Pressure Therapy for ECMO Cannula Stabilization
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Abstract
Background: Cannula stabilization on extracorporeal membrane oxygenation (ECMO) is important for patient transfer for testing and rehabilitation. Limitations to mobilization include staff comfort and cannula stability. The objective of this study was to review our experience utilizing negative pressure therapy (NPT) for cannula stabilization.

Methods: We reviewed our experience with NPT for cannula stabilization from Jan 2021-Dec 2022. Cannulation sites included neck, chest and groin.

Results: There were 33 ECMO runs. NPT was used for cannula stabilization in 12 of 33 patients (36%). NPT increased from 5 patients (24%) in 2021 to 7 (54%) in 2022. Eight of 12 (66%) were placed proactively within 24 hrs of cannulation. NPT used on cannulation sites in the neck n=6 (50%), chest n=5 (42%) and groin n=1 (8%). Average patient age and weight was 7 + 10 years (median 1.5 years; range 10 days-55 years), 27 + 29 kgs (median 12.2; range 2.7-87kgs) respectively. Average time on ECMO was 269 + 367 hrs (median 159; range 72-1629 hrs). Two of the 6 (33%) with neck cannulation received therapy sessions that included mobilization to chair, tumble form and/or walking or wheelchair riding. Patients with chest or femoral cannulation did not get out of bed with therapies. No patient suffered adverse events related to their mobilization or therapy.

Conclusions: Negative pressure therapy for ECMO cannula stabilization can be utilized safely for a variety of cannulation sites from newborns to adults. This wound management strategy may facilitate patient mobilization, rehabilitation therapies and extend cannula site durations.
Therapeutic Plasma Exchange for Refractory Verapamil Poisoning

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Abstract

INTRODUCTION: Verapamil poisoning results in significant morbidity and mortality, but management is challenging due to decreased myocardial contractility and conduction. We present a case of verapamil poisoning requiring ECMO support and the use of therapeutic plasma exchange (TPE) to provide stability and enhanced drug clearance.

DESCRIPTION: A 14-year-old female with depression presented after ingestion of approximately 4080 mg of extended-release verapamil. She was taken to an outside hospital and progressed to 3rd degree AV block. She was intubated and transferred to a tertiary PICU, where upon arrival, she was bradycardic and hypotensive despite high dose epinephrine and norepinephrine infusions. High-dose insulin-euglycemic and lipid emulsion therapy was initiated. She was cannulated onto VA-ECMO using a 17-French catheter into the right carotid artery and a 23-French cannula into the right internal jugular vein. Despite VA-ECMO flows of 100 ml/kg/min, she continued to require high vasoactive support. TPE of 1.5 plasma volume exchange with all 5% albumin was performed. The verapamil concentration pre-TPE was 7500 ng/ml and post-TPE was 1300 ng/ml, suggesting enhanced clearance (half-life is 3-7 hours). Following TPE, the patient’s vasoactive needs decreased. She was decannulated from ECMO after 5 days and ultimately transferred to an inpatient psychiatric facility.

DISCUSSION: There are limited case reports for the use of TPE in verapamil poisoning. Verapamil is a highly protein bound medication, and the use of TPE may be an important adjunctive therapy to enhance drug clearance.

Artery Morphology Following Peripheral Arterial Cannulation in Neonates and Children

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Abstract

Background: Arterial decannulation after extracorporeal life support (ECLS) is addressed variably, with carotid arteries either ligated or reconstructed and femoral artery cannulation sites closed either primarily or with patch repair. We sought to characterize arterial morphology following decannulation in pediatric patients, focusing on arterial thrombosis or narrowing, or intimal changes with presumed long-term risk of flow alteration.

Methods: Retrospective chart review of patients undergoing peripheral arterial cannulation from 2002-2022 at a tertiary care, free-standing children’s hospital. The primary outcome of interest was any arterial anomaly after decannulation with arterial reconstruction.

Results: Peripheral arterial cannulation accounted for 431 cannulations (393 carotid and 38 femoral). Among the carotid group survivors, 103 (33.4%) underwent carotid artery reconstruction; 45 (43.7%) of this group had post-operative imaging (median interval 21 days, IQR 4-50 days) and 21 (46.7%) had arterial morphologic changes. Among the femoral artery survivors, 24 (100%) underwent femoral artery reconstruction (12 primarily, 12 with autologous venous patch repair). 22 (91.7%) had post-operative imaging (interval median 9 days, IQR 4-22 days) and 7 (31.8%) of these showed arterial morphologic anomalies. In the carotid group, neonates were associated with higher odds of abnormal arterial morphology than older patients when adjusting for sex and ECLS duration (OR 6.3; 95% CI: 1.49-26.3).

Conclusions: Arterial reconstruction following decannulation of peripheral arterial ECLS in pediatric patients is accompanied by a significant risk for acquired vessel morphologic changes and rigorous long-term follow-up should be standard practice.
Microbial Cell Free DNA: A New Landscape Screening Tool for Infection in ECMO Patients

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Abstract

Introduction: Infections are common complications in mechanical circulatory support patients. ECMO patients exhibit abnormal inflammatory response, making them susceptible to frequent infection screening and to empirical antibiotic use. We aim to describe the role of microbial cell free DNA (mcfDNA) in a child with persistently negative culture sepsis on ECMO.

Case Description: A 1-month-old, 3.1 kg child with hypoplastic left heart syndrome underwent hybrid palliation. The patient required post-operative ECMO, converting to Berlin Heart EXCOR (BH) 6mm cannulas central cannulation on postoperative day (POD) 13 as bridge to transplant due to severe tricuspid regurgitation. By POD17, the patient developed signs of septic shock, elevated inflammatory markers, but persistently negative cultures. A mcfDNA test (Karius test) was performed, revealing the presence of Staphylococcus coagulase-negative DNA. Anti-staphylococcal coverage was narrowed for a 6 week course, targeting hardware infection. Improvement occurred in clinical and laboratorial parameters during the course of treatment. Subsequently, the patient was transitioned to a BH 10ml pump while awaiting transplantation. After a total of 61 days on ECMO and 87 days on BH, the patient died due to overwhelming Citrobacter sepsis.

Conclusion: We highlight a novel role for mcfDNA as a potentially valuable tool for screening invasive infections in patients receiving mechanical circulatory support. This population is highly susceptible to frequent and prolonged antibiotic exposure, making accurate identification and targeted treatment crucial. mcfDNA can provide valuable insights when traditional culture-based methods yield negative results, potentially improving patient outcomes by guiding appropriate antibiotic therapy.

Clinical Outcomes in Critically Ill Children on Extracorporeal Membrane Oxygenation with Severe Thrombocytopenia.

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Abstract

Objective: As international guidelines suggest keeping platelet counts above 80x10^9 cells/L in children on extracorporeal membrane oxygenation (ECMO), platelet transfusions are administered to two-thirds of ECMO days, and up to 70% of these patients still bleed. Our objective was to describe outcomes in children who develop severe thrombocytopenia on ECMO and had a restrictive transfusion strategy.

Methods: Single-center retrospective study, enrolling critically ill children on cardiac ECMO, at Memorial Hermann, between 1/2020 and 12/2022, with at least one platelet count below 50x10^9 cells/L. We report platelet counts measured four times a day, platelet transfusion, bleeding and clotting events within the subsequent 6 hours.

Results: We enrolled 34 patients over 3 years, representing 239 ECMO days and 860 platelet counts. Median weight was 3.3kg (IQR 2.7;4.4) and 44% were male. The overall 28-day mortality was 56%. The overall median platelet count was 39 (IQR 27;58). Of the 566 instances with a platelet count below 50, 16% (95%CI 13;19) were transfused platelets in the following 6 hours, 13% (95%CI 10;16) had a bleeding event, and 0.5% (95%CI 0.2;1.6) had a thrombotic event. Only 3% (95%CI 2;5) had both bleeding and platelet transfusions.

Discussion: While current recommendations result in large proportion of transfusions of children on ECMO, our results seem to indicate a more restrictive transfusion strategy, where platelet counts are allowed to fall below 50x10^9 cells/L, isn’t associated with higher proportions of bleeding or transfusion requirements. Multicenter studies are needed to evaluate further the appropriateness of this strategy.
Incidence And Outcomes of Arrhythmias During Pediatric Cardiac Extracorporeal Circulatory Support

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Abstract
Background: Patients on venoarterial extracorporeal membrane oxygenation (VA-ECMO) support may develop arrhythmias, however, data are limited regarding arrhythmia incidence, type, and their effect on outcomes.

Methods: We performed a retrospective review of pediatric patients with heart disease requiring VA-ECMO from 1/2020-1/2023. Indications included extracorporeal cardiopulmonary resuscitation (eCPR), cardiogenic shock, hypoxemia, or inability to wean from cardiopulmonary bypass (CPB). Data including demographics, arrhythmia type, and treatment were collected and analyzed using univariable and multivariable analysis.

Results: Ninety-one VA-ECMO cannulations in 82 patients were included for study (median age 5.7 months, weight 5.8kg). Diagnoses included congenital heart disease (n=68, 74%), cardiomyopathy (n=18, 19%), and myocarditis (n=3, 3%). Twenty-six patients experienced arrhythmias during 27 (30%) ECMO runs. Arrhythmias included ventricular tachycardia (n=10, 37%), ventricular fibrillation (n=9, 33%), atrial flutter (n=4, 15%), and atrioventricular block (n=4, 15%). Treatment occurred in 26 runs (96%), through a combination of medical therapy (n=15, 57%), defibrillation or cardioversion (n=12, 46%), and/or pacing (n=8, 31%). Arrhythmias on ECMO were associated with increased mortality or need for ventricular assist device (VAD) or transplant (OR 3.63, 95% CI 1.11-8.28), particularly in ventricular arrhythmias (OR 5.37, 95% CI 1.1-26.0). Ventricular arrhythmias on ECMO were associated with longer ECMO duration (322 vs. 144 hours, p<0.0001) and need for heart transplantation (OR 14.8, 95% CI 3.4-65.4).

Conclusion: Patients on VA-ECMO for cardiac indications have a high risk of developing arrhythmias while on mechanical support. Arrhythmias, particularly ventricular arrhythmias, while on ECMO are associated with increased ECMO duration and worse transplant and VAD free survival.

Process Improvement: Nomenclature Change Improves Response Times
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Abstract
Introduction: Establishing Extracorporeal Membrane Oxygenation (ECMO) during Cardiopulmonary Resuscitation (CPR) requires rapid response and timely initiation for the best chance at intact survival. We proposed that changing the existing language surrounding the rapid deployment of ECMO would lead to improved activation times.

Methods: A multidisciplinary team completed a comprehensive review of the existing system, identified gaps, areas for improvement, and developed a robust education program. Identified gaps included misinterpretation of “e” during eCPR, and “ECMO” when stating ECMO Stat. The team recommended utilizing CODE ECMO for designation and implemented in July 2021.

