VOLUME 37, NUMBER 1S, MAY 2022 ISSN 0267-6591

Perfusion

Supplement for the 10th EuroELSO Congress, 4-6 May 2022, London, UK.

Volume 37, Number 1S May 2022

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Supplement for the 10th EuroELSO Congress 4 – 6 May 2022 London/UK

Perfusion
2022, Vol. 37(1S) 3–111

DOI: 10.1177/02676591221089240
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Adult - Cardiac failure

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Treatment of right ventricular failure following heart transplant with percutaneous right ventricular assist device. A retrospective observational study

G.M. Ruggeri[1], D. De Caria[1], B. Calogero[1], G. Olivieri[2], M. Bosi[3], M. Carrozzini[2], C.F. Russo[2], M. Mondino[1]

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Objectives: Right ventricular (RV) failure following heart transplant (HTx) carries significant morbidity and mortality. When medical therapy becomes ineffective, mechanical circulatory support (MCS) could be lifesaving.

Protek Duo (LivaNova) is a recent temporary right ventricular assist device (RVAD). The dual-lumen cannula is inserted percutaneously via right internal jugular vein (IJV) under fluoroscopy and trans-esophageal echocardiography guidance. The inflow portion is positioned in the right atrium and the outflow tip in the pulmonary trunk, the cannula is then connected to an extracorporeal centrifugal pump (CentriMagTMAbbott) and provides up to 4 L/min in order to unload the RV. Aim of the study was to verify the feasibility and safety of this novel approach in the setting of RV failure after HTx.

Methods: Single-center observational retrospective study investigating the use of Protek Duo percutaneous RVAD for RV failure after HTx was conducted from May 2019 to November 2021.

Results: Main characteristics are shown in the table. Six patients were included in the study, 66 % had a MCS prior HTx. RVAD was successfully implanted in all patients on a median time of 34[4–53] hours after HTx. All patients were successfully weaned off RVAD after a median of 17[9–26] days. There were no major device-related adverse events. None of the patients required conversion to surgical RVAD. 66% developed IJV thrombosis despite adequate anticoagulation therapy. Survival at ICU discharge was 83%, only one patient died due to fungal endocarditis. In-hospital mortality was 17%.

Main population characteristics	
Age, years - median [IQR]	50 [47–55]
Male, N (%)	6 (100)
Succesfull RVAD implantation, N (%)	6 (100)
Complications - IJV thrombosis, N (%)	4 (66)
ICU survival, N (%)	5 (83)
Hospital survival, N (%)	5 (83)

Conclusions: In our experience, Protek Duo as a temporary percutaneous RVAD is a safe and effective treatment for patients who develop acute RV failure after HTx.

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Massive pulmonary embolism in a patient with COVID-19 on VV-ECMO – catheter-directed thrombolysis to the rescue

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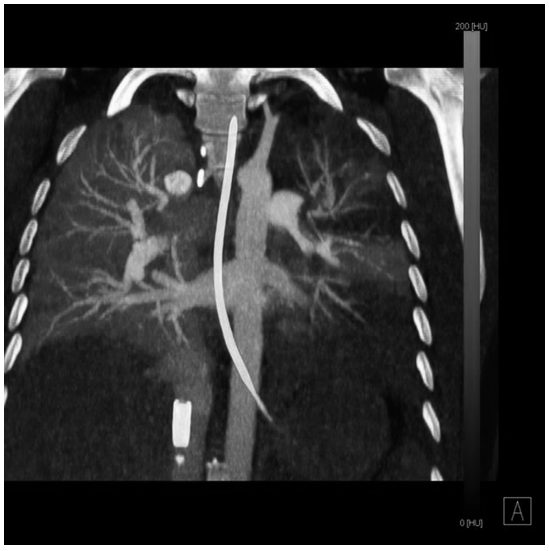
Objectives: Scant guidance exists on managing massive PE in COVID-19 patients on VV-ECMO. Here we present a case treated with catheter-directed thrombolysis (CDT).

Methods: A 40 y.o. female; relevant background of asthma and T2DM; retrieved on VV-ECMO due to acute severe respiratory failure secondary to COVID-19 pneumonitis refractory to conventional management. Despite systemic anticoagulation, a CTPA on admission demonstrated multiple PE involving the left main and left lower lobar pulmonary arteries (CT obstruction index (Qanadli score) 24/40). Echocardiography showed a dilated (RV/LV ratio > 1) and impaired RV with

indirect features of pressure overload, and discrete thrombi in the tricuspid apparatus and main pulmonary artery. Clinically, the patient had high noradrenaline requirements; acute kidney injury; and raised BNP (608 pg/mL), troponin (36 ng/L), and lactate (2.8 mmol/L).



Admission DECTPA showing a left pulmonary artery thrombus and left lung hypoperfusion.

Results: High-risk occlusive PE were diagnosed and a multi-disciplinary decision to undergo CDT was made. Alteplase was administered as a 10mg bolus followed by a 7 mg/10hours infusion via a 5 Fr catheter placed within a large left pulmonary artery thrombus. Post-procedurally, the lactate normalised and the noradrenaline was weaned within 13 hours. No bleeding complications were observed. The patient was decannulated and discharged following 60 days of ECMO. A follow-up CTPA at 6-months demonstrated resolution of the PE (Qanadli score 1/40). Echocardiography showed improved RV dilatation (RV/LV ratio < 1) with no indirect features of pulmonary hypertension (normal pulmonary acceleration time and RV/RA gradient). She has survived to her latest follow-up at 11 months.

Conclusions: CDT and systemic anticoagulation led to resolution of the PE on DECTPA, improved RV size and function, and survival. Further research into massive PE in COVID-19 patients receiving ECMO is critical for future guidance.

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Feasibility and safety of levosimendan in patients after cardiac arrest treated with eCPR

C. Gaisendrees, S. Gerfer, B. Ivanov, A. Sabashnikov, K. Eghbalzadeh, I. Djordjevic, T. Wahlers

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Objectives: Extracorporeal cardiopulmonary resuscitation (eCPR) is increasingly used due to its beneficial outcomes and results compared to conventional CPR. After cardiac arrest, overall ejection fraction is severely impaired and thus, weaning from ECMO is prolonged. We hypothesized that early application of levosimendan in these patients facilitates ECMO weaning and survival.

Methods: From 2016 until 2020, patients who underwent eCPR after cardiac arrest at our institution were retrospectively analyzed and divided into two groups: patients who received levosimendan during ICU stay (n=24) and patients who did not receive levosimendan (n=84) and analyzed for outcome parameters.

Results: Overall, in-hospital mortality was significantly lower in the group who received levosimendan (28% vs. 88%, p=<0.01), ECMO weaning was more feasible in patients that received levosimendan (88% vs. 20%, p=<0.01). CPR duration until ECMO cannulation was significantly shorter in the levosimendan group (44+26 vs. 65+28, p=0.002); interestingly, the rate of mechanical chest compressions before ECMO cannulation was lower in the levosimendan group (50% vs. 69%, p=0.005).

Conclusions: In patients after cardiac arrest treated with eCPR, levosimendan seems to contribute to faster rates of ECMO weaning, potentially due to a short to mid-term increase in inotropy and ejection fraction. Also, survival after levosimendan application is higher compared to patients who did not receive levosimendan after eCPR.

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Outcomes after mechanical versus manual chest compressions in eCPR patients

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Objectives: Extracorporeal cardiopulmonary resuscitation (eCPR) is an established treatment option for cardiac arrest. Mechanical reanimation devices are increasingly used but have been associated with complications. This study evaluates typical injury patterns and differences after mechanical versus manual chest compressions among patients undergoing eCPR.

Methods: From 2016 to 2020, 108 eCPR patients were retrospectively analyzed. Primary endpoints were traumatic, hemorrhagic, or inner organ-related complications, defined as pneumothorax, pulmonary bleeding, major bleeding, gastrointestinal bleeding,

gastrointestinal ischemia, cardiac tamponade, aortic dissection, sternal or rib fracture.

Results: 70 patients were treated with mechanical CPR (mCPR) and 38 with conventional CPR (cCPR). There were more CPR-related injuries in the mCPR group (55 % vs. 83 %, p = 0.01), CPR duration was longer (cCPR 40 ± 28 min vs. mCPR 69 ± 25 min, p = 0.01). There was no significant difference in mortality between the groups.

Conclusions: Mechanical CPR devices are associated with a higher incidence of traumatic and hemorrhagic injuries in patients undergoing eCPR.

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Improvement of the ECMO dilation procedure with a novel telescoping dilator device

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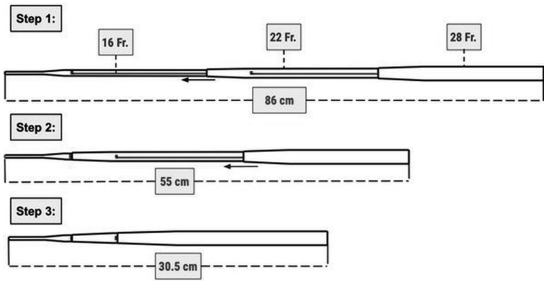
Objectives: Heart failure is a leading cause of death in the USA accounting for roughly 655,000 annually. Extracorporeal membrane oxygenation (ECMO) bypasses a failing heart and lungs and perfuses oxygenated blood throughout the body. The initial catheterization process, though, has been described by physicians as being "tedious" and "time- consuming." A single device capable of fully dilating a vessel would serve as a superior method by decreasing procedure length and risk of infection.

Methods: The telescoping dilator device consists of three parts of increasing diameter that slide over each other to dilate the vessel and a locking mechanism to prevent further entry of the device into the body. International Organizations for Standardization (ISO) standard 11070:2014 was the basis for specifications. The prototype was designed on SolidWorks and printed using the stereolithography (SLA) method with Accura-25.



Results: The device proved to have "No Rollback" and be "Flexible but Rigid Enough to Dilate." The procedure time is estimated to be cut by half and the number of parts inserted cut by over half. Overall, the device will reduce the risk of infection and time a patient is without oxygenated blood.

Conclusions: ECMO's initial catheterization process is considered by physicians to be unnecessarily time-consuming. A novel telescoping catheter designed to fully dilate a vessel with one device has been shown to reduce the procedure time by approximately half and limit the number of foreign objects entering the body. This increases the patient's likelihood of recovery by perfusing oxygenated blood throughout the body faster and decreasing the risk of infection. Future work will involve modifying the material used to better align with regulatory standards, developing additional sizes, clinical testing, and applications beyond ECMO.

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The estimated incidence of candidates for extracorporeal cardiopulmonary resuscitation amongst out-of-hospital cardiac arrests in Sweden, a registry based study

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Objectives: Extracorporeal cardiopulmonary resuscitation (ECPR) is an accepted treatment for refractory cardiac arrest in selective cases. Success of an ECPR-program is dependent on numbers treated. The incidence of ECPR candidates amongst out of hospital cardiac arrests (OHCA) in Sweden is not known. The Swedish cardiac arrest registry (SCAR) is a validated registry including more than 98% of all hospitals in Sweden, making it nationally representable and internationally unique. The study aimed to calculate and describe the ECPR eligible cohort amongst OHCA in Sweden, using SCAR.

Methods: Data of witnessed OHCA were extracted from SCAR between 1st of January 2015 to 30th of August 2019. Treatment with ECPR was considered contraindicated if no-flow time extended beyond five minutes. Two groups were defined, based on inclusion criteria. $Group_{Restrictive}$; 18-65 years of age with a primary shockable rhythm (VT/VF) and $Group_{Liberal}$; 18-70 years of age, independent of primary rhythm. OHCA were plotted on a map according to the coordinates of the EMS-crew responding, and time for transportation to nearest ECPR-capable hospital calculated. Maximum time for transportation was set to 40 minutes.

Results: Out of 15911 OHCA, 6372 were excluded due to extended no-flow time. $Group_{Restrictive}$ consisted of 1519 patients whereof 58% achieved ROSC with conventional treatment. The equivalent number for $Group_{Liberal}$ was 5851 patients, with 39% ROSC at hospital admission. The remaining OHCA were considered eligible for ECPR, constituting 636 patients in $Group_{Restrictive}$ and 3558 in $Group_{Liberal}$. When excluding OHCA not able to reach an ECPR-capable hospital within the set time limit, 218 and 1246 patients remained candidates for ECPR in $Group_{Restrictive}$ and $Group_{Liberal}$ respectively.

Conclusions: The quantity of ECPR-candidates amongst OHCA is highly dependent on selection criteria and geographics. In Sweden, we estimate 1.4-7.8% of all witnessed OHCA to be potential ECPR-candidates, on average corresponding to 4-22 OHCA per month, nationwide.

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Comparison of blood trauma in an ovine model of cardiogenic shock supported by pulsatile- and continuous-flow VA-ECMO

S. Heinsar[1,2], C.H.H. Chan[1], M. Passmore[1], K. Sato[1], N. Obonyo[1], C. Ainola[1,2], M. Bouquet[1], K. Wildi[1], S.M Farah[1], K. Liu[1], E.S Wilson[1], N. Bartnikowski[1], N. Sato[1], B. Schneider[1], G. Fior[1], K. Hyslop[1], M. Tucker[1], M. Siriwardena[1], I. Rätsep[2], J.Y Suen[1], G. Li Bassi[1], J.F Fraser[1]

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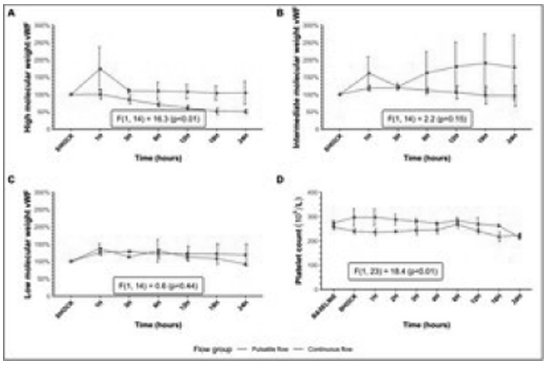
Objectives: Pulsatile flow (PF) venoarterial extracorporeal membrane oxygenation (VA-ECMO) has been proposed as an alternative for continuous flow (CF) devices and shown preliminary efficacy for tissue microcirculatory and cardiac function preservation. Studies on ventricular assist devices and cardiopulmonary bypass patients have suggested PF might limit blood trauma, yet investigations in ECMO are scarce.

Methods: Four female sheep (48±4 kg) were anesthetised, intubated, mechanically ventilated and on standard invasive haemodynamic monitoring. Left femoral artery and right jugular vein were cannulated for VA-ECMO, which was commenced at 1L/min. Thereafter, cardiogenic shock (defined by the European Society of Cardiology criteria) was induced through 1mL intramyocardial injections of 96% ethanol, and ECMO flow was increased to maintain mean arterial pressure ≥65mmHg. Animals were randomly allocated to pulsatile (n=2, Xenios i-cor, 1:1 counter-pulse mode) or continuous (n=2) VA-ECMO. At predetermined intervals (Figure 1), blood samples were taken for haemolysis, von Willebrand factor (vWF) multimeric structure analysis, platelet number and activation assessment. Comparisons between groups were analysed using an aligned ranks transformation ANOVA.

Results: Cardiogenic shock developed after 52±18 direct intramyocardial injections. All animals survived until the end of the 24-hour follow-up period. Mean flow rates were comparable between PF and CF (51 vs 56 ml/kg/min, p = .09). PF was associated with higher levels of high molecular weight vWF and trended towards higher intermediate molecular weight vWF multimers (Figures 1A and 1B). Additionally, animals with PF had higher platelet counts (Figure 1D), whilst no difference in hemolysis, platelet activation, low molecular weight vWF (Figure 1C).



Conclusions: Our preliminary results suggest PF VA-ECMO preserves high molecular weight vWF multimers and platelets compared to CF VA-ECMO. We are currently planning clinical investigations to determine if this translates to fewer bleeding/thrombosis complications.

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Incidence of venous and arterial complications in patients requiring veno-arterial extracorporeal membrane oxygenation

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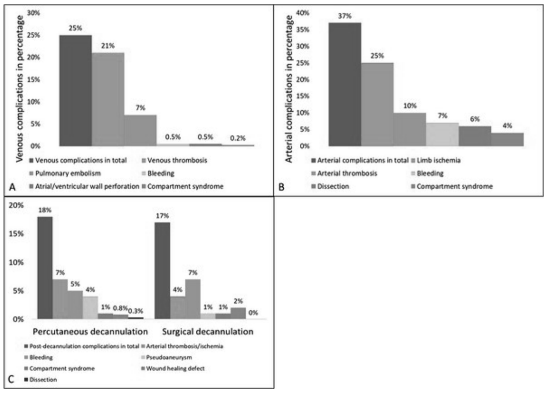
Objectives: The aim of the study was to determine the incidence of vascular complications and associated risk

factors in patients requiring veno-arterial extracorporeal membrane oxygenation (VA-ECMO).

Methods: Of 1030 eligible VA-ECMO patients (01/2010–01/2020), 427 patients were included, receiving and surviving peripheral VA-ECMO. Duplex sonography after decannulation was conducted to screen for venous and arterial complications. Pulmonary embolism was diagnosed by CT-scan. Limb ischemia was defined according to clinical signs of ischemia and/or decrease in regional oxygen saturation (rSO_2) by ≥25% compared to the contralateral leg or absolute rSO_2 below 40%. RSO_2 was measured on both legs during and after cannulation.

Results: The incidence of venous thrombosis and pulmonary embolism was 21% and 7%. Neither the cannula-size, nor biochemistries, nor bilaterally vs. unilaterally cannulation, but jugular cannulation for drainage were risk factors in multivariate analysis. Limb ischemia was observed in 25%. At time of cannulation, absence of distal perfusion cannula, lower rSO_2 (cannulated leg) and elevated D-Dimers were associated with limb ischemia in multivariate analysis, but the best predictive factor was the difference of rSO_2 (18%) between the non-cannulated and the cannulated leg (sensitivity 93%). During ECMO support only absence of distal perfusion cannula was a risk factor. Complications in association with decannulation were observed in 17% of patients. Other vascular complications are presented in Figure 1. Patients discharged from hospital had a comparable incidence of venous thrombosis and pulmonary embolism (venous thrombosis 21% vs. 21%, p = 0.939; pulmonary embolism 6% vs. 9%, p = 0.438), but a lower incidence of limb ischemia than patients who died after decannulation (22% vs. 34%, p = 0.005).



Conclusions: The incidence of venous and arterial complication in VA-ECMO patients is high (25% and 37%). Complications associated with decannulation were present in 17%.

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Veno Arterial ECMO: The Trieste intensive care unit 10-year experience

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Objectives: The purpose of our research was to analyse the experience of a low/medium-volume centre ICU and compare our results to the ones in literature.

Methods: We analysed clinical data from 61 consecutive patients who were assisted via VA-ECMO from December 2009 to December 2019, using an *ad hoc* Microsoft Excel® database. Primary endpoints were survival, neurological outcome and bleeding.

Survival and neurological outcomes were evaluated at ICU discharge and at 30 days.

Severe bleeding was defined by BARC, PLATO and ELSO scores.

Results: Our patients were predominantly males (79%), with a median age of 64 years (IQR: 54-71). Indications to place VA-ECMO were: cardiogenic shock (CS; 16%), post-cardiotomy shock (PCS; 54%), cardiac arrest (CA; 20%), non-cardiogenic shock (10%).

Survival

All of the patients alive at ICU discharge were alive at 30 days (43%). Older age (OR 1.06[95%CI 1.01-1.10]; p = 0.012), PCS as indication (OR 3.07 [95%CI 1.07-8.80]; p = 0.0037), high lactates at baseline (OR 1.17[95%CI 1.04-1.33]; p = 0.012), LV dysfunction (OR 6.33[95%CI 1.81-22.11]; p = 0.004), severe bleeding (OR 2.38[CI 2.38-24.03]; p = 0.001) were associated with an increased risk for death.

Neurological outcome

Impaired RV (20 [71%]versus 7[41%]; p = 0.045), RRT(17 [61%]versus 2[12%]; p =0.001), SAPT(9[32%] versus 0; p = 0.009) and bleeding (9[68%]versus 5[29%]; p = 0.012) were associated with an unfavourable outcome *at ICU discharge*.

At 30 days, 77% of patients analysed had a favourable outcome; only SAPT, RV dysfunction and previous stroke were associated to poor neurological outcome; none of the variables retained significance at the univariate analyses.

Bleeding

Older age (OR 1.05 [95%CI 1.01-1.09]; p = 0.012), PCS (OR 11.82 [95% CI 3.43-4.80]; p<0.001), LV dysfunction (OR 1.04 [95%CI 1.01-1.07]; p = 0.017) were associated with higher risk for bleeding. After correction for age, CA as indication and LV dysfunction at baseline, PCS as

indication retained its association to severe bleeding at 30 days from discharge (OR 6.72 [CI 1.53-29.60]; p = 0.012).

Conclusions: Although the small sample size of our population, results are consistent with literature in terms of mortality rate (~43%). Furthermore, our data show the importance of patient selection when considering placing a VA-ECMO.

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Regional cerebral oxygen saturation as an outcome-predicting marker for ECPR recipients: A meta-analysis

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Objectives: Extracorporeal cardiopulmonary resuscitation (ECPR) is increasingly used despite no change in risk-adjusted survival over time and in neurological outcome. In last years studies and meta-analysis highlighted some prognostic markers for ECPR, despite not high-quality evidence. Regional cerebral oxygen saturation (rSO_2) measured through NIRS showed promising results in predicting neurological outcome and return of spontaneous circulation during conventional CPR. This good predictive power could play a role even in ECPR recipients to prevent futile cannulations, reducing the risk of patients with poor neurological outcome and avoiding unnecessary costs.

Methods: We performed a comprehensive search of relevant databases (Pubmed/Medline, Embase and Cochrane Library). We searched for studies comparing the pre-cannulation rSO_2 in patients treated with ECPR. We focused on the following outcomes: mortality and neurological outcome. We did not find any RCT addressing our scope.

We finally meta-analyzed two retrospective studies. We chose a pre-cannulation rSO_2 cut-off of 16%, dividing patients into two groups ($rSO_2 \leq 16\%$ and $rSO_2 > 16\%$) to analyze the outcomes proposed, then performing analysis for the subpopulation of out of hospital cardiac arrest (OHCA).

Results: A pre-cannulation $rSO_2 > 16\%$ is associated with a reduced risk of mortality in ECPR recipients (odds ratio (OR) 0.23; 95% confidence interval (CI) [0.09 - 0.59], fig.1), even in the sub-group of OHCA (OR 0.24; 95% CI [0.09 - 0.63]).

A pre-cannulation $rSO_2 > 16\%$ is also associated with a statistically significant increase in the probability of a good neurological outcome (OR 9.32; 95% CI [2.33 - 37.23], fig.1), also for the OHCA sub-population (OR 8.32; 95% CI [2.07 - 33.41]). We considered good neurological outcome a Cerebral Performance Category (CPC) of 1 or 2.

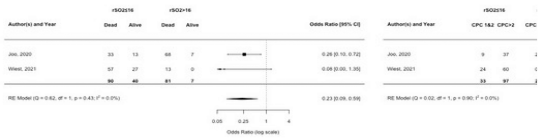

fig 1

Conclusions: rSO_2 >16% seems to have an outcome-predicting value for ECPR recipients. Our analysis accounts for several limitations, first of all, the small number of studies taken into consideration. Nevertheless, we found a low heterogeneity of the study population, powering our results. According to these data, a specific RCT seems mandatory to confirm the power of rSO_2 as a criterion to avoid unnecessary cannulation.

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Heparin dosing in cardiogenic shock patients supported by short-term percutaneous microaxial left ventricular assist devices: Less might be more

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Objectives: Impella™ is increasingly used in cardiogenic shock (CS). However, both thromboembolic and bleeding events are frequent during pMCS and the optimal anticoagulation strategy remains underexplored.

Methods: This hypothesis generating multi-center cohort study investigated 170 matched patients with left-Impella™ support. We (A) compared bleeding/thrombotic events in two centers aiming at therapeutic range activated partial thromboplastin time (aPTT 60-80s) and (B) compared bleeding/thrombotic events of these centers with one center aiming at intermediate range aPTT (aPTT 40-60s).

Results: After matching, there were no differences in patients characteristics. In centers aiming at therapeutic range aPTT, major bleeding was significantly higher in patients that achieved aPTT ≥ 60s within 48h of left-Impella™ support versus patients that did not [aPTT ≥ 60s: 22 (37.3%) vs. aPTT< 60s 14 (23.7%); Hazard ratio

[HR], 0.06 (95%) CI, 0.01 – 0.45; p = 0.006]. Major cardiovascular and cerebrovascular adverse events (MACCE) did not differ between groups. In comparison of centers, therapeutic range aPTT strategy showed higher major bleeding rates [therapeutic range: 8 (47.1%) *vs.* intermediate range: 1 (5.9%); Hazard ratio [HR], 0.06 (95%) CI, 0.01 – 0.45; p = 0.006]. MACCE were lower in the intermediate range aPTT group as well [MACCE - therapeutic range 12 (70.6%) vs. intermediate range 5 (29.4%) HR, 0.32 (95%) CI, 0.11-0.92; p = 0.034].

Conclusions: This multi-center pilot analysis showed that lowering the UHF-targets in left-Impella^{TM} supported CS patients seems to be a safe and promising strategy for reducing major bleeds without increasing MACCE. This needs to be validated in larger, randomized clinical trials.

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Clinician perspectives on extracorporeal cardiopulmonary resuscitation: A mixed methods analysis

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Objectives: Timely application of extracorporeal cardiopulmonary resuscitation (ECPR) has shown to improve survival rates in refractory cardiac arrest patients by re-establishing improved vital organ perfusion. However, ECPR is a complex and time-intensive intervention with a high risk of complications that impair widespread clinical adoption. This study aimed to investigate the procedures within the therapy to uncover the major hurdles faced by clinicians during ECPR initiation.

Methods: Eight ECPR intensive care specialists with 2-10 years experience from the Alfred hospital, Melbourne (a tertiary ECPR center in Australia) participated in the study. To evaluate the ECPR procedures, the therapy was sectioned into ten individual stages; CPR, mechanical CPR, decision making for ECPR patient selection, draping, imaging, needle insertion, guide wire insertion, dilation, cannula insertion and ECPR initiation. The most time-consuming and skill-intensive steps on a scale of 1-5 (1-least, 5-most) were identified with the aid of a Likert scale questionnaire. In-depth investigation of the challenges present within each stage was conducted through a semi-structured interview.

Results: Analysis of questionnaire responses revealed dilation (3.75 ± 0.60) as the most time-consuming procedure of ECPR followed by draping (3.25 ± 0.98) and decision making (2.75 ± 0.75). Scores of 3 or greater were given by all participants for dilation and 87% of participants for draping. Decision making (4.13 ± 0.75) followed by dilation (3.88 ± 0.87) and imaging (3.63 ± 0.91) were identified to be the most skill-demanding steps. Standard deviations were low (0.00 – 1.11) across all scores, indicating consistent views in our cohort.

Conclusions: The interviews identified dilation, draping, imaging and decision making to be critical areas to shorten implantation time and decrease risk, despite participant experience level. In-depth investigation into these procedures and the risks involved demonstrated the importance of improved clinical training and the need for novel developments and technologies, particularly with respect to cannulation.

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Treatment with Impella® and veno-arterial extracorporeal membrane oxygenation during cardiac arrest improves survival – a multicenter cohort study

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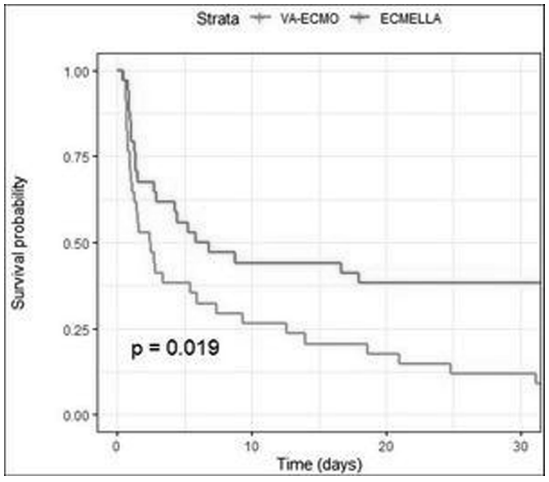
Objectives: To the best of our knowledge this is the first study which aimed to investigate whether treatment with VA-ECMO and Impella® (so called "ECMELLA") during therapy-refractory cardiac arrest caused by acute myocardial was associated with improved survival rates (primary outcome), as well as hospital and intensive care unit (ICU) length of stay (secondary outcomes), compared to VA-ECMO treatment alone.

Methods: Propensity score-matching between ECMELLA and VA-ECMO treatment groups was performed based on age, location of cardiac arrest (out-of-hospital or in-hospital), initial ECG rhythm (shockable or non-shockable) and score on Survival After Veno-arterial ECMO (SAVE). Cox proportional-hazard and Poisson regression models were used to analyze the association between treatment groups and outcomes.

Results: 95 adult patients from three tertiary care centers were included, out of whom 38 (40%) with ECMELLA were matched to 38 (40%) with VA-ECMO treatment. ECMELLA treatment was associated with

47% lower in-hospital mortality (HR 0.53 [95% CI 0.31-0.91], P = 0.021), as well as 71% longer hospital and 81% longer ICU length of stay (IRR 1.71 [95% CI 1.50-1.95] and 1.81 [95% CI 1.57-2.08], each P<0.001). Kaplan-Meier analysis (Figure 1) and multiple sub-group analyses (age, sex, initial ECG rhythm, Charlson comorbidity index, body mass index, SAVE and SAPS II score, cardiologist experience, location of cardiac arrest, lactate and pH levels) confirmed survival benefits in the ECMELLA group. Moreover, left ventricular (LV) ejection fraction strongly improved in the ECMELLA group from ICU admission to discharge (from 15% to 40%) in exploratory analyses.



Conclusions: LV unloading with Impella® in patients treated with VA-ECMO was associated with lower mortality rates after extracorporeal cardiopulmonary resuscitation. A randomized clinical trial is urgently needed to further evaluate benefits of LV unloading in patients with therapy-refractory cardiac arrest.

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Neurological complication in post cardiotomy shock with ECMO

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Objectives: Patients supported by veno-arterial (V-A) ECMO for post-cardiotomy shock (PCS), are prone to develop neurological complications. There are limited data regarding the management and neuromonitoring strategy of these complications. This systematic review sought to study the available literature on this topic.

Methods: A systematic literature search on PubMed of papers from inception until December 2021 was performed. Patients supported with V-A ECMO for PCS and any type of neurological complications were included.

Results: We identified 126 papers regarding V-A ECMO and neurological complications, of which only 25 (n=7686 patients) were specific for PCS. The most common neurological complication was ischemic stroke, intracranial hemorrage (ICH) and hypoxic ischemic brain injury (HIBI). Overt ischemic stroke is reported in 11-25% of adults with V-A ECMO for PCS. Commonly reported etiology of ischemic stroke was thromboembolism or from de novo thrombus. Risk factors include central cannulation, intracardiac or aortic root thrombus. No specific management guidelines on ECMO-associated stroke were find.

ICH occurs up to 12% of patients with V-A ECMO for PCS. ICH on V-A ECMO is associated with up to a 90% in-hospital mortality, higher than of the 57% seen in ischemic stroke. Although HIBI is one of the most common neurological complications in non-PCS V-A ECMO, the prevalence in PCS patients was not reported in any of the included studies. There is no clear evidence regarding neuromonitoring in V-A ECMO for PCS patients, although specific EEG patterns may be related to poor neurological outcome in a single retrospective study.

Conclusions: Neurological complications are commonly reported in PCS patients treated with V-A ECMO and appears to be more frequent than in non-PCS V-A ECMO. ICH and ischemic stroke appear to be the most common types of brain injury, although data is still lacking. Our study highlights the importance of further investigation on management strategy and neuromonitoring protocols to improve the outcomes in patients with neurological complications.

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Comparison of the prognosis of patients with mixed cardiogenic-septic, cardiogenic and septic shock supported by veno-arterial extracorporeal membrane oxygenation

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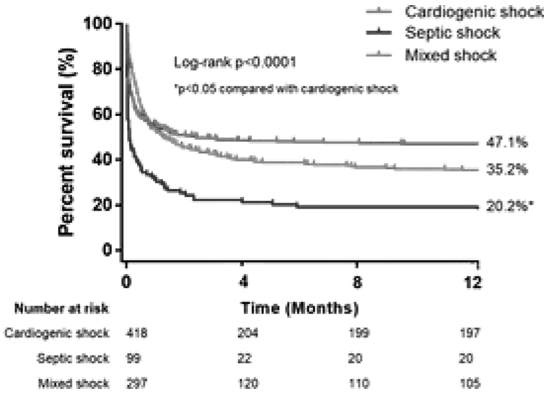
Objectives: Mixed cardiogenic-septic shock (MS), defined as the combined cardiogenic and septic shock at diagnosis, is often observed in the current cardiac intensive care unit. We compared the role of veno-arterial extracorporeal membrane oxygenation (VA-ECMO) on patients with mixed cardiogenic-septic shock, cardiogenic shock (CS), and septic shock (SS).

Methods: Of 1025 patients undergoing VA-ECMO support from January 2012 to February 2020, 210 patients were excluded because of pulmonary embolism, hypovolemic shock, aortic dissection, and unknown cause of shock. The remaining 815 subjects were grouped based on the cause of shock at the time of VA-ECMO application: (i) MS (n=298, 36.6%), (ii) CS alone (n=418, 51.3%), (iii) SS alone (n=99, 12.1%).

Results: There has been an increase in the prevalence of MS with VA-ECMO [30.7% vs. 35.7% vs. 42.3 in the period 2012-2014 vs. 2015-2017 vs. 2018-2020 (p<0.001), respectively]. Baseline characteristics showed that MS group had younger age and lower left ventricular ejection fraction than CS or SS group. 30-day and 1-year mortalities were the highest in SS group (30-day mortality; 47.3% vs. 44.5% vs. 68.7%, p<0.001 for MS vs. CS. vs. SS, respectively: 1-year mortality; 64.8% vs. 52.9% vs. 79.8%, p<0.001, Figure). By post-hoc analysis, the prognosis of MS group was not different from CS group despite a trend toward lower survival rate. Factor affecting 30-days and 1-year mortality in MS patients was serum-lactate level before VA-ECMO apply [30-days; hazard ratio 1.10 (95% CI 1.05 – 1.15, p<0.001): 1-year; hazard ratio 1.08 (95% CI 1.04 – 1.12, p<0.001)].



Conclusions: The clinical outcomes of MS group were better than SS group and comparable with CS group. Thus, the application of VA-ECMO for MS can help improve survival and be considered as positively as for CS if indicated.

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Outcomes of veno-arterial extracorporeal membrane oxygenation for drug intoxications: A single center, 14-year experience

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Objectives: Acute cardiovascular failure with cardiogenic shock or even cardiac arrest represents a leading cause of mortality in severe poisonings. Veno-arterial extracorporeal membrane oxygenation (VA-ECMO) has been increasingly used as a rescue therapeutic option for those cases refractory to optimal conventional treatment. The objective of the present analysis was to evaluate the outcomes after VA-ECMO used for drug intoxications in a single-center experience.

Methods: We performed an observational analysis of our prospective institutional database. The primary endpoint was survival to hospital discharge.

Results: Of the 712 patients who received VA-ECMO from January 2007 to December 2020, 32 (4.4%) were supported for drug intoxication-induced refractory cardiogenic shock (n=25) or cardiac arrest (n=7). Our Mobile Unit of Mechanical Circulatory Support implanted VA-ECMO in 4 (12.5%) patients hospitalized in referring peripheral hospitals and then transported them on VA-ECMO to our centre. The mean age was 45.4 ± 15.8 (range, 19-71) years, 62.5% were female. Seven (21.8%) patients developed lower limb ischemia during VA-ECMO support. Twenty-six (81.2%) patients were successfully weaned after a mean VA-ECMO support of 2.9 ± 1.3 days. One (3.1%) patient died after VA-ECMO weaning for multi-organ failure and survival to hospital discharge was 78.1% (n=25). In-hospital survivors were discharged from hospital with a good neurological status. Survival to hospital discharge was not statistically different according to sex (male=75.0% vs. female=80.0%; p = 0.535), type of intoxication (single drug=81.8% vs. multiple drugs=76.1%; p = 0.544) and location of VA-ECMO implantation (within our centre=75% vs. peripheral hospital using our Mobile Unit of Mechanical Circulatory Support=100%; p= 0.352). Survival to hospital discharge was significantly lower in patients receiving VA-ECMO during ongoing cardiopulmonary resuscitation (42.8% vs. 88.0%; p = 0.026).

Conclusions: Drug intoxications are potentially lethal conditions. VA-ECMO could represent a therapeutic option with satisfactory survival rate and acceptable complications' rate in poisonings complicated by refractory cardiogenic shock or cardiac arrest.

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Neuroinflammation and veno-arterial extracorporeal membrane oxygenation (V-A ECMO): Clinical evidence and literature review

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Objectives: The use of V-A ECMO (Veno-Arterial Extracorporeal Membrane Oxygenation) in patients with cardiac arrest (CA) or cardiogenic shock seems to improve survival and neurological outcomes when compared with conventional cardiopulmonary resuscitation (CCPR), with a still high risk of acquired brain injury. Neuroinflammation could play an important role in this setting. In fact, V-A ECMO induces a systemic inflammatory response syndrome (SIRS), but it is still unclear how it may lead to brain inflammation and damage.

Methods: We performed a literature review on PubMed, Scope and Cochrane databases using as keywords: V-A ECMO and neuroinflammation, CA and neuroinflammation, V-A ECMO and inflammatory response, V-A ECMO and cytokines, V-A ECMO and immunity. This yielded 251 studies from 2013 to 2021. For this review we included 14 of them.

Results: The exposure of blood to artificial surfaces during V-A ECMO results in coagulation and complement cascade abnormal activation, with an increased production of interleukin IL-1β, IL-6, IL-8, IL-10 and tumor necrosis factor-α (TNF-α). Pro-inflammatory cytokines (IL-1b, IL-6, TNF-α) enhance apoptosis and necrosis in neuron cells and directly activate microglia and astrocytes; they also alter blood brain barrier (BBB) permeability, causing cerebral edema, augmented expression of selectins on endothelium, and finally infiltration of activated neutrophils and monocytes into brain parenchyma. Furthermore, V-A ECMO can lead to a loss of cerebral blood flow and autoregulation, especially in pediatric patients, with a consequent higher shear stress on capillaries surface and disruption of the BBB: this damage may facilitate central nervous system antigens release into periphery and the activation of brain-targeted adaptive immunity.

Conclusions: Further studies should be conducted to improve knowledge on V-A ECMO-induced activation of innate and adaptive immunity leading to neuroinflammation. Better knowledge of these mechanisms could guide clinical management using, for example, immunosuppressants or cytokine adsorption therapies, in order to improve neurological outcome.

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Pupillometry during veno-arterial extracorporeal membrane oxygenation (V-A ECMO): An "eye inside the brain"

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Objectives: Veno-Arterial Extracorporeal Membrane Oxygenation (V-A ECMO) is an increasingly used support for patients with refractory cardiac arrest (CA) or cardiogenic shock (CS). In these settings the incidence of neurologic complications is high and caused by hypoxic-ischemic or reperfusion injury, cerebral edema, thromboembolism, hemorrhagic stroke or other underlying conditions. Brain injury is a major determinant of outcome for V-A ECMO patients. A bedside, repeatable, non-invasive, high-sensitivity and specificity monitoring tool would be useful for neuromonitoring. In particular quantitative pupillometry through use of the Neurological Pupil index (NPi) could play an important role.

Methods: We performed a literature review on PubMed, Scope and Cochrane database. Using as keywords: V-A ECMO and pupillometry, V-A ECMO and NPi, V-A ECMO and neurological complication, pupillometry and neuro prognostication. This yielded 112 studies from 1983 to 2021. For this review we included 19 studies.

Results: NPi (ranging from 0 to 5) is minimally influenced by light, sedatives and other variables. Abnormally low values (≤2) have shown to have high specificity for poor neurologic outcome from day 1 after V-A ECMO insertion, with no false positives. Other clinical uses of pupillometry could be for assessing and monitoring bedside the response to treatment as for example for cerebral edema or increasing intracranial pressure. Pupillometry should not be used alone to

neuroprognosticate sedated or comatose patients with CA or SC on V-A ECMO. A multimodal approach and including clinical examination, neurophysiological tests, biomarkers, imaging and other variables should be performed. Additional studies are needed to evaluate pupillometry as an early neuromonitoring tool during V-A ECMO, in order to identify high risk patients and to orient clinical decision making.

Conclusions: NPi is a novel point-of-care technique which uses "the eye as a window to the brain". Further studies for establishing the correlation between NPi and neurologic outcomes in V-A ECMO patients are needed.

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Early neurological assessment with pupillometry in cardiac arrest during resuscitation (EASY-CARE)

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Objectives: The main purpose of the study is to evaluate the prognostic value of quantitative pupillometry during CPR on ROSC. We will also evaluated NPi and ETCO2 as predictors of ROSC and the association between the NPi trend during CPR with PESS, EEG, Biomarkers (ENS, S100B, GFAP) and with neurological outcome (mRS).

Methods: Observational, prospective, multicentre study performed in a population pertaining to the Lombardy Region. The NPi data obtained from pupillometry will be collected by the rescuing technician in order not to interrupt or influence the resuscitation maneuvers.The following data will be collected: no-flow and low-flow times, CPR and ACC conditions upon arrival of rescuers, NPi and ETCO2 values at T0, every 2 minutes of CPR and after ROSC. In the ICU, the neurological outcome will be assessed by means of mRS at predefined deadlines: immediate (ROSC / death), at discharge from the ICU, at 30 days or at hospital discharge, at 6 months and at 1 year. During hospitalization, further data will be collected: best GCS, trend of neurological biomarkers, outcome of evoked potentials and EEG.

Results: Quantitative and qualitative variables will be calculated and the Shapiro-Wilk test will be used to verify their normal distribution. To evaluate the prognostic value of NPI during CPR, we will proceed with an analysis of the performance of the diagnostic test and the application of a repeated measures ANOVA model. We will apply logistic regression models and performance analysis for the endpoints. A sample size of 88 patients is estimated, corrected to 214, considering an attrition-rate of 50% and a dropout of 15%.

Conclusions: Has shown to be a valuable neurological assessment tool and with this trial we will evaluate the prognostic value of NPi and also define new benchmarks useful during CPR and post-ROSC in cardiac arrest victims.

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The role of cannulation strategies for postcardiotomy extracorporeal life support (PC-ECLS) on inpatient survival: A single center's experience

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Objectives: The use of postcardiotomy extracorporeal life support (PC-ECLS) has become increasingly common in recent years. However, the intrahospital mortality remains high. Different cannulation strategies (i.e., central vs. peripheral) can be implemented for PC-ECLS and may have an impact on the outcome. Accordingly, we aimed to evaluate the impact of the cannulation strategy on the in-hospital outcome after PC-ECLS.

Methods: We retrospectively included 102 consecutive patients from our hospital who required extracorporeal life support after cardiac surgery (PC-ECLS) between 02/2018 and 07/2021. The indication for PC-ECLS was made due to intra- or postoperative low cardiac output or circulatory arrest. ECLS was established either via central cannulation using vascular prosthesis at the ascending aorta (**central group**) or peripheral cannulation either via the common femoral artery, or the subclavian artery (**peripheral group**). The primary endpoint was in-hospital mortality in the subgroups central vs. peripheral PC-ECLS.

Results: A total of 56 patients with a mean age 64.9 years ± 10.1 years, 76.8% men required PC-ECLS during the study period. Index procedures were isolated coronary artery bypass grafting (CABG) (n=16 [28.6%]), isolated valve surgery (n=10 [17,9 %]), combined CABG and valve surgery (n=8 [14.3%]), acute type A aortic dissection (ATAAD) (n=7 [12.5%]), or other (n=15 [26.8%]).

A total of 45 [48.2%] patients were in the central group and the remaining 52 [51.8%] patients were in the peripheral group. The time on ECLS was comparable

between both groups, i.e., 6.1± 4.4 days in the … group vs. …. in the …. Group (p = .14). In-hospital mortality was 60.7% in the ….. group vs. ….% in the …. Group (p=…), again without significant difference between both cannulation strategies. [EG1]Gab es Unterschiede im Alter, Geschlecht, OP-Prozedur vor ECMO zwischen den beiden Gruppen?

Conclusions: Postcardiotomy extracorporeal life support is still associated with very high in-hospital mortality. Central cannulation with an antegrade arterial perfusion showed no significant advantage over peripheral femoral cannulation in our patient population.

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Effect of levosimendan use on mortality of extracorporeal cardiopulmonary resuscitation (ECPR) patients

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Objectives: Extracorporeal Cardiopulmonary Resuscitation (ECPR) is increasingly employed in patients with cardiac arrests, aiming to restore circulation for end organ perfusion as quickly as possible. The use of levosimendan in cardiac arrests has been studied in animal models, either as sole therapy or in combination with epinephrine. Improved myocardial performance and survival was observed. We aim to study the impact of levosimendan use on the mortality of ICU patients who underwent ECPR.

Methods: This retrospective cohort study was carried out from January 1, 2015, to July 31, 2021, in the 24-bed mixed medical/surgical ICU of a regional hospital in Hong Kong. Patients who had cardiac arrest and underwent ECPR were included.

Results: Our study included a total of 29 patients who received ECPR. Among them, 10 patients received levosimendan (LEVO group) and 19 patients did not (control group). Age, sex, APACHE IV score and predicted risk of death were similar between the two groups. Acute myocardial infarction was the most common cause of cardiac arrest requiring ECPR in both groups (80% vs 47.4%, p = 0.126), followed by right ventricular failure (10% vs 10.5%, p = 1.00). Concomitant use of intra-aortic balloon pump (IABP) was more common in the LEVO group than the control group (90% vs 26.3%, p = 0.002). The primary endpoint was ICU mortality, which was lower in LEVO group than control group. However, the difference failed to reach statistical significance (50% vs 73.7%, p = 0.244). Secondary endpoints including hospital mortality (50% vs 73.7%, p = 0.244) and success in weaning off ECMO (30% vs 31.6%, p = 1.00) were also not statistically significant between the groups.

Conclusions: In patients undergoing ECPR, use of levosimendan did not lead to statistically significant clinical outcomes including ICU and hospital mortality. Further studies with larger sample sizes can be considered in the future.

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A single centre review of practices managing right ventricular dysfunction in patients on Extracorporeal Membrane Oxygenation (ECMO)

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Objectives: Amongst cardiac pathologies, right ventricular (RV) dysfunction is associated with one of the poorest outcomes and is a significant contributor to morbidity and mortality in cardiology and cardiothoracic patients worldwide(1,2). Strategies to manage RV dysfunction range from intravenous, tablet, inhaled, to mechanical(3). However, there is associated increased mortality in patients with RV dysfunction who are receiving LV support(4).

Methods: A 'snapshot' retrospective review was performed at a single centre using the local ECMO registry. Data was collected between January and November 2021 and included all patients admitted to Harefield Hospital who underwent ECMO, which were investigated for incidence of RV dysfunction. The RV dysfunction was diagnosed via echocardiography and deemed severe enough to warrant further intervention; the modes of subsequent intervention were also reviewed.

Results: Management therapies included milrinone, levosimendan, and inhaled nitric oxide (iNO). Ventilation strategies to assist the RV were excluded as the intentions behind changes in ventilator modalities was too complex to interpret retrospectively. Of the 34 patients who underwent ECMO, 17 were identified as having RV dysfunction with a 47% 30-day mortality rate. 76% were initially managed with milrinone, and for those with no additional treatment, there was a 71% mortality rate. In comparison, patients on three therapies, a 16% mortality rate was noted. Milrinone was the most widely used treatment in 88% of patients, followed by iNO in 47% and levosimendan in 35%. None of the patients with RV dysfunction needed escalation to right heart mechanical support therapies.

Conclusions: These results highlight the risks of patient deterioration and mortality associated with RV dysfunction, even when on ECMO - which is largely understood to be a method of managing this pathology in itself. From this small sample, it appears that a multimodal approach to treatment was linked to better survival rates. We aim to broaden our review of this subject over a larger time scale and make comparisons with other forms mechanical circulatory support to elucidate factors that positively and negatively impact outcomes in these patient groups.

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The effect of venoarterial extracorporeal membrane oxygenation on left ventricular function in cardiogenic shock with aortic stenosis or mitral regurgitation

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Objectives: Venoarterial extracorporeal membrane oxygenation (VA-ECMO) is widely used in cardiogenic shock (CS). However, increased VA-ECMO blood flow (EBF) may significantly impair left ventricular (LV) performance. The objective of the present study was to assess the effect of VA-ECMO on LV function in acute CS with concomitant severe aortic stenosis (AS) or mitral regurgitation (MR) in a porcine model.

Methods: Eight female swine underwent VA-ECMO implantation under general anesthesia and artificial ventilation. Acute CS was induced by global myocardial hypoxia. Subsequently, severe AS was simulated by obstruction of aortic valve and then severe MR was created by mechanical destruction of mitral valve. Hemodynamic and LV performance variables were measured at different rates of EBF (ranging from 1 to 4 L/min), using arterial and venous catheters, a pulmonary artery catheter, and LV pressure-volume loop catheter. Data are presented as median (interquartile range).

Results: Myocardial hypoxia resulted in declines in cardiac output to 2.7 (1.9-3.1) L/min and LV ejection fraction to 15.2% (10.5-19.3). In severe AS, increasing EBF from 1 to 4 L/min was associated with significant rise of mean arterial pressure (MAP) from 33.5 (24.2-34.9) to 56.0 (51.9-73.3) mmHg, P<0.01, but the LV volumes (end-diastolic, end-systolic, stroke) remained unchanged and LV end-diastolic pressure (LVEDP) even significantly decreased from 24.9 (21.2-40.0) to 19.1 (15.2-29.0) mmHg, P<0.01. In severe MR, increasing EBF resulted in significant rise of MAP from 49.0 (28.0-53.4) to 72.5 (51.4-77.1) mmHg, P<0.01, LV volumes remained stable and LVEDP increased from 17.1 (13.7-19.1) to 20.8 (16.3-25.6) mmHg, P<0.01.

Conclusions: Our study indicates that the presence valvular heart disease may alleviate negative effect of VA-ECMO on LV performance in CS. Severe AS fully protects against LV overload and partial protection can be detected also with severe MR, but at a cost of increased LVEDP and thus higher risk of pulmonary oedema.

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Low-flow time and neurological intact survival in OHCA patients treated with and without extracorporeal cardiopulmonary resuscitation

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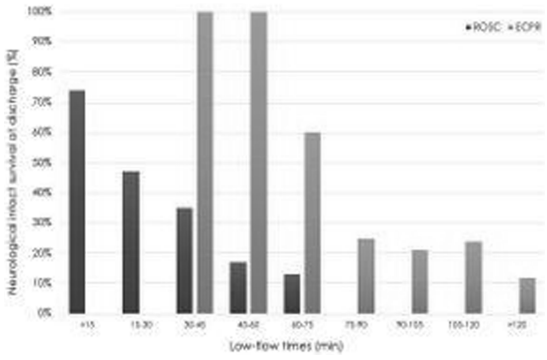
Objectives: The present study analyzed the association of low-flow time and neurological intact survival (Cerebral Performance Categories 1-2 at discharge) between out of hospital cardiac arrest (OHCA) patients with sustained return of spontaneous circulation (ROSC) and OHCA patients receiving extracorporeal cardiopulmonary resuscitation (ECPR).

Methods: This retrospective, observational study included all consecutive OHCA patients treated at Aarhus University Hospital between 2015-2019. Patients not receiving ECPR for refractory OHCA were excluded from the analysis. Low-flow time was defined as the time from CPR initiation to ROSC or deployment of veno-arterial extracorporeal membrane oxygenation. Good neurological outcome was defined as CPC score 1-2. Survival and neurological status at discharge was analyzed.

Results: A total of 698 patients were admitted with sustained ROSC and 97 patients were treated with ECPR during the study period. The median low-flow time was 15 [8-22] minutes in the ROSC-group and 105 [95-123] minutes in the ECPR group. No patients survived low-flow times > 75 minutes in the ROSC-group. Neurological intact survival was still prominent in patients with refractory OHCA treated with ECPR at low-flow times exceeding 75 minutes.



Conclusions: The rate of neurological intact survival decreased with increasing low-flow times in both groups. However, favourable neurological outcome was still observed in the ECPR-group despite long low-flow times exceeding > 75 minutes.

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Extracorporeal membrane oxygenation in transcatheter aortic valve implantation: A systematic review and meta-analysis

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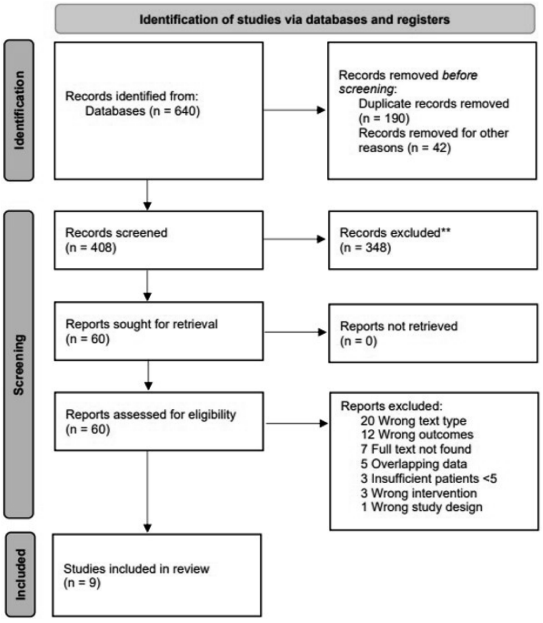
Objectives: Extracorporeal membrane oxygenation (ECMO) has been used in the management of patients undergoing transcatheter aortic valve implantation (TAVI). Despite this, the indications for the use of ECMO concurrently with TAVI has not been clearly elucidated. We reviewed the literature for the survival outcomes in such patients undergoing TAVI with ECMO support.

Methods: We conducted a systematic review and meta-analysis, searching four international databases for studies reporting on the outcomes of patients receiving ECMO and TAVI concurrently. Random effects (DerSimonian and Laird) meta-analyses were conducted. We rated the intrastudy risk of bias using the Joanna Briggs Institute checklist, and the certainty of evidence using the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) approach.

Results: From 640 references, 9 studies comprising 958 patients receiving ECMO and TAVI were included. The pooled age was 82.6 years (95%-CI: 79.5-86.5), and 45.6% (95%-CI: 28.4%-63.8%) of patients were male. The mean aortic valve area was 0.65 cm^2 (95%-CI: 0.50-0.79), while pooled EuroSCORE was 31.6 (95%-CI: 19.3-43.9). Pooled mortality amongst patients requiring ECMO and TAVI was 28.1% (95%-CI: 18.5%-42.0%, moderate certainty). Among five studies which provided a comparator group that did not receive ECMO, patients receiving ECMO had a significantly higher risk of mortality (risk ratio: 5.22, 95%-CI: 1.30-20.96, p = 0.020, high certainty). Pooled ICU length of stay (LOS) was 5.7 days (95%-CI: 1.7-9.7, low certainty) while pooled hospital LOS was 22.4 days (95%-CI: 12.7-32.1, low certainty).

Conclusions: ECMO is a viable adjunctive therapy in TAVI procedures. ECMO for TAVI was predominantly used in octogenarians with mortality less than 30%.



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Impact of primary procedures on outcome in patients requiring postcardiotomy extracorporeal life support

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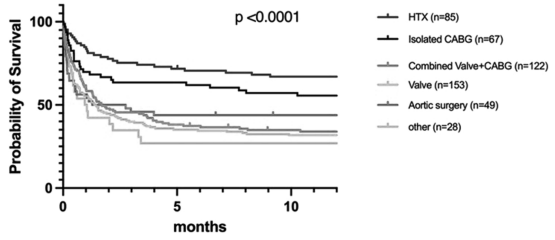
Objectives: To assess the impact of primary cardiac surgical procedures on outcome in patients requiring postcardiotomy extracorporeal life support(PC-ECLS).

Methods: A retrospective analysis of 504 patients requiring PC-ECLS between 2000-2021 at a single center was performed. Patients were divided into groups

according to the primary cardiac surgical procedure performed. Survival was visualized by Kaplan Meier curves and compared between groups by log rank test.

Results: 504 patients who required PC-ECLS from 2000-2021 were included in a retrospective analysis. Patients underwent isolated coronary artery bypass grafting (CABG) (n=67, 13.3%), combined valve surgery+CABG (n=122, 24.2%) valve surgery (n=153, 30.4%) aortic surgery (aneurysm or type a aortic dissection repair, n=49, 9.7%), heart transplantation (HTX, n=85,16.9%), or other procedures (n=28, 5.6%). There was a significant difference in overall survival between groups (p<0.0001), with highest survival rates observed in patients after HTX or isolated CABG, while mortality was significantly higher in patients undergoing valve surgery, combined valve+CABG, aortic surgery or other procedures.



The primary surgical procedure included replacement of at least one heart valve in 257 patients (51%). Bioprosthetic valves were used in aortic and/or in mitral position in 176 patients (34.9%) and mechanical valves (aortic and/or mitral) were implanted in 70 patients (13.9%). 4 patients received a combination of mechanical and bioprosthetic valves, and 7 patients received bioprosthetic pulmonary or tricuspid replacement. There was no statistically significant difference in overall crude survival between patients who received bioprosthetic vs. mechanical aortic/mitral/combined aortic and mitral valve replacement (p= 0.78).

Conclusions: The primary surgical procedure performed in patients requiring PC-ECLS had a significant impact on survival, with most beneficial outcome observed in patients who underwent HTX or isolated CABG.

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Temporary mechanical circulatory support in COVID-19 patients: A systematic review of literature

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Objectives: Myocardial injury occurs in up to 25% of patients diagnosed with coronavirus disease 2019 (COVID-19). Veno-venous extracorporeal membrane oxygenation (V-V ECMO) has been commonly used as respiratory support. However, in case of severe cardiac dysfunction, mechanical circulatory support (MCS) may be required. This systematic review summarizes the current literature regarding MCS use rates, disease drivers for MCS initiation, and MCS outcomes in COVID-19 patients.

Methods: PubMed was searched until October 2021. Articles including adults receiving MCS for COVID-19 were included. The primary outcome was the rate of MCS use. Secondary outcomes included mortality at follow-up, ECLS conversion rate, intubation-to-cannulation time, time on MCS, cardiac diseases and use of vasopressors.

Results: 28 observational studies included 4218 COVID-19 patients (females: 28.8%; median age: 54.3 years, 95%CI: 50.7-57.8) of whom 2774 (65.8%) required extracorporeal life support (ECLS) with the majority (92.7%) on V-V ECMO. 4.7% of included patients required veno-arterial ECMO and/or Impella and 2.6% required other ECLS. Acute heart failure, cardiogenic shock, and cardiac arrest were reported in 7.8%, 9.7%, and 6.6% of patients, respectively. Vasopressors were used in 37.2%. Overall, 3.1% of patients required an ECLS change from V-V ECMO to MCS for heart failure, myocarditis, or myocardial infarction. The median support time was 15.9 days (95%CI: 13.9-16.3), with an overall survival of 54.6% and 28.1% in V-V ECMO and MCS patients, respectively. One study reported 61.1% survival with oxy-right ventricular assist device.

Conclusions: MCS for cardio-circulatory support has been described in 7.3% of COVID-19 patients requiring any kind of ECLS, which is a lower percentage compared to the incidence of any severe cardio-circulatory complication. Based on this evidence, we can hypothesize an under-use of MCS in COVID-19 cases, with consequent low survival. Further investigations are warranted to establish adequate indications and timing for MCS in COVID-19.

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VA-ECMO as a bridge to heart transplantation: A brief analysis on the new heart allocation system in a Brazilian center

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Objectives: VA ECMO has become one important tool to treat patients with chronic cardiomyopathy who are on waiting list for heart transplantation (HT) and acutely worsens and need mechanical support. Some studies showed worse results, but with changes in the allocation system, these patients are designated to higher status, which can impact the outcomes. Our allocation system was modified in 2021. The objective of our study was to analyze the impact of the new allocation system on the results of patients bridged to HT using VA ECMO in a high volume heart transplant center.

Methods: Of the 298 HT performed between 2016 and 2021 in our center, 125 (42%) were in use of inotropic support, 150 (50%) were bridged with intra-aortic balloon pump and 23 (8%) patients were bridged with VA ECMO. 20 patients were also in ECMO support, but died on waiting list. About 75% of patients bridged with ECMO were during the last 3 years.

Results: Our mean list mortality on ECMO before the new allocation system (2016-2020) was 61.8% and after the new allocation (2021), 28,5%. The mean waiting time on ECMO was 7.2 days with the old system and 4 days after the new system. The survival to hospital discharge was 55% for patients bridged with ECMO in the old system and 80% for patients in the new allocation system. The total operative mortality during the old allocation system was 13,06% and 5.26% in the new allocation system.

Conclusions: The new allocation system positively influenced the mortality of patients bridged with VA ECMO to HT. The waiting list mortality was reduced, the days on ECMO were reduced and the survival to hospital discharge was improved.

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Annual variation in survival after OHCA treated with ECPR

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Objectives: Even minor changes in indications for ECPR has major impact on outcome. Consequently, published mortality rates vary from 2% to 50% between centers. However, limited data exist on temporal trends from centers in which daily clinical practice remained unchanged during the study period.The objective of this study is to examine temporal trends in survival of ECPR patients and in main prognostic factors and to illustrate the importance of running a quality improvement program including annual audits.

Methods: This observational study included all consecutive OHCA patients treated with ECPR at Aarhus University Hospital between 2015 and 2019. Annual 30-day survival rates and corresponding main known prognostic factors are presented. Low-flow time was defined as the time from CPR initiation to ROSC or deployment of veno-arterial extracorporeal membrane oxygenation.

Results: The annual number of ECPR patient varied from 12 in 2018 to 24 in 2015 and substantial variation in 30 day survival was observed (see table). In 2018, 75% of ECPR patients were younger than 65 years compared with 83% in 2015. Non-shockable first rhythm was more common among patients in 2018 (50%) as compared to 2015 (42%). An audit in August 2018 revealed a very low survival rate, primarily due to a substantial number of patients with asystoli as first rhythm and a number of patients older than 70; factors known to be associated with poor outcome.

	2015 N=24	2016 N=23	2017 N=20	2018 N=12	2019 N=22
30 day survival	10 (42%)	9 (39%)	4 (20%)	1 (8%)	5 (23%)
Age (years)	55 ± 9	50 ± 16	47 ± 16	53 ± 14	58 ± 13
Age ≤ 65 years	20 (83%)	20 (87%)	18 (90%)	9 (75%)	16 (73%)
Gender (male)	16 (67%)	21 (91%)	17 (85%)	9 (75%)	18 (82%)
Witnessed arrest	19 (79%)	19 (83%)	18 (90%)	11 (92%)	17 (77%)
Bystander CPR	24 (100%)	22 (96%)	20 (100%)	11 (92%)	22 (100%)
Shockable rhythme	14 (58%)	14 (61%)	11 (55%)	6 (50%)	16 (73%)
No shockable rhythme	10 (42%)	9 (39%)	9 (45%)	6 (50%)	6 (27%)
MI	15 (63%)	15 (65%)	7 (35%)	7 (58%)	12 (55%)

Conclusions: Even in a single ECPR center, annual survival rates vary substantially. The variations may, at least in part, be explained by changes in triage.

Annual audits may help identify even minor changes in selection criteria for ECPR and are important during initiation and development of an ECPR program.

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Triple mechanical circulatory support systems approach to support an LVAD patient with combined right heart failure and severe post-cardiac arrest syndrome to cardiopulmonary recovery

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Objectives: We report the postoperative intensive care management of a patient suffering from combined cardiogenic shock and post-cardiac arrest syndrome after LVAD replacement for pump thrombosis. Intraoperatively, the patient developed right heart failure resulting in cardiac arrest. Further course was complicated by persisting shock. Even though systemic blood pressure was adequate, the further course was complicated by consistent shock symptoms. The reason for that was to be found in insufficient systemic perfusion rather than blood pressure. Simultaneously occurring resuscitation-related acute respiratory distress syndrome (ARDS) further complicated finding an appropriate mechanical circulatory support (MCS) solution.

Methods: Implementation of an escalating, triple MCS approach.

Results: Initial resuscitation was performed with veno-arterial extracorporeal life support (v-a-ECLS) in parallel to the LVAD to address right heart failure. Despite an adequate perfusion pressure, the patient remained in a persistent shock-status with sustainably elevated indicators of systemic hypoperfusion. Due to the requirement for a higher systemic blood flow and to protect the LVAD from pump thrombosis, an additional temporary RVAD (tRVAD) was implanted. This resulted in a resolution of shock-status and moreover served as part of the subsequent weaning strategy. Meanwhile, the patient developed resuscitation-related ARDS with concomitant Harlequin syndrome. Therefore, a second oxygenator had to be incorporated into the tRVAD. After recovery, stepwise de-escalation of the MCS-strategy could be performed successfully.

Conclusions: With this triple mechanical circulatory support approach, recovery from multiple organ failure was achieved. The v-a-ECLS system was explanted first, followed by the RVAD-oxygenator and finally, after right ventricular recovery, the tRVAD.

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An unusual presentation of a mixed overdose resulting in the need for Extra-Corporeal Life Support (ECLS)

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Objectives: Limited evidence exists to support the use of ECLS in the context of cardiogenic shock due to drug toxicity, mainly in the form of case reports and case series.

Methods: A 43-year-old woman presented to the Emergency Department, after ingestion of a mixed intentional overdose of olanzapine, mirtazapine, and diazepam. At presentation she was alert and sinus tachycardia was the only abnormal physical finding. Within 3 hours her Glasgow Coma Score fell to E4M5V1 and she was noted to have ocular clonus, left gaze nystagmus and developed tonic-clonic seizure activity, requiring intubation. This collection of clinical signs was thought to be indicative of serotonin syndrome. Echocardiography revealed severe biventricular failure and subsequently developed ventricular tachycardia with haemodynamic compromise. She received electrical cardioversion, intravenous calcium chloride and sodium bicarbonate, and reverted to sinus tachycardia. She remained dependent on vasopressor and inotropic support, with a rising lactate and was referred to our centre for consideration of ECLS. High dose insulin with dextrose was administered as per guidance from the National Poisons Centre. Following a trial of milrinone to minimal effect, she was commenced on Veno-Arterial (VA)-ECMO.

Results: In the first 24 hours she was weaned from inotropic support, her lactate normalized, and LV function improved to 35% on echocardiography. On day 3 she was decannulated and had a normal echocardiogram the following day. She was stepped down to ward level care on day 7 and discharged home on day 15. On follow up at our Critical Care Follow Up clinic, she was at her baseline exercise tolerance and had improved significantly from a mental health point of view.

Conclusions: The rapidity of her cardiovascular collapse highlights the need for careful monitoring of these patients, even when clinically stable initially. Reflecting other case reports, despite severely impaired ventricular function, only a short run of ECLS was necessary and resulted in good recovery.

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Role of VA-ECMO in traumatic cardiac arrest? A shock team guided pathway to decision making – a case report

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Objectives: VA-ECMO is increasingly being used in severe trauma[1], but decisions regarding patient suitability for VA-ECMO in these cases are complex[2]. Here we describe a case highlighting clinical and logistical challenges faced when managing cardiogenic shock in trauma.

Methods: A pre-hospital resuscitative thoracotomy was performed on a 24-year-old male with witnessed out of hospital cardiac arrest following penetrating chest trauma. Return of spontaneous circulation (ROSC) was achieved after 20minutes. Upon transfer to a tertiary trauma centre, the patient went to theatre for surgical ligation of bleeding intercostal arteries, complicated by a further cardiac arrest lasting 12minutes. The patient remained in cardiogenic shock despite escalation of cardiovascular support on the intensive care unit, prompting referral to our centre for VA-ECMO. A "shock team" (multidisciplinary cardiac specialists) discussed the case and it was agreed that the patient was a potential candidate for VA-ECMO despite prior CPR and suspicion of myoclonic jerks, but with no obvious pathology on a CT head, normal reactive pupils and young age.