Results: Implementation of the change in nomenclature to CODE ECMO would lead to decreased time from CPR start to activation of ECMO to improve by 25%. Baseline data showed an average ECMO activation post CPR initiation of 13 minutes. Data through the current year has shown an improvement of 49% (13 min to 6.7 min).

Conclusion: Changing the existing nomenclature for the rapid deployment of ECMO has led to improved activation times. The increased knowledge of the capabilities of ECMO hospital-wide has led to an increased number of calls for CODE ECMO and the continued goal of increasing survivability. Lastly, the upgraded system has facilitated the multi-disciplinary team to review all CODE ECMO calls, increase data analysis, enabled monitoring of performance, and continues to identify further areas of improvement.
Favorable Vessel Patency Following Carotid Artery Reconstruction after ECMO in Children with Heart Disease
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Abstract

BACKGROUND: Carotid ligation following ECMO decannulation was previously the norm due to risk of embolization, cerebral infarction, aneurysm, and stenosis over time. Carotid artery reconstruction (CAR) has become common, with studies reporting variable stenosis. Data is lacking in children with heart disease in whom the need for carotid patency may be greater given the potential for repeat ECMO or surgery requiring bypass.

OBJECTIVE: We evaluated carotid patency following CAR after ECMO using CT and ultrasound and the incidence of cerebral infarction in children with heart disease.

METHODS: Retrospective review of children with heart disease 0 to 21-year-old who required venoarterial ECMO (VA-ECMO) via neck cannulation from 2015-2022 at a quaternary children’s hospital.

RESULTS: 57 children met study criteria (range 2-day-old - 21-years-old). Average ECMO duration was 8 days (range 1-25 days). 26/57 (45%) had carotid imaging after decannulation. 22/26 (85%) of carotid arteries remained patent. Duration from decannulation to follow up imaging ranged vastly from 2 days to 4 years, with most imaging being done within one year. 5 children had newly noted cerebral infarcts on the first CT or MRI after decannulation, though 2 of those children had no head imaging while on ECMO. The 4 children with carotid artery stenosis did not have cerebral infarcts.

CONCLUSION: In children with heart disease who had CAR following decannulation from VA-ECMO, 85% of those who had follow up imaging showed that the carotid artery remained patent. There was no increase in cerebral infarcts in patients who did not have patent carotid arteries.

The outcome of acute fulminant myocarditis in neonates and children requiring extracorporeal membrane oxygenation: A systematic review and meta-analysis
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Objective: Aggressive and robust treatments such as extracorporeal membrane oxygenation (ECMO) are warranted in patients with Acute fulminant myocarditis (AFM) because of favorable long-term prognosis with complete recovery of left ventricle function is reported. We conducted a systematic review and meta-analysis to assess the survival and the clinical outcomes of acute fulminant myocarditis in neonates and children requiring ECMO.

Methods: A search of the PubMed, Embase, and Cochrane databases was conducted for studies published from inception to May 1, 2022. Studies include a population of children and neonates who were admitted for AFM and underwent ECMO. The primary outcome was survival to hospital discharge.

Results: Ten studies were included in this meta-analysis, with a total of 788 patients. The overall pooled estimate of survival was 67% (95% CI 59 to 74%, p<0.01, I² = 57%) (Fig. 1). Meta-regression found that mean age and mean ECMO duration had no significant association with survival. When analyzing the trend of survival rates based on the years of inclusion studies, the survival rate did not increase (β: 0.085, 95%CI: - 0.000 to 0.171, p= 0.026) (Fig. 2).

Conclusion: The use of ECMO in neonates and children with AFM has a survival rate of 67%. Despite the aggressive nature and severity of AFM, ECMO deployment might be crucial for better outcomes. In more recent periods, survival was improved.
Safely Achieving Developmental Milestones of Pediatric Patients on Venoarterial Extracorporeal Membrane Oxygenation Awaiting Heart Transplants: Three Unique Patient Cases

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Abstract
Extracorporeal membrane oxygenation (ECMO) is utilized within our institution to support some of our neonatal and pediatric patients awaiting heart transplantation. ELSO guidelines for pediatric cardiac failure suggest that awake ECMO may be considered in older children, however, little is published regarding awake pre-heart transplant pediatric ECMO. Specifically, there is scant literature that discusses how to safely accomplish this whilst fostering the physical and developmental needs of this population. Prolonged sedation and immobility often due to concerns for cannula dislodgement results in deconditioning and can lead to delisting and is an unfortunate factor that plagues this population. At our institution, a multidisciplinary team developed an approach to safely meet the needs of neonates, infants, and children on ECMO as they await heart transplantation. Our team includes social workers, nutritionists, physicians, nurses, respiratory therapists, physical and occupational therapists, and ECMO specialists. The safety of patients during their rehabilitation is of paramount importance. To accomplish this, patients are supported with central ECMO, with early sternal closure, extubation, and attention paid to cannula securement that allows for safe mobilization. The team addresses daily goals with families to support the patient’s cognitive, physical, and mental health needs while also fostering developmentally appropriate milestones. Our case series presents an infant, a preschooler, and an adolescent successfully supported on ECMO for 98, 190, and 78 days respectively. All underwent mobilization and rehabilitation as they awaited transplantation.

Effect of longer extracorporeal life support and early treprostinil on survival in infants with severe congenital diaphragmatic hernia

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Abstract
BACKGROUND: Pulmonary hypertension (PH) and chronic respiratory failure in infants with severe congenital diaphragmatic hernia (CDH) contributes to poor survival. In 2021, we adopted a new strategy for neonates with severe CDH who received ECLS. This included repair on ECLS, use of bivalirudin, tolerance of longer ECLS runs and early initiation of treprostinil. Our goals were to come off ECLS on lower, lung-protective ventilator settings and with lower pulmonary artery pressures and improved right ventricular function. We hypothesized that this treatment strategy would lead to improved survival.

METHODS: We reviewed infants with severe CDH (defined as a lung to head ratio (LHR) < 1 and observed to expected total fetal lung volume (O/E TFLV) < 25%) who also received ECLS and treprostinil at our center born between 2015-2023 and compared outcomes before and after initiation of this strategy.

RESULTS: 15/136 infants met criteria for severe CDH and also received ECLS. Nine infants were treated prior to protocol implementation and 6 were treated with the new protocol. Survival among neonates with severe CDH was higher after introduction of our new protocol. At the time of decannulation from ECLS, there was a decrease in pulmonary hypertension and lower ventilator support was required in this later cohort. There was also both a higher average length of stay and an increase in average ECLS days in the new protocol group.

CONCLUSIONS: Early treatment of PH with treprostinil, longer ECLS and strict lung-protective ventilation strategies may lead to increased survival in severe CDH.
Validating a Pediatric ECMO Emergency Checklist for Clinical Specialist across Institutions using a Delphi Method

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Abstract
ECMO emergencies are high risk, low volume events requiring skilled training of clinical specialists, which can be assessed through simulation assessments. Wide variation amongst institutions in protocols and circuit designs make published assessment checklists difficult to generalize. This study aims to validate a published generalizable assessment tool for ECMO CS emergency skills using Messick’s framework for accreditation and evaluation.

A modified assessment checklist was created after an initial survey with focus on ECMO circuit components/configurations that could impact CS performance assessment. A modified Delphi process was used to develop content validity evidence with contribution from 8 experts with a rating scale of “Strongly Agree, Agree, Neither Agree nor disagree, Disagree, Strongly Disagree”. Items with >80% agreement in three rounds were kept or changed based on recommendations from the panel. Three trained raters then used the final modified checklist on ten simulations from five subjects at two different institutions with two ECMO circuit set ups. We then conducted fully crossed subject x rater x circuit generalizability (G) and decision (D) studies.

The G-study coefficient was 0 with 0% variance across subject and circuit. The greatest variance was between raters (28.7%) and 71.4% was attributed to third-order interactions and unknown. The D-study indicated it would take 10+ observing subjects across both circuit types to obtain a g-coefficient of 0.8.

This study was unable to validate a prior published generalizable assessment tool and suggests tools created specifically for an institution should be used with caution with confident application at another.

Pediatric MIS-C outcomes and complications after ECMO: ELSO registry study

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Abstract
Introduction and Objective: Literature on the use and outcomes of ECMO support in pediatric MIS-C patients is scant due to the relative novelty of the disease process. The aim of this study is to characterize the MIS-C patients needing ECMO support.

Methods: Observational retrospective cohort study in children aged 0 to 18 years with MIS-C supported on ECMO from January 1, 2020 to December 31, 2021, from the ELSO Registry database. Primary outcome was survival to hospital discharge. Univariate and multivariable logistic regression with backward elimination models were utilized to analyze the effects of different variables on survival in MIS-C patients.

Results: The ELSO Registry reported 184 pediatric ECMO patients with diagnosis of MIS-C. Veno-arterial support was the most frequent (62%) and cannulation via extracorporeal cardiopulmonary resuscitation occurred in 5.7% of patients. MIS-C patients required veno-venous support 38% of the time and had high rates of acute respiratory distress syndrome 45% and pneumonia 33.9%. Patients with MIS-C also had high rates of septic shock 25% and acute renal failure 28.7%. Median ECMO duration was MIS-C patients 182.5 hours. Survival to hospital discharge was 67.2% which is similar to all causes for pediatric ECMO.

Conclusions: Outcomes of children with MIS-C requiring ECMO support are similar to the national average of pediatric ECMO. These patient have significant need for pulmonary support along with cardiac support likely leading to longer ECMO run times. Prospective studies on the use of ECMO support in MIS-C patients may improve outcomes in this pediatric population.
Pediatric Non-Cardiac

Comparison of MIS-C and non-MIS-C myocarditis needing ECMO: ELSO registry study.
Noah Miller1, Pilar Anton-Martin2, Hitesh Sandhu3; 1Univeristy of Tennessee Health Science Center, Memphis, USA. 2Children’s Hospital of Philadelphia, Philadelphia, USA. 3Le Bonheur Children’s Hospital, Memphis, USA

Abstract
Introduction and Objective: Multisystem inflammatory disease in childhood (MIS-C) is a novel pediatric syndrome occurring after a COVID-19 infection with myocardial inflammation and vasoplegia with potential life-threatening hemodynamic compromise requiring ECMO support comparable to other forms of infectious and non-infectious myocarditis. Our aim was to describe the population needing ECMO and compare the characteristics and outcomes of MIS-C and non-MIS-C myocarditis.

Methods: Observational retrospective cohort study in children aged 0 to 18 years with MIS-C and non-MIS-C myocarditis supported on ECMO from January 1, 2020 to December 31, 2021, from the ELSO Registry database. Primary outcome was survival to hospital discharge. Secondary outcomes were ECMO duration, mechanical ventilation duration, length of stay, and requirement of heart transplantation or ventricular assist device for decannulation. Univariate and multivariable logistic regression with backward elimination models were utilized to analyze the effects of different variables on survival in MIS-C patients.