Results: Upon arrival to our unit, he had a pulmonary artery catheter inserted and his cardiac function improved with increased inotropic support and VA-ECMO was not required. An echocardiogram demonstrated the presence of a traumatic VSD and left-to-right shunt. Following cardiovascular improvement, a sudden deterioration resulted in an emergency surgical re-thoracotomy for bleeding and an inferior myocardial defect was repaired. Despite successful weaning of inopressors, different multimodal predictors of neurological outcome demonstrated severe hypoxic brain injury and a decision to withdraw life-sustaining therapy was made.

Conclusions: There is no current no consensus criteria for VA-ECMO in cardiogenic shock after severe trauma. Challenging decision making can be mitigated by real time multi-disciplinary team involvement along with multimodal patient physiological data.

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Postcardiotomy VA-ECMO outcomes and utility of the postcardiotomy ECMO (PC-ECMO) score

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Objectives: Extracorporeal life support use for postcardiotomy shock has increased substantially worldwide, but with disappointing outcomes. Various scores have been developed to help identify patients at high risk of early mortality after cardiac surgery, including the recent postcardiotomy extracorporeal membrane oxygenation (PC-ECMO) score. This review aimed to describe our experience with, and find predictors for, successful outcome in this highly select cohort of patients, and compare outcomes with the PC-ECMO score.

Methods: Retrospective analysis of consecutive postcardiotomy cases supported with venoarterial (V-A) ECMO from Aug 1st 2012 to December 31st 2021 were evaluated using electronic and paper medical records. Demographics, ECMO configuration, reason for cardiac surgery, management and outcomes were compared between survivors and non survivors.

Results: 22 patients (female 27.2%) were eligible for analysis. Median age was 55 years [IQR: 47-61]; SOFA score 14 [11-15]; peak lactate 14 [9-17]; PC-ECMO score 4 [2-7]. 20/22 (90.9%) received peripheral V-A ECMO. Overall, ECMO survival was 16/22 (72.7%); ICU and hospital survival 14/22 (63.6%). Survivors had longer ECMO runs 10 [7-13] vs 3 [1-6] ($p = 0.012$), and longer ICU LOS 30 [24-49] vs 3 [1-6] ($p<0.001$). PC-ECMO score was not significantly different between survivors and non-survivors 3 [2-6] vs 7 [4-11] ($p = 0.082$). Type of surgery ($p = 0.062$), peak lactate ($p = 0.261$), age ($p=1$), gender ($p = 0.351$) and SOFA score ($p = 0.406$) also did not differ between groups.

Conclusions: Postcardiotomy V-A ECMO outcomes are encouraging. The PC-ECMO score appeared to overestimate mortality in lower and higher predicted risk groups in our institution. Further research is still required to identify adverse prognostic factors in this population.

Adult - Lab session - fundamental research

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Effect of sevoflurane versus propofol for inflammatory response during veno-venous extra corporeal membrane oxygenation

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Objectives: Acute respiratory distress syndrome (ARDS) was a clinical syndrome caused by intrapulmonary and/or extrapulmonary causes, characterized by refractory hypoxemia. Venovenous extracorporeal membrane oxygenation (VV ECMO) was now considered as a

reasonable option to save ARDS, but this requires sedation of the patient. Several studies suggest that anesthetics, such as Sevoflurane and propofol, have lung protective and immunomodulatory functions. The aim of this study was to investigate the effects of Sevoflurane and propofol on ARDS in VV ECMO model of rats.

Methods: To establish the model of VV ECMO assisted oleic acid (OA)-induced ARDS in rats. Twenty-four SD rats were randomly divided into 2 groups: Sevoflurane group (Sevo group) and propofol group (Pro group). The basic vital signs of rats in each group were continuously monitored by a life monitor, arterial blood gas tests were performed at the following three time points: T0 (Baseline), T1 (The time to ARDS), T2 (Weaning from ECMO for 1h). Bicinchoninic acid assay (BCA) method was used to detect protein concentration in bronchial alveolar lavage fluid (BALF). HE staining was used to evaluate the lung pathological scores in each group, and inflammatory factor (IL-1β, TNF-α, MPO) in serum was detected by ELISA and immunohistochemistry (IHC).

Results: In terms of blood gas index, Sevo group was better than Pro group in improving oxygenation function ($P<0.05$). However, there was no significant difference in mean arterial pressure (MAP) between the two groups ($P>0.05$). After VV ECMO assistance, the degree of lung injury and inflammatory changes in the Sevo group were significantly reduced compared with the Pro group.

Conclusions: In our study, sedation with sevoflurane during VV ECMO assisted ARDS in rats could improved lung injury and inflammation, and was better than propofol in improving oxygenation function.

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In vitro hemocompatibility screening of a slippery liquid impregnated surface coating for extracorporeal organ support applications

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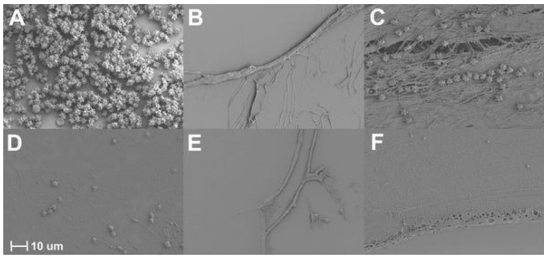
Objectives: Clot formation and biofouling are unfortunate but frequent complications associated with blood-contacting medical devices. The challenge of blood-foreign surface interactions is exacerbated during medical device applications involving substantial blood contact area and extended duration of use, such as extracorporeal life support (ECLS). The objective of this study was to evaluate the efficacy of a liquid-impregnated surface (LIS) designed to minimize protein adsorption and thrombus development on medical plastics. We hypothesized that LIS reduces protein adsorption and subsequent thrombus deposition relative to control medical polymers in a sequence of in vitro models.

Methods: The hemocompatibility and efficacy of LIS was investigated first in a low-shear model with LIS applied to the lumen of blood incubation vials and exposed to citrated human whole blood. Additionally, LIS was evaluated in a 6 h ex vivo circulation model with heparinized swine blood using full-scale ECLS circuit tubing and centrifugal pumps with clinically relevant flow rate (1.5 L/min) and shear conditions.

Results: Under low-shear, LIS preserved fibrinogen concentration in blood relative to control polymers (+40±6 mg/dL vs polyvinyl chloride, $p<0.0001$), suggesting protein adsorption was minimized. A fibrinogen adhesion assay demonstrated a dramatic reduction in protein adsorption under low shear (87% decrease vs polyvinyl chloride, $p = .01$). Thrombus deposition and platelet adhesion visualized by scanning electron microscopy was drastically reduced (Figure 1). During high-shear evaluation, platelets in blood exposed to LIS tubing did not become significantly activated or procoagulant, as occurred with control tubing; and again, thrombus deposition was visually reduced.



Conclusions: The LIS coating is a promising option to reduce thrombus formation on medical devices. Further testing is needed tailored to clinical setting and duration of use for specific medical target applications.

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Combination of dexamethasone with venoarterial extracorporeal membrane oxygenation against myocardial injury by attenuating inflammatory response

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Objectives: Myocardial ischemia potentially causes myocardial inflammation. Research indicates that the

venoarterial extracorporeal membrane oxygenation (VA ECMO) provides cardiac support; however, the inflammatory response caused by myocardial ischemia remains unresolved. Dexamethasone (Dex), a broad anti-inflammatory agent, exhibits a cardioprotective effect. This study aims to investigate the effect of dexamethasone on a rat model of acute myocardial infarction (AMI) resolved via VA ECMO strategy.

Methods: Male Sprague-Dawley rats (300 to 350 g) were randomly divided into three groups: Sham group (n=10), ECMO group (n=20) and ECMO+Dex group (n=20). The ECMO and ECMO+Dex groups were subjected to 30 minutes of AMI and 150 minutes of VA ECMO. AMI was induced by ligating the left anterior descending artery (LAD). In the ECMO+Dex group, dexamethasone (0.2 mg/kg) was intravenously injected into the rats 30 minutes after ligation of LAD. We performed continuous blood pressure and temperature monitoring. The parameters of blood gas analysis were recorded at two time points: 0 (T0, baseline), 30min (T1, after ligation of LAD) and 3.5h (T2, after VA-ECMO support). Lastly, myocardial tissue and blood samples were harvested for further evaluation.

Results: Compared with the ECMO group, the ECMO+Dex group significantly reduced infarct size ($P < 0.01$) and levels of cTnI, cTnT and CK-MB ($P < 0.001$, $P < 0.01$, $P < 0.01$, respectively). TUNEL staining showed that apoptotic cells were markedly lower in the ECMO+Dex group than that in the ECMO group ($P<0.01$). The expression levels of *Bax*, *Caspase3,* and *Cle-Caspase3* proteins were significantly downregulated in the ECMO+Dex group ($P<0.001$, $P <0.001$, $P <0.01$, respectively). Neutrophil and macrophage infiltration was lower in the ECMO+Dex group than that in the ECMO group ($P <0.001$, $P<0.01$, respectively). A significant reduction was noted in *ICAM-1*, *C5a*, *MMP-9*, *IL-1β*, *IL-6*, and *TNF-a*.

Conclusions: In summary, our findings revealed that through anti-inflammatory effects, dexamethasone alleviates myocardial injury in a rat model of AMI resolved via the VA ECMO approach.

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Overcoming the cerebral no-reflow phenomenon after cardiac arrest by extracorporeal circulation: Preliminary results of a [15O] water PET study

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Objectives: Survival after cardiac arrest (CA) and especially survival without neurological deficits remains low despite advances in cardiopulmonary resuscitation. A major cause appears to be the cerebral no-reflow phenomenon, which can still be observed hours after the return of spontaneous circulation. The aim of this study was to measure cerebral blood flow (CBF) during controlled whole-body reperfusion using extracorporeal circulation after prolonged normothermic CA.

Methods: N=4 pigs received an electrically induced CA. Following 20 minutes of normothermic, untreated CA, CARL reperfusion (controlled automated reperfusion of the whole body (CARL)) was performed over a period of up to 2 hours. CARL therapy is based on extracorporeal circulation and includes high pulsatile flow, hypothermia up to 32°C and a hyperosmolar priming solution. CBF was measured before CA (baseline) and during CARL therapy using [15O]water positron emission tomography (PET) and continuous arterial blood sampling. Intracranial pressure (ICP) was also measured continuously in N=1 pig.

Results: In all experiments, global CBF after 8 (±3) min of reperfusion was reduced on average by 38% (interval: [-6;-69]%) (21.0 ml/min/100g) compared to baseline (33.7 ml/min/100g). A regional analysis showed a virtually absent cortical CBF (no-reflow), while CBF in the brainstem and cerebellum presented unchanged to increased. As reperfusion progressed, CBF increased continuously in all regions until it exceeded baseline values. One hour after the start of reperfusion, global CBF was increased by an average of 102% compared to baseline (68.2 ml/min/100g, interval: [+3;+238]%) and seemed to approach baseline values again after 2 hours of reperfusion.

Conclusions: For the first time, we were able to measure CBF and ICP during extracorporeal resuscitation using CARL. CARL therapy with high pulsatile flow showed the potential to overcome the no-reflow phenomenon. Optimising reperfusion after CA could thus improve neurological survival after CA. In further trials, the measurement of markers of neuron vitality is planned.

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Multi-day intensive care unit evaluation of a nitric oxide eluting extracorporeal life support circuit for heparin free ECCO2R

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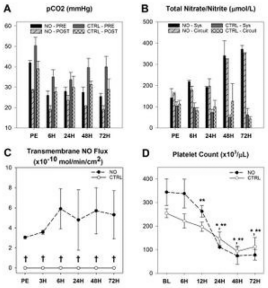
Objectives: Nitric oxide (NO)-releasing biomaterials that inhibit platelet activation and aggregation are of interest to minimize thrombosis during extracorporeal CO_2 removal ($ECCO_2R$). We developed an NO-eluting $ECCO_2R$ system including tubing with NO-catalyzing surface coating and NO gas delivered into the membrane. The objective was to compare NO-elution without systemic anticoagulation to standard $ECCO_2R$ for 72h in swine. We hypothesized that NO-elution enables 72h $ECCO_2R$ without significant bleeding/clotting.

Methods: Mechanically ventilated swine were assigned to: 1) CTRL (n=3; 53±2kg): VV-$ECCO_2R$ (1.5 L/min blood flow, 3 L/min sweep gas) using 23Fr dual-lumen cannula and heparin-coated circuit (HLS 7.0, Maquet/Getinge) with systemic heparin; or 2) NO (n=2; 50±1kg): $ECCO_2R$ with NO-catalyzing coating and NO gas admixed (80 ppm) into the membrane sweep. Blood was collected at baseline (BL), post-ECLS (PE) and through 72h to assess blood gases, NO metabolites (nitrate/nitrite), methemoglobin, coagulation, platelet aggregation, and platelet activation.

Results: CTRL required higher FiO_2 and sweep gas flow at 72h (n.s.). CTRL showed lower p_aO_2 and mild ARDS criteria by PFR at 72h (n.s.). The NO group showed higher PFR after PE indicating potential oxygenation benefit, although tidal volumes trended higher than CTRL (Table 1). p_aCO_2 was higher in CTRL from BL-6h. (Table 1). In both groups, reduction in $pCO_2$was observed across the membrane (Figure 1A, n.s.). NO metabolites were elevated numerically in the NO group (Figure 1B); however, methemoglobin was not (Table 1). Platelet count decreased in both groups (Figure 1D). aPTT was elevated in CTRL by 24h. One CTRL membrane occluded at 65h. In both groups bleeding at vascular cannulas and endotracheal tube occurred.

Conclusions: This interim analysis demonstrated the feasibility of 72h NO-eluting $ECCO_2R$ with a trend toward potential clinical benefit.



	Group	BL	PE	6H	24H	48H	72H
F_iO_2 (%)	CTRL	21 ± 0	21 ± 0	21 ± 0	21 ± 0	21 ± 10	63 ± 80
	NO	21 ± 0	21 ± 0	21 ± 0	21 ± 0	22 ± 3	26 ± 5
V_T (mL)	CTRL	517 ± 12	430 ± 12*	443 ± 7*	443 ± 7*	390 ± 23*	400 ± 30*
	NO	500 ± 10	366 ± 5*†	495 ± 5	445 ± 45	445 ± 45	470 ± 20
PFR	CTRL	430 ± 50	460 ± 40	460 ± 60	500 ± 80	390 ± 60	260 ± 200
	NO	440 ± 10	460 ± 0	520 ± 30	500 ± 50	470 ± 75	470 ± 20
Sweep Gas (L/min)	CTRL	N/A	3 ± 0	4 ± 1	4 ± 1	5 ± 1	9 ± 6
	NO	N/A	3 ± 0	5 ± 0	3 ± 1	4 ± 0	6 ± 2
$paCO_2$ (mmHg)	CTRL	40 ± 1‡	40 ± 1‡	30 ± 2*‡	28 ± 2*	33 ± 3*	30 ± 3*
	NO	44 ± 1*†	33 ± 2*†	20 ± 2*†	22 ± 2*	21 ± 2*	20 ± 2*†
paO_2 (mmHg)	CTRL	90 ± 10	94 ± 8	97 ± 13	103 ± 13	107 ± 18	82 ± 15
	NO	92 ± 10	98 ± 1	110 ± 7	104 ± 11	96 ± 15	118 ± 15
MetHb (%)	CTRL	1.0 ± 0.1	0.8 ± 0.3	1.0 ± 0.2	1.0 ± 0.2	1.4 ± 0.5	1.0 ± 0.1
	NO	1.0 ± 0.1	1.3 ± 0.4	1.3 ± 0.2	1.3 ± 0.2	1.2 ± 0.3	1.1 ± 0.2
ACT (sec)	CTRL	90 ± 2	132 ± 1	129 ± 10	135 ± 7	173 ± 44*	113 ± 4
	NO	92 ± 3	128 ± 5	77 ± 5*†	97 ± 2	82 ± 3	86 ± 1
aPTT (sec)	CTRL	30 ± 2	50 ± 5*	50 ± 9	72 ± 3*‡	82 ± 10*‡	32 ± 4
	NO	29 ± 0	58 ± 6	26 ± 0	25 ± 4	19 ± 0*†	10 ± 1

Table 1. Mean ± SE summary of blood gases, ventilator and extracorporeal circuit settings, methemoglobin fraction (MetHb) as an indicator of nitric oxide (NO) toxicity in animals receiving extracorporeal life support (ECLS) with standard circuitry and systemic anticoagulation (CTRL, n=3) versus ECLS with NO-eluting circuitry and no systemic anticoagulation (NO, n=2). All tests were two-sided with $p \leq 0.05$ for significance. Within-group significant difference from baseline for *CTRL and **NO. ‡Indicates between group difference. ACT, activated clotting time; aPTT, activated partial thromboplastin time; FiO_2, fraction of inspired oxygen; $paCO_2/paO_2$, partial pressure CO_2 and O_2 in arterial blood; PFR, paO_2 to FiO_2 ratio; V_T, tidal volume.

Figure 1. Mean ± SE of key outcome measures during 72 h extracorporeal CO_2 removal ($ECCO_2R$) using a nitric oxide (NO) eluting $ECCO_2R$ system without heparin anticoagulation (NO, n=2) or a standard $ECCO_2R$ system with immobilized heparin coating and systemic heparinization (CTRL, n=3) in healthy swine. Panel A. Pre- and post-membrane blood gas partial pressure of carbon dioxide (pCO_2). Panel B. Concentration of NO metabolites in plasma collected from the systemic circulation (Syst) or immediately post-membrane in the extracorporeal circuit (Circuit). Panel C. Calculated NO flux across the membrane oxygenator. Panel D. Platelet count. All tests were two-sided with $p \leq 0.05$ for significance. Within-group significant difference from baseline for *CTRL and **NO. ‡Indicates between group difference.

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Comparison of vWF and ADAMTS-13 activity after smoke inhalation and burns managed with and without $ECCO_2R$

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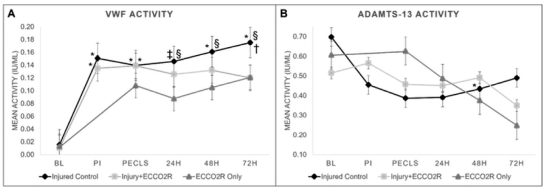
Objectives: Extracorporeal CO_2 removal ($ECCO_2R$) provides partial ventilatory support in respiratory failure after trauma. von Willebrand factor (vWF) is a blood glycoprotein that is integral in hemostasis and shown to increase after trauma. Extracorporeal circulation may impair vWF activity due to protein degradation, causing bleeding; however, it is unclear whether this is due to mechanical damage or enzymatic cleavage by ADAMTS-13. The study objective was to compare combined and individual effects of trauma and $ECCO_2R$ on vWF and ADAMTS-13 activity.

Methods: Female Yorkshire swine received smoke inhalation and 40% TBSA burn with 72-hour follow-up. Injured Controls (N=6) received mechanical ventilation. Injury+$ECCO_2R$ (N=9) received MV+$ECCO_2R$. Injured groups were compared to healthy/uninjured swine placed on MV+$ECCO_2R$ (N=5). Heparin was administered in all groups. Binding capacity of vWF to collagen and ADAMTS-13 activity were measured using vWF:CBA and ADAMTS-13 TECHNOZYM ELISA (Technoclone, Austria). One-way and two-way mixed models detected changes from baseline and among groups ($p<0.05$).

Results: In groups that encountered injury, vWF activity increased post-injury (Figure 1). This increase was sustained in Injured Control through 72-hours. In Injury+$ECCO_2R$, vWF was no longer elevated by 24-hours. In uninjured $ECCO_2R$ Only, no change in vWF was seen. vWF was significantly higher in Injured

Control vs $ECCO_2R$ Only at 24–72-hours. By 72-hours, vWF was 146% higher in Injured Control vs Injury+ECCO2R (p = 0.0029). In all groups, ADAMTS-13 numerically decreased, which was significant in Injured Controls at 48-hours (161% decrease, p = 0.0255).



Conclusions: Injury increased vWF activity regardless of treatment; however, this increase was not sustained in the Injury+$ECCO_2R$ treatment group. ADAMTS-13 activity decreased numerically, regardless of injury/treatment. Combination of elevated vWF activity and decreased ADAMTS-13 activity may suggest a prothrombotic phenotype, which was less pronounced in trauma treated with $ECCO_2R$.

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Changes in circulating H3 Histone levels during extracorporeal membrane oxygenation in patients with severe respiratory failure with correlation to haemostatic complications

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Objectives: Circulating histones are part of damage associate molecular pattern of lung injury. They are also recognised as contributing to a prothrombotic tendency and thrombocytopenia. However, their role during extracorporeal membrane oxygenation (ECMO) has not been described. The aims were 1) To assess changes in circulating H3.1 and citrullinated H3 (H3R8) levels, a marker of NETosis, in patients requiring veno-venous ECMO 2) To correlate H3 with haemostatic events and thrombocytopenia

Methods: Blood samples were taken from 17 patients >18 years old of varying disease aetiologies at a single, high-volume ECMO centre. Samples were taken at pre-ECMO, 1-hour, 1-day, 2-days, pre-decannulation and 1-day after. Samples were analysed by ELISA for H3.1 and H3R8 according to manufacturer's protocols (Volition, Belgium). Ethical approval was gained for the study with nominated consultee consent for patient samples.

Results: H3.1 (reference range 0-48ng/mL) was significantly elevated prior to cannulation and continued to increase during the first 2 days (median 1271 to 1924ng/mL, p = 0.031). There was a similar increase in H3R8 (reference range 0-4.7ng/mL) following the first 2 days (49.6 to 123.9ng/mL, p = 0.012) however H3.1/H3R8 ratio remained stable (19.7 to 12.5, p = 0.26). There was a decrease from preceding to decannulation to 1-day after in H3.1 (1321 to 953ng/mL, p = 0.030) and H3R8 (58.2 to 36.0ng/mL, p = 0.01). There was no significant difference in H3.1 or H3R8 levels in patients with pulmonary embolism, requiring circuit change, intracranial haemorrhage, or deep vein thrombosis compared to those without. There was no difference in H3.1 levels 24- and 48-hours preceding the development of thrombocytopenia at 2-days of ECMO.

Conclusions: These results suggest a combination of both lung injury and extracellular damage by the ECMO circuit contributing to high levels of circulating H3 histones. There was a lack of correlation between H3 histones to haemostatic events and thrombocytopenia, although given their highly elevated levels, it does not exclude their pathological role.

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Changes in fibrinolysis during extracorporeal membrane oxygenation in critically ill adult patients

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Objectives: Rates of major haemorrhage during the use of Extracorporeal Membrane Oxygenation (ECMO) are high. The fibrinolytic system plays a role in bleeding and survival following trauma and cardiopulmonary bypass but its role during ECMO is poorly described. The aims were to assess the changes in markers of fibrinolysis and fibrinolytic enzymes during veno-venous ECMO and their roles in haemostatic complications during ECMO.

Methods: Blood samples were taken from 17 patients of various disease aetiologies >18 years old at a single, high-volume ECMO centre. Samples were taken at pre-ECMO, 1-hour, 1-day, 2-days, 7-days, pre-decannulation, 1-hour and 1-day after, and during

major bleeding. Samples were analysed by ELISA for fibrinogen, Plasmin-Antiplasmin complexes (PAP), D-Dimer, tPA antigen (Ag), uPA Ag, PAI-1 and TAFI according to manufacturer's protocols. Ethical approval was gained for the study with nominated consultee consent.

Results: Fibrinogen, PAI-1, D-Dimer and PAP levels were increased before ECMO whereas other factors were normal. Fibrinogen fell 1-hour after cannulation. D-Dimers increased over the first 2-days of ECMO and stabilised at 7-days. PAP increased at 2- and 7-days. D-Dimers and PAP fell 1-day after decannulation in comparison to pre-decannulation. There was a positive correlation between D-Dimer and PAP during ECMO (R=+0.61).

Patient with intracranial haemorrhage (n=4) at ECMO initiation had a higher increase in D-Dimer than those without (median change +2421 vs -705 ng/mL FEU, p = 0.069). D-Dimer levels were increased in those with PE (n=4) to those without (n=13) at ECMO initiation (median 9948 vs PE 6192 ng/mL FEU, p = 0.047). During non-intracranial major haemorrhage (n=3), TAFI was lower compared to those without (median 114.5 vs 154.5%, p = 0.004) whereas PAI-1 levels were higher (median=111 ng/mL vs 54.3 ng/mL, p = 0.003).

Conclusions: Fibrinolysis is activated during ECMO in critically unwell patients, with D-Dimers reflective of fibrinolytic activity. This study suggests fibrinolysis may have a role in major bleeding during ECMO.

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A comparison of thrombin generation in an ex vivo circuit and critically ill patients requiring extracorporeal membrane oxygenation

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Objectives: Thrombin generation (TG) is increased with the use of extracorporeal circuits such as cardiopulmonary bypass. TG is also increased in patients with critical illness. The combination of these factors in patients receiving ECMO may therefore be significantly elevated but at present is poorly described. The aims of this study were to assess changes in TG markers in an *ex vivo* circuit of ECMO and in patients receiving veno-venous ECMO for severe respiratory failure before and after 24-hours of ECMO.

Methods: 6 *ex vivo* ECMO circuits with sodium citrate using healthy donor whole blood were run for 24-hours at a high-flow rate (4L/min). Blood samples were taken from 17 patients requiring ECMO prior to and 1-day after starting, and prior to decannulation and 1-day after. Samples were analysed by ELISA for Prothrombin Fragments 1+2 (PF1+2, reference range 200-1200pmol/L), Thrombin-Antithrombin complexes (TAT, 0.8-3.8μg/L) and D-Dimers (<400ng/ml FEU) according to manufacturer's protocols. Ethical approval was gained for the study with nominated consultee consent for patient samples.

Results: In the *ex vivo* circuit, there was no significant increase prior to circuit initiation to 24-hours after in PF1+2 (median 97 to 101pmol/L, p = 0.5), TAT (4.2 to 2.6 μg/L, p = 0.3) and D-Dimers (462 to 506 ng/ml, p = 0.3). Circuit thrombosis was not seen in any circuit.In critically ill patients, there was a significant increase prior to cannulation to 1-day after in PF1+2 (median 729 to 1305pmol/L, p = 0.03) and non-significant increases in TAT (19.5 to 36.9μg/L, p = .7) and D-Dimers (7398 to 9903ng/ml, p = 0.3). There was a significant decrease from prior to decannulation to 1-day after in PF1+2 (median 1453 to 658pmol/L, p<0.001), TAT (40.1 to 11.7μg/L, p<0.001) and D-Dimer (15450 to 11200ng/ml, p = 0.05). 8/9 (89%) circuits reviewed had visible macroscopic thrombus post-decannulation.

Conclusions: ECMO circuits lead to reversible increases in TG in critically patients but this change was not shown in an *ex vivo* model using healthy donor whole blood. Given elevated preceding TG markers in critically ill patients, this suggests that patient-attributable factors may increase TG during ECMO.

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Unloading the left ventricle during extracorporeal membrane oxygenation: Effects on cardiac performance in an experimental model of critical post-cardiotomy failure

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Objectives: Following cardiopulmonary bypass (CPB) and cardioplegic arrest in cardiac surgery, Extracorporeal membrane oxygenation (ECMO) is used for handling critical heart failure. Concomitant left ventricular

venting could protect the myocardium from pressure injury. In an acute porcine model of critical post-cardiotomy failure, haemodynamic and cardiac effects of left ventricular venting during ECMO-supported circulation are studied.

Methods: Nineteen anaesthetized pigs, 56 ± 8 (SD) kg, were put on CPB (90 mL/kg/min) with 40 min of aortic cross-clamping and cardioplegic arrest with a single dose of cold (12-14oC) crystalloid St Thomas 2 cardioplegia. After declamping and cardioversion, ECMO-supported circulation (72 mL/kg/min) was commenced with left ventricle apical venting (n = 9) and with clamped vent catheter (n = 10). After 180 min of assisted circulation, animals were weaned from ECMO and observed for 120 min. Haemodynamics and coronary artery blood flow were recorded throughout. In addition, left ventricular function (pressure-volume loops) and perfusion (microspheres) at baseline and after weaning were recorded.

Results: At Baseline mean aortic pressure (AOP_{mean}) was slightly higher in the group to be vented than in the group not to be vented (106±4 (SEM) and 94±4 mmHg, p = 0.047). There was no difference in other haemodynamic or cardiac variables. During cross-clamping, no haemodynamic differences were detected between groups. Both AOP_{mean} and left ventricular systolic pressure (LVSP) increased in the vented vs. not vented group at the end of the 180 min on ECMO. After weaning, AOP_{mean} and LVSP were increased in animals vented compared to not vented while on ECMO. At 120 min after weaning, Cardiac Index, indexed stroke work and the load independent contractility variable *Preload Recruitable Stroke Work* were increased in vented vs. not vented animals. The left ventricular pressure-volume area was increased in the vented group, whereas myocardial perfusion did not differ. Hence, unloading better preserved left ventricular efficiency.

Conclusions: Left ventricular function, contractility and efficiency is improved, and systemic blood pressure better maintained after wean from ECMO, if the left ventricle is vented during ECMO.

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Physical twin (mock circulatory loop) for evaluation of the impact of ECMELLA configuration on left ventricular pressure and work

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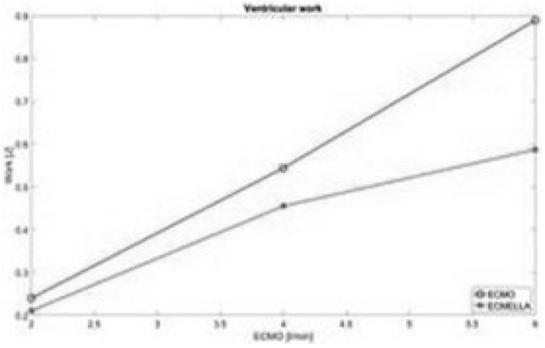
Objectives: To investigate the impact of ECMELLA configuration on left ventricle (LV) unloading by measuring the LV pressure and work.

Methods: We used a mock circulatory loop composed of a custom flow rate pump (representing LV), its software controller, and an aorta phantom. An ECMO system (centrifugal pump, Medtronic Biomedicus 550 Bio-console) was introduced to this circuit in a peripheral configuration and an Impella (ImpellaCP, Abiomed) from the right iliac artery. LV stroke volume was set to normal, -30% and -70% of the healthy condition volume. ECMO support varied from 2 L/ min to 6 L/min, initially without Impella support, then in ECMELLA configuration, by adding an Impella support at P5 level (approximately 2.5L /min). For each setting, we recorded the flow in the three epiaortic trunks, in the descending aorta and the lower body region, the mean and end-diastolic pressure of the left ventricle, and the mean systemic pressure and calculated the LV work.

Results:

- For patients with impaired cardiac output ECMELLA reduces the end-diastolic and mean pressures of the LV.
- For the same level of ECMO support, in the ECMELLA configuration, flows at the level of the epiaortic trunks and in the lower body region reach normal values earlier than with ECMO support alone.
- The flow in the descending aorta is affected by the displacement of the mixing zone.
- LV work is significantly reduced in the ECMELLA configuration for all shock conditions and all levels of ECMO support.



Conclusions: ECMELLA restores normal flow levels in the epiaortic and lower body districts earlier than ECMO alone. LV pressure and work are reduced in the ECMELLA configuration for all shock conditions and ECMO support.

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A porcine model of changes in organ perfusion during veno-arterial extracorporeal membrane oxygenation in cardiac arrest after opening a high-flow arteriovenous fistula

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Objectives: Veno-arterial extracorporeal membrane oxygenation (V-A ECMO) is being used as extracorporeal life support or left-ventricle support during invasive procedures or in cardiogenic shock. Arteriovenous fistulas (AVFs) represent a low-resistant circuit and are suspected to compete with other low-resistance vascular beds (brain, heart, kidney). We created an animal model to study the effect of high-flow AVF on organ perfusion in V-A ECMO in ventricular fibrillation (VF).

Methods: Six female domestic pigs were enrolled. Catheters, wires, and flow probes were inserted to perform haemodynamic and organ flow measurements. Baseline measurements were obtained before start of V-A ECMO. The ECMO circuit was inserted percutaneously by femoro-femoral approach. The high-flow AVF was created percutaneously by directly connecting two ECMO cannulas, also by femoro-femoral approach (see Figure 1). Catheters, wires, and flow probes were inserted to perform haemodynamic and organ flow measurements. VF was induced by rapid right ventricle pacing.

Results: Despite decrease in mean arterial pressure (from 82 to 65 mmHg; p = .07), induction of VF and start of ECMO did not significantly impact brain perfusion and oxygenation compared to baseline. Tissue oxygen tension in liver dropped (p = .0003). Opening of AVF during VF led to unsignificant drop in mean arterial pressure. Carotid blood flow volume decreased (p = .001) and so did the frontal lobe microvascular blood flow (p = .01). Cerebral tissue oxygenation measured by near-infrared spectroscopy decreased after VF induction compared to baseline and did not further decrease after AVF opening.

Conclusions: High flow arteriovenous fistula limits brain perfusion during V-A ECMO on both macrovascular and microvascular levels.

Adult - Nurse

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Nursing ECMO Target Temperature Management (TTM): A retrospective study

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Objectives: During ECMO support, blood goes out from patient, running into a biocompatible circuit though a pump and a mechanical lung, to return finally in the patient, into a vein or an artery. During the external blood course in the circuit, the patient loose temperature: to prevent hypothermia, the heat exchange can manage temperature. When a patient is pyretic? When a patient is hypothermic?ARDS due to Sars-Cov 2 increases ECMO support arroung the world. During hospitalization, nosocomial infections increase, with a high incident of mortality. At ICU bedsides, the common signs of sepsis are hypothension, tachycardia, hyperpyrexia, reduction of mixed venous saturation but these are not the same in relation to ECMO support.

Methods: The aims of the study were a retrospective single center study and a literature review to research temperature management strategies. A literature review was conducted. Inclusion criteria were V-A or V-V support, including adult and pediatric population. Guidelines review of Elso Guidelines and 5th Red Book was applied.

Results: 33 articles were founded, but 13 were considered in relation to the aim of the study. In relation to target management, we have identified the elements to create a Temperature Target Management (TTM). The TTM aims are to identify when a patient has fever, when the heat exchange works and when patient is hypothermic. 14 ECMO patients were analyzed from 2020 to 2022, analyzing ECMO data (i.e. BF, GF, Temperature and Watts of Heat Exchanger) and patient data (i.e. Body Temperature, c-reactive protein, procalcitonin,

white blood cells, blood, urinary, and bronchoaspirate colture).

Conclusions: Temperature of an ECMO patient can be influenced by several factors, represented by conditions related to the ECMO and related to the patient. In relation to ECMO conditions, the BF, the GF and the length of the circuit are risk factors, while in relation to the patient, a septic status can be discovered by a careful assessment of the patient's temperature, heat exchanger and components.

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CRRT on ECMO: A case report of an oxygenator thrombosis near miss

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Objectives: Continuous renal replacement therapy is applied in case of acute kidney injury or in case of fluid overload. CRRT can be connected directly on ECMO circuit, with many advantage in relation to an adeguate blood flow to the CRRT, but with many problems related to anticoagulation management and ECMO - CRRT connections.In this case report, a man of 46 years old was supported by V-V ECMO due to Covid pneumonia. During the ECMO support, he developed an acute kidney injury, with application of CRRT in CVVH mode, with Calcium - Citrate Anticoagulation in addition to Bivalirudin to ECMO anticoagulation. CRRT was applied on ECMO: the access line (from patient to CRRT device) was connected on post oxygenator attack while the reentry line (from device to patient) was locked on pre oxygenator connection. On a morning shift, CRRT alarmed high reentry pressure with no blood flow by device. CRRT was disconnected by ECMO with difficulty of blood sample.

Methods: Literature review was applied and 2014 - 2021 Elso anticoagulation guidelines were consulted.

Results: In literature there is no large articles on anticoagulation management, 2021 ELSO anticoagulation guidelines affirms that bivalirudin is removed by CRRT with major concentration. In relation to the case report, with a lure lock siringhe was suctioned a clot of three centimetres. After the clot removal, the preoxygenator line patency was applied and a new CRRT set was applied without any problems.

Conclusions: During ECMO support in CRRT, tha anticoagulation must be tritated in relation to anticoagulant and blood exams, bilancing thrombosis - bleeding risk. An infusion of systemic heparin can be utilized to anticolagulation of CRRT and ECMO, but only bivalirudin could not be enough. The connection of CRRT on ECMO can be a bleeding or thrombosis risk site, in which a bedside nurse must identify any problems on ECMO and on CRRT.

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ECMO emergencies: The nursing role

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Objectives: ECMO troubleshooting are a life-treating emergency. An ECMO nurse must know ECMO and Patient Emergency management to reduce the mortality. Some ECMO emergency are similar in case of V-V or V-A ECMO, but there are many differences in relation to respiratory or cardiac support: in particular, an ECMO nurse should manage emergency on ECMO and on patient with a rapid sequence of actions. Some technical and non-technical skills are involved, in particular decision making, teamwork, leadership, stress management.

Emergency examples are represented by a pump failure with cardiogenic shock or cardiac arrest in case of V-A ECMO or accidental decannulation with acute hypoxemia and hemorrhagic shock in case of V-V ECMO.

A literature review was applied to create an ECMO emergency action card algorithm.

Methods: A literature review was applied in PubMed and in ELSO Guidelines. The inclusion criteria were troubleshooting in adult population, while pediatric population was excluded. Articles about V-V or V-A ECMO were included.

Results: Some articles were founded in relation to ECMO troubleshooting and ECMO Emergencies related to patient and to extracorporeal support. Articles about an emergency management on patient not related to ECMO troubleshooting were excluded.

Conclusions: The principal ECMO life – treating emergencies were converted into an algorithm, an action card in which a nurse can identify the right action in the right time. The algorithm is divided in life-treating emergencies and urgency, with indication on actions that must be done to preserve ECMO and patient. The action card can show what and when do something, who to call in case of emergency and how optimize the ventilation and cardiocirculatory support until extracorporeal support recovery.

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ECMO nursing activities score: A retrospective study

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Objectives: The nursing activies score (NAS) measures the nursing workload in intensive care unit. In relation to other ICU patients, an ECMO patient increases NAS, with a ratio of 1:1, as cited in ELSO Guidelines. In many Italian centers, the 1:1 ratio can not be guaranteed, with one nurse to two patients.During Covid pandemia, V-V and V-A ECMO was widely increased: V-V ECMO increases cause of Covid ARDS while V-A ECMO was applied in patient with a "C" or "D" class of SCAI cardiogenic shock pyramid, due to a delay of hospitalization in relation to Covid Emergency Respond as reported by WHO diseases reports.

Methods: A retrospective study was done on V-V ECMO of a Covid Intensive Care Unit. NAS was calculated on patients before and after ECMO implant and it was related to other ICU patient in the same time. The data was collected from October 2020 to January 2022. Inclusion criteria were patients admitted in Covid Intensive Care Unit, analyzing NAS in experimental group (ECMO patients) vs control group (Non-ECMO patients). V-A ECMO were excluded.

Results: 269 was admitted in our ICU from 10th october 2020 to 22th january 2022. In these period, iNO, CRRT, ECMO, ECCO2r were applied.About ECMO patients, in a total of 14 V-V ECMO reported by Covid EuroElso Survey, 12 ECMO were applied in our ICU.

Conclusions: Actually, NAS is the only score that can evaluate the nursing workload, but it's incomplete in relation to specific ECMO care (i.e. implantation, complications, circuit changing, ECMO removing) and in relation to health care providers (i.e. application of personal protective equipments - PPE).From NAS calculation, ECMO patients must have a minimum ratio of one nurse to one patient. in many cases the ratio should be elevated to 1.5 - 2 nurses to one ECMO patient, but in many shifts this ratio was no possible, with a median of 60%, 0.6 nurse to 1 V-V ECMO patient.

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Cerebral NIRS in ECMO: An algorithm to bedside ECMO nurse

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Objectives: During ECMO support, cerebral accident are associated to a poor neurological outcome. (Pozzebon et al., 2018) In relation to neurological assessment and a good neurological outcome, the international resuscitation guidelines of European Resuscitation Council enphasize a good CPR and a good post cardiac arrest care. (Yagi et al., 2020) ECMO can play a key role in the resuscitation, in return of spontaneous circulation, in acute respiratory distress syndrome , but many cerebral accident can occur in relation to cardiac arrest period, to hypoxemia during ARDS, to thrombotic or hemorrhagic stroke during ECMO support. A neurological assessment can be provided by NIRS that measures the regional saturation of oxygen (rSO_2), impending hypoxic damage in relation to respiratory or cardiocirculatory problems, in cerebral o peripherical monitoring (i.e. in distal perfusion cannula monitoring). Changing in NIRS values are differents in relation to V-V ECMO and to V-A ECMO and a correct interpretation can change the neurological outcome.

Methods: A literature review was conducted on Pubmed. The key words were "NIRS" AND "ECMO" OR "extracorporeal membrane oxygenator" AND "adult". The limit of publication was ten years. The inclusion criteria were both configurations of ECMO (V-A and V-V) and adult population. Pediatric population was excluded.ELSO guidelines and principal ECMO bibliography in english and italian language were consulted.

Results: From a total of 13 articles were identified by literature review. From those, 5 articles were excluded due to NIRS application to distal leg monitoring in V-A ECMO. Five books about ECMO care were consulted.

Conclusions: From clinical experience and in relation to literature review, an algorithm to guide the bedside nurse was created about Cerebral NIRS Nursing Assessment. From this algorithm, a nurse can identify when a value can be dangerous or not, when a nurse can verify the correct device functioning or when a nurse must call help for advanced medical treatment, as in case of Arlequin Sindrome in V-A ECMO or in case of recirculation in V-V ECMO.

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Evaluation of nursing records before and after multidisciplinary training in extracorporeal membrane oxygenation

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Objectives: To compare the content of the nursing record regarding extracorporeal membrane oxygenation (ECMO) information, between the pre and post-training periods of the multidisciplinary team.

Methods: This is a retrospective study, realized in an adult intensive care unit, in which the sample was composed of all the medical records of patients who underwent ECMO between 2012 and 2019. Nursing records referring to the specific ECMO content during the first three days of therapy were analyzed. To compare the records, they were divided between the pre and post-training periods of the multidisciplinary team.

Results: 72 medical records were included, of which 194 nursing records were analyzed. Descriptions about ECMO were more evident in the post-training period, with emphasis on the information of whipping (8.7% vs 60.8%, $p<0.001$), circuit and membrane conditions (28.3% vs 75.7%, $p<0.001$), blender (34.8% vs 81.8%, $p<0.001$), sweep gas (39.1% vs 85.1%, $p<0.001$), flow (58.7% vs 85.8%, $p<0.001$), rotation (43,5% vs 81,8%, $p<0.001$), heater temperature (32.6% vs 73.0%, $p<0.001$), ECMO and patient complication (58.7% vs 90.5%, $p<0.001$), pre and post coloring of circuit (13.0% vs 58.8%, $p<0.001$), and alarm adjustment (0 vs 16.9%, $p = .003$).

Conclusions: It is evident that the multidisciplinary training in ECMO was fundamental for the improvement of information regarding this therapy in the nursing records.

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ECMO nurses training courses: An international survey on EuroELSO ECMO centers

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Objectives: Nurses caring for ECMO patients need specific training and continuous education for acquiring and maintaining technical and non-technical skills.Although available guidelines, many countries, as well as Italy, do not have officially recognized training programs for ECMO, and few are dedicated to nurses specifically. We have proposed a survey to investigate various training models across Europe.

Methods: A multiple-choice questionnaire has been submitted to the European ECMO centers members of EuroELSO to investigate what training program was put in place and in particular if specifically dedicated to nurses.The local Ethics Committee approved the dissemination of the questionnaire and data collection.

Results: In Europe ECMO centers adopt similar methods for training nurses, but each center has developed its own program, with different frequency and covered topics. An official certification is not always provided. The main results of the questionnaire are reported in figure 1.

Survey participation rate	14/92 (15%)
ECMO Centers with more of 10 years of experience	13 (92.9%)
Official ECMO Nurse profile present in the center	8 (57.1%)
Presence of Training programs for ECMO nurses	14 (100%)
Training Program for ECMO BedSide Nurses	6 (75%)
Training Program for ECMO Nurse Specialist	5 (62.5%)
Training Program for ECMO Nurse Coordinator	4 (50%)
Use of frontal lessons	11 (91.7%)
Use of Bedside Training	12 (92.3%)
Use of simulation	13 (100%)
Frequency of practical sessions	4 (30.8%) Twice a year 3 (23.1%) More of Twice a Year 3 (23.1%) Once a year 1 (7.7%) Each month 1 (7.7%) Twice a month 1 (7.7%) Once every two years
How the Simulation is performed	8 (61.5%) Use of Training manikins 6 (46.2%) High Fidelity 6 (46.2%) Use of circuit without manikins
Use of emergency scenarios simulations	12 (92.3%)
Techniques to evaluate training performance	8 (61.5%) Written exam 5 38.5%) Practical exam 4 30.8%) Oral exam 2 (15.7%) ongoing assessment
Presence of certification at the end of training program	9 (69.2%)
National/Regional recognition of the certification	4 (25%)
Retraining performed at least once a year	7 (53.8%)
Maintaining of certification after retraining	11 (84.6%)

Figure 1

Conclusions: Although training programs for personnel who care for ECMO patients is crucial, our survey shows that there is a wide variability in the mode of training, retraining and maintaining the skill levels of ECMO attending nurses.

We believe that defining common standards for ECMO educational programs should be encouraged and that an official certification for nurses specifically trained for ECMO should be provided both locally and at an European level.

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The FMECA (Failure Mode, Effects and Criticality Analysis) investigation seems an effective and feasible method to ensure clinical safety during transport of patients to VV-ECMO

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Objectives: Careggi Teaching Hospital ECMO Team has been active since 2009. It is composed of Intensivist, Cardiac Surgeon, Cardiologist, Nurse and Perfusionist available 24/7 for interhospital transfer of ECMO patients in Tuscany and neighboring Regions. This study reports the improvement of our transportation method following the FMECA analysis.

Methods: All adverse events occurred during transports from 2017 to 2019 have been considered and the whole system of our transportation procedures has been analyzed by a FMECA approach.Cross-referring to the detected adverse events and the more critical aspects as revealed by FMECA analysis the whole procedure was thoroughly revised and points for improvement have been identified.

Results: Check-lists were in use and covered most phases of the transport helping the ECMO team to stay focused on safety. In the study period, 30 transports were performed (approx. 185 hours). Thirteen adverse events were detected without clinical consequences for patients. 38,46% of the events occurred due to deviation from standard procedures while 61.54% occurred in phases not covered by the actual check-lists. A FMECA analysis was conducted by a multidisciplinary team composed of intensivist, nurse and perfusionist.

15 phases of the transport process and 178 possible adverse events have been analyzed; 64,04% of them were insufficiently detectable by our checklists. RPN (Risk Priority Number) values varying from 5 to 600 were assigned (mean 142.31, StDev 123.50). The thirteen errors had occurred in phases with high

RPN values (mean 120, StDev 130,64). Thanks to this analysis, the most critical phases of ECMO transport could be identified and some improvement could be developed. Among these, more powerful check-lists were introduced to cover VV-ECMO transport activity. The Nurse coordinator for the transfer was appointed as responsible for the safety of the transport phases and was in charge of compiling the new check-lists.

Conclusions: Implanting ECMO in peripheral hospitals and transporting patients on ECMO is a complex procedure and adverse events can occur. The FMECA analysis seems an effective and feasible method of addressing the risks of the procedure.

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Active participation during the educational process of Donation after Circulatory Death (DCD) at Extra Corporeal Membrane Oxygenation (ECMO) intensive care units. An intervention study

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Objectives: Participatory Action Research (PAR) is a theoretical approach offering experimentation with evidence-based and people-based inquiry and are promoting the grounding of knowledge in human agency and social history. Intervention research examines the effects of an intervention with an outcome of interest, in this case how active participation from ICUnurses can frame a feeling of participation, secureness and curiosity for the ICUnurse in the complex caring situation of DCD at ECMO-ICU.

Methods: Aim: Evaluate active participation during the education process of DCD and if active participation can frame a feeling of comfortability and secureness for the ICU nurses in the caring situation of an potential DCD donor patient with on-going ECMO-treatment.

- Can active participation from the ICUnurse during educational process lead to an experience of comfortably and secureness in the complicated process of DCD and ECMO-treated patients?
- Can a specific made education plan lead to a feeling of participation, secureness and curiosity for the complex process of DCD and ECMO-treated patients.

A quasi-experimental, nonequivalent two group design. One experimental group and one active control group. A quantitative non-standardized questionaries will collect data before and after the intervention. Study will take place at New Karolinska Hospital, Sweden.

Results: Caring of a potential organ donor patient is described as a complex and multidimensional situation. ICUnurses' cares for the patient as a patient with an extreme need of intensive treatment. When treatment goes from lifesaving for the patient himself to a situation with focus on medical treatment for the organs for someone else, the dimension of caring changes, and a deeper level with a need for reflection and contemplation for the ICUnurse is illuminated.

Conclusions: DCD-process and ECMO-treatment is an un-explored area, which leads to a huge need for further dissemination of this type of studies worldwide. By create an education plan managed by ICUnurses', for ICUnurses' by using their active participation, the process hopefully manage a new way to avoid ethical challenges and dilemmas during implementation of complicated processes at ECMO-ICUs' worldwide in the future.

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ECMO SAT-extracorporeal membrane oxygenation site assessment tool

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Objectives: To create and validate a site assessment tool to allow visualization and facilitate cannula insertion site assessment, to preserve patient skin integrity, prevent further skin breakdown by frequent dressing change, difficult removal, and cannula site infection prevention on long-term ECMO patients.g term ECMO patient Hard to visualize the cannula site.

Methods: The literature search used the Medical Subject Headings (MeSH) via the online Biomedical Library´s database at the University of California, Los Angeles, Harvard Medical School, and Ohio State University Library. Studies indexed until August 15, 2021, were searched via PubMed, EMBASE, ProQuest, and Cochrane. The terms, including indexed terms (MeSH), individually or using Boolean operators (AND and OR), were "Extracorporeal Membrane Oxygenation," "dressing change," "assessment", "bloodstream infection", and "central line". The original peer-reviewed articles were appraised (17) and selected (7). The articles were focused on long-term ECMO patients´ dressing change practice, cannula securement device, cannula site assessment, ECMO patients mobility, bloodstream infection prevention.

Results: The ECMO SAT was created to support daily assessment and to trigger interventions such as "send culture", "suture", "new dressing", other intervention", or "none". The tool allows the inventory of all insertion points, securement device, bleeding, the need for hemostasis, skin color, drainage, surrounding skin, and to record the patient's mobility level. Also, it allows recording the patient's experience (when they can communicate) regarding how comfortable the patient with their cannula site is. The data collection was completed in October 2021. Study personnel independently complete the ECMO SAT for inter-rater reliability (98% - preliminary results).

Conclusions: ECMO SAT supports evidence-based practice change in regards to ECMO site assessment, dressing change, and securement methods promoting timely intervention to avoid any complications that may occur at the cannula site insertion in long-term ECMO patients. In selected cases allows including ECMO patients' experience.

Adult - Perfusion

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Evaluation's test of the intuitiveness about health workers in the management of the ECMOLIFE system in intensive care unit

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Objectives: Quantification of reaction time through test on individuation and resolution of alarm management during Extracorporeal Life Support (ECLS) simulations between two devices ECMOLIFE (group) VS Levitronix Centrimag (group), for perfusionists, nurses and physicians, who have used ECMOLIFE Technology it for the first time.

Methods: Serial simulations were made with GlassUP Augmented Reality glasses for recording the reaction time in relation to the problems of Cavitation of the venous cannula; Power outage, low arterial saturation; high pressure drop of the oxygenator; presence of air in the venous line, low venous saturation. Reaction time was timed on 9 doctors 9 nurses 6 perfusionists (experts), taking into account the different curve of expertise between professions.

Results: Reaction time for perfusionist mean values (8 ± 2 Sec. For ECMOLIFE vs 14 ± 1 Sec. Levitronix Centrimag p-value 0.002). Reaction time for Nurse mean values (10 ± 1 Sec. For ECMOLIFE vs 15 ± 2 Sec. Levitronix Centrimag p-value 0.033). Reaction time for Physicians mean values (9 ± 1 Sec. For ECMOLIFE vs 14 ± 2 Sec. Levitronix Centrimag p-value 0.029).

Conclusions: Healthcare professionals who have used ECMOLIFE have reported a lower reaction time in individuation and resolving alarms, which is statistically significant compared to levitronix centrimag. However, further studies and a larger population are required to validate this finding.

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Normothermic regional perfusion provides better liver function preservation than hypothermic regional perfusion for circulatory death donors

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Objectives: Donation after circulatory death (DCD) liver grafts have a poor prognosis after transplantation. How to restore the function of DCD donor liver and improve the utilization rate of DCD donor liver is an urgent problem to be solved in the field of liver transplantation. In recent years, extracorporeal membrane oxygenation (ECMO) technology has attracted wide attention in DCD organ protection, which can effectively expand the number of potential donors, improve the utilization rate of donated organs, repair and improve the quality of donated organs. At present, two temperature modes are often used for regional ECMO perfusion of DCD donor liver: normal temperature (36°C) and low temperature (18-30°C). In this study, we established a regional perfusion in a DCD model and applied ECMO to regional perfusion to explore the optimal organ perfusion temperature and potential mechanism of ECMO.

Methods: Rat livers were subjected to 20 min in situ warm ischemia. ECMO was used for regional perfusion, and 12 rats were randomly divided into two groups: normothermic regional perfusion(NRP) group (n=6) and hypothermic regional perfusion(HRP) group (n=6). After two hours of perfusion, changes in ALT and AST between the livers of the two groups were detected. He (hemotoxylin and eosin staining) staining was used to evaluate the liver pathological scores in each group, and inflammatory factors (Il-1β, Tnf-a, Il-6, Il-8) in serum was detected by ELISA according to the manufacturer's instructions.

Results: In terms of liver function, ALT and AST in the NRP group were lower than that in HRP group ($p<0.05$), and the degree of liver injury and inflammatory changes in the NRP group was significantly reduced compared with the HRP group ($p<0.05$).

Conclusions: Our study suggests that NRP during organ recovery from DCD donors leads to superior liver outcomes compared to HRP.

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Demographics and outcomes of COVID19 patients placed on ECMO at a platinum ECLS center

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Objectives: During the COVID-19 pandemic, ECMO was utilized to treat 175 COVID-19 pneumonia patients at Toronto General Hospital (TGH) from April 2020 to December 2021. The aim of this presentation is to review our COVID-19 ECMO outcomes from a uniquely perfusion perspective.

Methods: We conducted a retrospective analysis of 175 COVID-19 pneumonia patients with severe ARDS requiring ECMO from April 2020 to December 2021 at Toronto General Hospital. Demographics, mode of support, cannula configuration, length of treatment, oxygenator performance and patient outcomes were collected and summarized.

Results: The average age of COVID-19 pneumonia patients requiring ECMO was 46.6 years old (ranging from 20 to 65 years old) and 79% of patients were male. The initial mode of support for 99% of this population was veno-venous and 10% were cannulated at a peripheral hospital prior to being transferred back to TGH. Of 175 patients, 90 (52%) were successfully weaned from ECMO support. Median days of ECMO support for survivors and non-survivors were 26.9 and 23.2 days respectively. During the specified time period, a total of 146 oxygenators were changed out, with 81 (47%) patients requiring one or more oxygenator change-outs and 36 (21%) patients requiring two or more oxygenators throughout their ECMO course. 73% of the oxygenator changeouts were a result of poor oxygen transfer, while 22% of changeouts were caused by significant clot burden and rising transmembrane pressures. Ultimately, 47% of the patients weaned from ECMO were discharged from hospital or repatriated back to their community hospital. Three of our ECMO patients were bridged successfully to double lung transplantation.

Conclusions: COVID-19 presented a patient population with many unique pathophysiologic challenges, creating many complicated ECMO runs and the need for creative treatment options. As a department, staff Perfusionists were constantly pushing the boundaries of our ECMO capacity and have gained significant troubleshooting and ECMO management knowledge.

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Numerical and experimental investigation of a drainage cannula

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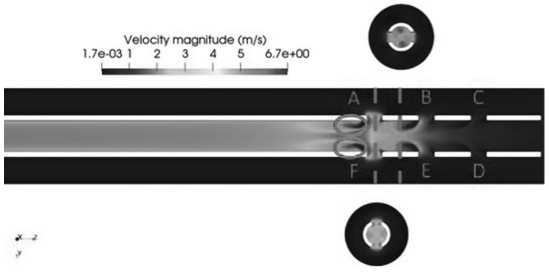
Objectives: The aim of the study was to investigate flow structures and drainage performance of a conventional single stage (lighthouse tip) cannula. The sensitivity of such structures to boundary conditions (drainage and vessel flow), fluid modelling (Newtonian and non-Newtonian), and hematocrit was assessed.

Methods: Cross-validated Computational Fluid Dynamics and Particle Image Velocimetry (PIV) were used on a glass replica of a 24 Fr cannula. Different flow rates were considered experimentally with water (vessel flow to drainage flow ratios: 0.5, 1 and 2). A non-Newtonian model of blood at different hematocrits (20%, 30%, 35%) was employed for the simulations. A water baseline case was considered to validate both setups.

Results: Across all cases the most proximal set of holes (see Figure: A-F) drained the largest fluid fraction (~15% per hole); inside the cannula in flow direction of those holes large recirculation regions developed, with a *jet in crossflow* pattern. The flow rate ratio influenced the amount of flow drained by the end hole. The non-Newtonian behavior of blood showed less significance and was important only in regions distant from the drainage zone. This allowed the use of a simple Reynolds number-based analogy to recover global drainage properties from water data. The use of 2D data coming from PIV led to an underestimation of the shear rate levels of almost 20%.



Conclusions: The considered cannula drained the largest fraction of flow through the proximal holes. The non-Newtonian behavior of blood was less significant, allowing a scaling between water and blood drainage properties.

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First applications of the CARL system in out-of-hospital cardiac arrest

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Objectives: There is increasing evidence for extracorporeal cardiopulmonary resuscitation (ECPR) as a rescue therapy for selected patients in refractory cardiac arrest (CA). Besides patient selection, the control of reperfusion parameters is of eminent importance. Especially in out-of-hospital CA, monitoring and individualized, targeted reperfusion remains a great challenge for emergency personnel. The CARL® system (Resuscitec GmbH, Freiburg, Germany) is designed to enable an early control of a variety of reperfusion parameters and to pursue a targeted reperfusion strategy in ECPR.

Methods: We report the first N=14 out-of-hospital ECPR applications of the CARL® system in Regensburg, Germany. All patients underwent femoro-femoral cannulation. Combination of CARL® Controller with CARL® MOX enabled an immediate control of a variety of reperfusion parameters (i.e., flow, arterial pressure, temperature, venous hemoglobin, oxygen saturation and built-in blood gas analysis) and thereby empowered the ECMO team to pursue a targeted reperfusion strategy in ECPR from the very start.

Results: Early blood gas analysis, oxygen titration and pressure monitoring enabled an individualized and targeted reperfusion strategy in all patients. Despite refractory CA and prolonged resuscitation attempts (mean duration from collapse/start of CPR until start of the CARL® Controller was 41 min [range: 25–85 min]). N=9 (64.3%) of all patients treated with the CARL® system survived and were successfully discharged from the hospital (CPC 1 at hospital discharge). The surviving patients stayed on intensive care unit for a mean time of 16 days [range: 5–33 days] and were discharged from the hospital on average after 24 days [range: 12–48 days].

Conclusions: Targeted ECPR has the potential to improve outcomes in refractory CA. Application of the CARL® system contributed to early monitoring and control of reperfusion parameters.

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Use of nafamostat mesilate for anticoagulation during extracorporeal membrane oxygenation: A systematic review

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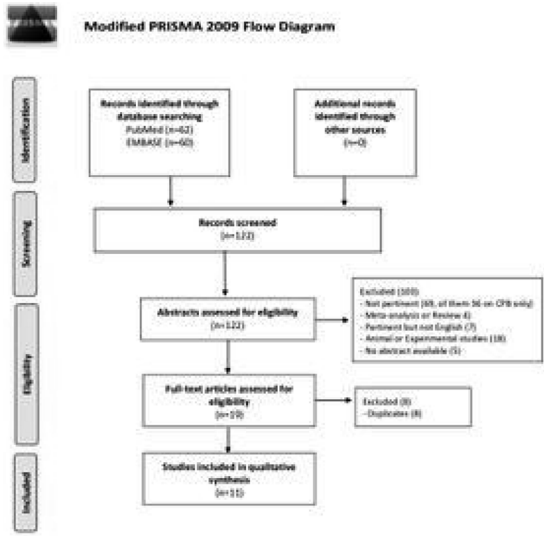
Objectives: Extracorporeal membrane oxygenation (ECMO) represents an advanced therapeutic option for refractory respiratory and/or cardiac failure. Systemic

anticoagulation with unfractionated heparin (UFH) is routinely used. However, patients with bleeding risk and/or heparin-related side effects may necessitate alternative strategies: among these, nafamostat mesilate (NM) has been reported. We performed a systematic search of literature to explore the role of NM in ECMO as compared to the conventional management with UFH.

Methods: We conducted a systematic literature search (PubMed and EMBASE, updated 12/08/2021), including all studies reporting NM anticoagulation for ECMO. We focused on reasons for starting NM, its dose and the anticoagulation monitoring approach, the incidence of bleeding/thrombosis complications, the NM-related side effects, ECMO weaning and mortality.

Results: The search revealed 11 relevant findings, all with retrospective design. Of these, three large studies reported a control group treated with UFH, the other were case series (n=3) or case reports (n=5). The main reason reported for NM use was ongoing or high-risk of bleeding. The NM dose varied largely as did the anticoagulation monitoring approach. The average NM dose ranged from 0.46 to 0.67 mg/kg/h, but two groups of authors reported larger doses when monitoring anticoagulation with ACT. Conflicting findings were found on bleeding and thrombosis. The only NM-related side effect was hyperkalemia (n=2 studies) with an incidence of 15%-18% in patients treated with NM. Weaning and survival varied across studies.



Conclusions: Anticoagulation with NM in ECMO has not been prospectively studied. Whilst several centers have experience with this approach in high risk patients, prospective studies are warranted to establish the optimal space of this approach in ECMO.

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Extracorporeal cardiopulmonary resuscitation (eCPR) - should the patient go to the machine or the machine to the patient? Experiences from 3 years of preclinical extracorporeal cardiopulmonary resuscitation in Freiburg

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Objectives: Survival from cardiac arrest, and particularly survival without neurological deficits, remains low despite advances in cardiopulmonary resuscitation (CPR). With the widespread introduction of mechanical resuscitation devices, more and more patients with ongoing CPR are arriving at cardiac arrest centres. As a result, the decision to continue CPR (typically with extracorporeal systems (eCPR)) is shifted to the hospital, leading to long resuscitation times of up to 120 minutes.

Methods: A concept for establishing prehospital eCPR was developed in collaboration with the local emergency services and the University Hospital Freiburg. In addition to the integration into the alarm and response order, a specially equipped emergency vehicle was configured, the procedures simulated and trained in order to integrate the highly invasive measure of eCPR cannulation as smoothly as possible into the Advanced Life Support algorithm. On weekdays from 8am-4pm, a team of 4 (2 doctors, 1 perfusionist, 1 paramedic) was on call for the project and available via pager.

Results: From September 2018 to July 2021, the team was alerted N=120 times and attended a total of N=90 patients. In 30% of patients, spontaneous circulation (ROSC) was restored before arrival. In N=5 cases, no CPR was performed. N=55 patients still required CPR on arrival, of which N=24 patients received eCPR. The team arrived on scene on average 11.9 (±7.1) minutes after being alerted, reducing resuscitation time from 72.2 (±7.4) minutes to 32.9 (±8.8) minutes compared to in-hospital eCPR.

Conclusions: eCPR is feasible in the prehospital setting and is an alternative to lengthy patient transports under ongoing CPR to the nearest cardiac arrest centre. Not to be neglected is the financial and, above all, personnel effort that this project requires. In particular, patients in favourable neuroprotective situations (e.g., hypothermia) could benefit from the use of prehospital eCPR if the team is alerted to the scene early.

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V-V ECMO in the management of acute Budd-Chiari syndrome

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Objectives: Temporary Adequate Venous Drainage until resolution of Caval and Hepatic vein Obstruction.

Methods: V-VECMO utilisation to achieve adequate lower body venous drainage and return in the clinical scenario of Acute Budd Chiari Syndrome causing acute hepatic failure in a renal failure- dialysis patient.

Results: Budd-Chiari Syndrome is characterized by hepatic venous outflow tract obstruction resulting in congestive hepatopathy and liver failure. It can present as either an acute or chronic process. Management centres on anti-coagulation, restoration of hepatic venous outflow, decompression of the congested liver and the management of associated complications of liver dysfunction. Liver transplantation is sometimes required. The application of veno-venous extracorporeal membrane oxygenation (V-V ECMO) in the management of such cases has scarcely been reported in the literature. In this case report we present the clinical course of a young dialysis patient who presented with liver dysfunction due to acute Budd-Chiari syndrome as a result of an extensive thrombus originating from her dialysis catheter and involving the superior vena cava, right cardiac atrium and inferior vena cava. The patient was initially managed with catheter removal, thrombolysis and anti-coagulation, however, owing to the limited clinical response and complete occlusion of the inferior vena cava V-V ECMO was initiated as a bridge to more definitive cardiothoracic surgery. Within a short period of V-V ECMO initiation a marked improvement in hepatic function was seen. This allowed for clinical stabilisation and prevented fulminant hepatic failure. The patient subsequently underwent successful surgical thrombectomy, was weaned off ECMO, extubated and ultimately discharged home.

Conclusions: V-V ECMO can serve as a versatile and effective tool to in providing adequate venous drainage to the heart in a scenario of canal and hepatic vein obstruction. This can provide effective drainage and hepatic decongestion until definitive therapy is provided with minimal side effects.

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Observational duplex analysis of cannulated vessels during femoro-femoral veno-arterial extracorporeal membrane oxygenation

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Objectives: Femoral extracorporeal membrane oxygenation (ECMO) cannulas have major repercussion on vascular hemodynamics which can potentially lead to limb ischemia. Duplex ultrasound enables non-invasive analysis of vascular hemodynamics. This study aims to describe the duplex parameters of the femoral vessels during femoro-femoral veno-arterial (VA) ECMO and determine reference values.

Methods: Nineteen adult (≥18 years) patients, treated with femoro-femoral VA ECMO, underwent duplex analysis of the cannulated and non-cannulated femoral vessels during ECMO. Parameters measured were flow velocities, waveforms, and vessel diameters of the superior femoral artery and femoral vein. Ratios were determined between cannulated and non-cannulated vessels.

Results: Eighteen of the nineteen patients had a (prophylactic) distal perfusion cannula. The mean peak systolic velocity (PSV) and end-systolic velocity (EDV) of the cannulated arteries were respectively 42.4 and 21.4 cm/s. Non-cannulated arteries had a mean PSV and EDV of 87.4 and 19.6 cm/s. The mean PSV ratio was 0.53. The velocity difference (PSV-EDV) ratio between cannulated and non-cannulated vessels was 0.35 and there was no difference in diameter. All cannulated arteries had a monophasic waveform, whereas 42% of non-cannulated vessels had a triphasic waveform. Cannulated veins had a mean maximum and minimal flow velocity of 18.4 and 10.5 cm/s and non-cannulated veins respectively 23.7 and 9.8 cm/s. The mean velocity difference ratio was 0.59. The mean diameter of the cannulated vein was 1.08 times the diameter of the non-cannulated vein. Continuous/decreased waveforms were seen in 63% of cannulated veins and the waveforms of non-cannulated vessels were respirophasic in 61%.