Results: The ELSO Registry reported 310 pediatric ECMO patients with diagnosis of MIS-C (n=174, 56.1%) and non-MIS-C myocarditis (n=136, 43.9%). No statistical difference was found in survival to hospital discharge between groups (67.2% for MIS-C vs 69.1% for non-MIS-C myocarditis, p 0.725). Multivariable analysis comparing all support types demonstrated that ECPR and co-infection were significantly associated with decreased survival to hospital discharge (OR 0.138, p 0.01 and OR 0.44, p 0.02, respectively).

Conclusions: Outcomes of children with MIS-C requiring ECMO support are similar to those of non-MIS-C myocarditis despite higher infectious, multiorgan dysfunction and respiratory complications accompanying COVID-19 infections.

Comparison of Outcomes of Central and Peripheral VA ECMO Cannulation for Pediatric Patients with Septic Shock
Abhinav Totapally1, Melissa Danko1, Heidi Chen2, Alyssa Altheimer3, Ryan Stark1, Daphne Hardison1, Elizabeth Zivick4, Mathew Malone1, Brian Bridges1; 1Monroe Carell Jr. Children’s Hospital at Vanderbilt, Nashville, USA. 2Vanderbilt University Medical Center, Nashville, USA. 3Vanderbilt University Medical School, Nashville, USA. 4Medical University of South Carolina, Charleston, USA. 5University of Arkansas for Medical Sciences, Little Rock, USA

Abstract
Introduction: Small studies of ECMO support for children with septic shock suggest that high-flow (>150 mL/kg/min) VA ECMO and a central cannulation strategy may improve survival compared with standard-flow and peripheral cannulation.

Methods: We queried ELSO for patients <18 years with a diagnosis code of sepsis, septicemia, or septic shock requiring VA ECMO from January 1, 2000-December 31, 2021. Survival to hospital discharge was assessed in patients requiring high-flow VA ECMO (³150 mL/kg/min) versus standard-flow (<150 mL/kg/min). Amongst high-flow patients, we compared survival and complications between central and peripheral cannulation strategies. A subgroup analysis was performed for patients with a primary diagnosis of sepsis and without congenital heart disease (CHD). We performed chi square, Wilcoxon rank sum, and logistical regression analyses.

Results: Of 6,154 qualifying VA ECMO runs, multivariate analysis demonstrated that peripheral cannulation was associated with lower mortality (OR 0.7; 95% CI 0.6-0.9). Mortality was inversely related to flow at four hours, but directly related to flow at twenty-four hours. Within the multivariate analysis of our primary sepsis subgroup (n=1,235), peripheral cannulation (OR 1.7; 95% CI 1.1-2.6) was associated with increased mortality. Mortality was inversely related to flow at four hours, while flow at twenty-four hours was not significant.

Conclusion: Peripheral cannulation was associated with decreased mortality in the overall cohort but associated with increased mortality in patients with sepsis without CHD. Higher flow at four hours was associated with decreased mortality, while the outcomes of flows at twenty-four hours are inconclusive.
Table 1: Univariate Analysis of Survival for High vs. Standard-Flow at 4 and 24 Hours in All Patients and in Patients with a Primary Diagnosis of Sepsis and Without Congenital Heart Disease

<table>
<thead>
<tr>
<th>Flow Time</th>
<th>All Patients (% Survival)</th>
<th>Primary Dx of Sepsis w/out CHD Diagnosis (% Survival)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 hours n (%)</td>
<td>≥ 150 mL/kg/min</td>
<td>&lt; 150 mL/kg/min</td>
</tr>
<tr>
<td>321 (42%)</td>
<td>p &lt; 0.001</td>
<td>65 (41%)</td>
</tr>
<tr>
<td>24 hours n (%)</td>
<td>343 (41%)</td>
<td>2,406 (53%)</td>
</tr>
</tbody>
</table>

Table 2: Univariate Analysis of Survival for Central vs. Peripheral Cannulation on High-Flow at 24 Hours in All Patients and in Patients with a Primary Diagnosis of Sepsis and Without Congenital Heart Disease

<table>
<thead>
<tr>
<th>All Patients (% Survival)</th>
<th>Primary Dx of Sepsis w/out CHD Diagnosis (% Survival)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central 89 (32%) Peripheral 225 (45%)</td>
<td>p = 0.0007</td>
</tr>
</tbody>
</table>

Table 3: Complication Rate of Central vs. Peripheral Cannulation in All Patients

<table>
<thead>
<tr>
<th>Complication</th>
<th>Central (n=1,230)</th>
<th>Peripheral (n=4,320)</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cannula Site Bleeding 101 (8.1%)</td>
<td>95 (2.1%)</td>
<td>p = 0.001</td>
<td></td>
</tr>
<tr>
<td>Cannula Problems 78 (6.3%)</td>
<td>468 (10.4%)</td>
<td>p = 0.001</td>
<td></td>
</tr>
<tr>
<td>CNS Infarction 61 (4.9%)</td>
<td>317 (7.0%)</td>
<td>p = 0.008</td>
<td></td>
</tr>
<tr>
<td>Renal Replacement 555 (45%)</td>
<td>2402 (53%)</td>
<td>p = 0.19</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Multivariable Analysis of Mortality in All Patients and in Patients with a Primary Diagnosis of Sepsis and Without Congenital Heart Disease

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>Confidence Interval</th>
<th>p - value</th>
<th>OR</th>
<th>Confidence Interval</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peripheral Location</td>
<td>0.7</td>
<td>0.6-0.9</td>
<td>p = 0.001</td>
<td>1.7</td>
<td>1.1-2.6</td>
<td>p = 0.02</td>
</tr>
<tr>
<td>Pre-ECLS Arrest</td>
<td>1.7</td>
<td>1.5-1.9</td>
<td>p = 0.001</td>
<td>1.8</td>
<td>1.1-2.3</td>
<td>p = 0.001</td>
</tr>
<tr>
<td>CNS Infarction</td>
<td>2.4</td>
<td>1.9-3.0</td>
<td>p = 0.001</td>
<td>2.5</td>
<td>1.5-4.0</td>
<td>p = 0.001</td>
</tr>
<tr>
<td>Mediastinal Cannula Bleeding</td>
<td>1.9</td>
<td>0.6-1.3</td>
<td>p = 0.5</td>
<td>1.1</td>
<td>0.3-4.2</td>
<td>p = 0.9</td>
</tr>
<tr>
<td>Renal Replacement Therapy</td>
<td>1.8</td>
<td>1.6-2.0</td>
<td>p &lt; 0.001</td>
<td>1.1</td>
<td>0.9-1.5</td>
<td>p = 0.3</td>
</tr>
</tbody>
</table>
A comprehensive pediatric database of venovenous extracorporeal membrane oxygenation for refractory respiratory failure

Oman Justine1, Kaushik Gokul1, John Lin1, Ahmed Said1; 1Washington University School of Medicine, St Louis, MO, USA. 2St. Louis University School of Medicine, St, USA

Abstract

Our database is a single-center, pediatric-specific database of patients admitted to a quaternary-level children’s hospital and supported on extracorporeal membrane oxygenation (ECMO) for refractory respiratory failure. To date, the majority of ECMO research utilizes low resolution registry data that inherently overlook the level of data intensity involved in managing these patients. The exhaustive nature of our database stands in direct contrast and captures information that would otherwise be missed. In addition to including patient demographics, vital signs, ventilator settings, vasoactive support, ECMO parameters, and laboratory markers of tissue oxygenation and gas exchange, our database uniquely incorporates airway clearance regimens, chest radiography findings, and functional status scales to assess patient outcomes. By constructing a more comprehensive database representing the data-rich critical care environment, we hope to glean more accurate insights into how management strategies impact patient outcomes.

Invasive Surgical Procedures Impact Mortality in Pediatric Extracorporeal Membrane Oxygenation Patients

Rupak Mukherjee, MD, Abigail Albritton, BS, Laura E. Hollinger, MD; Medical University of South Carolina, Charleston, USA

Abstract

Introduction: We hypothesized that pediatric patients on pulmonary ECMO support who required invasive surgical procedures incur more complications and worse survival.

Methods: Prospectively collected ELSO registry data for all neonatal and pediatric patients cannulated for pulmonary ECLS at our institution from 1/1/2015-12/1/2022 was stratified by procedures performed. All cardiac support patients and second runs were excluded.

Results: Seventy patients were reviewed, of which 56% were neonates. 22 patients (31%) required 33 invasive surgical procedures while on ECMO, including tube thoracostomy (18%), exploratory laparotomy (18%), cannula repositioning (6%), atrial septostomy (6%), tracheostomy (3%), and repair of congenital diaphragmatic hernia (33%). 14% required only bronchoscopies, and after confirming a low risk profile, these subjects were grouped with patients who underwent no procedures. Aside from birth weight (medians: 2.90 vs 3.18 kg, p = 0.047), patients who underwent invasive procedures had no significant demographic differences compared to those who did not. Patients who underwent invasive procedures required significantly longer ECMO support (354 vs 123 hours, p = 0.002) and incurred more mechanical complications (2.3 vs 1.4, p = 0.08) compared to those who underwent no procedures or only bronchoscopies. Cox hazards regression analysis revealed a statistically significant effect (p=0.011) of invasive surgical procedures on mortality. The more invasive a procedure, the more complications the patient endured, and both negatively affected survival (p=0.002).