Conclusions: Femoral cannulas have a significant influence on flow velocities in the cannulated vessels during VA ECMO. Major alternations in waveforms were seen in all cannulated arteries and in the majority of cannulated veins. These results could be used as

reference values during the decision making in the treatment of (possible) limb ischemia during ECMO.

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Facilitating ECMO medical supply exchange through a novel online platform

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Objectives: The global medical manufacturing supply has been disrupted following the impact of the Coronavirus (COVID-19) pandemic, affecting cardiopulmonary product production. Supply shortages have been observed, perpetuating varied distribution across hospitals. In particular, extracorporeal membrane oxygenation (ECMO), a resource-intensive life-saving method for critically ill patients with respiratory and/or cardiorespiratory failure, suffered in fulfilling its equipment demands. In this work, a novel solution is proposed to address ECMO supplies deficiency through an online platform.

Methods: With centers of all sizes experiencing equipment shortages during the pandemic, there was an opportunity for improved patient care by more systemic product availability for ELSO centers. Hence, an online platform to systemically support of trading, donating, or borrowing medical equipment is developed (https://supplies.elso.org).

In practice, equipment requests were sent by 'Requester' centers. Each request is processed by platform 'Moderators', who assign each request to a corresponding 'Supplier' center depending on the request product availability and geographical location. Then once the 'Supplier' confirm the request, the requested product is shipped to the 'Requester' center, fulfilling a need and potentially saving a life. All the aforementioned operations are completed on an easy-to-use online system, dynamically optimizing resources based on demand.

Results: In a pilot in 2020, the platform was evaluated with nine ELSO centers located in the United States. Initially, oxygenators are selected as the platform's starting product, due to its rate-limiting effect on ECMO. Each center has created at least one request that has been successfully fulfilled. Also, an evaluation survey has been issued to quantitively assess the platform based on centers' feedback, with average positive responses.

Conclusions: In summary, the ELSO Supplies platform is a promising solution to medical supply shortages. Preliminarily started on a regional basis, future work plans include expanding nationally, and and gradually paving the way toward a global solution to extracorporeal life support supply.

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Evaluating simulation education in the training and certification of ECMO specialists – a systematic review

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Objectives: To review currently published evidence for ECMO specialist training with simulation and assess the adult ECMO specialist training program at the University of Alberta (UofA).

Methods: A systematic search of the following databases was performed: PubMed, Embase, Cumulated Index to Nursing and Allied Health Literature (CINAHL), Cochrane Library (Trials), SCOPUS, the Best Evidence Medical Education (BEME) Collaboration, and Web of Science. We included prospective and retrospective studies where simulation training programs for veno-venous (VV), veno-arterial (VA) ECMO and/or cardiopulmonary bypass (CPB) were being implemented or evaluated. Studies were assessed for program design, implementation and evaluation, then meta-analyzed for the primary outcome of improved participant performance (post-training exam), and self-reported training satisfaction. The UofA adult ECMO training program was then examined within the framework of current literature.

Results: A total of 6758 records were identified. 38 full text articles were included in the analysis. Of these, 28 collected participant feedback on their ECMO simulation interventions and 31 reported quantitative measures of clinician competence. Evaluation methods to measure competence were heterogenous. 2 studies used animal models while 36 used adult, pediatric, or neonatal simulations. High-fidelity simulation models were associated with improved participant knowledge and confidence. 2 studies were randomized controlled trials, both showing statistically significant increases in clinician competence in the simulation group. There was no validated assessment tool evaluated across multiple studies. Adult ECMO specialists at the UofA attend an annual 5-day course which combines didactic and simulation components.

Conclusions: There are numerous reports of simulation training for ECMO. High-acuity simulation techniques have been independently developed for VA-ECMO, VV-ECMO, and CPB. There are no standardized measures of clinician competence, with several studies using ad hoc evaluation procedures. Clinical assessment in conjunction with participant feedback surveys can assess training component effectiveness. More research is required to determine optimal training program design and evaluation standardization.

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Neuroprotective effect of selective hypothermia cerebral perfusion in extracorporeal cardiopulmonary resuscitation for cardiac arrest: A pre-clinical study

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Objectives: The neurological complications seriously affect the survival rate and quality of life in ECPR patients undergoing cardiac arrest (CA). This study proposed a new approach of brain protection for these patients - selective hypothermia cerebral perfusion (SHCP).

Methods: Sprague-Dawley rats were randomly allocated to sham group, ECPR group, and SHCP combined ECPR group (CP-ECPR group). In ECPR group, circulatory resuscitation was performed at 6 minutes after asphyxial CA by ECMO. The vital signs were monitored for 3 hours, and both body temperature and brain temperature were maintained at 35-36 °C. In CP-ECPR group, the right carotid artery catheterization serving as the cerebral perfusion was connected with the ECMO device to achieve selective brain cooling (26-28°C). Biochemical serum markers of brain injury and the pathomorphological changes in the hippocampus were evaluated. Three biological replicates further received RNA sequencing in ECPR and CP-ECPR groups. And the microglia activation and inflammatory cytokines in brain tissue and serum were detected.

Results: The application of SHCP could quickly reduce the brain-targeted temperature in a short time after the beginning of resuscitation, and significantly alleviated nerve injury (The levels of serum S100 β, NSE, and UCH-L1 were markedly decreased. And CP-ECPR group had the lower pathological scores and more Nissl bodies in hippocampal CA1 and CA3 regions). More differentially expressed genes for inflammatory responses were clustered functionally by KEGG pathway analysis. Furthermore, SHCP robustly reduced microglia activation and the release of pro-inflammatory mediators.

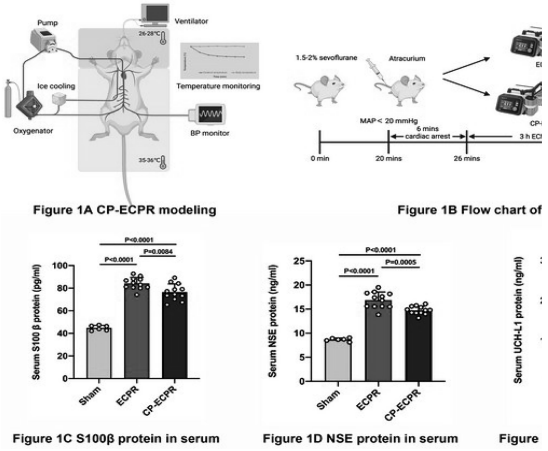

Figure 1A CP-ECPR modeling | Figure 1B Flow chart of

Figure 1C S100β protein in serum | Figure 1D NSE protein in serum | Figure

Conclusions: Our preliminary data indicates that SHCP may serve as a potential therapy to attenuate brain injury via downregulation of neuroinflammation in ECPR patients.

Adult - Respiratory failure

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Incidence of clinically significant bleeding and thromboembolism among patients with leptospirosis requiring extra corporeal membrane oxygenation: A descriptive study

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Objectives: The use of extracorporeal membrane oxygenation (ECMO) as novel treatment for severe leptospirosis has been proposed. Hemorrhagic and thromboembolic complications of ECMO, however, may produce negative outcomes. This study determined the clinical and hematologic profiles and outcomes of patients with severe leptospirosis who received ECMO support.

Methods: This study used descriptive univariate analysis from a single center. All adult inpatients with severe leptospirosis undergoing ECMO from 2018 to 2020 were included. Primary outcomes of interest were presence of bleeding, thromboembolism, and in-hospital mortality.

Results: From a census of 28 patients, 89% (n=25) had bleeding. Of which, 92% (n=23) had pulmonary hemorrhage and 64% (n=16) had gastrointestinal bleeding. Twenty-one percent (n=6) developed thromboembolic events – majority were circuit-oxygenator thrombosis (83%, n=5) and 23% (n=2) with systemic thrombosis.

Mean hemoglobin levels were highest on admission (12.8 ± 1.95 g/dL). Mean partial thromboplastin time (PTT) during ECMO was at 51.2 ± 8.6 seconds overall and was lowest in the subgroup with thromboembolism (48 seconds). Mean total red cell units (pRBC) transfused during ECMO was at 10.3 units, with an average daily transfusion of 1.1 units. Average daily platelet transfusion was at three platelet concentrates with total random platelet concentrate transfusion during ECMO at 26.4 units.

Patients with no bleeding had lower mean total cannulation days (6 ± 5), total length of stay (19 ± 12.5), days on ventilation (10 ± 4), and days on dialysis (9 ± 3.8). Patients with thromboembolism had higher mortality (33%) than overall census (25%).

Conclusions: Factors that influence bleeding are nature of illness, continuous anticoagulation, and qualitative platelet dysfunction. The artificial circuit interface, pro-inflammatory state, and unique patient factors predispose to thromboembolism. ECMO, therefore, requires a balance of bleeding with coagulation. While limited to univariate analysis, this study demonstrated that bleeding is more frequent than thromboembolism among severe leptospirosis patients who underwent ECMO. Both had negative impact on mortality and secondary outcomes.

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Pregnancy, COVID 19 and ECMO: It can be performed safely

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Objectives: There is an overall dearth of information regarding ECMO support in active pregnancy with only 358 women being supported as noted in a review by Naoum et al. There are individual case reports of ECMO support and COIVD 19 during pregnancy. We now report on our institutional experience with ARDS, COVID 19 and ECMO during pregnancy.

Methods: A retrospective review of of all pregnant women with COVID - 19 /ARDS supported on ECMO at Piedmont Atlanta Hospital from January 2020 through November 2021 . Complete followup is known and ongoing.

Results: From January 2020 till November 2021 a total of 7 PCR + COVID -19 pregnant women were supported on ECMO. Ages were 41,37,39,35,37,36,22; Average 35.2, Standard COVID-19 treatment consisting of 100% Received Remdesivir, 100% Received Decadron 6 mg/day for 10 days, 90% Received Azithromycin, 100% Received LMWH prior to ECMO. Average duration on ECMO was 26 days (13-54). All were groin cannulation in Veno-venous configuration. Six out of seven had emergent C-section for fetal or maternal distress. There were two maternal deaths (One acute Subarachnoid hemorrhage and one multi-system organ failure). Survival to discharge was 71.4%. All infants were discharged from the neonatal intensive care unit to home. Four out of the seven women were in the early second trimester and three out of the seven women were in the third trimester. There were two cases of SRA proven Heparin induced thrombocytopenia resulting in Acute renal failure requiring Continuous renal replacement therapy. Both patients recovered renal function.

Conclusions: ECMO support can be done safely in pregnant women who develop ARDS from COVID -19 infection. There is a high maternal survival rate > 70% and a high infant survival rate 100 %. A multidisciplinary team approach between critical care medicine, maternal-fetal-medicine and OB/hospitalist is mandatory. Direct thrombin inhibition can safely be used in the second or third trimester if heparin induced thrombocytopenia develops. One must remain committed through complications. Till death do us part.

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A comparison of echocardiographic findings in critically Ill patients with COVID-19 with and without extracorporeal membrane oxygenation

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Objectives: Although respiratory failure is the cornerstone of severe COVID-19, cardiac disease has been described in up to 20% of the patients, with increased associated mortality. Currently, there is a paucity of data regarding the echocardiographic findings in patients with COVID-19 supported with ECMO. This study aims to compare the baseline and follow-up echocardiographic characteristics of mechanically ventilated patients with COVID-19 with and without ECMO support.

Methods: We performed a single-center, retrospective cohort study of patients admitted to the ICU with COVID-19 from March to June 2020. Patients were included if they required mechanical ventilation, and had an available echocardiogram performed in the first 48 hours of admission. Follow-up echocardiograms during ICU stay were reviewed.

Results: 75 patients were included, 32 (43%) with ECMO support. Median (IQR) PaO2/FiO2 was 79 (64-112) and 95 (75-128) in the ECMO and non-ECMO patients respectively. There were no significant differences in the echocardiographic abnormalities between the ECMO and non-ECMO groups, including LV systolic dysfunction (12% vs 9%, p=0.18), RV systolic dysfunction (22% vs 21%, p = 0.13), RV dilation (31% vs 23%, p= 0.44) and paradoxical septal motion (34 vs 35%, p=0 .96). However, 25% of the ECMO patients presented new echocardiographic abnormalities during their ICU stay, as compared to none in non-ECMO patients. ICU mortality was 47% for the ECMO group and 33% for the non-ECMO patients.

Table 1. Echocardiographic findings at admission.

Parameter	ECMO n=32 (%)	Non-ECMO N=43 (%)	p-value
LV dimensions			
LV hypertrophy	11 (34)	19 (44)	0.47
LV dilation	3 (9)	4 (9)	1.00
LV Visual function			
Normal	27 (84)	35 (81)	0.18
Mild dysfunction	1 (3)	4 (9)	
Moderate dysfunction	1 (3)	0	
Severe dysfunction	2 (6)	0	
Hyperdynamic	1 (3)	4 (9)	
RV dimensions			
RV dilation	10 (31)	10 (23)	0.44
RV function			
Paradoxical septal motion	11 (34)	15 (35)	0.96
Visual function			
Normal	25 (78)	34 (79)	0.13
Mild dysfunction	4 (13)	9 (21)	
Moderate dysfunction	1 (3)	0	
Severe dysfunction	2 (6)	0	
RVS'	13.6 (3.9)	15.0 (4.3)	0.28
TAPSE	2.0 (0.4)	2.0 (0.4)	1.00
Diastolic function			
Data unavailable	12 (37)	13 (30)	0.64
Grade I	5 (16)	5 (12)	
Grade II	0	2 (5)	
Grade III	6 (19)	12 (28)	
Indeterminate	7 (22)	10 (23)	
E-A fusion	2 (6)	1 (2)	
Pericardial effusion			
None	25 (78)	31 (72)	0.47
Present	12 (28)	12 (28)	

Conclusions: Echocardiographic findings at admission, are comparable in the COVID-ECMO and the non-ECMO patients. However, a higher percentage of patients on ECMO develop new abnormalities during follow-up.

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Analysis of fibre configurations and specifications for the development of a novel, highly integrated artificial device combining pulmonary and renal support

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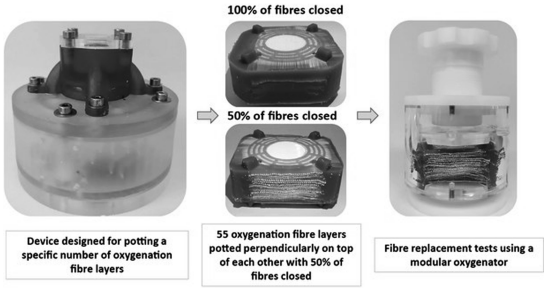
Objectives: Patients undergoing extracorporeal membrane oxygenation (ECMO) are at high risk of acute kidney injury. In clinical settings, continuous renal replacement therapy provides renal support for ECMO patients. So far, lung and kidney support are provided by two separate circuits, resulting in high infection risks. A more sensible treatment derives from combining lung and kidney support in a single device integrating oxygenation and hemofiltration fibres. Thus, in our study, we analysed the number and configuration of oxygenation fibres, which could be replaced by hemofiltration fibres losing less than 10% of gas exchange capacity of a model oxygenator.

Methods: Our device was designed for potting a specified number of oxygenator fibre layers (Oxyplus 3M™ Membrana™). The potting device was subjected to centrifugal forces and filled with silicone, creating membrane bundles with 55 fibre layers. Oxygenation fibre layers were potted perpendicularly on top of each other with 25% or 50% of fibres closed in a way that they did not contribute to gas exchange. The potted membrane bundles were inserted into a modular oxygenator housing and tested according to the ISO 7199 standard (see figure).



Results: Preliminary analysis showed that multiple fibre layers in an oxygenator mainly contribute to gas exchange by deflecting blood flow, enhancing the mixing of blood cells. Based on these results we will determine how many oxygenation fibre layers can be substituted by hemofiltration fibres in our model oxygenator without losing more than 10% of its gas exchange capacity.

Conclusions: Standardized blood tests reveal the influence of replacing oxygenation fibres in different numbers and configurations. Preliminary results suggest that multiple alternating oxygenation fibre layers could be replaced by hemofiltration fibres without an important loss of gas exchange capacity of the oxygenator.

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Study on the relationship between ECMO introduction and obesity paradox in COVID-19 patients

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Objectives: To investigate the relationship between BMI and prognosis in patients with VV-ECMO for COVID-19.

Methods: We retrospectively examined the association between ECMO withdrawal and BMI in 24 patients who underwent VV-ECMO for COVID-19 at Yokohama City University Comprehensive Medical Center from March 2020 to October 2021.

Results: Of all patients, 18 (75%) were male, and 2 died. BMI was 28.6, APACHE score was 23, SOFA score was 10, Murray score was 3.3, RESP score was 2, time from onset to ECMO introduction was 12 days, and ECMO introduction period was 10 days (all median). The ECMO survival withdrawal rate was 91%. Next, we examined the association between BMI and the number of days off ECMO in the 22 patients who survived ECMO, and found a correlation coefficient of -0.14 (p= 0.534). The cut-off value of BMI for 18 days of ECMO withdrawal was 32.36. The predictive ability of BMI cut-off value for 18 days of ECMO withdrawal was 55% sensitivity, 100% specificity, and AUC 0.72 (p=0.0002).

Conclusions: In the introduction of VV-ECMO for COVID-19, it was considered that obese patients may have led to early withdrawal.

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Veno-venous extracorporeal membrane oxygenation during COVID-19 pandemic: Case series

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Objectives: The course of COVID-19 viral infectious disease with an incidence of 15-42% can be complicated by the development of acute respiratory distress syndrome (ARDS). The mortality rate with severe forms exceeds 60%, which sometimes requires extracorporeal methods of life support. The purpose of this study was to analyse the therapeutic efficacy of V-V ECMO in patients with acute respiratory distress syndrome caused by SARS-CoV-2.

Methods: A retrospective analysis was performed in patients with acute lung injury caused by COVID-19 infection and treated with V-V ECMO within a period from February 2020 to May 2021 at the ECMO Center of the Heart Institute Ministry of Health of Ukraine. All patients had PCR testing for viral RNA particles using RT-PCR ELITe analyser.

Results: During this period, 7 cases reported of V-V ECMO for ARDS caused by COVID-19 infection. Five of seven patients were urgently transferred to our ECMO Center from other medical institutions, while 2 patients were transferred to the hospital being already connected to ECMO, and one patient was connected to ECMO immediately after hospitalization. The most common ECMO complication was circuit thrombosis – 42.9% (3/7), which required oxygenator replacement – in 2 cases and circuit replacement – in 1 case. Three patients had bleeding at the cannulation site. ECMO mortality rate was 57.1% (4/7), while the 30-day mortality rate – 71.4% (5/7)

Conclusions: In our case series, out of seven critically ill SARS-CoV-2 COVID-19 patients who required ECMO to maintain adequate oxygenation, in-patient mortality was observed in 71.4%. We believe that additional studies are required to investigate the role of ECMO in the treatment of critically ill SARS-CoV-2 patients. Clear criteria should be set for using ECMO in this cohort of patients.

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Improving oxygenation with beta-blockers during veno-venous ECMO in COVID-19 pneumonia

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Objectives: Refractory hypoxemia during veno-venous ECMO (V-V ECMO) in patients with COVID-19 pneumonia can be challenging. One of contributing factors is an increased cardiac output (CO) compared to ECMO flow, i.e. a low QECMO/QCO ratio. In case of elevated CO, beta-blockers may have a beneficial effect on oxygenation by improving QECMO/QCO-ratio. However, evidence on this subject is limited. We therefore aim to assess the efficacy and safety of beta-blockers in improving oxygenation during V-V ECMO in patients with COVID-19 pneumonia.

Methods: A retrospective case series was conducted of COVID-19 patients on V-V ECMO treated with ultrashort-acting beta-blockers (i.e. esmolol or landiolol) for refractory hypoxemia in the ICU of Maastricht University Medical Center, the Netherlands, between March 2020 and April 2021. Measurements were performed at baseline and after 2 hours of intervention. Efficacy was defined as increase in arterial oxygen partial pressure (paO2) or P/F ratio. Safety was defined by the absence of hemodynamic instability (bradycardia < 50/min, MAP <60 mmHg or serum lactate >1.5 mmol/L) with need for discontinuation of beta-blocker or increase of norepinephrine dose >0.1 µcg/kg/min. A descriptive statistical analysis with paired *t*-test was performed and *p* values below 0.05 were considered significant.

Results: *Of 45 patients treated with V-V ECMO, 11 subjects receiving beta-blockers for refractory hypoxemia in COVID-19 pneumonia were enrolled.* Tables 1 and 2 *show patient characteristics, and hemodynamic and respiratory parameters before and after intervention, respectively. After beta-blockers heart rate decreased from 83 bpm (IQR 63-110) to 74 bpm (IQR 46-107), paO2 increased from 56 mmHg (IQR 50-67) to 72 mmHg (IQR 57-89) and P/F ratio increased from 75 mmHg (IQR 53-135) to 105 mmHg (IQR 53-173), all significantly (p value < 0.05). MAP, serum lactate and norepinephrine dose did not change significantly. In none of the patients intervention had to be discontinued.*

Conclusions: This study confirms the efficacy and safety of ultrashort-acting beta-blockers in refractory hypoxemia during V-V ECMO in patients with COVID-19 pneumonia. Beta-blockers can be a safer alternative to other rescue therapies (e.g. increase in PEEP or driving pressure) which might impair lung protective strategies.

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The investigation of KL-6 in the most severe COVID-19 cases requiring ECMO

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Objectives: KL-6 is a marker of lung damage, and its usefulness has been reported in COVID-19. However, it has not been studied in very severe cases requiring ECMO, and there are no reports of KL-6 measurements over time.

Methods: The design was a single-center, prospective, observational study. Patients with severe COVID-19 requiring ventilatory management who were admitted to our hospital between December 2020 and September 2021 were included in the study. KL-6 was measured on admission, on day 7 and on day 14, and statistical analysis was performed on ECMO status, patient background, course of admission, treatment, outcome, blood gas findings and KL-6.

Results: Of the 60 patients admitted to hospital, 45 were included in the analysis: 16 in the ECMO group and 29 in the non-ECMO group. There were no significant differences during hospitalization, treatment, or outcomes between the ECMO and non-ECMO groups, but there were significant differences in KL-6 and PaCO2 on admission ($p<0.05$). The cut-off values were 751 and 32.6. Multivariate analysis showed a significant difference only in KL-6 at admission ($p=0.034$). There was no change in KL-6 over time between the ECMO and non-ECMO groups.

Conclusions: Although KL-6 can assess the severity of COVID-19, including ECMO, it does not show any change over time even after 2 weeks of hospitalization and is inappropriate for assessing disease activity in the acute stage of COVID-19.

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Cerebrovascular complications for COVID-19 patients supported by veno-venous extracorporeal membrane oxygenation

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Table 1. Baseline patient characteristics and patient outcome (n=11).

		median (IQR)	n
Patient demographics			
	Age (years)	55 (47-62)	
	Male gender		10
	Body Mass Index (kg/m^2)	28 (25-31)	
	APACHE IV score	60 (56-72)	
Characteristics on V-V ECMO initiation			
	Days on ICU before V-V ECMO initiation	6 (5-7)	
	SOFA score on V-V ECMO initiation	7 (5-8)	
	Left ventricular function:		
	- Good (>55%)		8
	- Moderate (40-55%)		1
	- Low (<40%)		0
	- Undocumented		2
	Recirculation (%)	18 (15-25)	
	Haemoglobin level (mmo/lL)	6.0 (5.7-6.3)	
Characteristics of beta-blocker treatment			
	Type of beta-blocker:		
	- Landiolol		8
	- Esmolol		3
Patient Outcome			
	Days on ECMO	17 (16-32)	
	Successful weaning		3

Table 2. Hemodynamic and respiratory parameters before and after beta-blockers.

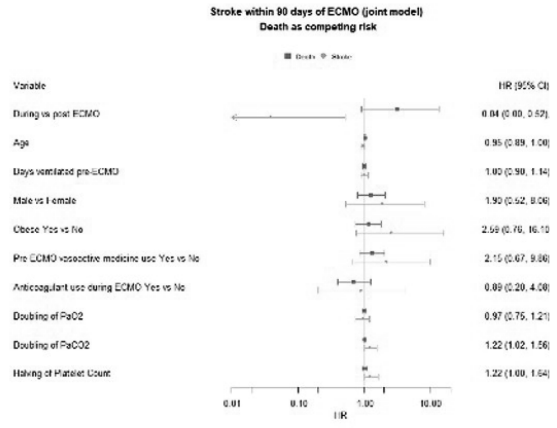
	Before beta-blocker mean (min-max)	After beta-blocker mean (min-max)	*p* value
Blood flow ECMO (L/min)	4.39 (4.05-5.22)	4.39 (3.80-5.24)	*ns*
Fio2 ECMO (%)	100 (100-100)	100 (100-100)	*ns*
Fio2 mechanical ventilator (%)	84 (50-100)	75 (21-100)	*ns*
PEEP (cmH_2O)	12 (6-16)	12 (6-16)	*ns*
Saturation (%)	91 (88-96)	93 (86-100)	*ns*
Arterial oxygen partial pressure (mmHg)	56 (50-67)	72 (57-89)	$p < 0.05$ ($p < 0.001$)
P/F ratio (mmHg)	75 (53-135)	105 (53-173)	$p < 0.05$ ($p = 0.03$)
Heart rate (bpm)	83 (63-110)	74 (46-107)	$p < 0.05$ ($p = 0.01$)
Mean arterial blood pressure (mmHg)	80 (54-102)	75 (55-109)	*ns*
Vasopressor dose (mcg/kg/min)	0.08 (0-0.345)	0.10 (0-0.365)	*ns*
Lactate (mmol/L)	1.4 (0.7-2.0)	1.5 (0.6-2.5)	*ns*

Objectives: The current understanding of cerebrovascular complications of patients with severe Coronavirus disease 2019 (COVID-19) requiring venovenous extracorporeal membrane oxygenation (VV-ECMO) is limited. We aimed to characterize the prevalence and risk factors of stroke secondary to COVID-19 acute respiratory distress syndrome (ARDS) requiring VV-ECMO intervention.

Methods: Prospectively collected observational data of adults (age > 18 years) with severe COVID-19 associated ARDS requiring VV-ECMO support were extracted from the COVID-19 Critical Care Consortium international registry from February/19/2020 to December/3/2021. Univariable and multivariable survival modeling was performed to investigate the risk factors of COVID-19 associated stroke during VV-ECMO. Cox proportional hazards and Fine-Gray models, with death treated as a competing risk, were used. Risk factors with <50% missing data were included in multivariable models. Patients were

followed up to 90 days after ECMO initiation until stroke or death, censored at hospital discharge or 90 days.

Results:



Overall, 595 patients (median age [IQR]: 51 years [42-59]; male: 71%) had VV-ECMO support across 380 participating institutions. During follow-up, forty-three patients (7%) suffered strokes, 80% of which were hemorrhagic and there were 208 deaths without stroke. In both univariable and multivariable survival analysis (N=402, 33 strokes), obesity (adjusted subdistribution Hazard Ratio (asubHR) 2.08, 95% CI 1.01, 4.29) and use of vasoactive drugs before ECMO (asubHR 2.24, 95% CI 1.03, 4.86) were associated with an increased risk of stroke. As of December 3, 2021, total in-hospital mortality was 52%. Patients with stroke had 79% in-hospital mortality compared with 13% mortality for stroke-free patients.

Conclusions: Our study highlights the association of obesity and pre-ECMO vasoactive medication requirements with the development of stroke in COVID-19 patients supported by VV-ECMO. Additionally, larger studies are needed to validate these observations.

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A retrospective analysis of COVID-19-associated ARDS patients with extensive lung aeration loss during veno-venous ECMO

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Objectives: Veno-venous extracorporeal membrane oxygenation(VV-ECMO)is a rescue therapy in COVID-19 patients, but there is a lack of evidence about how long ECMO should be continued when patients fail to improve.The lung parenchyma of COVID-19 patients needing VV-ECMO is severely affected and an extensive lung aeration loss(ELAL)can occur.We investigated the clinical course of COVID-19 patients who developed an ELAL during VV-ECMO.

Methods: We retrospectively reviewed patients with COVID-19-associated ARDS and VV-ECMO support admitted to our Intensive Care Unit(ICU)from January to June 2021.ELAL was defined as an expiratory tidal volume of less than 100ml for at least 48hours with bilateral opacities at chest X-ray and extremely low respiratory system compliance, during the first 45 days of ECMO support.

Results: 34 patients were enrolled(clinical data reported in Table 1). 20 patients presented an ELAL.One patient underwent lung transplantation and was excluded,16 patients did not have lung recovery and died, 4 patients showed lung recovery with ICU discharge. The clinical and outcome data of survivors and non-survivor patients with ELAL are reported in Table 2.

Table 1

	ALL	ELAL	n-ELAL	p-value
Number (n,%)	33	20 (61)	13 (39)	
Age	58.5 (50.75-63)	54 (48-63)	57 (50-63)	0.8681 #
ICU admission-intubation (days)	1 (0-2)	1 (0-3)	0 (0-0.75)	0.0717 #
Intubation-ECMO start (days)	4 (2-6)	4 (2.75-6)	3 (2-5)	0.4569 #
ECMO duration (days)	23 (17-44)	41.5 (20.75-59.75)	17 (13-26)	0.0060 #
ICU length of stay (days)	43 (25-57)	53.5 (28.75-74.75)	32 (18-48)	0.0234 #
In ICU mortality (n,%)	22 (67)	16 (80)	6 (46)	0.0439$^{\chi}$

Table 2

	ELAL Survivors	ELAL non-survivors	p-value
Number (n, %)	4 (20)	16 (80)	
Males (n, %)	1 (25)	9 (56)	0.2635 $^{\chi}$
Age	48 (36.25-57.75)	60.5 (51.75-63)	0.1081 #
ECMO duration (days)	36.5 (30.75-46.25)	43 (19.75-63.25)	0.8133 #
ICU admission-intubation (days)	0 (0-1)	1 (0.75-3)	0.2669 #
Intubation-ECMO start (days)	3 (2.75-3)	5 (2.75-7)	0.14 #
ECMO start-ELAL (days)	8 (4.75-12)	10 (7.75-16)	0.5082 #
Time ELAL (days)	5.5 (3.75-9.5)	15.5 (10.25-32.25)	0.0587 #
Airway bleeding (n. %)	3 (75)	10 (62)	0.6392 $^{\chi}$
ICU length of stay (days)	48 (40.5-66.25)	55.5 (27-74.75)	0.9623 #
Airway plateau pressure during ELAL(cmH_20)	20.48 ± 1.0	23.2 ± 0.2	0.0003 §
PEEP during ELAL(cmH_20)	9.1 ± 0.5	11.2 ± 0.1	<0.0001 §
Respiratory system compliance during ELAL(ml/CmH_2O)	1.5 ± 0.3	2.7 ± 0.1	0.0002 §
ECMO blood flow during ELAL(l/m)	5.1 ± 0.1	4.8 ± 0	0.0026 §
ECMO sweep gas flow during ELAL(l/m)	8.2 ± 0.2	8.4 ± 0.3	0.8558 §

$^{\chi}$ Chi-square test; § t-Student test; # Mann-Whitney U test.

Conclusions: ELAL is frequent in patients with COVID-19-associated ARDS during VV-ECMO and is associated with prolonged ECMO support, but it cannot be always considered as a terminal event, since recovery has occurred in 20% of cases.

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A multidisciplinary effort to improve ECMO management during the COVID-19 pandemic

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Objectives: According to the Extracorporeal Life Support Organization (ELSO) registry, 11,224 confirmed coronavirus disease (COVID-19) patients have been placed on extracorporeal membrane oxygenation (ECMO) with an in-hospital mortality of 48% . ECMO management has evolved throughout the pandemic. Here, we summarize our journey of success in improving outcomes using a restructured, multidisciplinary, patient-centered approach. We developed an ECMO program pre-COVID, and evaluated the program with COVID ARDS patients which are one of the most challenging cohorts to manage.

Methods: This study was conducted in a tertiary care hospital with a capacity of 8-10 ECMO cannulations at a time. Our 2018 Vizient data reported 65% mortality compared to 46 % ELSO mortality, which prompted us to restructure our ECMO program. We established an ECMO Clinical Management Performance Improvement (CMPI) committee. The ECMO CMPI developed algorithms to improve management based on 1) collaboration with and review of similar-sized programs with successful outcomes; 2) retroactive analysis of ECMO patients' medical records for missed opportunities, and 3) review of current evidence-based literature. The committee revised ECMO inclusion/exclusion criteria, constituted multidisciplinary teams to discuss cases and exit strategies (bridge to recovery vs. bridge to transplant), and reviewed ECMO cases with leadership biweekly.

Results: After a year of the ECMO CMPI's implementation of processes, inpatient mortality decreased to 38.18% per 2019 Vizient data, placing our hospital in the top quartile. Furthermore, 2020 Vizient data showed 36.89% inpatient mortality and 2021 Q1-Q3 mortality was 26.92%, which was within the top decile. Currently, our hospital's 2021 mortality (COVID and non-COVID) is 27.3% (adjusted) vs. 50.5% ELSO mortality (adjusted).

Conclusions: Based on our results, we conclude that the revised inclusion/exclusion criteria and improved ECMO management strategies proved to be instrumental in the utilization of ECMO as a supportive treatment for the critically ill COVID-19 patient population.

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The impact of COVID-19 on the use of the Passy Muir Valve (PMV) with veno-venous extra corporeal membrane oxygenation (VV-ECMO) patients

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Objectives: Describing a change in practice using the one-way PMV speaking valve with COVID-19 patients on VV-ECMO.

Methods: Implementation of the PMV into clinical practice has been lead by the Critical Care Physiotherapy Team Lead and accompanied by a clinical guideline, training program and competency document at our Trust. This has meant that the PMV, a high risk device, has been used safely and effectively with patients.

Trust guidance outlines parameters where the PMV is indicated and contraindicated. Contraindications include patients requiring a FiO_2 >60% via the ventilator or those with respiratory failure.The dawn of the COVID-19 pandemic saw an increase in the number of VV ECMO patients with profound respiratory failure requiring near maximal levels of ECMO and ventilator support via tracheostomy. Ordinarily this would have precluded such patients from using the PMV. Due to ventilator dependence a proportion of patients could not tolerate a conventional speaking valve. Without the PMV these patients would have been unable to vocalise or begin oral intake for a protracted period of time.