Conclusion: Excluding bronchoscopy, pediatric patients supported with ECMO for pulmonary failure who undergo invasive surgical procedures have a higher mortality, longer ECMO runs, and increased risk of complications.
Compassionate Deactivation of Pediatric ECMO: An EBQI Project
Emily Neely, Kelly Sigler, Daphne Hardison, MSN, Patti Runyan, DNP, Brian Bridges, MD, Melissa Danko, MD; Monroe Carell Jr. Children’s Hospital at Vanderbilt, Nashville, TN, USA

Abstract
Aim To reduce distress with the end of life process for staff and families within pediatric ECMO
Background Pediatric extracorporeal membrane oxygenation (pECMO) is a high risk of mortality therapy. Historically across units in our hospital utilizing ECMO services, there has been a lack of clarity and consistency regarding the end of life (EOL) process and family decision-making for patients cannulated to ECMO. Since a large percentage of ECMO patients progressing to withdrawal of support result in EOL, we seek to promote a patient/family-focused EOL process to reduce distress and improve family satisfaction after EOL.
Outcomes An evidence-based quality improvement (EBQI) analysis was performed on EOL and compassionate deactivation (CD) within pECMO. We recognized four items to promote or standardize within the EOL process: Promotion of family participation in their child’s EOL care, a standardized process for ECMO circuit discontinuation, in-depth education on EOL practices for all healthcare providers involved in the care of pECMO patients, and collaboration between the healthcare team and family on a unified plan for withdrawal of support.
Implementation Plan We will obtain surveys from our staff on the technical and psychological aspects of the EOL process, and survey the families of our pECMO patients post CD. The research goal is to recognize whether a standardized process for EOL on ECMO provides the healthcare team with the tools to effectively provide compassionate EOL care that is family-centered and least distressful for families and staff.
Keywords: Extracorporeal membrane oxygenation, compassionate deactivation, end of life, critical care, palliative care, death

Low Surgical Complication Rate with Early Repair of Congenital Diaphragmatic Hernia on Extracorporeal Life Support Using a Standardized Protocol and Bivalirudin for Anticoagulation
Rebecca Stark, Graeme Segal, Kimberly Riehle, Matthew Dellinger, Mihai Puia-Dumitrescu, Carrie Foster, Michael Collins, Larissa Yalon, Zeenia Billimoria, Sarah Handley, Delphine Yung, Jackson Emma, Jimiane Ashe, Robert Digeronimo, Samuel Rice-Townsend; Seattle Children’s Hospital, Seattle, USA

Abstract
BACKGROUND: Neonates with severe congenital diaphragmatic hernia (CDH) often require extracorporeal life support (ECLS) for survival. Early repair of CDH on ECLS (within 24-48 hours of cannulation) has been shown to decrease mortality, but perioperative complications remain a concern. We developed a standardized protocol for early CDH repair on ECLS using bivalirudin as the anticoagulant. We hypothesized that bleeding complications would be low, with associated improvements in survival.
METHODS: A retrospective analysis was conducted on neonates with CDH who underwent early repair on ECLS using bivalirudin between 2021 and 2023. A standardized protocol was implemented that included peri-operative ECLS management and standardized operative technique. We collected data on demographics, operative details, ECLS parameters, hemorrhagic/thrombotic complications and survival.
Results: 12 CDH patients received ECLS using bivalirudin and underwent early repair between 2021-2023. 8.3% (n=1) developed a clinically significant ICH post operatively (within first 48 hours), none had bleeding complications related to the surgery requiring return to OR. Intra-op 33.3% (n=4) of patients had bivalirudin held for some portion of the case. In this high-risk cohort, 75% (n=9) of the infants survived to decannulation, 75% (n=9) survived to 6 months of age and 59% (n=7*) survived to discharge. The average length of days on ECLS was 22.5 (range 5-39).
Conclusion: Early repair of CDH on ECLS utilizing a standardized operative protocol and bivalirudin for anticoagulation resulted in low surgical and hemorrhagic complication rates. Further studies are warranted to validate these findings and refine the management of CDH patients on ECLS.
Exploratory Factor Analysis Yields Identification and Grouping of Brain Injury Biomarkers Significantly Associated with Outcomes in Pediatric ECMO
Victoria Huang1, Jennifer Roem2, Derek Ng1, Allen Everett1, Christopher Campbell3, Melania Bembea1; 1Johns Hopkins Children’s Center, Baltimore, USA. 2Johns Hopkins Bloomberg School of Public Health, Baltimore, USA. 3Meso Scale Discovery, Rockville, USA

Abstract
Plasma brain injury biomarkers have been associated with acute neurologic injury in ECMO. In this two-center prospective cohort study of children on ECMO, we aimed to evaluate a panel of plasma biomarkers with exploratory factor analysis (EFA) to better understand their interplay and association with outcomes. Peak biomarker levels from 95 participants were processed by EFA, a technique that uses unsupervised learning to uncover unique clusters of biomarkers within individuals. Unfavorable outcome was defined as in-hospital mortality or Pediatric Cerebral Performance Category ≥3 with decline >1 point. EFA grouped 11 brain injury biomarkers into three factors. Factor 1 comprised markers of cellular brain injury (NSE, BDNF, GFAP, S100b, MCP1, VILIP-1, and neurogranin); Factor 2 comprised markers related to vascular processes (vWF, PDGFR-b, and NPTX1); and Factor 3 comprised the BDNF/MMP-9 signaling pathway. Univariable linear regression analyses demonstrated that unfavorable outcomes had higher mean Factor 1 and 2 levels (+0.91, p<0.001 and +0.50, p=0.015) and lower mean Factor 3 levels (-0.49, p=0.017) compared to favorable outcomes. Multivariable logistic models similarly demonstrated that higher Factor 1 and 2 scores were associated with higher odds of unfavorable outcomes (adjusted OR 2.88 [1.61, 5.66] and 1.89 [1.12, 3.43]). Higher Factor 3 scores were associated with lower odds of unfavorable outcomes (adjusted OR 0.54 [0.31, 0.88]), which is biologically plausible given that BDNF has roles in neuroplasticity. Application of EFA on plasma brain injury biomarkers in children on ECMO yielded identification and grouping of biomarkers into three factors that were significantly associated with outcomes.

Optimizing Sedation for ECMO Patients in the Pediatric ICU: Outcomes after Implementation of a Hydromorphone Based Sedation Protocol
Robin Atha, MD, Tracie Walker, MD, Katherine Clement, MD, Michael Phillips, MD, Sara Levintow, PhD, Stephanie Schwartz, MD; University of North Carolina at Chapel Hill, Chapel Hill, USA

Abstract
OBJECTIVE: To evaluate whether a hydromorphone based sedation protocol improves outcomes in the pediatric ECMO population
IMPORTANCE: There continues to be a paucity of data regarding optimal sedation practices in the pediatric ECMO population
DESIGN/SETTING: Quality improvement based study involving retrospective chart review. The project took place in a tertiary care hospital with 20 PICU beds and high ECMO volume.
PATIENTS: All neonates and children requiring ECMO support between late November 2021- May 2022 (pre group) and between June 2022 and February 2023 (post group)
INTERVENTIONS: Development and implementation of a hydromorphone based sedation protocol
MEASUREMENTS AND RESULTS: 41 patients were included (21 pre, 20 post). Primary outcomes included duration of neuromuscular blockade and amount of opioids received (in MME/kg) over first 72 hours of ECMO run. Secondary outcomes included: hospital length of stay, ICU length of stay, duration of mechanical ventilation, ECMO run duration, and in-hospital mortality. For the primary outcomes, there was found to be less opioid use in the post group at 24, 48, and 72 hours post cannulation as well as a shorter duration spent on neuromuscular blockade, however these results were not statistically significant. There was no significant difference between groups in any of the secondary outcomes.
CONCLUSIONS: The implementation of a hydromorphone based sedation protocol was found to result in decreased opioid exposure as well as a shorter time spent on neuromuscular blockade. The statistical validity of our results was limited due to the small sample size and highly variable population.
New Right Ventricular Dysfunction is Common Among Pediatric Patients with ARDS on VV ECMO
Caroline Holton, Jenna Miller, Sanket Shah; Children’s Mercy Hospital, Kansas City, USA

Abstract
In adult patients with acute respiratory distress syndrome (ARDS) on veno venous (VV) extracorporeal membrane oxygenation (ECMO), new right ventricular (RV) dysfunction can develop after cannulation and is associated with worse outcomes. To our knowledge, no published studies have examined this phenomenon in pediatric patients.

A single center retrospective case series was conducted from 2010 to 2022 and included 25 neonatal and pediatric patients cannulated on VV ECMO for ARDS with an echocardiogram performed. About half (12/25, 48%) had echo evidence of new qualitative RV systolic dysfunction during their ECMO run. Of those without RV dysfunction, 10/13 (77%) survived to ICU discharge. Survival was similar for those with RV dysfunction (9/12, 75%). Notably, patients with both RV dysfunction and RV dilation had the lowest survival (62.5%).

Patients with RV dysfunction had a trend towards longer ECMO run, duration of mechanical ventilation, ICU length of stay and hospital length of stay. RV dysfunction was 50% more common in “long run” patients (> 21 days) compared to those with shorter runs. The majority of survivors with RV dysfunction continued to have abnormal echos following decannulation and time to resolution on echo varied from 1 to 181 days after decannulation. Autopsy results and cardiac cath findings in three patients demonstrated clinically relevant RV injury that was not detected by echocardiogram.

New RV dysfunction is common among pediatric patients on VV ECMO for ARDS and may persist after decannulation. Additionally, echo alone may not be sufficient to diagnose clinically relevant RV injury on ECMO.

Long Term Functional Outcomes and Important Need for Follow-Up in Neonatal And Pediatric ECMO
Ishaan Sangwan1, Lakshmi Raman1, Michael Morriss1, Ricardo Medrano2, Laura Hatton2, Michael Williams2, Margarita Ramos2, Darly Lytton1, Bob Villanueva3, Tyler Terrill3, Erin Tresselt3; 1UT Southwestern Medical Center, Dallas, USA. 2Children’s Health Medical Center Dallas, Dallas, USA. 3Children’s Health Medical Center Dallas, Dallas, USA. 4children’s Health Medical Center Dallas, Dallas, USA. 5UT Southwestern Medica Center, Dallas, USA

Abstract
Background: ECMO patients are at significant risk for neurological injury. One-third of pediatric ECMO survivors have developmental delay and 67% of those have severe MRI findings. ELSO guidelines recommend structured follow-up of ECMO patients, but there is limited information on how to counsel families on expected outcomes. We implemented developmental screening as the new standard of care for our ECMO population to improve long-term outcomes.

Methods: The goal of this project was to assess whether severity of MRI/CT scores obtained after decannulation (a validated methodology) was predictive of functional outcomes. Functional outcome was assessed by the Adaptive Behavior Assessment 3 (ABAS-3) obtained at 6-12 months follow-up. ABAS-3 is a comprehensive and standardized tool that measures adaptive behaviors displayed by children in all settings.

Children from 0-18 years cannulated onto VA or VA ECMO November 2021 to January 2023, in CVICU or PICU, alive at discharge, were included. ABAS-3 was completed by the patient’s parents 6-12 months from the time of decannulation.

Results: There were 18 patients consisting of 7 neonates, 4 infants, and 7 children (14 – VA, 4 – VV) with completed ABAS screens. Fifteen patients had head imaging (1-CT/14-MRI). We considered MRI/CT grading > 10 a severe result and observed correlations between severe MRI/CT grades and lower global ABAS scores. These patients scored 30% lower compared to peers their age consistent with moderate to severe developmental delay.

Conclusion: Utilizing MRI severity, we can counsel families on expected cognitive delays and importance of aggressive therapies and long-term follow-up.
ECMO in community cardiac surgery program: comparable results?
Matthew Nagle, Brian Roberts, Dylan Ryan, Lydia McDermott, Kathleen Miller, Claudine Pasquarello, Anissa Braddock, Chum Choi, Qiong Yang, Hitoshi Hirose; Virtua Health, Camden, USA

Abstract
Introduction: ECMO outcomes in small volume centers are commonly thought to be less favorable than those in large volume centers. Two years ago, ECMO protocols and procedures were established in our regional community hospital system as part of a cardiogenic shock initiative. A study was conducted to evaluate whether the outcomes of this new ECMO program were comparable to the US national averages.

Methods: Our regional system is comprised of five hospitals with 1500 beds covering southwestern New Jersey with only one of these hospitals having capability for cardiac surgery and ECMO. In May 2021, the new ECMO program was initiated. Patients with ECMO candidacy were screened by a multidisciplinary call, and when appropriate, cannulated by the ECMO team and subsequently monitored in the cardiac ICU. ECMO data was entered into the IRB approved database and hospital survivals were analyzed.

Results: Since the current ECMO protocol and procedures were introduced to the cardiogenic shock program, a total of 60 patients (46 male, 14 female, mean age of 59), including 17 (28%) patients who required ECPR for cardiac arrest, were placed on VA ECMO. The hospital survival for this ECMO program was 27/60 (45%) in cardiac VA ECMO, and 7/17 (41%) in ECPR. Thus, these outcomes were comparable to the ELSO reported statistics: 44% of VA ECMO and 29% of ECPR.

Conclusions: Once protocol and cannulation standards were optimized, the ECMO results of a community hospital system with cardiac surgery capability were parallel to those of larger centers.

Results of ECMO training for pediatric ICU staff: a report from China National Children Center
Yinyu Yang1, Wei Dong2, Wen Zhang1; 1Shanghai Children Medical Center, Shanghai, China. 2Shanghai Children Medical Center, Shanghai, China

Abstract
Objective: To evaluate the effectiveness of ECMO theory and simulation training organized by Shanghai Children’s Medical Center for pediatric intensive care staff in China.

Method: From April 2020 to May 2023, 167 medical staff from 32 hospitals across the country participated in our training, including 66 doctors, 95 nurses and 6 perfusionists. The training includes pre-test, theoretical study, simulation practice, post-test and follow up. The difference between the pre- and post-tests was compared.

Results: The median score in pre-test was 50 points (interquartile interval: 42~65 points), and the median score post-test was 80 points (interquartile interval: 73~86 points) (P<0.001). Before our training course, 62 participants (47%) had no ECMO experience, 51 participants (39%) had less than 10 ECMO cases experience, and 18 participants (14%) had more than 10 ECMO cases experience. The pre-test scores of the three groups with different ECMO experience showed no statistical difference (51±13 points, 55±17 points, 59±15 points, respectively; P=0.076). After the training, the post-test scores of the three groups were significantly improved (all P<0.001), and there was no statistical difference among the three groups (81±11 points, 78±10 points, 80±12 points; P=0.534).

Conclusions: Pediatric ECMO theory and simulation training courses can significantly improve the ECMO knowledge and management skill at different levels to achieve the purpose of homogenization.
No Pressure! - Getting to Zero Hospital Acquired Pressure Injuries (HAPIs) on Extracorporeal Life Support Patients
Donna Taylor¹, Leslie Huntington¹, Kris Noel³; ¹Childrens Medical Center Dallas, Dallas, USA. ³Children’s Medical Center Dallas, Dallas, USA

Abstract
Background: Patients on extracorporeal membrane oxygenation (ECMO) are at an increased risk for pressure injuries due to immobility and device-related issues. Bedside staff are often reluctant to move and turn these critical patients as they can desaturate and take time to recover. Also, cannula position issues can make repositioning problematic and interrupt flow. In 2021, of the 59 patients that were on ECMO, 11 developed a pressure injury during their ECMO course.

Methods: A number of interventions were implemented over the course of 2022 with the goal of reducing our pressure injury events to zero. Such interventions included revamping the ECMO canulation checklist to include checking skin integrity prior to cannulation, adding the Tortoise repositioner, InterDry, and the crib-sized Dabir overlays to our product list, the development of a turning and repositioning guideline for high-risk patients, and additional education for all PICU staff members.

Results: Pressure injuries in 2022 decreased to 2 of the 57 patients who were on ECMO during the year. This trend has continued, and we have not seen a pressure injury for an ECMO patient for the first six months of 2023.

Discussion: Pressure-injury prevention is a practice that must be owned by bedside staff in order to provide the most appropriate support. Collaboratively, implementing interventions at the bedside positively impacted the quality of patient outcomes for these patients. We will continue to advocate for our patients when it comes to safety and will continue to aim to keep our pressure injury rate at zero.

Revised ECMO education increases confidence and knowledge of ECMO specialists
Micheal Heard, Justin Young, Brandon Lowe, Scott Wagoner; Children’s Healthcare of Atlanta, Atlanta, USA

Abstract
Introduction: Children’s Healthcare of Atlanta’s new ECMO Specialists are RNs and RRTs and required to learn multiple pumps, modes of ECMO and patient populations. Our orientation process was based on ELSO Training Guidelines requiring 16-32 hours. At 36 hours, we met the guideline, but often additional hours were added haphazardly. We completely deconstructed our educational and bedside orientation process and revised to meet the educational needs of our team.

Discussion: A multi-disciplinary team requires a unique perspective when delivering education. After breaking down our old course, we initiated pre-course requirements; revised the training course so that didactic is paired with reinforcing simulations; and added skills sessions specific to the Specialist.

We revised our bedside orientation process to include six, 12-hour shifts. The new checklist starts with the basic, including a scavenger hunt and then adds new skills and knowledge each shift.

Finally, we added an ECMO Mega Simulation Day approximately two months after bedside orientation is complete. This 8-hour day encompasses all of the high and low fidelity simulations on both platforms from the ECMO Training Course. This sim reinforces new skills and increases confidence for the new Specialist.

Results: Post Mega Sim the Specialists reported a 29% increase in confidence in emergency management, 27% increase in general management, and 22% increase in confidence in anticoagulation management. In addition, overall test scores improved from 70% Pre Simulation to 95% Post Simulation.

Conclusion: Revision of educational process can result in increased confidence and test scores.
Standardizing Education for Bedside ECMO Nurses by Utilizing a Multi-tiered Approach.

Jenelle Sheasby, Suzanne Krais, Aasim Afzal, Timothy George; Baylor Scott and White The Heart Hospital Plano, Plano, USA

Abstract

Background: Although organized and structured education programs for nurses can improve outcomes,1, 2 standardized education for bedside nurses caring for ECMO patients remains elusive.

Methods: Prior to 2021, no standardized education training existed for nurses caring for ECMO patients. In 2021, we pivoted to a 3-tiered pathway, for those new to ECMO (GOLD), those with >1yr experience of ECMO (PLATINUM), and a top tier for ECMO Specialists (DIAMOND). The three tiers have a specific education plan for each nurse and was applied according to their previous level of ECMO experience (see pyramid graphic). We conducted a retrospective review of outcomes for 343 ECMO cases managed from Jan 2018- May 2023. All cardiac, pulmonary, and other cases (mixed and ECPR) were stratified with regards to education strategy.

Results: After training implementation, mean weaning rates increased in cardiac (68% to 73%) and pulmonary ECMO (55% to 90%). The average survival to discharge also increased for both cardiac (37% to 46%) and pulmonary patients (32% to 75%). Finally, our combined ECMO weaning rate improved (60% to 70%) with an increase in our overall ECMO survival (35% to 52%).

Implications: Implementation of a standardized education pathway for ECMO nurses may be associated with improved outcomes, but further studies are warranted.

Comprehensive and Standardized Onboarding for New Extracorporeal Life Support (ECLS) Specialists: Boosting Patient Care, Productivity, and Job Satisfaction

Robert Ripper, Rose Warnick, Jonathan Paquette; Atrium Health/ Levine Children’s Hospital, Charlotte, USA

Abstract

Problem: Previously, inconsistent, and brief 5-8 weeks onboarding for new hires led to variable competence, increased error frequency, reduced productivity, and high burnout rates. This was exacerbated by our minimal 2 years of Intensive Care Unit (ICU) experience requirements for applicants.

Method: Our Clinical Specialist devised a comprehensive 16-week onboarding program with a structured curriculum including didactic, bedside hours, wet drills, and competency review. We raised the skill and experience requirement to 3 years of current ICU experience, defined 26 core competencies, and used tools like Daily Orientation Progress Note, Competency Validation, and Review with preceptor, educator, and manager for regular assessment.

Results: The revamped onboarding yielded more skilled and confident ECMO specialists, leading to a reduction in adverse events and improved patient care. Their enhanced skillset facilitated better workload management, increasing productivity. Job satisfaction increased significantly, reflected in lower burnout rates and improved employee retention. Furthermore, the marked improvements catalyzed by our new onboarding process fortified our application for the prestigious ELSO (Extracorporeal Life Support Organization) Center of Excellence designation.

Conclusion: The inconsistency of our previous onboarding process undermined patient care, job satisfaction, and retention. Our systematized and comprehensive orientation schedule, with an extended training period and well-defined competency expectations, has cultivated highly competent ECMO specialists. This has not only enhanced patient care and workload management but also bolstered job satisfaction, thus reducing staff turnover. Our structured onboarding has fostered the growth of our ECMO program.
Valuation of a Training Model for Austere Veno-Venous Extracorporeal Membrane Oxygenation Cannulation and Management

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Abstract

Introduction: Veno-venous extracorporeal membrane oxygenation (VV ECMO) is used in trauma patients with pulmonary injury in the acute setting. The United States Military has an experienced ECMO transport and management capability; however, future conflicts may require forward prolonged casualty care (PCC). Special Operations Surgical Teams (SOST) provide damage control surgery, resuscitation, and PCC in forward, unregulated, multi-domain environments. We hypothesize that SOST can be trained to cannulate and manage patients requiring VV ECMO.

Methods: We developed a 2.5-day course using knowledge assessments (25 questions), self-assessments (5-point Likert scale, moderate confidence=3), and instruction checklists. The instruction checklists were used to assess performance during final evaluation with Yorkshire swine (Sus scrofa) models. Data was tested for normality and statistical significance was defined as p<0.05.

Results: 12 qualified SOST personnel completed the training. Four participants reported previous ECMO clinical exposure, and none reported formal ECMO training. When comparing pre- and post-course knowledge assessment scores, there was a significant improvement in overall scores (12.5 v 20.6, p<0.001). The number of participants who self-reported at least moderate confidence in cognitive (2.8 v 11.3, p<0.001), technical (1.2 v 11.6, p<0.001), and behavioral (2 v 12, p<0.001) aspects of VV ECMO set up, cannulation and management increased. Each team successfully set up, cannulated, and managed models with lights and in darkness.