As a team we appreciated the benefits to the patient and weighed these against the risks to establish whether a patient could use the PMV.

Results: Managing risk with a thorough assessment and close monitoring throughout each PMV session allowed four of our 28 ECMO patients in the first COVID-19 surge to use the PMV. Each of these patients were able to communicate with MDT and family members. Two were able to begin oral intake.

Adverse events encountered were coughing and hypotension on a total of 7 out of 43 sessions. All adverse events resolved once the PMV stopped. No medical intervention was required.

Conclusions: The implementation of guidelines and education to reduce risk when using high risk devices is essential. Although a small cohort, this review indicates that robust risk assessment and MDT involvement can identify patients who lay outside previously considered safe parameters can facilitate the use of PMV and improve patient care.

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Outcome of patients with severe acute hypoxaemic respiratory failure receiving extracorporeal membrane oxygenation: Single center comparison between COVID-19 and non-COVID-19 aetiologies

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Objectives: Extra corporeal membrane oxygenation (ECMO) is indicated in patients with severe and potentially reversible respiratory failure (SRF) from any aetiology. COVID-19 has substantially increased the demand for ECMO in the UK and worldwide. However, the outcome of COVID-19 compared with SRF from other etiologies varies widely in the literature and in surveys. The purpose of this research was to analyse the mortality rates of patients seen in our unit before and during the COVID pandemic.

Methods: Single centre, retrospective analysis in patients who underwent veno-venous ECMO at St Thomas' Hospital – London (UK) over a 10 period from 30th March 2010 to 10th September 2021. The study was approved as a service evaluation and informed consent was waived.

Results: In total 862 patients were analysed: 650 patients admitted before March 2020 (pre-COVID) and 212 between March 2020-September 2021 (intra-COVID). Survival data from these two time points shows a comparable unit mortality of 80% pre-COVID and 79% intra-COVID. The survival was significantly higher for non-COVID-19 aetiology (90% vs 74%; p=0.009) OR 0.3; 95%CI 0.12-0.77; p=0.012). The ECMO length of stay was significantly longer in the intra-COVID population (20.3±17 vs 12.9 ±11.7 days; p<0.0001). This difference was present both in non-survivors (25.5±17 vs 14.2 ±13.7 days; p<0.0001) as well as in survivors (18.9±16.2 vs 12.9 ±11.1 days; p<0.0001). This difference was more marked during the second COVID-19 wave. In the intra-COVID, patients with COVID-19 had a significantly longer ECMO LOS (20.9±17.2 vs 10.2±7.7 days; p<0.0001).

Conclusions: This study shows that within our unit the mortality rates were not affected overall by the increased strain. Survival rates were consistently higher in the non-COVID cohort with significantly shorter – length of stay on ECMO. Whether different selection criteria had an influence on outcome requires further studies.

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Unfractionated heparin anticoagulation monitoring during veno-venous ECMO in COVID-19 patients: A retrospective analysis

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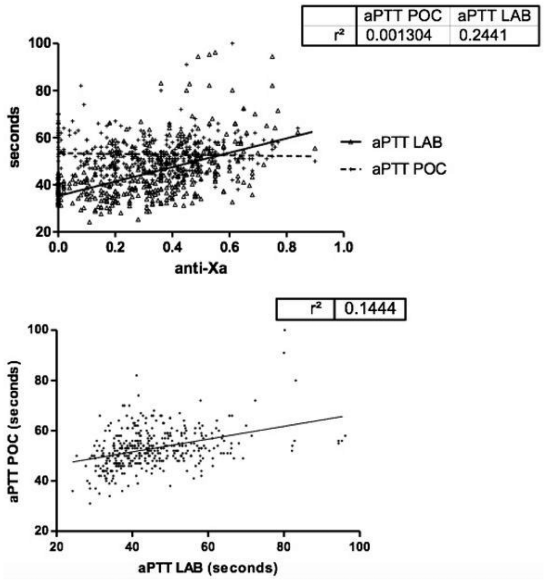
Objectives: Assessing coagulation in COVID-19 patients supported with veno-venous extracorporeal membrane oxygenation (VV-ECMO) is complex. It depends on COVID-19-associated coagulopathy that is characterized by an excess of thrombosis, and the effect of ECMO that activates prothrombotic and fibrinolytic pathways. A discordance between activated Partial Thromboplastin Time (aPTT) and anti-Xa have been described during unfractionated heparin (UFH) infusion on VV-ECMO. We have investigated the correlation between anti-Xa values and aPTT, assessed by Point-of-Care (aPTT-POC) device and laboratory test (aPTT-LAB), in COVID-19 patients supported with VV-ECMO.

Methods: Patients with COVID-19-associated ARDS and VV-ECMO support admitted to our Intensive Care Unit from January to August 2021 were retrospectively reviewed. A low-intensity protocol for UFH infusion during VV-ECMO was adopted, aiming at a target POC aPTT range of 50–60 seconds. We analyzed the simultaneous determinations of anti-Xa values, aPTT-LAB and aPTT-POC performed by the attending nurse. Any coagulation test from patients not receiving UFH was excluded from analysis.

Results: Thirty-four patients were selected. Three of them were pregnant or postpartum women and were excluded from the analysis. Thirty-one patients were considered and simultaneous determinations of aPTT-LAB, aPTT-POC and anti-Xa were compared.

The correlation between aPTT-LAB and anti-Xa was weak (R^2 of 0.2441) and similarly the correlation between aPTT-POC and anti-Xa (R^2 of 0.001) (Figure 1). The correlation between aPTT-LAB and aPTT-POC was also weak (R^2 of 0.1444, Figure 2).



Conclusions: We found a discordance between the aPTT and anti-Xa values during UFH infusion in COVID-19 patients supported by VV-ECMO. Both laboratory determination and POC determination seem inaccurate. We suppose that COVID-19 related coagulopathy and inflammation could interfere with the therapeutic values of aPTT and its assessment. Therefore, monitoring UFH treatment is challenging in these patients.

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Blood purification therapy in patients with severe COVID-19 requiring veno-venous ECMO therapy: A retrospective study

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Objectives: Patients with severe manifestations of COVID-19 might exhibit characteristics of a sepsis-like syndrome that can progress to multiple organ failure and ultimately death. Underlying mechanism have been explored and suggest a profound dysregulation of the immune system associated with hyperinflammation, hemodynamic instability and respiratory failure. Besides standard intensive care treatment, approaches modulating the dysregulated immune response, such as CytoSorb hemoadsorption, have been used. However, data of ECMO-dependent patients in comparison to a control cohort remain scarce.

Methods: Included were 26 critically ill COVID-19 patients requiring high-flow veno-venous extracorporeal membrane oxygenation (high-flow VV ECMO) therapy due to severe acute respiratory distress syndrome (ARDS), of whom 16 were additionally treated with an extracorporeal hemoadsorption device, and compared to a control group of 10 patients. Assessed were levels of inflammatory markers, vasopressor requirements, oxygenation parameters, as well as clinically relevant outcome variables. Data were prospectively recorded and retrospectively analyzed.

Results: Treatment with the applied multimodal therapy approach resulted in a stabilization in hemodynamics, a control of the hyperinflammatory response as evidenced by a significant reduction in inflammatory mediators, as well as a marked improvement in lung function. No device related adverse events were observed while treatment appeared safe and feasible.

Conclusions: Treatment of a critically ill COVID-19 ARDS patients with combined VV ECMO support and hemoadsorption therapy led to a rapid and sustained hemodynamic stabilization, a control of the uncontrolled inflammatory response and an improvement in oxygenation. Given these signals pointing towards a patient-oriented benefit of extracorporeal hemoadsorption therapy in those patients, future controlled, randomized studies should focus on the investigation of the appropriate timing and dosing of this promising treatment modality.

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Our experience: ECMO referrals from a remote district general hospital in the UK (The Royal Cornwall Hospital)

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Objectives: Extracorporeal membrane oxygenation (ECMO) is a potentially life-saving rescue therapy in the management of patients with severe acute respiratory failure that have failed conventional ventilation. Evidence on the efficacy largely comes from the 2010 CESAR and 2018 EOLIA trials. Data from these trials have supported the World Health Organisation in recommending ECMO for ARDS related to coronavirus disease (COVID-19) which has seen a greater use of ECMO in recent years. In 2018 data collected from our hospital revealed three patients were retrieved for ECMO over a six year period (2012-2018). We present a further case series of ECMO referrals since 2018 from a district general hospital in the South-West to a tertiary centre at the Royal Brompton Hospital (RBH).

Methods: A search was performed of electronic patient records (Carevue) of ICU patients from the Royal

Cornwall Hospital between February 2018 and August 2021 inclusive, searching for terms 'ECMO', 'ECLS' and the name of the tertiary hospital 'Brompton'.

Results: A total of 16 patients were referred for ECMO from February 2018 until August 2021, with nine of those patients accepted and retrieved to RBH. Of those referred patients tested for COVID-19, there were three positive cases and one of these was retrieved for ECMO.

Conclusions: There has been a substantial increase in the number of patients referred for ECMO from our hospital in recent years. This increase is likely to reflect developing technology, increasing demand due to the pandemic and evolving data on the mortality benefit of ECMO. The latter remains controversial with trials for ECMO challenging to design. We expect to see the trajectory of our referrals continue as further data emerges.

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Outcomes in patients with COVID-19 induced acute respiratory distress syndrome receiving venovenous extracorporeal membrane oxygenation: An inverse probability weighted analysis

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Objectives: To describe characteristics and outcomes in patients receiving venovenous extracorporeal membrane oxygenation (VV-ECMO) due to COVID-19 induced acute respiratory distress syndrome (C-ARDS), and to assess the influence of C-ARDS on mortality in case of ARDS as indication for VV-ECMO.

Methods: An international multicenter retrospective cohort study was performed in 15 Intensive Care Units, including all patients (>18 years old) with ARDS receiving VV-ECMO. Two groups were created: a C-ARDS cohort from March to December 2020 (n=193); and an ARDS cohort from January 2018 to July 2019 (n=105). The primary outcome was 28-day mortality. Secondary outcomes included demographic parameters, C-ARDS related therapies before and during ECMO, complication rate and 60-day mortality. To assess the influence of C-ARDS, inverse probability weighted (IPW) analyses were used to correct for confounding variables.

Results: Patients with C-ARDS were mainly male (78%), with a median age of 53 years (IQR 48 – 60) and a BMI of 29.4 kg/m^2 (Interquartile range [IQR] 26.3 – 32.2). In total, 57% suffered from one or more comorbidities, mainly hypertension (n=68) and diabetes (n=49). Before ECMO initiation, median P_aO_2/F_iO_2 ratio was 69 mmHg (IQR 54 – 94). Main indications were isolated refractory hypoxemia (n=95) or combined with hypercapnia (n=84). Median time receiving ECMO was 15 days (IQR 9 – 24). During ECMO, neuromuscular blockage was used in 130 patients (68%) and 96 patients underwent prone positioning (50%). 90% had one or more complications, 65% was alive at 28 versus 52% at 60 days. After IPW correction for confounders, 28-day and 60-day moratlity was equal in ARDS on VV-ECMO, independent of COVID-19 (Weighted Hazard Ratio 1.23 [95%CI 0.78 – 1.94] resp. 1.24 [95%CI 0.84 - 1.85]).

Conclusions: Survival of patients receiving VV-ECMO for C-ARDS in 2020 is similar to patients receiving VV-ECMO for non C-ARDS.

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ECMO utilization with adjunctive hemoadsorption therapy in COVID-19 patients: An observational analysis from the CytoSorb therapy in COVID-19 (CTC) registry

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Objectives: The multicenter CTC Registry study collected patient-level data in COVID-19 patients receiving

CytoSorb therapy under FDA Emergency Use Authorization. In a prior analysis, the first 52 CTC patients on ECMO treated with CytoSorb showed 69% survival [Song et al. *Frontiers In Medicine*, DOI:10.3389/fmed.2021.773461]. The current analysis focuses on ECMO utilization with adjunctive CytoSorb therapy.

Methods: A total of 56 patients from 5 U.S. centers were included. Data on demographics, arterial blood gases, ECMO parameters, and CytoSorb use were analyzed. The relationship between the time of CytoSorb start and ECMO duration for groups above and below the median time to CytoSorb start after ICU admission was also analyzed.

Results: In the current analysis, 71% (40/56) overall survival was observed. Survivors were started on adjunctive CytoSorb therapy earlier after ICU admission than non-survivors (138 ± 171.3 vs. 217 ± 134.5 hours, P=0.104) despite similar duration of CytoSorb use (83 ± 29.1 vs. 88 ± 35.1 hours, P=0.583). Twenty-four hours after the end of CytoSorb therapy, ECMO parameters (sweep flow, pump speed, blood flow, FdO_2) were improved in survivors but not in non-survivors. Among survivors, the median time to start of CytoSorb therapy after ICU admission was 80.7 hours. Survivors with start of CytoSorb therapy below this median time had shorter total ECMO duration by 287 hours on average compared to those above this median time (609.5 ± 540.72 vs. 896.6 ± 739.11 hours), however, this trend did not achieve statistical significance (P=0.169).

Conclusions: Higher survival rates have been observed in critically ill patients with COVID-19 on ECMO who received adjunctive CytoSorb therapy. The current analysis suggests that early initiation of hemoadsorption therapy during ECMO following ICU admission may contribute to shorter duration of ECMO support.

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Corticosteroid exposure and outcome in patients with severe COVID-19 receiving veno-venous extracorporeal membrane oxygenation

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Objectives: To describe the association between corticosteroid exposure and outcomes up to 90-day survival and discharge from hospital in patients receiving vvECMO.

Methods: Single-centre retrospective study including adult patients receiving vvECMO and systemic corticosteroids (dexamethasone, hydrocortisone, methylprednisolone or prednisolone) between March 2020 and March 2021. Total steroid exposure was converted to dexamethasone dose-equivalence. 90 day survival, hospital discharge, corticosteroid exposure, additional therapeutic agents, age, weight and APACHE II were analysed.

Results: Ninety-four consecutive patients were included in the study, of whom 64 (68%) were male with median (IQR) age 46 (39-53) years, median weight 90 (80-108) kg, and median APACHE II 15(12-17). Survival outcomes at 30, 60, 90-days and hospital discharge at 90 days were 81%, 67%, 64% and 59% respectively. Median (IQR) length of ICU stay at ECMO centre was 24 (13-44) days.Median (IQR) dexamethasone-equivalent steroid exposure during critical care admission was 572mg (270-1212mg) and median exposure per day of critical care admission was 19mg (8-38mg). Fifty-seven (61%) patients received at least one 'pulse' of IV methylprednisolone (pIVMP) (defined as >250mg/day), median time (IQR) from admission to receiving pIVMP was nine days (2-15 days). Twenty-two (23%) patients received remdesivir, 20 (21%) anakinra, nine patients received tocilizumab or sarilumab. Median (IQR) lymphocyte count was 0.6 (0.4-0.9).

Conclusions: Exposure of dexamethasone equivalence for those receiving vvECMO treatment in this study was four to eight-fold higher than in the RECOVERY and CODEX clinical trials. The impact of high steroid dose on lung function, muscular weakness, heath related quality of life and rehabilitation will need further study.

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Percutaneous Tracheostomy in patients with COVID-19 supported with VV ECMO: A case series and review of the literature

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Objectives: To describe our experience of percutaneous dilational tracheostomy (PDT) in patients supported on V-V ECMO for respiratory failure due to COVID 19.

Methods: Records of all patients supported with V-V ECMO for respiratory failure due to COVID 19 infection were retrieved from the local ECMO database. Patients who underwent PDT were identified and

individual charts reviewed. Baseline demographic data, details of ECMO configuration and procedural notes were recorded in addition to any evidence of complications related to the procedure.

Results:

8 of 30 patients underwent PDT while supported on V-V ECMO, baseline characteristics are presented in Table 1.

Description of patients	
Male	6 (75%)
Resp Score	2
VV Jug-Fem	7 (88%)
VV Dual Lumen Bicaval Cannula	1 (12%)
Duration of MV pre ECMO (IQR) - days	12 (11.25)
Duration of ECMO pre PDT (IQR) - days	22 (6.5)
Total duration of ECMO (IQR) - days	32 (15)
Time off Heparin Pre PDT (IQR) - hours	4.5 (2)
Time off Heparin Post PDT (IQR) hours	6 (1.5)

There was no major bleeding related to PDT formation in our group. In one patient with an upper body dual lumen cannula a small amount of air was entrained into the circuit during the procedure however the circuit continued to run with no impact on the patient. 7 patients survived to decannulation from ECMO and ultimately to hospital discharge.

Conclusions: PDT in patients supported on V-V ECMO is safe when performed by experienced operators. The risk of air entrainment in patients with an upper body drainage cannula should be carefully considered pre-procedure and steps taken to mitigate against this potentially fatal complication. Major bleeding was not a feature in our group which may be related to the small numbers but can be partially attributed to appropriate anticoagulation management and/or the use of bipolar diathermy.

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A single centre retrospective observational study comparing the sedative requirements of patients with COVID-19 requiring ECMO compared to a historical control

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Objectives: To compare sedative strategies and patient outcomes in COVID-19 patients receiving extracorporeal membrane oxygenation (ECMO) with a historical control.

Methods: Single-centre retrospective study in patients ≥16 years-old, receiving continuous intravenous sedation and treated with ECMO between January 2016 and July 2021. We compared outcomes of survival (up to 90 days) and hospital discharge and examined variables such as age, sex, weight, previous alcohol or illicit drug abuse, smoking history, and adjunctive treatment (alpha-2 receptor agonist, opioid analgesia, benzodiazepine or antipsychotic medication) during ECMO treatment.

Results: We included 549 consecutive patients, 95 (17%) with Covid-19; 454 controls (83%). Median (IQR) age and weight were similar. More Covid-19 patients were male (68% vs 58%). Alcohol, smoking and illicit drug use more common in the control group (23% vs 15%, 30% vs 3%, 9% vs 0%).Median (IQR) tertiary hospital ICU length of stay (LOS) and ECMO duration for Covid-19 and control group were 24 (13-40) vs 18 (11-29) days ($p<0.001$) and 13 (7-23) vs 9 (5-16) days ($p<0.001$). 30, 60, 90-day survival and hospital discharge at 90 days for Covid-19 and control group were 80% vs 78%, 67% vs 76%, 66% vs 75%, 66% vs 75%. Propofol was the most commonly used sedative (95% in both cohorts), fentanyl the most commonly used opioid (100% Covid-19 and 84% control group). More Covid-19 patients received midazolam 89% vs 51% ($p<0.001$). Adjunctive medications used in 60% for Covid-19 vs 55% for the control group.

Conclusions: Propofol and fentanyl were most frequently used sedative agents in both cohorts. Midazolam was more common in Covid-19. ECMO duration and ICU length of stay were significantly longer in Covid-19 patients. The impact of these findings on muscular weakness, heath related quality of life and rehabilitation will need further study.

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Hemodynamic assessment of six commercially available oxygenators as paracorporeal artificial lung by a hybrid simulator

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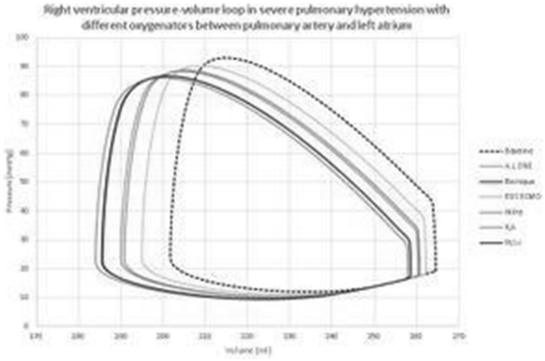
Objectives: To compare the hemodynamic effects of six commercially available oxygenators as paracorporeal artificial lung (PAL).

Methods: A hybrid cardiovascular simulator, including a model of atrial, ventricular, pulmonary and systemic circulation, reproduced 4 pulmonary hypertension (PH) profiles: mild, moderate, severe and cardiogenic shock. Six different oxygenators: 1) A.L.ONE (Eurosets S.r.l, Milano, Italy), 2) Bionique (Hemovent GmbH, Aachen,

Germany), 3) EOS ECMO (LivaNova PLC, London, UK), 4) Hilite 7000 LT (Medos, XENIOS AG, Heilbronn, Germany), 5) ILA (Novalung, XENIOS AG, Heilbronn, Germany) and 6) PLS-i (Maquet GmbH, Gettinge Group, Gothenburg, Sweden) were connected between the simulated pulmonary artery and left atrium.

Results: Improved organ perfusion, reflected by increases in arterial blood pressure (ABP) and cardiac output (CO) and right ventricular (RV) unloading, reflected by decreases in central venous pressure (CVP), RV end diastolic volume (RVEDV), RV peak pressure (RVP_{max}) and pressure-volume area (PVA) were achieved by every oxygenator in moderate and severe PH and in cardiogenic shock. RV unloading was most successful in severe PH and most pronounced when using a Bionique, a PLS-i or an ILA oxygenator. For the latter, e.g., mean ABP increased from 70 to 84 mmHg and CO from 3.5 to 4.6 L/min while CVP decreased from 22 to 21 mmHg, RVEDV from 265 to 258 mL, RVP_{max} from 93.0 to 86.1 mmHg and PVA from 12601 to 11552 mmHg.mL.



Conclusions: Currently, the Bionique, PLS-i and ILA oxygenators seem to be the best hemodynamically suited devices on the market to act as short-term PAL (e.g. during lung transplantation). For long-term use, gas exchange and hemocompatibility should be assessed and optimized. The most optimal moment for implantation seems to be in the phase of severe PH, not awaiting cardiogenic shock to occur.

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Morbidly obese COVID-19 patients have similar survival rates to the non-morbidly obese when supported by veno-venous extracorporeal membrane oxygenation

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Objectives: Morbid obesity presents unique challenges in consideration of patients for veno-venous extracorporeal membrane oxygenation (VV-ECMO) support. Previous studies in the non-COVID-19 population have shown unchanged or improved outcomes in morbidly obese (body mass index (BMI) ≥ 40) patients. However, interim Extracorporeal Life Support Organization (ELSO) guidelines for support in COVID-19 patients utilize BMI ≥40 as a relative contraindication in times of resource limitation. The aims of this study are (1) to compare survival at discharge and length of stay (LOS) in the morbidly obese non-COVID-19 and COVID 19 populations, and (2) compare outcomes in the morbidly obese and non-morbidly obese COVID-19 population supported on VV-ECMO.

Methods: This is a single center, retrospective study. Patients requiring VV-ECMO support for acute respiratory failure from January 2014 to November 2021 were reviewed. COVID-19 patient selection criteria at time of support included BMI as a consideration. Morbid obesity was defined as BMI ≥ 40. Univariate and multivariate analyses were performed.

Results: 380 patients were placed on VV-ECMO; 275 patients in the non-COVID cohort, and 105 patients in the COVID-19 cohort. Survival in non-COVID-19 patients was significantly higher than in COVID-19 patients (74.9%, 65.7%, p<0.0001). In logistic regression analysis, BMI was not significantly associated with mortality. COVID-19-positive status was associated with increased mortality (OR 2.46, 95% CI 1.42-4.28, p= 0.01). Non-COVID-19 patients had shorter VV-ECMO durations (hours) than COVID-19 patients (507, 1075, p<0.001) and shorter LOS (days) (39.1, 57.6, 57.6 p<0.0001). In obese versus non-obese COVID-19 patients, there was no difference in VV-ECMO duration or LOS. Obese COVID-19 patients trend toward improved survival, but this was not statistically significant (73.3%, 62.7%, p=0.298). BMI between COVID-19 survivors and non-survivors was not significant (36.06, 34.23, p= 0.34).

Conclusions: Morbid obesity, in the setting of criteria that include BMI as a consideration, does not affect mortality at discharge, LOS, or ECMO duration,

irrespective of COVID-19 status. BMI should not be considered as a sole factor in VV-ECMO candidate selection. However, larger powered studies are required to confirm our results.

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Prevalence and outcome of patients with bronchopleural fistula requiring extra-corporeal membrane oxygenation for severe respiratory failure

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Objectives: Extra corporeal membrane oxygenation (ECMO) is indicated in patients with severe respiratory failure and massive air leak from broncho/alveolo-pleural fistulae (BPF). The clinical complexity and the limited treatment options compound uncertainty regarding prevalence, mortality and ECMO duration - important considerations when assessing suitability or futility of ECMO.

Methods: Single centre, retrospective analysis in patients with severe respiratory failure who received ECMO at St Thomas' Hospital–London (UK) over an 18-month period (01/02/2020 - 01/08/2021). The study was approved as a service evaluation and informed consent was waived.

Results: We screened 199 patients who received ECMO – of whom 192 received VV-ECMO. Out of 192 patients, 50 (26%) had persistent BPF (for >24 hours). The BPF was present prior to cannulation in 40% (20) of patients. The prevalence of BPF was numerically higher in COVID-19 (72% vs 28%) however, this was not statistically significant (p=0.992). The length of stay in patients with BPF was significantly longer than in patients without BPF (25.7±21.1 vs 15.2 ±12.7 days; p<0.0001). The ECMO LOS was significantly longer between BPF and non-BPF patients only in COVID-19 (31.2±22.5 vs 11.7±13.7 days; p<0.0001), whereas this was similar in non-COVID-19 patients (9.5±7.6 vs 12.4 ±7.7 days; p=0.226). Overall, survival was similar between BPF vs non-BPF (70% vs 80%; p=0.13). Multivariate logistic regression shows that the presence of BPF had no significant association with survival (OR 0.57; 95%CI 0.27-1.21; p=0.147); while COVID-19 aetiology was an independent variable associated with lower survival (OR 0.3; 95%CI 0.12-0.77; p=0.012).

Conclusions: This study shows that for patients with BPF there is an association with longer length of stay but similar survival when compared with patients without BPF for the same aetiology. COVID-19 is the only independent factor associated with worse outcome in this cohort.

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Physiotherapy intervention and patients on VV-ECMO due to COVID-19

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Objectives: Physiotherapy is an established treatment for patients on ECLS. The range and intensity of physiotherapy input varies based on the patients underlying respiratory and physical condition and level of consciousness. COVID-19 has presented new challenges for physiotherapists working with this patient population. The objective was to explore the physiotherapy treatments provided to patients on ECMO due to COVID-19 during the first pandemic wave in the UK.

Methods: Retrospective observational data were collected and analysed for all patients admitted to a commissioned UK ECMO centre from March to June 2020.

Results: Thirty-five patients were admitted for VV ECMO due to COVID-19 over four months. All patients were included in the data collection and analysis.

All patients received a respiratory assessment and chest clearance treatment; predominantly suctioning, escalating to saline instillation and manual techniques as required. 28 patients commenced active rehabilitation; the remaining seven patients were sedated throughout their admission and did not achieve a RASS score of 0 which would enable them to participate in active rehabilitation. Active rehabilitation started with sitting on the edge of the bed or hoist to chair. The activity of marching on the spot or mobilising away from the bed space was achieved by six patients on 36 occasions documented

by the physiotherapy team. The other twenty-two patients who participated in active rehabilitation did not progress to be able to step therefore did not march or walk, but were sitting on edge of bed or practising standing prior to ECMO ICU discharge. **Table 1** presents the outcomes of the 28 patients:

ICU mobility score: range (mean)	0-8 (1.7)
CPAx score: range (mean)	0-37 (6.7)
ECMO survival to decannulation (n)	69% (24)
Length of ECMO ICU stay (days)	4-142

Conclusions: This abstracts provides information on the physiotherapeutic interventions provided to patients who received ECMO due to COVID-19.

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Characteristics and outcomes of Veno-venous extracorporeal membrane oxygenation (VV-ECMO) for COVID-19 across pandemic waves

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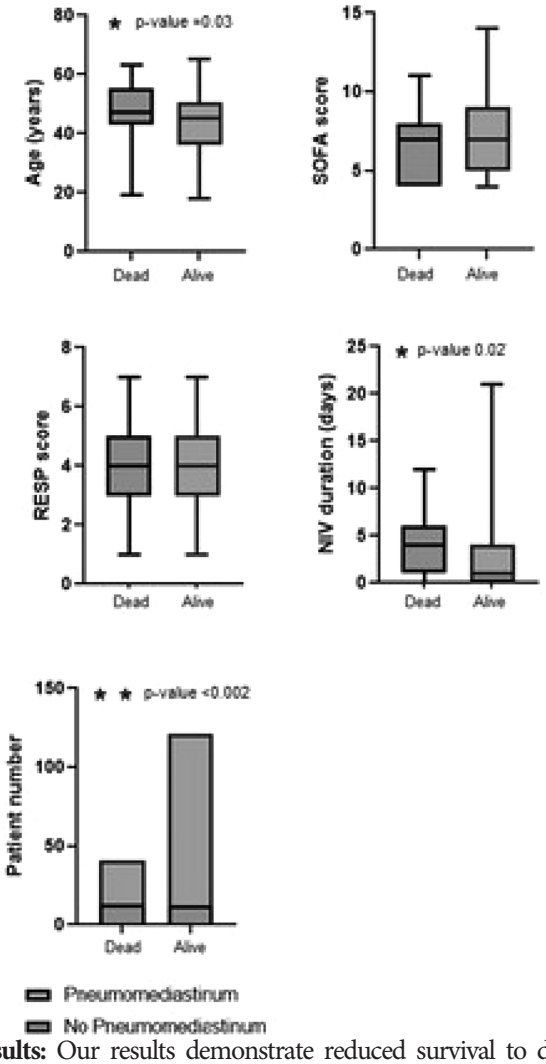
Objectives: Compare the characteristics and outcomes of patients supported on VV-ECMO for COVID-19 across all three waves of the pandemic in an UK ECMO centre.

Methods: We analysed characteristics and outcomes of each cohort and survival across the entire group using GraphPad PRISM software.



Results: Our results demonstrate reduced survival to decannulation in the 2nd and 3rd waves despite lower severity scores (RESP and SOFA) and increased use of immunomodulation prior to ECMO initiation. There were

	1st wave (01/03/20-31/08/20)(n=53)	2nd wave (01/09/20-31/05/21)(n=70)	3rd wave (01/06/21-13/01/22)(n=39)	p-value
Age	46.0(7.8)	46.4(11.5)	40.0(10.0)†(1,2)	0.004
Sex (male)	39.0(73.6%)	46(65.7%)	26(66.7%)	0.061
NIV pre-ECMO	0.0(0.0-3.3)	3.0(0.0-7.0)†(1)	2.0(0.0-4.0)	0.009
RESP Score	4.0(3.0-5.0)	4.0(3.0-5.0)	5.0(4.0-6.0)†(1,2)	<0.001
SOFA Score	8.0(7.0-10.5)	7.0(4.5-8.0)†(1,3)	4.0(4.0-7.0)†(1,2)	<0.001
Pneumomediastinum pre-ECMO	3.0(5.7%)	13.0(18.6%)	9.0(23.1%)	0.046
Steroids or IL6 inhibition pre-ECMO	11.0(20.8%)	70.0(100.0%)†(1)	38.0(97.4%)†(1)	<0.001
Mortality at decannulation	5.0(9.4%)	21.0(30.0%)†(1)	15.0(38.5%)†(1)	0.003
ECMO days	18.0(12.0-30.0)	30.0(16.0-58.0)†(1)	36.0(22.0-40.0)†(1)	0.002

P-values are comparison across all groups. † denotes significant differences on sub-analysis with numbers in brackets representing the wave to the which the difference refers.

also differences in incidence of pneumomediastinum and duration of NIV between waves. Despite similar RESP and SOFA scores; age, presence of pneumomediastinum and duration of NIV were different between survivors and non-survivors at decannulation (figure 1).

Conclusions: Our data demonstrates reduced survival to decannulation between the 1st and subsequent waves alongside a changing phenotype of patients receiving ECMO. Overall, outcome is associated with NIV duration and incidence of barotrauma. Further studies to define the optimal application of ECMO in COVID-19 are required.

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Extracorporeal membrane oxygenation for critically ill patients with COVID-19 pneumonia: A propensity-matched cohort study

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Objectives: In select patients with severe COVID-19 pneumonia, treatment with extracorporeal membrane oxygenation (ECMO) can facilitate lung-protective ventilation and may improve. To date, only one propensity matched cohort study comparing the impact of ECMO and maximum invasive mechanical ventilation alone (MVA) on mortality in severe COVID-19 pneumonia has been published.

This study demonstrated 3-fold improvement in survival with ECMO (75%) compared to MVA (26.2%). We aimed to perform a confirmatory propensity matched cohort study.

Methods: All 295 consecutive adult patients with confirmed COVID-19 pneumonia admitted to intensive care unit (ICU) from March 13th 2020 to July 31th, 2021 were studied. Based on medical history, age and clinical frailty index, patients were classified into 3 categories: 1) full code including initiation of ECMO therapy (AAA code), 2) full code excluding ECMO (AA code), 3) Do-not-intubate (A code). Match eligibility was determined for all patients with AAA-code treated with MVA. Propensity score matching was performed using a logistic regression model including following variables: gender, age, P/F ratio and Rockwood Clinical Frailty index score. Primary endpoint was ICU mortality.

Results: A total of 24 ECMO patients were propensity matched to an equal number of MVA patients. ICU-mortality was significantly higher in the ECMO arm (45.8%) compared with the MVA cohort (8.33%) (OR 9.30 (1.78 -48.72); p<0.01). Three-month mortality was 50% with ECMO compared to 8.33% after MVA (OR 11.00 (2.10-57.50); p<0.01). Applied peak inspiratory pressures (33.47 ± 8.60 vs 24.74 ± 4.86mmHg; p<0.01) and maximal PEEP levels (13.95 ± 3.86 vs 11.05 ± 2.20mmHg; p=0.01) were higher with MVA.

Conclusions: ECMO therapy may be associated with an up to five-fold increase in ICU mortality and 3-month mortality compared to MVA despite the facilitation of lung-protective ventilation settings in mechanically ventilated COVID-19 patients. We cannot confirm the results of Mustafa et al.

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VV ECMO for peripartum COVID -19 pneumonia related ARDS

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Objectives: Veno venous Extracorporeal Membrane Oxygenation (VV-ECMO) is the end stage treatment modality for ARDS. Data about use of VV-ECMO for COVID-19 related ARDS for peripartum period is limited. We share our experience for VV-ECMO use in COVID -19 related ARDS in the peripartum period.

Methods: From april 2021 to December 2021 we performed VV-ECMO to 11 patients (10 postpartum-1 pregnant) at Kosuyolu Higher Specialization Education and Research Hospital. All the patients were cannulated with femoro-jugular veno-venous approach. Sorin (LivaNova,London,UK) ECMO pump console and oxygenator were used for all the patients. Bivaluridin were used for anticoagulation for all the patients.

Results: Mean ECMO time was 42,36 (min14-max 68) days. 8 of 11 (72,7%) patients was weaned successfully. 6 (54,5%) of them was discharged and 2 of them are receiving rehabilitation at the ward. 3 patients died during follow up because of sepsis

Conclusions: Covid-19 related ARDS is a mortal condition. Use of VV ECMO is still debate because of high mortality. We think that patient selection is crucial and our results showed that use of VV ECMO at the peripartum period has acceptable results. Multidisciplinary approach is crucial for these patients and with quick decision making and intervention ECMO could be a lifesaving procedure for these patients.

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VV-ECMO for COVID-19 related ARDS during pregnancy

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Objectives: Covid-19 infection during pregnancy may have worse outcomes for both mother and the baby. Current data about using VV-ECMO for COVID-19 related ARDS infection especially for the pregnant is limited. We share the first succesful living delivery during ECMO follow up for COVID-19 related ARDS.

Methods: 27 years old (gravida 2 para 1) at 30 gestational weeks patient with COVID-19 related ARDS at another center is evaluated with our ECMO TEAM. ECMO was implanted by our mobil ECMO TEAM with urgent decision via femoro-jugulary veno-venous approach. The patient was evaluated and followed by multidisciplinary approach. The babies' wellbeing was evaluated by perinatologists. Bivaluridin used for anticoagulation. Sorin (LivaNova,London,UK) ECMO pump console and oxygenator were used for follow up.

Results: The delivery was performed with C/S at the 8th day (31+2 gestational week) of ECMO support. The baby was followed at newborn ice for a few days and discharged 2 weeks later. The mother was followed for 30 days with ECMO support and successfully weaned off. 1 week later the patient was taken to ward for rehabilitation.

Conclusions: Decision for implanting ECMO and follow-up for the general population is a complicated process. For the pregnant patients decision for timing of intubation, implanting ECMO, and delivery needs multidisciplinary approach and close follow up. Generally physicians prefer urgent delivery without waiting for fatal maturation and support with ECMO after C/S for these type of patients. On the other hand for selected patients our approach provides an opportunity for fatal maturation and save the mother's life at the same time.

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Level of sedation in patients with COVID-19 supported with ECMO: a comparative analysis of the Critical Care Consortium international database

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Objectives: To compare two sedation strategies used in patients with COVID-19 supported with ECMO.

Methods: Retrospective, observational substudy of the COVID-19 Critical Care Consortium database including COVID-19 patients supported with ECMO, from March 2020 to September 2021. Among these, we identified two cohorts. The *awake* cohort included patients with consecutive RASS values achieving zero value at some point. Control group included patients receiving neuromuscular blockers during their full ECMO run. We compared their profile prior to ECMO, complications and outcomes.

Results: Within a total of 851 patients, 59 accomplished criteria for the awake cohort and 62 for the control group. Table 1 summarizes the profile of both cohorts. Of note, we did not identify significant differences in the clinical condition prior to ECMO initiation. No difference was found between the mean blood flows, but mean sweep flow was lower in the awake cohort. These patients needed longer ECMO runs and circuit was changed in 26 (44%) of them [14 (23%) in the control group, P=0.02]. Despite longer ECMO runs, infectious events were not more frequent in the awake cohort and hemorrhagic complications were more frequent in the control group. Mortality was significantly lower in the awake group.

Variable	Awake (N=59)	Control (N=62)	p-value
Age, years	49.5 (12)	50 (12)	0.81
Sex, male	35 (59%)	46 (74%)	0.12
Time MV to ECMO	4.8 (5)	4.4 (4)	0.29
APACHE II score	17.5 (9)	16.3 (9)	0.59
SOFA socre	7.9 (4)	7.3 (3)	0.54
P/F preECMO, mmHg	100 (50)	91.5 (41)	0.12
$PaCO_2$ preECMO, mmHg	60.4 (42)	51.8 (16)	0.25
Driving pressure preECMO, cmH_2O	13.5 (4)	13.5 (4)	0.61
Mean ECMO blood flow, Lpm	4 (1)	3.9 (1)	0.68
Mean gas flow, Lpm	3.7 (2)	5.3 (2)	<0.01
Patients with infectious complications	31 (53%)	39 (63%)	0.33
Patients with hemorrhagic complications	13 (22%)	27 (44%)	0.02
ECMO days	33.8 (53)	16 (12)	0.02
Hospital days	45 (29)	30.5 (26)	0.11
Survived	42 (71%)	26 (42%)	<0.01

Conclusions: Decreased sedation in COVID-19 patients needing ECMO is feasible. In our cohort, this maneuver was associated with longer runs and higher incidence of circuit replacements than in

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Lower PRESET scores correspond to decreased mortality rates in COVID-19 patients on VV-ECMO

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Objectives: The PREdiction of Survival on ECMO Therapy Score (PRESET) predicts mortality while on veno-venous extracorporeal membrane oxygenation (VV ECMO) for acute respiratory distress syndrome. We studied overall mortality using PRESET in a COVID-19 VV ECMO cohort and evaluated differences in survival before and after implementation of PRESET as a triage tool for candidacy.

Methods: This is a single-center retrospective study of COVID-19 VV ECMO patients from March 1, 2020 to November 30, 2021. Our institution implemented PRESET as part of a multi-disciplinary VV ECMO candidate screening process on November 26, 2020. Univariate and multivariate analyses were performed to assess patient mortality and score differences.

Results: Out of 105 patients, a PRESET less than or equal to 6 corresponded to improved survival compared to a score greater than or equal to 7 (97.7%, 43.5%, $p < 0.0001$). All survivors (n= 69) had a mean PRESET of 6.03 (SD 2), while non-survivors (n= 36) had a mean score of 8.11 (SD 1) ($p < 0.0001$). Logistic regression found PRESET was significant in predicting mortality (OR 2.84, 95% CI 1.75, 4.63, $p < 0.0001$). There were 55 patients in the pre-implementation group and 50 patients in post-implementation group. BMI, SOFA, and RESP, scores were not statistically different between the groups. Mean PRESET scores were not different (6.95, 6.51, p= 0.253). Patients in the post-implementation group were more likely to have a PRESET less than or equal to 6 (30.9%, 52%, p= 0.03). Survival rates between the pre and post-implementation groups were not statistically significant (60%, 72%, p= 0.2).

Conclusions: COVID-19 patients selected for VV ECMO with lower PRESET scores had improved mortality. After implementation of PRESET as part of our screening process, more patients with lower PRESET scores were selected. Though survival percentages improved, this was not statistically significant. Further research and larger cohorts are needed.

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Mobilization and awake extracorporeal membrane oxygenation for COVID-19 acute respiratory distress syndrome: A prolonged course with successful outcome

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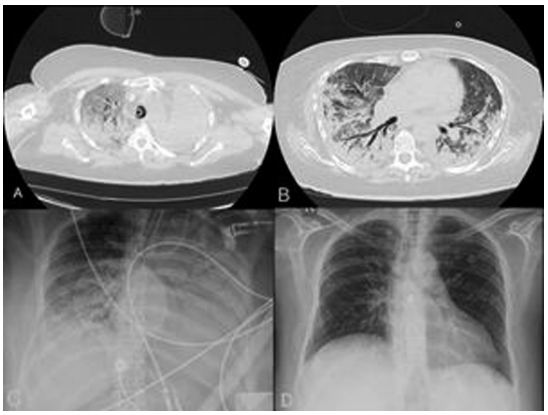
Objectives: To present a case; demonstrating the successful outcome following an awake ECMO with extensive physiotherapy and mobilization resulting in avoiding lung transplantation.

Methods: A 55 years old diabetic lady presented with severe ARDS secondary to COVID pneumonia which was not responsive to conventional therapy and was therefore started on VV-ECMO. The patient was extubated successfully after three days of initiation of ECMO. She remained extubated throughout the ECMO course which lasted for 66 days till the lungs showed full recovery and ECMO decannulation was achieved. Her total ICU stay was 100 days and her total hospital stay was 120 days. ECMO cannulation was achieved through femoro-jugular cannulation. Aggressive physiotherapy was started early with gradual mobilization reaching the level of walking on ECMO within the ICU. Early extubation and mobilization contributed significantly to avoiding several complications including development of VAP, pressure ulcers and critical care myopathy. Being awake on ECMO had the advantage of better patient communication with the staff and family, better feeding and maintaining of muscle power. Mobilizing a COVID patient on ECMO is challenging considering the risks of viral transmission but was achievable with an experienced team in mobilizing ECMO patients. The patient was referred for consideration for lung transplant after 50 days on ECMO, however, she managed to avoid that after showing full lung recovery whilst on the waiting list.



Results: Successful decannulation was achieved after full lung recovery with subsequent home discharge and avoidance of lung transplantation.

Conclusions: Awake ECMO and extensive mobilization for a COVID patient is achievable and may lead to lung recovery and avoidance of lung transplantation. This highlights importance of further investigating the effects of this approach on the recovery of this group of patients.

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The first mobile extracorporeal membrane oxygenation (ECMO) course in Japan

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Objectives: With the COVID-19 pandemic, the demand for ECMO and critically ill patient transport has increased sharply. However, in Japan, a system for transporting critically ill patients has not been sufficiently constructed. Our hospital, which has a Critical Care & ECMO Transport team (CCETT), which is rare in Japan, has developed the first CCETT training course. We conducted a questionnaire survey and investigated its effectiveness.

Methods: The course, which is based on participation as a multidisciplinary team, consists of lectures (including introduction to transport, physiology of transfer, mode of transport, team resource management, logistics, troubleshooting, risks and costs) and simulations (including preparation, packaging, troubleshooting in vehicles and team debriefing). For each program, the course's effectiveness was examined by conducting a questionnaire using Likert scale before and after the course. In our course, ECMO Transport process is divided into three steps: Phase 1, call ~ dispatch; Phase 2, Activities at the referral agency (retrieval); Phase 3, Transfer. For these, also examined by conducting a same questionnaire.

Results: Of the 34 participants, 57% had no experience with ECMO transport, but 23% had experience with four or more cases. Of the participants, 95% were confident about improving their ECMO transport skills and knowledge, and 81% understood the importance of non-technical skills within the team after taking the course. The participants' improvement for each transport step was: Phase1: 9.5 → 57.1%, Phase 2: 14.3 → 57.2%, Phase 3: 9.5 → 33.3%. Additionally, 95.2% of the participants understood the need for continuous training. Most of the participants were satisfied with the presentation and provision of the documents used by our hospital for transport.

Conclusions: Our course may help to achieve safe and effective Critical Care & ECMO Transport (CCET) and may even help in building a CCET system in Japan.

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Risk factors of thrombotic complications in COVID-19 patients with ECMO support

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Objectives: To analyze factors related to thrombotic events in COVID-19 patients supported with ECMO in a center.

Methods: Retrospective, observational study including COVID-19 patients supported with V-V ECMO from March 2020 to September 2021 in the Vall d'Hebron University Hospital. By protocol, patients receive heparin for ACT of 180s, except if bleeding is present. A comparison between patients with thrombotic complications against those with no events was done using chi2 test, Fisher exact test, Student T-test or Mann-

Withney's U-test as appropriate. Logistic regression analysis was performed to analyze the occurrence of thrombotic events. Variables with p< 0.1 in univariate analysis were included in the model.

Results: Among 90 patients [55 years (49-61), 80% male] the overall hospital survival was 70%. Thrombotic events were identified in 52 patients (58%). Pulmonary embolism and deep venous thrombosis were evidenced in 11 (21%), circuit thrombosis in 32 (62%) and all the events in 9 (17%). Table 1 summarizes the comparison between cohorts. In the multivariate analysis higher levels of D-dimer prior to ECMO initiation were associated with a higher risk of thrombotic complications (OR 1.001 95%CI [1.0001-1.002]).

Conclusions: Thrombotic events are frequent during ECMO support in COVID-19 patients. Patients with higher levels of D-dimer prior to cannulation are at higher risk of suffering this complication and may benefit from specific anticoagulation adjustment.

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The impact of duration of symptoms prior to extracorporeal membrane oxygenation initiation on outcomes of COVID-19 patients

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Objectives: Coronavirus disease 2019 (COVID-19) is a global threat due to its rapid spread. COVID-19 patients who develop acute respiratory distress syndrome (ARDS) are at a high risk of mortality. Venovenous (VV) Extracorporeal Membrane Oxygenation (ECMO) is a well-established rescue intervention for COVID-19 patients associated with severe ARDS. However, the optimal timing of initiation of ECMO is unclear. Therefore, the goal of the study is to investigate the impact of the duration of symptoms before ECMO initiation on patient outcomes.

Methods: A retrospective analysis of patients with COVID-19 pneumonia who required VV ECMO for respiratory support was conducted at a single institution. The study period extended from March 2020 to April 2021. Data captured include baseline patient characteristics, comorbidities, pre-ECMO respiratory support, duration of symptoms before ECMO support, laboratory results, therapeutic interventions, and ICU length of stay (LOS). Survival to hospital discharge was the primary endpoint.

Results: 46 patients (mean age of 44.83±10.46 years, 29 (63.0%) male, and 19 (45.2%) Hispanics race) supported by VV ECMO for COVID-19 associated severe ARDS were included in this study. 25 (54.3%) patients deceased during the study period. The median of COVID-19 symptoms duration before ECMO initiation was 15.00 days (IQR=10.50 - 18.89) in survivors vs. 13.00 days (IQR= 6.00 – 21.00) in non-survivors. No significant difference was found in the median of COVID-19 symptoms duration before ECMO initiation between survivors and non-survivors (p=0.899, two-sided Wilcoxon rank-sum test). The median ICU LOS based on Kaplan-Meier analysis was 56 days. Based on the univariate Cox proportional hazards models, increased COVID-19 symptoms duration before ECMO initiation was associated with a decreased hazard of ICU discharge (hazard ratio=0.918, p=0.022).

Conclusions: The impact of duration of symptoms prior to ECMO initiation on outcomes of COVID-19 patients remains unclear. Future prospective studies with larger sample size and longer duration of follow-up are needed.

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Severe COVID-19 in postpartum women: Respiratory failure and pulmonary embolism after ECMO

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Objectives: COVID19, a disease caused by the SARS-Cov-2 virus, emerged in 2019. Different manifestations occur in the general population. In pregnant and postpartum women, the clinical presentation is more severe with a significant increase in thromboembolic events.

Methods: Case report.

Results: 6-day-old puerperal woman, 24 years old, admitted to the emergency unit due to respiratory failure associated with mild flu-like symptoms. Supplementary oxygen was started by mask, HFNC and NIV, with no improvement in hypoxemia. Lung X-Ray showing significant bilateral opacity of the lung parenchyma. Intubated 24 hours after admission. Optimized mechanical ventilation parameters, started NO, without clinical or blood gas improvement, with maximum P/F 78. ICU team tried prone positioning but she started severe hypotension and bradycardia . 12 hours

Table 1. *Clinical and laboratory data in COVID 19 patients supported with V-V ECMO.*

Variable	All (N=90)	No Thrombosis (N=38)	Thrombosis (N=52)	p-value
Anticoagulation pre ECMO	27 (30)	7 (18)	20 (38)	0.04
PaO2/FiO2 pre ECMO (mmHg)	64.5 (58-80)	62.5 (59-72)	70 (57-80)	0.293
pCO2 pre ECMO (mmHg)	59 (53-75)	57 (50-72)	62 (53.5-79)	0.105
pH pre ECMO	7.3 (7.23-7.32)	7.3 (7.25-7.34)	7.29 (7.22-7.32)	0.069
WBC pre ECMO (x 10^9 cells/L)	12.4 (8.32-18.21)	10.9 (8.8-15.7)	14.4 (9.2-19.4)	0.088
Platelet pre ECMO (x 109 cells/L)	220 (161-329)	205 (153-329)	229 (190-328)	0.316
D-dimer pre ECMO (ng/ml)	1503 (776-3151.5)	900 (567-2506)	2384 (1205-3846)	0.018
ECMO (days)	20 (11-40)	17.5 (10-30)	27 (13-43)	0.54
Hospital survival	63 (70)	22 (59.5)	42 (82.4)	0.017

after intubation, pulmonary support was indicated and started VV ECMO (Flow 75 ml/kg, Sweep 2.5, FiO2 100%). After 12 hours of support she was on pressure support mode MV, and was extubated on D2 ECMO. She remained extubated, underwent active motor and pulmonary rehabilitation. ECMO weaning started on D6, with decannulation on D7. During the run, strict anticoagulation control with aPTT 2.5-3. After decannulation, patient presented tachycardia with chest pain. She evolved with a new respiratory worsening, marked by severe hypoxemia. Reintubated and restarted again 36 hours after decannulation by P/F 55. Echocardiogram showed indirect signs of PTE. So was indicated a second VV ECMO run, and was optimized anticoagulation scheme with introduction of fondaparinux. Decannulated on D6 of the second run, with hospital discharge 12 days after decannulation.

Conclusions: Pulmonary involvement associated with the postpartum woman's hypercoagulable state, infers more severe conditions associated with COVID to this group. Pulmonary involvement associated with the postpartum woman's hypercoagulable state, infers more severe conditions associated with COVID to this group.

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Add-on prostaglandin e_1 in venovenous extracorporeal membrane oxygenation: A randomized, double-blind, placebo-controlled trial

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Objectives: Prostaglandin E_1 (alprostadil; PGE_1), in addition to low-dose unfractionated heparin, increases the biocompatibility of extracorporeal systems and enhances the efficacy of artificial organs without increasing bleeding risk. We investigated the safety and efficacy of PGE_1 in adults receiving venovenous extracorporeal membrane oxygenation.

Methods: This study was a randomized, double-blind, placebo-controlled phase-II-pilot trial at two medical intensive care units at the Medical University of Vienna, Austria. Adults with venovenous extracorporeal membrane oxygenation were randomly assigned to receive an intravenous infusion of 5 ng/kg/min PGE_1 or placebo (0.9% saline), in addition to standard anticoagulation with unfractionated heparin.

The primary outcome was the rate of transfused packed red blood cells per ECMO day. Secondary outcomes were the incidence of and the time to clinically overt bleeding and thromboembolic events. A post-hoc subgroup analysis included only patients with COVID-19.

Results: Between September 2016 and April 2021, of 133 screened patients, 50 patients were randomized, of whom 48 received the assigned study medication (24 per group). The transfusion rate was similar between groups (0.41 vs. 0.39;p=0.733). Prostaglandin E_1 was associated with fewer thromboembolic events (7 vs. 16;p=0.020) and longer thromboembolism-free time (HR 0.302;p=0.01), fewer clinically overt bleeding events (2 vs. 11; p = .017), and longer bleeding-free time (HR 0.213;p=0.047). In COVID-19 patients (n=25), the hazard ratios for clinically significant bleeding and thromboembolism were 0.276 (95% CI 0.035-2.186) and 0.521 (95% CI 0.149-1.825), respectively.

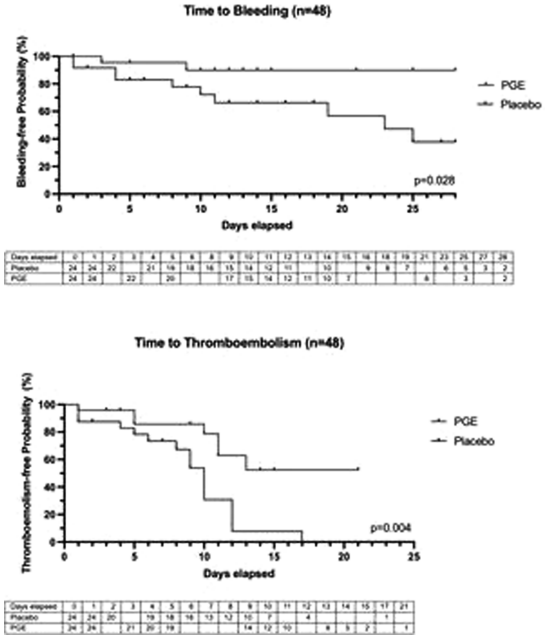

Figure 1. Time to first thromboembolic (a) and clinically significant bleeding event (b).

Conclusions: Add-on treatment with PGE_1 was safe but did not meet the primary endpoint of reducing the rate of red blood cell transfusions in patients on venovenous ECMO. Larger studies need to evaluate the safety and efficacy of additional PGE_1 in ECMO.

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Intracranial hemorrhage and veno-venous ECMO. A retrospective single center analysis

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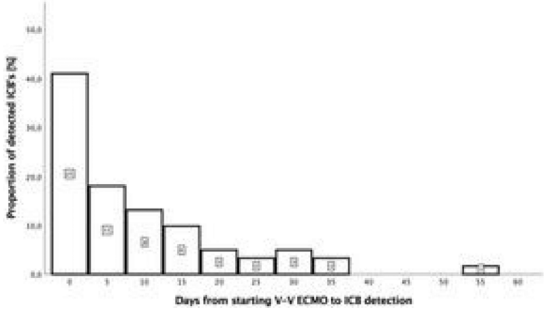
Objectives: The use of V-V ECMO is steadily increasing. Intracranial bleeding (ICB) is a serious complication with potentially fatal consequences. This study aimed to evaluate the incidence and onset of ICB among patients treated with V-V ECMO and to identify potential risk factors.

Methods: Retrospective single center analysis of 739 V-V ECMO runs from 2006 to 2019. Screening for ICB with CT scans was performed. Traumatic ICB's were excluded. First recognition of ICB in cerebral imaging was defined as date of ICB.

Results: 556 patients were included in the analysis. 61 ICB's were found (incidence 10.9%). Only 17 ICB's presented with obvious symptoms, while 43 ICB'S were detected in screening CT's. ICB was detected in median 5 days after starting V-V ECMO (Figure 1). Overall survival to ICU discharge was 63.7%, survival in patients with ICB was worse (29.5%; p<0.001). Identified main risk factors prior to cannulation were: platelets below 100/nl (OR: 3.57), impaired kidney function (creatinine >1.5mg/dl; OR: 2.13) and high doses of norepinephrine (>2.5mg/h; OR: 2.5). Rapid decrease in $paCO_2$ (>35mmHg in 2 hours, OR: 2.56) and norepinephrine (>1mg/h in 2 hours, OR: 2.53) after cannulation increase risk for ICB. Persistently high levels of CRP (>160mg/dl in median during V-V ECMO treatment; OR: 2.24), bilirubin (> 2mg/dl, OR: 2.16) and alkaline phosphatase (>180U/L, OR: 3.63) were found to increase risk for ICB.



Conclusions: ICB during V-V ECMO is frequent and occurs rather early. Many bleedings were incidental findings, therefore screening for ICB is advisable.

Identified risk factors reflect underlying disease' severity, peri-cannulation factors and persistent multiorgan failure. Risk factors that can be influenced are avoiding rapid decrease in $paCO_2$ and coagulation disorders prior to cannulation.

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Long-term outcome of extracorporeal membrane oxygenation in COVID-19 related severe respiratory failure in low-volume ECMO centre

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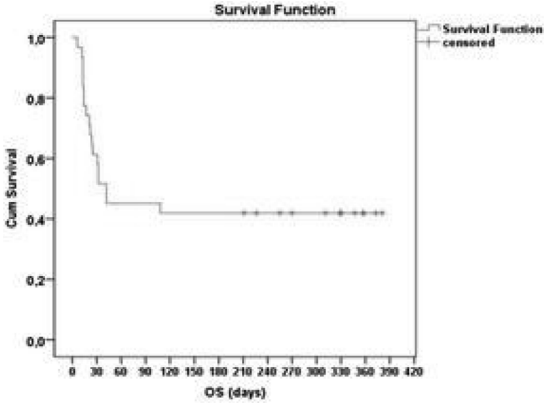
Objectives: We sought to evaluate long-term outcome of V-V ECMO support in COVID-19 related severe respiratory failure within the 2nd to 4th wave of coronavirus pandemic.

Methods: Retrospective analysis of 31 consecutive patients (78.6% male, mean age 54.3±12.2 years, mean

BMI 35.3±8.5 kg/m2) with critical hypoxemic and/or hypercapnic refractory respiratory failure (mean P/F ratio 69.8±12.3 mmHg, mean pCO2 78.0±15.7 mmHg, Murray Score3.68±0.4) on V-V ECMO support from October 2020 to May 2021.

Results: With mean support duration 243.8±65.1 hours, 22 patients (70.9%) were successfully weaned off. Finally, 14 of them (45.2%) were discharged home with good neurological outcome (CPC 1,2). During follow-up, 30-day, 3-, 6-, and 12-month survival rate was 61.3%, 45.2%, 41.9%, and 41,9% respectively. In survivor group shorter symptoms onset to respiratory failure time (4±4.7 vs. 7±6.7 days, p=0.04), higher P/F ration (86±41.5 vs. 65±37.5 mmHg, p=0.04) and norepinephrine support (0.03±0.06 vs. 0.09±0.12 ug/kg/min, p=0.04), and lower IL-6 level (12.3±7.5 vs. 25.9±8.8 ng/l, p=0.03) p=0.01) were analysed before cannulation. Mean in-ICU stay and in-hospital stay in survivors' groups reached 29.5±25.7 days and 44.5±33.7 days, respectively. All long-term survivors (13 patients) complained about slight functional health limitation only with normal 6MWT (542.6± 89.2 min), near to normal spirometry parameters (FEV/VC 87±7.4%, DLCO 63.1±13.7%, KCO 82.,1±19.4%) and slight neurological disability (CPC 1-2).

Conclusions: Outcome of V-V ECMO support in COVID-19 severe respiratory failure is acceptable even in the scope of low-volume ECMO centre. Reported functional status of long-term survivors was good despite the complicated and prolonged in-hospital stay. Supported by MH CZ – DRO (FNOl, 00098892).



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Advantages of anticoagulation with bivlidrudin in ECMO therapy for Covid-19 related ARDS

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Objectives: To compare the stability of anticoagulation and other variables associated with it in critical patients undergoing ECMO therapy in treatment with unfractioned heparin (UFH) vs Bivalirudin.

Methods: Prospective observational study that includes all patients with COVID-19 related ARDS with ECMO therapy (March 2020 to July 2021). In all cases, AC was started with UFH, changing to Bivalirudin in case of suspicion of Heparin-Induced Thrombocytopenia (HIT). A descriptive analysis of the clinical data of the patients included was performed. Statistical analysis: Descriptive analysis: qualitative variables in percentages (95% CI) and quantitative variables in means or medians (95% CI) according to normality (Kolmogorov-Smirnov test). Univariate analysis: Chi-Square or F-Fisher test (qualitative variables) and T-Student or Mann-Whitney U test (quantitative variables).

Results: All patients in our study (n=49) were initially anticoagulated with UFH and later with BV 9/49: 0.18 (95% CI: 0.1 to 0.3). In 11/49 patients (0.22 95% CI: 0.09 to 0.5) anti-platelet factor 4 antibodies (anti-FP4 AC) were requested, being positive in 6/11 (0.12 95% CI: 0.05 to 0.25). Three PF4-negative patients continued BV based on clinical decision. Anticoagulation therapy had to be stopped because of complications in some cases of both groups, being the proportion of time needed without UFH greater than without BV [0.6 (95% CI: 0.4 to 0.6) vs 0.3 (95% CI: 0.2 to 0.4); p=0.04]. Anticoagulated patients with UFH required more dose adjustment than those with Bivalirudin [5 times in 10 days (95% CI: 4.3 to 5.3) vs 2 times in 10 days (95% CI: 1.2 to 2.9) (p<0.0001). Membrane oxygenator half-life in treatment with UFH was shorter than with Bivalirudin [11 days (95% CI: 4 to 16.8) vs 27 days (95% CI: 12.2 to 43.1); p=0.037].

Conclusions: In our samples, anticoagulation with Bivalirudin of patients with COVID-19 related ARDS on ECMO therapy was more stable than with UFH.

The patients treated with Bivalirudin were during more time under anticoagulation therapy and the membranes have a longer half-life. More studies are needed to support this claim.

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Increased bleeding risk in COVID-19 patients on VV-ECMO

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Objectives: ECMO is organ support for patients with refractory respiratory failure. The use of ECMO has

dramatically increased during the COVID-19 pandemic, but it has a persistent risk of thrombosis. Anticoagulant treatment can lead to an increased risk of bleeding. Therefore, the balance between thrombosis and bleeding reflects opposing risks during the use of ECMO. The aim of this study was to explore whether the balance between thrombotic and bleeding events differ in COVID-19 versus non-COVID-19 patients supported by VV-ECMO.

Methods: This was a retrospective cohort study composed of patients admitted to general/COVID-19 critical care departments at a single tertiary center between 2012 and 2021. They were supported by VV-ECMO for respiratory failure. Therapeutic anticoagulation with heparin or bivalirudin was administered. Special attention to hemostasis and coagulation status was given.

Results: Thirty COVID-19 patients and 20 non-COVID-19 patients were analyzed with survival rates of 46.7% and 40%, accordingly. The duration on ECMO was 18.2±15.2 days versus 10.5±5.1 (p=0.035) for COVID-19 and non-COVID-19 patients with a maximal blood flow of 5.33±1.08 L/min versus 4.05±0.88 L/min (p<0.001), respectively. Bleeding episodes occurred in 86.7% of COVID-19 patients vs. 65% of non-COVID-19; thrombosis was seen in only two COVID-19 patients vs. one non-COVID-19 patient. D-dimer was significantly higher in COVID-19 patients reaching 25148±22538.03 ng/mL vs. 7676.5±61.5 ng/mL in non-COVID-19; p=0.014. Heparin induced thrombocytopenia antibodies were analyzed by rapid immunoassay and were found in 14 (46.6%) COVID-19 patients vs. 2 (10%) without, p = 0.066, respectively.

Conclusions: Bleeding was seen in both groups during VV-ECMO whilst on therapeutic doses of anticoagulants, but it was more common in COVID-19 patients; new thrombotic events were rare. Further studies are urgently needed to find the optimal anticoagulant regime to reduce bleeding during VV-ECMO, to explore the pathophysiology of bleeding related to the ECMO itself, and to identify patients who are at a particularly high risk of bleeding.

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Pathologic evaluation of COVID-19 related ARDS patients under ECMO support - is this a reversible late ARDS form ?

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Objectives: Covid-19 pneumonia may cause ARDS and patients may need ECMO support. It is still not clear that pulmonary damage caused by this infection is reversible or not. We aimed in our study to evaluate the infected lungs pathologically on the late (after ten days) ARDS phase and to reveal the pathological changes.

Methods: 6 patients which we supported with ECMO because of COVID-19 related ARDS and needed surgical exploration because of prolonged air leak or empyema were evaluated. All the patients were supported with femoro-jugular veno-venous ECMO approach. All the samples were taken with wedge resection with VATS(3 patients) or thoracotomy(3 patients) approach. Tissue samples for histopathologic analysis were immeadiately fixed in 10% neutral buffered formalin for 24 hours, then processed with hematoxylin eosin staining and immunochemical markers.

Results: 2 patients were weaned from ECMO and discharged from hospital. 4 patients died because of sepsis. Mean follow up time on ECMO was 36,8 (max 72-min 12) days. Pre-ECMO mean follow up time was 7,3 (max 17 min 1) days. All the examinations revealed same pathologic changes which are consistent with reversible changes. These changes are characterised with increased mononuclear cell infiltration at the interstitial area, type 2 pneumocyte hyperplasia. Fibrinous pleurit at the pleura.

Conclusions: Covid -19 pneumonia related ARDS is a fatal situation. In our experience we supported more than 80 patients who had ARDS after Covid-19 infection with ECMO for long term (up to 2,5 months). We keep up supporting ECMO long term to these patients and experienced that lungs may recover near totally during healing phase. Pathologic examinations supported our results and revelaed the inflammation was reversible and there were no fibrotic chronic changes at the lungs. We think that our experience with long term support shows that decision for lung transplantation could be postponed and we may give the chance for healing for longer time during support.

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Succesful ECMO support to a lung transplanted patient after Covid-19 related ARDS

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Objectives: After Covid-19 Pandemic ECMO therapy began to be used widely in case of ARDS development. In this study, we share the successful ECMO support to a patient who had a history of lung transplantation1 year ago and had COVID-19 related ARDS which is a rare condition in the literature.

Methods: 41 year old male patient with history of lung transplantation 1 year ago and infected with COVID-19 infection was evaluated. The patient was supported with femoro-jugular VV-ECMO because of ARDS. Bivaluridin was used for anticoagulation. Sorin (LivaNova,-London,UK) ECMO pump console and oxygenator were used for follow up.

Results: The patient was supported with VV-ECMO for 14 days. ICU stay was 24 days. Hospital stay was 103 days. Pre-ECMO ventilation time was 1 one day. Orotracheal intubation time was 4 days. Tracheostomy time was 85 days. There was no neurologic, gastrointestinal or bleeding complications during follow-up.

Conclusions: Our experience revealed that ECMO could be a life saving therapy even for patients under immunosuppressive therapy like a lung transplanted patient in our case.

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Trends in survival during the pandemic in patients with severe COVID-19 receiving ventilation with or without ECMO: Final analysis of the Japanese national registry

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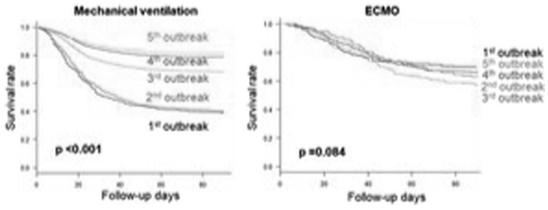
Objectives: The survival rate of patients with severe coronavirus disease-19 (COVID-19) may have gradually declined over time. This study aimed to evaluate serial changes in survival of the severe COVID-19 patients receiving mechanical ventilation with/without extracorporeal membrane oxygenation (ECMO) in Japan.