Conclusions: Forward surgical teams can be rapidly trained to safely and effectively cannulate and manage patients requiring VV ECMO. Given the possibility of PCC and the demonstrated benefit in trauma, forward VV ECMO should be explored.

Utilizing Escape Rooms in ECMO Training

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Abstract

Rationale: ECMO programs are consistently challenged to develop simulation activities that will build problem-solving skills, communication skills, and develop competency. Traditional medical learning is still passive and adult learners can benefit from active engagement. Escape rooms can be used as a training tool for team building, a way of delivering technical and non-technical skills, and as well as to acquire or refresh knowledge. We describe how we used ECMO Escapes rooms to “flip the classroom” and engage ECMO team members to strengthen their knowledge and skill set.

Methods: We developed and implemented ECMO escape rooms into our creative training program. The escape rooms were designed to evaluate learners problem-solving skills, communication skills, technical skills, and competency when performing procedures as a team. The design ensured that learning objectives and puzzle solutions were attainable and engaged learners to help stimulate collaborative multidisciplinary learning and teamwork. Since the escapes rooms were multidisciplinary, the puzzle solutions encompassed a range of clinical expertise. The puzzles were all common topics in ECMO management that participants reasonably could expect to encounter on any given day in clinical practice and helped engrain resources already available to them for their clinical practice. The learners had 40 minutes to solve the puzzles and perform the procedure.

Results: Escape rooms are an innovative way to evaluate ECMO team members' problem-solving skills, communication skills, technical skills, and competency. The training was well received by the learners and provided a novel approach to practice skills and knowledge required in their practice.
Creating a comprehensive mobilization program for adult ECMO patients
Sara Collins, Rheana Hernandez, Carla Tamayo, Casey Howard; University Hospital, San Antonio, USA

Abstract
Objective: Determine the factors that hinder early mobility in adult ECMO patients at University Hospital.
Method: Informal surveys were used to identify concerns from staff, patients and family members. A work group comprised of ECMO staff, the Rehabilitation team, and bedside nurses was formed to identify and address issues and concerns.
Results: 1. Safety concerns due to a lack of knowledge regarding ECMO and cannula securement was the main barrier; hence, staff education was a priority. Online modules were used to provide an overview OR provide an introduction to the basics of ECMO and hands-on in-services to demonstrate securement. 2. Communication between staff, patients and family members regarding goals and expectations needed improvement. Staffing roles along with the equipment needed by each team member were identified using a created checklist. A weekly schedule, which also include therapy/mobility goals, was made by the Rehabilitation team then discussed and written down for everyone involved in the patients care to visualize. 3. Mobilizing patients requires time, manpower, and patient cooperation. Our hospital began using tilt beds to assist with weight bearing when a patient was reluctant, too unstable to stand on their own or when the Rehab team was not available.
Conclusion: Prework group (7 patients) had no form of therapy by day 7 or weight bearing by the 15th day on ECMO. Postwork group (18 patients) 61% started some form of therapy such as range of motion in bed and 33.3% had weight bearing on tilt bed or ambulating.

Development of an Electronic Medical Record Based Comprehensive Report for ELSO Registry
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Abstract
Introduction: The ELSO registry is a vital repository of demographic, clinical and outcomes data that relies on ECMO Center self-report of over 200 data points. Because of growth in our ECMO program and surges in patient volume during the COVID-19 pandemic, our center’s capacity to enter data in real-time was strained resulting in backlogs and delays in data entry. Therefore, we identified an opportunity for improvement to allow for more rapid data collection and reporting to the ELSO registry utilizing our electronic medical record (EMR).
Methods/Results: Our previous process of data collection for the ELSO registry included manual tracking of basic patient demographics and ECMO run specifics, manual tracking of ELSO-defined complications for each ECMO run, and a manual chart audit for each data point within the EMR with concurrent registry entry. In order to streamline these processes, we collaborated with our information technology (IT) department to develop a comprehensive ECMO quality report utilizing Epic Clarity Reports. This report automated contains 93 of ELSO registry variables needed for entry. Manual chart audit is still performed for quality assurance and several data points continue to require manual collection.
Conclusion: An EMR based ECMO Clarity Report provides an automated report of the key data points and eases the burden of manual abstraction efforts, reducing the time it takes to enter the information into the ELSO registry. This in turn will allow for more real-time data entry and more complete information dissemination to the larger ECMO community.
BENEFITS OF THE ECMO SURVIVOR SUPPORT GROUP
Frances Ber; Scripps Health, La Jolla, USA

Abstract
Scripps Health created the very first ECMO survivor support group which launched during Covid-19 when the need was eminent for emotional support for the survivors and their families. This unique population of patients deserved continuity of care post hospitalization. In this exploratory study, patients who had been on VA or VV ECMO between 2018-2021 were identified, contacted over the phone and those that agreed to be a part of the original online support group were invited via email. Scripps Health utilized Microsoft Teams to conduct the online support group and began offering the ECMO survivors support group once a month starting in 2022. ECMO survivors, their families, and Scripps Health ECMO staff members attended the monthly support groups and the number of participants varied between 20-35. The participants benefited from having a safe forum to discuss a range of topics from mental health, medical conditions that may have lingering effects, interpersonal relationships, and memory loss. The ECMO survivor support group has become a means and resource of community outreach which includes providing a professional service to a group of people who would not otherwise have this service. The online support group is a promising concept for facilitating recovery-oriented care and warrants continued research. Further research is recommended to assess and measure if the total benefits increase with longer periods of participation in the group.

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Abstract
Background: Extracorporeal Cardiopulmonary Resuscitation (ECPR) is a support option for patients experiencing refractory cardiac arrest. In 2018, Riley Hospital for Children introduced a protocol for activation of CPR to extracorporeal support. We predicted there would be improved time to ECPR initiation and clinical outcomes after implementation.

Methods: Pediatric patients who underwent ECPR from 2014-2022 at Riley Hospital for Children were reviewed, comparing patients pre- and post-protocol implementation, excluding those with prior ECPR and patients with cessation of CPR prior to cannulation. Demographics, ECMO parameters, and outcomes were analyzed, with a significance defined as p<0.05.

Results: 17 of 64 (30%) patients were cannulated pre-implementation. Median time to ECMO initiation was lower post-implementation (77 minutes[59.8, 92.0] vs 42 minutes[38.5, 59.8], p=0.006). Head ultrasounds were routinely performed over the first 3 days after cannulation, with more abnormalities identified prior to protocol implementation (29.4% vs 6.4%, p=0.026). There was no difference in post-ECMO MRI or CT head imaging or subjective functional neurological outcomes. There was a trend toward decreased mortality after protocol implementation, 47.1% vs 42.6% (p=0.783). Mortality was similar in post-cardiotomy patients compared to those who did not undergo cardiac surgery.

Conclusion and Potential Impact: Time from code to ECMO support and incidence of abnormal head ultrasound findings decreased after implementation of a systematic ECPR protocol. There was no significant difference in mortality or functional neurologic outcomes, showing continued opportunity for process improvement.
ECMO Cannulation Assistant: A Novel Approach to Include ICU Nurses in the eCPR Team
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Abstract
Background: Hospital of the University of Pennsylvania has a hybrid ECMO program with HVICU nurses who are certified in the care of ECMO patients. Since 2021, the in-hospital ECMO cannulation program has responded to over 30 ECMO Alert consults per month, resulting in over 50% of cannulations occurring outside of the operating room (Figure 1-A). An HVICU nurse is an essential member of the eCPR/ECMO Alert team during off-hours and outside of the HVICU. Advanced education about ECMO cannulation is crucial to support successful outcomes.

Methods: Areas of improvement were identified by senior ECMO leadership. Curriculum was developed to address these areas through lectures, SIM, and competency requirements. Criteria were established by leadership, and HVICU nurses were selected to participate in the eCPR program.

Results: The ECMO Cannulation Assistant Training program utilizes didactic and SIM education. The 8-hour class reviews sterile technique, instrument set-up, cannula prep, insertion technique, suture guidelines and safety standards (Figure 1-B,C). Each individual participates in a SIM insertion with full set up and cannula models. Nurses who participate in the training must achieve a passing exam grade and perform a timed proficiency exercise for certification. Biannual competency with SIM exercises is assessed with ECMO leadership.

Discussion: Nurses who have attended training report greater confidence in their ability to assist with ECMO insertions. Positive feedback from members of the team has been expressed during post-procedure debriefing sessions and during M&M conferences. A qualitative study may be needed for a more formal review of the program.

Implementation of a Multidisciplinary Pediatric ECMO Cannula Surveillance Protocol
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Abstract
Background: Our center experienced a devastating complication from VV ECMO cannula malpositioning which led to the death of a child secondary to atrial perforation. Root cause analysis identified delayed diagnosis of cannula malpositioning with inadequate inter-provider communication to be opportunities for programmatic improvement. We implemented a new multidisciplinary ECMO cannula surveillance protocol and herein describe pre- and post-implementation results.

Methods: Patient charts were manually queried both retrospectively and prospectively per ECMO shift for surveillance protocol components: 1) Q12hr specialist documentation of external cannula position (skin to coil), 2) daily chest x-rays, and 3) weekly echocardiography. Protocol compliance was quantified and ELSO registry data was queried for outcomes. We hypothesized that increased vigilance concerning ECMO cannulae would lead to greater frequency of cannula repositioning.

Results: 23 pediatric ECMO runs were examined (Table 1). Primary metrics included percent of shifts with correct cannula position documentation and cannula repositioning events. Cannula position documentation improved from 7% to 87% of shifts after protocol implementation. Slightly more chest X-rays were performed per ECMO day in the post-implementation groups (1.6 vs 1.5); however, the rates of echocardiography per ECMO day were equivalent (0.6). Malpositioned cannulae were repositioned in 36% of ECMO runs post-implementation compared to 25% before implementation; normalized over ECMO run length, this did not reach statistical significance.

Conclusion: Close introspection after catastrophic complications can improve programmatic systems reliability and inter-provider communication. Rather than a “complication”, cannula repositioning can be viewed as a necessary patient safety intervention for maintenance of optimal ECMO support.
Single-Center Experience of a Successful Transition from a Pharmacist-Managed to a Nurse-Managed Bivalirudin Protocol in Patients on Extracorporeal Membrane Oxygenation

Ayesha Ather, Kevin Hatton, Natasha Crain; UK HealthCare, Lexington, USA

Abstract

Background: Adjusting dosages for direct thrombin inhibitors (DTIs) can pose challenges. However, bivalirudin exhibits favorable pharmacokinetic properties that may facilitate standardized dosing adjustments, similar to those used in heparin administration.

Methods: This single-center, retrospective study evaluated the safety and efficacy of pharmacist-managed (PM) to nurse-managed (NM) transition of bivalirudin standardized protocols in extracorporeal life support (ECLS) patients from 07/31/2021 to 03/30/2023. The primary outcomes were time to achieve therapeutic range, time in therapeutic range and number of dose titrations. The secondary outcomes were thrombotic and bleeding events, and survival to discharge. Outcomes were compared in pharmacist-managed and nurse-managed groups.

Results: Total of 142 patients were included in the analysis, 91 in the NM and 51 in the PM group. There were significant differences in baseline characteristics, including indication for ECLS (p<0.001), mode (p<0.001), continuous renal replacement therapy (p<0.001), and bivalirudin initiation post-cannulation (p=0.03) in the NM group compared to the PM group. No significant differences were found in time to achieve therapeutic range (6h vs. 8.3h; p=0.09) and time in therapeutic range (87.2% vs. 86.5%; p=0.8) between the groups. Number of dose titrations needed was significant in RM group (1.1 vs. 1.7; p<0.01). However, significant differences in baseline characteristics may have contributed to this result. Thrombotic and bleeding events in both groups were non-significant, including survival to discharge.

Conclusions: These nurse-managed bivalirudin standardized protocols provided similar safety and efficacy outcomes and are a feasible strategy to manage DTIs when compared to pharmacist-managed ECLS patients.

Critical Care Support Coach

Frances Ber; Scripps Health, La Jolla, USA

Abstract

Scripps Health created the “Critical Care Support Coach” volunteer position to provide positive emotional support by utilizing personal experience with ICU hospitalizations. The Critical Care Support Coach is a prior ECMO/MCS ICU patient who will improve the current ECMO/MCS ICU patient’s hospital experience by providing hope, support, positive feedback, and encouragement. The Critical Care Support Coach assists the patient in identifying achievable goals, helps boost confidence, and can empathize with their inpatient experience. The Critical Care Support Coach enrolls as a volunteer at Scripps Health and complies with the orientation requirements as outlined by Scripps Memorial La Jolla Hospital Volunteer Services. The Critical Care Support Coach completes an orientation from the ECMO RN coordinator and the ECMO Social Worker for ECMO patient support. They must demonstrate respect, concern, and empathy for the spiritual, cultural, emotional, and informational needs of the patient. The Critical Care Support Coach is a volunteer and stays within their scope and refrains from providing any medical advice to the patients and defer those conversations to the primary medical team. The ECMO patients benefit from the peer support of prior ECMO/MCS patients by sharing their experiences in-person, offers empathetic understanding of their physical and emotional health, and a social connection. Social isolation presents a risk to mental health and the quality of life of our ECMO/MCS ICU surviving patients and the Critical Care Support Coach provides the human connection and lessens the psychological distress experienced by the ICU patients currently hospitalized.
Early Outcomes Associated with the Implementation of the ECMO Clinic: Promoting Continuity of Care in Veno-Arterial (VA-ECMO) Patients Post-Hospitalization.
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Abstract
Background: Management of VA-ECMO patients in the hospital setting is widely published. However, there is limited literature nor a clinic model for managing post-VA-ECMO patients in the outpatient setting. Our team identified a gap in the continuity of care in this patient population and established a VA-ECMO clinic led by mid-level providers, who specialize in both cardiothoracic surgery and critical care. Here we present our VA-ECMO Clinic experience.

Methods: A retrospective study of patients discharged from the hospital post-VA-ECMO therapy was conducted from January 2022 to July 2023. Patients were enrolled in the ECMO clinic, seen + two weeks post-discharge, at three months, at six months, and one year post-decannulation.

Results: During the study period 11 out of the 24 discharged VA-ECMO patients were captured by the clinic. Patients that were not captured were due to discharge to other facilities and geographical displacement. Of the eleven patients seen by ECMO clinic, one (9.1%) was lost-to-follow up after initial visit, three (27.3%) after three-month visit and zero (0%) after six-month visit. Two active patients (18.2%) and three (27%) patients who completed one-year visit. Two patients (18.2%) expired prior to three-month visit due to acute MI and decompensated heart failure. To date, no ECMO related re-admissions or mortalities have occurred.

Conclusion: ECMO centers should consider establishing an outpatient clinic where VA EMCO patients can be seen by providers who are familiar with ECMO and manage ECMO specific complications. Continuity of care should not be limited to chronic conditions or diagnoses.

Ethical and Moral Issues in Providing Extracorporeal Membrane Oxygenation (ECMO) Support: A Survey of the American Society of Anesthesiologists (ASA) Committee on Critical Care Medicine (CCM) and Extracorporeal Life Support Organization (ELSO) Membership
Shahla Siddiqui1, Lovkesh Arora2, Michael Wall3, Monica Lupei4, Miguel Cobas5, Gozde Demirilap5, Raquel Bartz6; 1BIDMC, Boston, USA. 2University of Iowa, Iowa, USA. 3Univ of Minnesota, Minnesota, USA. 4Univ of Miami, Miami, USA. 5Univ of Wisconsin, Wisconsin, USA. 6Brigham and Women’s Hospital, Boston, USA

Abstract
Introduction: We aimed to survey the members of 2 societies to assess the ethical and moral challenges faced by teams when initiating as well as managing patients requiring ECMO.

Methods: A simple 5-minute survey was sent to members of the ASA and ELSO.

Results: 60 participants responded to the survey as of July 2023. Only 68% of the participants who manage ECMO patients are involved in the ECMO initiation decision process. Of these, 80% are part of a team. The majority do not involve Ethics or Palliative care at the initial decision. 58% percent said their volumes are less than 100/ year. 70% do not have a separate consent process and in 87% of cases, a timeline is not adhered to for withdrawal. 55% do not have transplant surgeons involved in initiation decisions. Sixty percent do not have regular goals of care discussion and 70% of the participants reported that insurance or state of residence are irrelevant. Ethical issues involved: 1. Prognostication of patients receiving ECMO support, 2. Lack of knowledge of patient’s wishes, 3. Disconnect between expectations of families and outcomes and 4. Staff moral distress around when to stop.

Conclusion: Streamlining consent processes, involvement of transplant teams for candidacy for transplantation, structured and regular communication, the use of ethics and palliative care teams in family discussions and clear expectations can be some strategies which can mitigate moral distress and burnout among care providers as well as assist families in the sustained and prolonged ordeal after a devastating event.
Beyond the Bridge: ECMO as Destination Therapy
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Abstract
ECMO is broadly conceived as only a bridge, whether bridge to recovery, bridge to transplant, bridge to device, or bridge to decision.[1] When none of these bridges is possible, some describe ECMO, perhaps insensitively, as a so-called “bridge to nowhere.”[2] In such situations, patient life is indefinitely limited to the ICU and discontinuation of ECMO is recommended.[3]

We challenge this perspective and defend continuation of ECMO as destination therapy (ECMO-DT), if in accordance with the (presumed) patient’s will. Because ECMO-DT fulfills its intended physiologic goal (blood oxygenation and CO2 removal), it is not futile, and treatments should not be terminated unilaterally against the will of patients or family.[4]

One major argument against ECMO-DT is that patients on ECMO cannot survive outside the ICU, so cannot have a meaningful life. But despite this traditional understanding and despite the original intent to use ECMO as bridge-only, such resolute immutability is incongruous and unacceptable. Analogous therapies like RRT, LVAD and mechanical ventilation all originat-ed as bridges. But they evolved to become “destination” therapies. It is time for ECMO to evolve similarly from bridge to destination therapy. Even if less desirable than the original destination, many patients prefer technology-supported life to death.

References
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Karolinska ECMO Centre: Implementing a Goal Mission Driven Organization
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Abstract
To understand the needs of the individual staff the contextual environment where the work is taking place has to be looked into. Furthermore, fundamental needs like sense of belonging, safety and trust are important when addressing a healthy working environment.

As to have a concept when assessing the needs of the staff we choose to use Maslow’s hierarchy of needs. The results showed that, with a focus on staff recovery and safety, we had not actively addressed the need of belongingness i.e., social needs. We also fell short of addressing the co-workers need of feeling esteem and accomplishment. To work with these softer values we brought in help from a behavioral scientist and physiologist. The organization was refurbished from ground up to support the co-workers and the line-managers. At a management level the organization was changed from a hierarchical command model to a flipped pyramid with the staff at the top and the managers supporting the levels above, respectively.

By outlining the organization in this way, it was clarified that 1) the effect of the organization lies at the patient level, 2) the staff’s work with the patient is the most important part of the whole organization and 3) the whole organization must support this work.

Successively we gathered and evaluated these actions and bundled them into Goal Mission Driven Organization and Leadership (GMDO-L) where the overall aim is to secure ECMO as a critical care resource as well as increasing the resilience of the ECMO organization.
Sharpening the Focus: How Focused Attending Rounds (FARs) Improved ECMO Utilization and Outcomes

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Abstract
Objective: To examine the impact of implementing twice-weekly focused attending rounds (FARs), in addition to daily multidisciplinary ICU rounds, on ECMO patient outcomes and timing of ECMO initiations. FARs occurred Tuesdays virtually and Thursdays in person, attended by Cardiothoracic Surgery/ICU/Heart Failure/Transplant leadership and the on-service ICU team to discuss current patients, identify the need for potential escalation, and bridge any gaps in patient care.

Methods: A retrospective single-center study was conducted examining ECMO initiation, runtime, and mortality pre and post FARs implementation. All patients from 1/2020-3/2023 on ECMO (n=283) were included, with May 2021 marking the implementation of FARs. ECMO initiation was divided into weekdays, weekdays after-hours (M-F after 5PM) and weekends.

Results: The average volume of ECMO patients pre and post-FARs increased by 17% (78 to 91), with a concurrent increase in Case-Mix-Index (CMI; 19.4 to 21.9) and decrease in average ECMO-Runtime (16.2 to 8.12 days). The percentage of total initiations on weekends decreased by 65% (29% to 10%), and initiations on weekdays before 5PM increased by 71% (28% to 48%). Overall risk-adjusted mortality rate has decreased from 52.3% to 39.1%.

Conclusion: Implementation of FARs was associated with decreased risk-adjusted mortality and improved resource utilization with a decrease in emergent ECMO initiations on weekends and a decrease in average time on ECMO. The opportunity for collaboration of senior clinicians provided by FARs enabled an increased ability to provide care for larger volumes of higher acuity patients as evidenced by the increase in CMI and ECMO volume.

Nursing Care Plan for ECMO Patient Management: Early Experience from a Single Center Program in Ecuador

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Abstract
Introduction: Despite the exponential use of extracorporeal membrane oxygenation (ECMO) in recent years, it continues to present challenges in intensive care units. The success of ECMO programs relies on the training of a multidisciplinary team, including nurses. By applying the nursing care process using standardized taxonomies, the evaluation of patient progress and the effectiveness of nursing activities can be assessed, thereby ensuring quality care.

Objective: To determine the number of nurse-related care complications and establish a standardized nursing care plan for patients on ECMO, utilizing the NANDA (North American Nursing Diagnosis Association), NOC (Nursing Outcomes Classification), and NIC (Nursing Interventions Classification) taxonomies.

Materials and Methods: From April 2021 to July 2023, 38 consecutive adult patients were included. Data analysis involved reviewing the ELSO Registry center’s report, clinical charts, and nursing notes. Complications related to nursing care, both for the patient and the ECMO device, were examined. A nursing care plan was developed based on the theory of Marjory Gordon.

Results: Two nurse-related complications were identified among the 38 ECMO runs, namely 1 cannula connector rupture and 1 occurrence of air entry into the circuit. A total of 35 diagnoses were recognized, categorized by organ systems and patient environment. From these diagnoses, 57 interventions and 51 outcomes were proposed.

Conclusions: The establishment of a systematic and individualized nursing care plan utilizing these taxonomies will enhance the nursing care provided to ECMO patients. This approach will ensure appropriate and relevant care based on the specific assistance required, thereby guaranteeing patient safety.
ECMO Experience Increases Cannulation Strategies for Abdominal Normothermic Regional Perfusion

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Abstract
Introduction: Normothermic regional perfusion (NRP) is increasingly utilized to expand the organ donor pool from donors after circulatory death (DCD). ECMO professionals – physicians, perfusionists, nurses, and respiratory therapists – can contribute significant knowledge and experience to enhance the capabilities of NRP.

Methods: In September 2021, an NRP program was developed at a high-volume ECMO and transplant center. Initial strategy mirrored established ECMO protocols, with pre-mortem placement of femoral arterial/venous sheaths that were wire-exchanged for post-expiration cannulas, with an intra-aortic occlusion balloon. When pre-mortem intervention was not possible, rapid central cannulation, as in thoraco-abdominal NRP, was utilized, requiring cardiothoracic surgery expertise, which became a limiting factor as the abdominal program grew. As our team’s efficiency, protocolization, and pump configuration developed, so did a protocol for abdominal transplant surgeons to directly cannulate intra-abdominal vessels. A retrospective review was performed with primary endpoints of organ utilization and outcome as well as cannulation strategy.

Results: From 9/2021 to 7/2023, A-NRP was utilized in 24 DCDs (femoral=10, central=5, intra-abdominal=9). Fourteen livers have been successfully transplanted (livers declined for: functional assessment=5, biopsy=3, visual=2). NRP was performed in the OR, PACU, and ICU. To date, all recipients are alive with no known ischemic cholangiopathy.

Discussion: Previous ECMO experience increases cannulation strategy variations that allow for maximal utilization of donor organs using NRP in different donor circumstances. Advantages and disadvantages of various cannulation strategies are summarized in the table. As experience increases, cannulation times and organ acceptance rates improve.

<table>
<thead>
<tr>
<th>Femoral Cannulation/Occl balloon</th>
<th>Central Cannulation</th>
<th>Intra-abdominal Cannulation</th>
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<tbody>
<tr>
<td>Requires ECMO cannulator</td>
<td>Requires central cannulator</td>
<td>Abd transplant surgeons</td>
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<tr>
<td>Cannulate in ICU/PACU with perfused transport</td>
<td>All post-mortem</td>
<td>All post-mortem</td>
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<tr>
<td>Hostile Abdomen</td>
<td>Perfuses Heart/Lungs</td>
<td>Aortic balloon occlusion or clamp</td>
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<tr>
<td>Rapid</td>
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<td>Rapid recovery of thoracic organs possible</td>
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Organ Donation from ECLS Donors: ECMO patients can become life-saving organ donors with little additional allocation of ECLS resources.

Geoffrey Funk, MD, Britton Blough, MD, Jessica Eon, BSN, RN, CCRN-CSC, Mario Padilla, MSN, APRN, AGACNP, CCRN, Katherine Vandervest, MD, Kaitlyn Lingle, BSN, RN, CCRN-CSC, Dan Meyer, Gary Schwartz, MD, Kara Monday, MD; Baylor University Medical Center, Dallas, USA

Abstract
Despite heroic efforts, not all ECLS patients survive, but organ donation offers an alternative way to save lives and provides solace to the donor family. ECLS maintains organ perfusion, maximizing organ quality, but transplant evaluation and procurement can be complicated by the presence of ECLS and reluctance of transplant centers to accept these organs. We report organ donor volumes and characteristics in a large organ procurement organization (OPO).

Southwest Transplant Alliance is high volume OPO that includes 14 ELSO ECMO centers. A retrospective review of all organ donors from January 2015-June 2023 revealed 23 ECMO organ donors, aged 2-58, donating 51 organs for transplant. There were 10 donors on VV-ECMO (8 DBD, 2 DCD), and 13 donors on VA-ECMO (12 DBD, 1 DCD). Notably, one heart was transplanted from a VV-ECMO donor, and one DBD VV-ECMO donor was transferred to the OPO free-standing organ recovery center. Two donors were covid positive. Donors had been on ECLS 1 to 54 days before OPO referral prior to donation authorization, illustrating that despite a prolonged ECMO run, organ donation is an option. While ECLS resources should be allocated wisely, average time on ECLS from donation authorization to procurement was only 1.7 days (0.5d -4d). Organs transplanted per donor (OTPD) was 2.15 for VA-ECMO donors and 2.3 for VV-ECMO donors, in line with non-ECLS donor national average.

ECMO patients with grim prognoses can become life-saving organ donors with little additional allocation of ECLS resources.
Incorporating the ABAS (Adaptive Behavior Development System) to Follow Cognitive and Developmental Milestones of Patients after ECLS

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Abstract
Purpose: To track patient’s developmental milestones prior to ECLS and 6 months post decannulation to better understand long term impact of ECLS interventions to increase positive outcomes and quality of life after hospitalization and increase family involvement.

Background: There is a lack of long term follow up for patients that have been on ECLS. They may require multiple disciplines of medical and/or therapies. There has been a lack of follow up post hospital for this population of patients to assess their needs and/or complications.

Methodology: When a patient is placed on ECLS, a mass text is sent to members of the core ECLS specialists that have taken on the role of ensuring the ABAS-3 (Adaptive Behavior Assessment System) questionnaires get completed. The inclusion criteria to have the initial assessment completed is they must be over 2 months of age. The ECLS core members then go to the bedside to complete the 232 question within 1-3 of being cannulated. There is a shared folder the specialists document that the patient has a completed questionnaire. Then, the partnering physician is notified the questionnaire has been completed and is ready for review. Six months post cannulation, these patients are contacted to complete an additional ABAS to identify any deficits.

Results: Since May of 2022, more than 30 initial ABAS questionnaires have been completed. The first clinic day for these post ECLS patients has been set.

Conclusion: The use of the ABAS questionnaire has assisted follow up of ECLS patients post discharge.
MOBILE EXTRACORPOREAL MEMBRANE OXYGENATION PROGRAM IN A SOUTHEAST ASIA COUNTRY: A FOUR-YEAR EXPERIENCE.

Thao Pham Thi Ngoc1,2, Xuan Thi Phan3, Huy Pham Minh1, Tuan Anh Mai2, Ngan Hoang Kim Trieu1, Tuan Nguyen Manh1, Dai Quang Huynh1, Yen Nguyen Hai Le1, Anh Viet Ngo1, Hung Quy Nguyen1, Duy Ba Nguyen1, Tuan Thanh Kha1, Toan Le Ngoc1, Linh Tran Thanh1; 1Department of Critical Care Unit, Cho Ray Hospital, Ho Chi Minh, Vietnam. 2University of Medicine and Pharmacy at Ho Chi Minh, Ho Chi Minh, Vietnam. 3Department of Emergency and Critical Care Unit, Ho Chi Minh, Vietnam

Abstract

Introduction: Extracorporeal Membrane Oxygenation (ECMO) is an advanced life-support technique for cardiopulmonary failure refractory to conventional treatment. In a resource-limited setting, the implementation of a mobile ECMO program can be challenging, particularly in difficult-to-transfer areas such as mountainous and rural regions, due to the complexity of the procedure, the requirement for a highly trained team, and costly equipment.

Methods: A retrospective study review of four-year experiences in setting up mobile ECMO in a Southeast Asian country.

Results: A total of 369 patients were ECMO-supported from January 2019 to January 2023 in our institute. Among the 39 patients who underwent mobile ECMO, venovenous ECMO was performed in 92.3% of cases. All patients were transferred by ambulance with an average distance of 28.0 kilometers, and the maximum transferring distance from the hospital in a mountainous area of 512 kilometers. During transport, one mobile ECMO case was managed by utilizing a hand crank due to power supply failure, with no subsequent complications. The most common complication during mobile ECMO was an infection, occurring in 53.8%. Furthermore, 51.2% of the patients required renal replacement therapy. The overall mortality rate was 33.5%. The mortality rate in the ARDS-COVID-19 group was higher than that of the ARDS-non-COVID-19 group, being 57.1% and 18.2%, respectively (p =0.029).

Conclusion: Mobile ECMO was proved to be an effective, safe, and valuable tool in resource-restrain countries. However, further exploration and integration of mobile ECMO into clinical practice are necessary to optimize its implementation and transportation protocols to improve patient outcomes.
Outcomes of Transport of Post-Cardiotomy Patients on Venoarterial Extracorporeal Membrane Oxygenation: Is it Worth the Effort?

Katharina Fetten, MD1,2, Kaitlyn Lingle, RN1, Aldo Rafael, MD1,2, Mario Padilla, ACNP2, Melissa Medina, MD1,2, Kara Monday, MD1, Britton Blough, MD1, Gary Schwartz, MD2, Dan Meyer, MD1; 1Baylor Scott & White Heart and Vascular Institute, Dallas, USA. 2Baylor University Medical Center, Dallas, USA

Abstract

Purpose: Patients requiring mechanical support for post-cardiotomy cardiogenic shock have an incredibly high mortality. Transporting such patients poses significant logistical and resource challenges. However, the outcomes of such patients remain unknown, questioning if the effort is justified.

Methods: A retrospective review was performed at a high volume ECMO center for all patients treated with VA-ECMO for post-cardiotomy shock requiring transport. Primary endpoints were ability to wean from mechanical support and survival to discharge neurologically intact. Secondary outcomes were initial indication for surgery, need for adjunctive therapies, mode of transportation, and differentiation between central and peripheral cannulation.

Results: A total of 28 post-cardiotomy VA-ECMO patients were identified. 46.4% (13/28) were weaned off ECMO and survived to hospital discharge. 21.4% (6/28) were weaned from ECMO but expired during hospital stay. 32.2% (9/28) expired on ECMO. Secondary endpoints are summarized in Table 1.

Conclusion: Despite the severity of illness and challenges associated with transporting post-cardiotomy VA-ECMO patients, 46% survived to discharge, justifying the resource utilization.

Table 1. Secondary Endpoints

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