Methods: We developed a prospective national registry covering >80% of intensive care units in Japan, and analyzed the association between the patient backgrounds treated between February 2020 and November 2021, the number of institutional ECMO experiences, and the timing of treatment initiation and prognosis. Serial changes in survival were evaluated by Kaplan-Meier analysis. Prognostic factors were evaluated by Cox proportional hazards analysis.

Results: A total of 9,745 patients received mechanical ventilation, of whom 1,214 (12%) received ECMO. The overall survival rate for ventilated patients was 78%, and 64% for those receiving ECMO. There have been five outbreaks in Japan to date. The survival rate of ventilated patients increased from 40% in the first outbreak to 80% in the fifth outbreak (p<0.001). The survival rate of ECMO patients remained unchanged at 60-68% from the first to the fifth outbreak (p=0.084) (Figure). Age (hazard ratio [HR], 1.04; 95% confidence interval [CI], 1.03-1.05), number of ventilator days before starting ECMO (HR, 1.56; 95% CI, 1.28-1.91), and number of institutional ECMO experiences (HR, 0.99; 95% CI, 0.98-1.00) were independent prognostic factors for ECMO.



Conclusions: During five outbreaks of COVID-19 in Japan, the survival rate of ventilated patients continuously improved, and that of ECMO patients remained unchanged. Older age, longer ventilator days before starting ECMO, and fewer institutional ECMO experiences were independent prognostic factors for severe COVID-19 patients receiving ECMO.

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Extracorporeal membrane oxygenation for COVID-19: Intracranial coagulopathy and mortality

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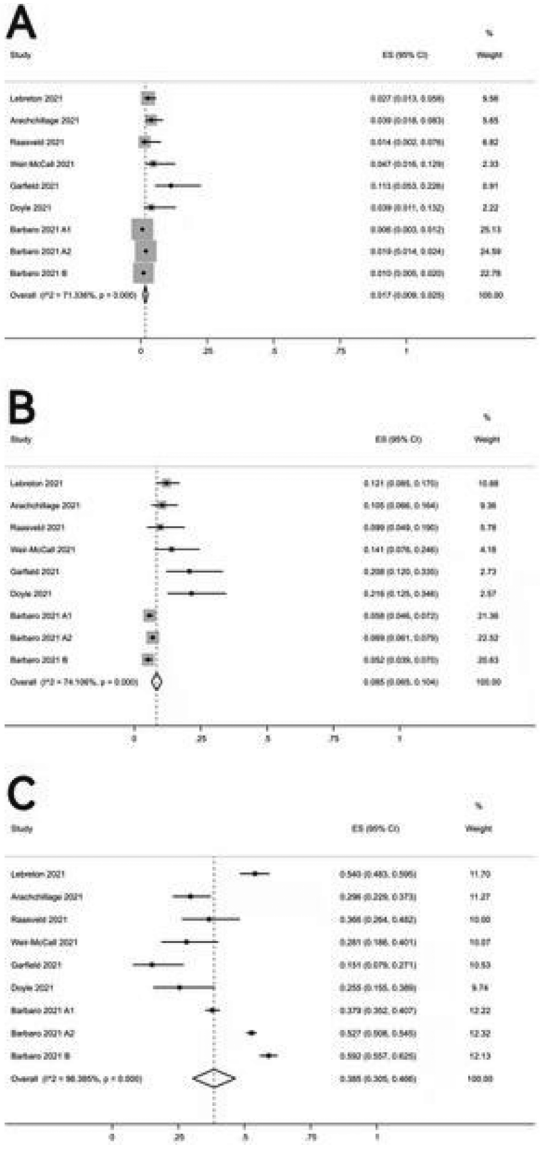
Objectives: Extracorporeal membrane oxygenation (ECMO) is employed to support patients with severe COVID-19. The intracranial coagulopathies associated with both COVID-19 and ECMO present a high risk of thrombosis and bleeding. We conducted a systematic review and meta-analysis to describe the ischemic stroke, ICH and mortality in COVID-19 patients receiving ECMO, and summarizes the anticoagulation regimens.

Methods: EMBASE, PubMed, Cochrane, and Scopus were searched up to October 25, 2021, for studies examining intracranial coagulopathies and mortality in COVID-19 patients supported with ECMO. The outcomes were incidences of ischemic stroke and intracranial hemorrhage, in-hospital mortality and antioagulation regimens. We calculated the pooled

proportions and 95% confidence intervals to summarize the results. (CRD 42020224880)

Results: We analyze 7 peer-reviewed studies involving 5502 COVID-19 patients. Most outcomes had high certainty. The incidence of ischemic stroke had a pooled estimate of 1.7% (95% CI: 0.9% to 2.5%, P < 0.004). The prevalence of ICH had a pooled estimate of 8.5% (95% CI: 6.5% to 10.4%, P < 0.001). The pooled estimate of in-hospital mortality was 38.5% (95% CI: 30.5% to 46.6%, P < 0.001). Unfractionated heparin was the most commonly used anticoagulant, and anticoagulation monitoring practice varied among centers.



Conclusions: The prevalence of ICH is significantly higher in COVID-19 patients supported with ECMO. The impact of COVID-19 and anticoagulation regimens on intracranial coagulopathy is needed to explore. The association between intracranial coagulopathy and mortality in COVID-19-related ECMO remains unclear. More detailed research and further exploration are needed to clarify the underlying mechanism.

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An audit of time to achieve rehabilitation milestones in critically-ill covid-19 patients requiring VV-ECLS

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Objectives: To a) establish time to achievement of rehabilitation milestones in critically-ill COVID-19 patients treated with VV-ECLS and b) compare this cohort to critically-ill patients (Covid and non-Covid positive) receiving conventional therapies only.

Methods: A retrospective chart review of all patients admitted to an 18-bedded tertiary ICU in June 2021. "Complex" rehabilitation was defined as requiring input from a minimum of 3 Health & Social Care Professions [HSCP] which included physiotherapy, nutrition, speech & language therapy, occupational therapy, social work & psychology [British Society of Rehabilitation Medicine]. The key rehabilitation milestones measured were a)time to commencement of anti-gravity rehabilitation b)transfer to a chair c) first standing and d) first stepping. Time taken to achieve each goal was measured as days from critical care admission. Data collected included mean, median and range of times taken to achieve these key rehabilitation milestones.

Results: Complex rehabilitation needs were identified in 71 (41%) of the 174 patients admitted - 12 were COVID-19 positive, 6 of whom required VV- ECLS. The mean time to achievement of goals in all patients with complex rehabilitation needs [n=71] was 10 days to commence antigravity movements, 12 days to first chair transfer, 13 days to standing and 14 days to stepping. Covid 19 positive patients [n=12] required a longer time to achieve each of these rehabilitation milestones. Mean time to commencing antigravity movements, chair transfer, standing and stepping were 28, 33, 39 and 52 days respectively. Covid-19 patients requiring VV-ECLS [n=6] experienced further delays in achieving rehabilitation milestones with mean time to commencement of antigravity movements, chair transfer, standing and stepping of 35, 44, 53 and 68 days respectively.

Conclusions: Many patients admitted to critical care with Covid-19 have complex rehabilitation needs and experience delays in achieving key rehabilitation milestones. These delays are increased if treated with VV-ECLS.

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Conclusions from 347 days on Veno-venous ECMO: The longest reported ECLS run in the COVID era

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Objectives: The COVID-19 pandemic led to a surge in the use of extracorporeal membrane oxygenation (ECMO) for extended periods. We present the lessons learned from a patient who survived for 347 days on Veno-venous (VV) ECMO.

Methods: We review the unique case of a patient requiring a prolonged period of ECLS support, and detail the programmatic changes informed by this experience.

Results: A 52-year-old male with acute respiratory failure due to COVID-19 pneumonia met EOLIA criteria and was placed on VV ECMO on April 27, 2020, using a femoral vein to internal jugular vein configuration. He was unable to be liberated from the circuit and required ECLS support for 347 days until his death, despite being transferred and listed for transplant on day 193. The characteristics and challenges of his prolonged course advised integral components of our ECLS program including complex long-term sedation and withdrawal management, maintenance and cessation of anticoagulation, oxygenator durability management, aggressive mobilization and rehabilitation while on circuit, and ethical considerations of prolonged mechanical life support and end of life decision-making. The information gained from this extended course led to significant alterations in our practice and the development of new protocols.

Conclusions: The COVID-19 pandemic was accompanied by an increase in ECMO utilization and the need for significantly longer runs. This case illustrates the possibility of supporting patients for extremely prolonged periods, and the significant programmatic changes to which a single patient can contribute.

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Successful use of VV-ECMO for ARDS in a patient with spontaneous intracerebral hemorrhage

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Objectives: Describe the successful use of VV ECMO in a patient with spontaneous ICH.

Methods: Intracranial hemorrhage (ICH) and inability to tolerate anticoagulation are relative contraindications for venovenous extracorporeal membrane oxygenation (VV ECMO).[1] However, advancements in neurosurgical treatments for non-traumatic ICH suggest improved neurologic prognosis[2-4], and the feasibility and safety of ECMO without systemic anticoagulation has been recently demonstrated [5,8,9]. We present a case of spontaneous ICH complicated by severe acute respiratory distress syndrome (ARDS) that was successfully treated with VV ECMO.

Results: A 51-year-old female with super morbid obesity (BMI 51kg/m^2) presented with acute onset decreased level of consciousness, left hemiparesis and evidence of aspiration. CT head demonstrated right caudate hemorrhage with intraventricular hemorrhage and hydrocephalus. Emergent intravenous mannitol was given and the patient was intubated. Neurosurgery placed an external ventriculostomy drain and performed an angiogram with endoscopic clot extraction. Neurologic exam improved but extubation was precluded by aspiration-related ARDS. Despite lung-protective ventilation strategies and prone-positioning the respiratory status deteriorated and the patient was placed on VV ECMO via femoral-internal jugular venous access configuration. Systemic anticoagulation was not utilized during cannulation or throughout her VV ECMO course. After nine days of VV ECMO support she was decannulated. The patient was eventually discharged on tracheostomy collar and was following commands but with persistent left hemiparesis.

Conclusions: To our knowledge this is the first case describing the successful use of VV ECMO to support a patient with ARDS and spontaneous ICH. Prior reports of VV ECMO and ICH have been in traumatic brain injury and secondary ICH while on VV ECMO.[6-7] Systemic anticoagulation was not used in our case and there were no thrombotic complications. The use of VV ECMO for ARDS in a patient with spontaneous ICH should be considered if good neurological outcome is anticipated.

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Outcomes of transferred versus directly admitted patients requiring venovenous extracorporeal membrane oxygenation

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Objectives: Patients with severe ARDS benefit from care at an ECMO capable center. Risk of decompensation often limits transfer. The objective of this study is to compare outcomes between patients cannulated for VV ECMO who are transferred versus entirely treated at the ECMO center.

Methods: We conducted a retrospective review of patients requiring VV ECMO at a tertiary academic medical center between March 1, 2020 and December 31, 2021. Patients were divided into two groups: those transferred to the ECMO center and those treated entirely at the ECMO center. Outcomes included time to cannulation, percent cannulation within one day of transfer, ECMO duration, percent off-hour cannulation, AKI requiring CRRT, superimposed bacterial infection, and mortality, A subset of patients transferred from a non-ECMO center was treated by the same faculty group as the ECMO center. We compared pre and post transfer data including change in p/F ratio, $PaCO_2$, shock index, and vasopressor dose.

Results: 35 patients required VV ECMO. 24 patients were transferred from outside hospitals, and 11 patients were treated entirely at the ECMO center. There was no difference between time to cannulation (10.04 vs 10 days), bacterial infection (75% vs 72.73%), and mortality (54.17% vs 54.55%). The transfer group had a longer average ECMO run (27.9 vs 20.8 days). The non-transfer group had a higher percentage of off hour cannulation (41.67% vs 54.55%) and rate of AKI requiring CRRT (37.5% vs 54.55%). Most transferred patients were cannulated within 1 day of transfer (79.17%). Transferred patients who were treated by the ECMO capable faculty group had minimal change in p/F ratio (-3), PaCO2 (9mmHg), shock index (0.02), and norepinephrine dose (7.71mcg.min). Most patients (85%) met VV ECMO criteria prior to transfer.

Conclusions: Critically ill patients who qualify for VV ECMO can safely tolerate transfer without change in mortality, oxygenation, ventilation, or shock.

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Transesophageal echocardiography-guided bedside extracorporeal membrane oxygenation cannulation in COVID-19 patients

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Objectives: There is a paucity of data supporting the use of transesophageal echocardiography (TEE) for bedside extracorporeal membrane oxygenation (ECMO) cannulation. Concerns have been raised about the safety of TEE in patients with COVID-19. The aim of this study was to describe the use and safety of TEE guidance for bedside ECMO cannulation in a large academic center.

Methods: In this retrospective cohort study, we report the findings of 100 patients who underwent bedside venovenous ECMO (VV-ECMO) cannulation under TEE guidance in the intensive care unit between May 2020 and June 2021. Patient characteristics, physiological, and ventilatory parameters, as well as echocardiographic findings were recorded and analyzed. All patients had confirmed SARS-CoV-2 infection.

Results: TEE-guided cannulation was successful in 99% of the cases. During cannulation, one superficial arterial injury and one pneumothorax were diagnosed. Initial cannula position was adequate in 98 cases (99%). Twelve patients (12%) required cannula repositioning during ECMO support. When echocardiograms were analyzed, 39 patients (39%) had right ventricular systolic dysfunction, and six (6%) had left ventricular systolic dysfunction. Ten patients (10%) had intra-cardiac thrombi. No major procedural complications (such as pericardial tamponade, hemothorax or intra-abdominal bleeding), TEE-related complications or COVID-19 infection of healthcare providers were reported during this study.

Conclusions: We report the safe utilization of bedside TEE-guidance for VV-ECMO cannulation in 100 patients with severe respiratory failure due to COVID-19. No serious complications from the TEE, were noted over the course of patients' ICU stay.

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Outcomes of extracorporeal membrane oxygenation in patients with COVID-19 infection based on duration of extracorporeal membrane oxygenation

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Objectives: To compare the patient outcomes based on duration of extracorporeal membrane oxygenation (ECMO) support in COVID-19 patients.

Methods: Patients with acute respiratory failure secondary to COVID-19 infection, supported with ECMO, from January 2019 to October 2021 were included in this retrospective study.

Results: There were a total of 58 COVID-19 patients who received ECMO therapy during the study period.

Among them, **20 patients** required ECMO for **less than 3 weeks** and **38 patients** for **more than 3 weeks**. ECMO **survival rates** were **85%** (17/20) in < 3 weeks group and **63%** (24/38) in ≥ 3 weeks group (p = 0.129). Statistical analyses did not reveal any significant difference with regards to the rates of acute kidney injury (32% vs 20%; p = 0.538), bloodstream infection (39% vs 25%; p = 0.385), pulmonary embolism (16% vs 10%; p = 0.701), pneumothorax (32% vs 20%; p = 0.538) or the requirement for lung transplant (8% vs 5%; p = 1.000).

Conclusions: Patients requiring ECMO for more than 3 weeks following acute respiratory failure secondary to COVID-19 have comparable outcomes to those requiring the support for shorter duration.

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Early prone positioning under VV-ECMO in SARS-CoV-2-induced acute respiratory distress syndrome - a retrospective cohort study

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Objectives: The effectiveness of prone positioning (PP) under VV-ECMO for severe COVID-19 still be unclear. Until now, PP under VV-ECMO was often performed as the trump card for refractory hypoxemia and weaning off ECMO. On the other hand, PP has the effect of promoting homogenization of Lung aeration and leading to prevention of VILI. Combine use of early prone positioning together VV-ECMO may have synergy effects of ultra-lung protective strategy. In this study, we analyzed early PP cases under VV-ECMO for severe COVID-19 in our hospital and examined their efficacy and feasibility.

Methods: We performed a retrospective study of patients with SARS-CoV-2-induced ARDS submitted to early PP during VV-ECMO. During VV-ECMO, PP was considered in case of "Type-H transition in imaging findings (CT / LUS)" and cases that the physician deemed necessary. The lung aeration is evaluated by LUS before and after each PP. If there is a finding that the dorsal collapsed lung is improved through PP, it is implemented as effective, and it continued.

Results: From April 2021 to August 2021, there were a total of 10 early PP cases under ECMO, and the age was (average) 56 years. ECMO was implanted with P/F 98 and Murray score 3.3 points, and PP was started 14 hours after the ECMO implantation. The average PP duration is 17.4 hours and PP performed 5.8 times per patient. Comparing blood gas and respiratory mechanics before and after PP showed a significant difference in PaCO2 (before: 46 ± 8 vs after: 42 ± 9, p = 0.02). Finally, there were 10 ECMO successful weaning (100%) and 8 surviving discharges (80%). No major complications were observed.

Conclusions: Early PP under VV-ECMO for severe COVID-19 can be safely performed, and it is suggested that the synergy effect of ultra-lung protective strategy may be associated with a reduction of hospital mortality.

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Results after V-V ECMO use in COVID-19 patients. Comparative analysis of outcomes and profile of the population along 5 waves of the pandemic

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Objectives: To describe the evolution of profile, management and outcomes of COVID-19 patients supported with V-V ECMO in a Spanish ECMO Center, taking into account the timeline of the pandemic.

Methods: Retrospective, observational study including COVID-19 patients supported with V-V ECMO from March 2020 to September 2021 in the Vall d'Hebron University Hospital, Barcelona. Cutpoints to define waves were 1th/July/2020, 1st/January/2021, 1st/March/2021, 1th/July/2021 and 1st/October/2021. A comparison of patients clinical profile, ECMO management and outcomes was performed using Chi2 or Fisher for qualitative, ANOVA or Kruskal-Wallis for quantitative as appropriate.

Results: Among 90 patients the overall hospital survival was 70%, with no significant variations between waves. Table 1 summarizes the comparison of variables. Of note, we didn't find significant differences neither in comorbidities nor in the clinical condition before ECMO initiation except on immunosuppression and coinfection, which was especially frequent on the second and fifth waves. Interestingly, patients supported during the last two waves, needed higher ECMO support at day 3, needed longer ECMO runs and received more frequently an awake ECMO strategy.

Conclusions: In our cohort, the survival of patients with COVID-19 and ECMO support was high and did not change along the pandemic. Patients supported in later

phases of the pandemic needed higher levels of support and needed ECMO for longer time, but they did not stay more days in the hospital and survival was not different.

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The management staircase for hypoxaemia in patients receiving VV-ECMO

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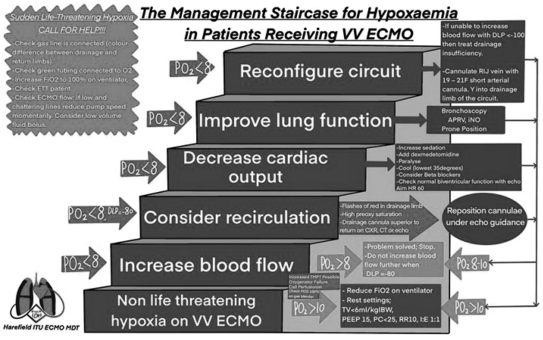
Objectives: During the COVID pandemic in the UK, our centre acted as a surge facility for the UK severe acute respiratory failure (SARF) network. This required rapid up-skilling of staff and development of new policies and procedures. As part of this project we designed a step-by-step escalation plan for the management of non-life threatening hypoxaemia in VV ECMO patients.

Methods: We used a modified Delphi process, harnessing the expertise of a multidisciplinary team with medical, nursing and perfusion representation. The output was a staircase-based protocol containing five sequential stages. This was then reviewed by junior nursing staff as the key demographic. The content was then presented as a striking design by a member of our team (see Figure).



The poster was printed, laminated and displayed at the bed space of every patient on VV ECMO and an educational programme about all aspects of the management of ARDS was rolled out to the wider critical care team. In addition 12 nurses were rapidly trained in advanced competencies of ECMO management.

Results: Between 2020 and 2021, 11 COVID patients from the UK SARF network received VV-ECMO in our hospital .9 (82%) survived to hospital discharge. 3 patients required all 5 steps of the protocol. No clinical incidents were reported about the management of these patients despite their care being delivered by previously inexperienced staff. Feedback was universally positive.

Conclusions: The staircase management of hypoxaemia in the VV ECMO patient tool was welcomed by all members of the extended surge critical care team. It provided standardisation, practical guidance and support in the management of an unfamiliar patient cohort during a time of significant uncertainty and crisis.

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Ongoing long-term VV-ECMO support for recovery of COVID-ARDS lung

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Objectives: COVID-ARDS is a serios respiratory failure leading in total lung collapse. Patients may need long-term vv-ECMO support to be survived during healing process of lungs.

Methods: 82 patients with COVID-ARDS followed under vv-ECMO support more than 1 week in our center between May 2020 and January 2022 were included in this study. 79 (96%) of the patients were transferred by the ECMO-team into our center under vv-ECMO support from an external center. All patients were anticoagulated with Bivalirudin.

Results: 31 (37.8%) of the patients were female and 51 (62.2%) of them were male. Mean age was 45.07 ± 11.49 years (ranged, 21 to 67). Mean pre-ECMO ventilation duration was 6.67±6.9 days (ranged, 0 to 41 days)and mean ECMO follow-time was 33.88±24.42 days (ranged, 2 to 74). 28 (34.1%) patients were weaned from ECMO and 3 of them died due to bacterial sepsis. 7 (8.5%) patients are still on ECMO support. Age (<45years), presence of pregnancy, and shorter pre-ECMO vent duration (< 5 days) were associated with lower mortality in the univariate analysis. ($p<0.001$, 0.014, 0.06, respectively). In multivariate analysis, only "age above 45" significantly increased mortality ($p = 0.007$; 95% CI:1.489-13.162; AUC:0.701).

Conclusions: The effective result of vv-ECMO support on mortality during the treatment of COVID-ARDS will pave the way for more widespread use of vv-ECMO,

Variable	All (N=90)	1st wave (N=23)	2nd wave (N=18)	3rd wave (N=14)	4th wave (N=21)	5th wave (N=14)	p-value
Epidemiological and comorbidities							
Age, years	55 (49-61)	55 (47-58)	59.2 (49-63)	56 (53-62)	55 (53-59)	50 (45-55)	0.147
Sex, male	72 (80)	17 (74)	17 (94)	12 (86)	17 (81)	9 (64)	0.254
BMI	29 (27-34)	31 (26-34)	27 (25-30)	33 (28-35)	30 (28-35)	29 (27-35)	0.093
Arterial hypertension	30 (33)	9 (39)	6 (33)	8 (57)	6 (29)	1(7)	0.076
COPD	3 (3)	0 (0)	2 (11)	1 (7)	0 (0)	0 (0)	0.194
Diabetes	9 (10)	5 (22)	1 (6)	1 (7)	2 (9)	0 (0)	0.327
Cardiovascular disease	4 (4)	0 (0)	2 (11)	1 (7)	1 (5)	0 (0)	0.425
Chronic renal failure	3 (3)	1 (4)		0 (0)	0 (0)	0 (0)	0.301
Pre ECMO							
MV days preECMO	8 (5-13)	6 (5-10)	8 (6-13)	7 (1-13)	10 (6-15)	5 (4-8)	0.327
PaO_2/FIO_2 preECMO	64 (58-80)	69 (59-85)	60 (55-80)	77 (64-81)	64 (58-75)	60 (58-78)	0.253
(mmHg)	59 (53-75)	58 (52-82)	64.5 (48-75)	61.5 (55-72)	64 (56-70)	55.5 (50-60)	0.519
$PaCO_2$ preECMO (mmHg)	7.3 (7.2-7.3)	7.29 (7.2-7.31)	7.32 (7.21-7.34)	7.31 (7.23-7.33)	7.3 (7.26-7.32)	7.29 (7.2-7.3)	0.193
pH preECMO	19 (5)	22.4 (0.9)	17.5 (1.3)	19.4 (1.8)	20.2 (1.2)	16.4 (1)	0.532
DP preECMO (cmH_2O)	2 (1)	2.3 (0.2)	1.9 (0.3)	1.3 (0.3)	2.2 (0.2)	2.6 (0.3)	0.828
CV SOFA preECMO							
Steroids preECMO	80 (89)	16 (59)	16 (89)	13 (93)	21 (100)	14 (100)	0.010
Tocilizumab preECMO	22 (24)	17 (74)	2 (11)	2 (14)	1 (5)	0 (0)	<0.001
Anticoagulanted preECMO	27 (30)	5 (22)	4 (22)	4 (29)	10 (48)	4 (28)	0.355
Coinfection preECMO	27 (30)	3 (13)	9 (50)	5 (36)	3 (14)	7 (50)	0.018
ECMO management							
ECMO flow day 3	4.05 (3.8-4.7)	4 (3.5-4.5)	4 (4-4.3)	4 (3.8-4.5)	4.4 (4-5)	4.4 (3.8-5)	0.086
Sweep gas flow day 3	6.25 (5-8)	5 (4-7)	7 (5-8)	6 (5-9)	8 (7-8)	7 (5-9)	0.022
Minor bleeding	18 (20)	3 (13)	5 (27.8)	5 (35.7)	4 (19.1)	1 (7.1)	0.288
Major bleeding	20 (22.2)	4 (17.4)	8 (44.4)	4 (28.6)	3 (14.3)	1 (7.1)	0.078
Pneumonia	47 (52.2)	9 (39.1)	13 (72.2)	9 (64.3)	9 (42.9)	6 (42.9)	0.163
Acute renal failure	42 (46.7)	22 (95.7)	7 (38.9)	4 (35.7)	5 (23.8)	3 (21.4)	<0.001
Thrombosis	52 (57.8)	11 (47.9)	11 (61.1)	9 (64.3)	17 (81)	4 (28.6)	0.029
Circuit change	1 (0-1)	0 (0-1)	1 (0-1)	1 (0-1)	1 (1-2)	1 (0-2)	0.038
Long ECMO	31 (34.4)	5 (21.7)	5 (27.8)	6 (42.9)	9 (42.9)	6 (42.9)	0.473
Awake ECMO	33 (36.7)	0 (0)	5 (27.8)	4 (28.6)	13 (61.9)	11 (78.6)	<0.001
Outcomes							
ECMO survival	66 (73.3)	16 (69.6)	11 (61.1)	9 (64.3)	19 (90.5)	11 (78.6)	0.241
Hospital survival	63 (70)	16 (69.6)	11 (61.1)	9 (64.3)	19 (90.5)	9 (75)	0.266
MV days	45 (29-60)	48 (38-61)	45 (23-56)	47.5 (27-76)	41 (30-59)	39 (26-59)	0.774
ECMO days	20 (11-40)	11 (6-20)	18 (10-30)	22 (14-46)	28 (20-45)	27 (18-47)	0.018
Hospital days	62 (45.5-85)	63 (54-92)	48 (32-77)	58 (54-97)	67 (55-85)	57 (39-79)	0.316

which has positive effects, especially in patients with lower comorbidity, younger age, pregnancy, and shorter duration of pre-ECMO ventilation duration.

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Veno-venous extracorporeal membrane oxygenation therapy in aspiration syndrome after elective cardiac surgery: Case report

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Objectives: Aspiration or Mendelson syndrome is a condition in which foreign substances are inhaled into the lungs, creating inflammation. This serious complication can occur during or after surgical intervention; in cardiac surgery perioperative prevalence may be up to 1-2%, mortality may reach 30%. The consequences of this can be severe, for example, pulmonary insufficiency and ARDS, which might require a replacement of the lung function by veno-venous extracorporeal membrane oxygenation (VV-ECMO).

Methods: This case report compiles detailed information about a patient who received VV-ECMO following intestinal obstruction and aspiration syndrome after cardiac surgery.

Results: Patient (age 51) presented for elective cardiac surgery, he received aortic valve prosthesis and ascending aorta prosthesis as planned. In the third postoperative day the patient presented with severe abdominal pain, and computed tomography showed signs of dynamic bowel obstruction. This led to abdominal surgery, during which massive gastric content aspiration occurred. The patient's condition and lung function deteriorated and in the first day after aspiration it was decided to implement VV-ECMO. Few hours after VV-ECMO implantation patient presented with hemodynamic instability which resulted in circulatory arrest and cardiopulmonary resuscitation. Resternotomy was made and massive tamponade was found, the probable cause being hypocoagulation due to heparinisation used in VV-ECMO. After resolving this issue the respiratory function steadily improved. The patient was successfully disconnected from VV-ECMO after five days, and was weaned off mechanical ventilation after 16 days. The patient spent 21 days in intensive care unit, and was discharged in 37 days after initial presentation for surgery.

Conclusions: VV-ECMO is an effective and safe therapy for aspiration syndrome.

Adult - Other

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It's not just the prices: Sources of cost variation for initiation of veno-venous extra corporeal membrane oxygenation at three international sites

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Objectives: (1) Measure and compare the costs and efficiencies of delivering VV ECMO in three hospitals, each in a different country; (2) apply time-driven activity-based costing (TDABC) as a tool to measure costs in the ICU; and (3) explore opportunities for cost and process improvement by comparing practices in three geographically distant hospitals treating the same types of patients.

Methods: TDABC of VV ECMO at Cedars Sinai (Los Angeles), Hôpital Pitié-Salpêtrière (Paris), and The Alfred Hospital (Melbourne) from 2017-2019. The primary outcome was daily ECMO cost. The hypothesis, determined prior to data collection, was that cost differences among the hospitals could be explained by the efficiencies and skill mix of personnel, as well as prices paid for personnel, equipment, and consumables.

Results: Sources of cost variation were broken down into costs for personnel, durables, and disposables. Results are presented relative to Los Angeles's total personnel cost per VV ECMO patient day, indexed at 100. Los Angeles's total indexed daily cost of care was 147 (personnel–100, durables–5, disposables–42). Paris's total cost was 39 (26% of Los Angeles) (personnel–12, durables–1, disposables–26). Melbourne's total cost was 53 (36% of Los Angeles) (personnel–32, durables–2, disposables–19) (rounded). The higher personnel prices at Los Angeles explained only 26% of its much higher personnel costs than Paris, and 21% relative to Melbourne. Los Angeles's higher staffing levels accounted for 49% (36%) and its costlier mix of personnel accounted for 12% (10%) of its higher personnel costs relative to Paris (Melbourne). Unadjusted outcomes, measured by survival to hospital discharge rates, were Los Angeles (46%) Paris (56%) and Melbourne (52%).

Conclusions: Differential prices paid to personnel explained only 30% of the higher personnel costs at the Los Angeles hospital. Most of the cost differential was caused by personnel staffing levels and mix. This study demonstrates how TDABC may be used in ICU administration to quantify costs associated with different ECMO delivery models.

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What happens if gas blender doesn't work? A case report

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Objectives: A male of 50 years old was admitted to Covid intensive care unit due to Covid pneumonia, and after 24 hours of non-invasive ventilation, he was intubated.After three days of proning positions, femoral V-V ECMO was implanted due to respiratory acidosis. During a night shift, the Gas Blender marked "0" in the air flow, while the fiO2 setted to 100%. The blood of drainage and reinfusion cannula was a similar dark red color. The patient progressively began to desaturate, the central venous, arterial and pulmonary pressures increased and the SvO2 precipitated to low values.

Methods: A case report is presented about a Gas Flow malfunction, with desaturation of the patient and emergency management of the patient and ECMO

during V - V ECMO support in Covid patient complicated by aspergillosis.During the emergency, the intensivist optimized the patient mechanical ventilation, and she called the perfusionist on-call at home. Despite the optimization of mechanical ventilation, the patient remained at a saturation of 70%. The bedside nurse bypassed the Gas Blender, connecting membrane lung to a portable oxygen cylinder at 3 l / m.

Results: The vital signs of patient were stabilized, with reduction of central venous, arterial and pulmonary pressures, increasing of saturation, reduction of cardiac rate. The blood color changed to dark red in drainage cannula and bright red color in reinfusion cannula.

Conclusions: Gas Blender malfunctioning was identified because the medical gas connections on the wall were functioning correctly (i.e. air and oxygen leaking at the connection of a ventilator). A new Gas Blender was applied and V-V ECMO ventilation was restored.In this critical case report, technical and non-technical skills were fundamental: in particular, situation awareness, decision making, communication and teamwork. These made it possible to effectively manage the crisis situation.

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10 years of high-fidelity simulation: Improvement in self-perception of learning in an ECMO workshop

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Objectives: To evaluate the perceived learning of participants in a one-day ECMO management workshop.

Methods: The approach to learning in the workshop is; didactic presentation, then practical demonstration and hands-on practice. All attendees then participate in a series of simulated scenarios and debriefing.Participants are administered an anonymous, pre-assessment, clinician-validated, Likert-type questionnaire at workshop commencement. They identify their staff category and how they would rate their current level of proficiency from beginner through to expert. They rate from 1 = worst/most negative to 9 = best possible/ most positive their perception of their current level of knowledge regarding veno-arterial (VA)/ veno/venous (VV) ECMO, confidence with ECMO patients, confidence with ECMO emergencies and skill with ECMO circuit issues. At conclusion participants rate themselves on the same elements.

Results: 470 participants have attended one of 33 workshops from 2010 - 2019. The pre/post assessment tool has been used for 18 workshops with 251 participants: nurses, doctors, perfusionists and physiotherapist. The mean improvement (with $p<0.001$) on the scale of 1 - 9 was: knowledge VV ECMO +2.9(sd±1.4); knowledge VA ECMO +2.9 (sd±1.4); confidence caring for ECMO patients +3.0 (sd±1.6); confidence dealing with ECMO emergencies +3.6 (sd±1.6); and skill in managing circuit issues +3.6 (sd±1.6). All participants agreed they could incorporate learning into clinical practice.

Conclusions: An easily administered pre/post evaluation in a simulation based ECMO workshop provides an indication of learning that occurs in a one day multimodal education session. Participants perceived an increased knowledge base, improved confidence and skill development.

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Did the COVID-19 pandemic change the care of non-COVID ECMO patients in Germany? A nationwide retrospective study

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Objectives: Due to the Covid-19 pandemic, the number of severe ARDS cases treated with ECMO in Germany has increased significantly, pushing the health system's capacity to the limit. The question arises to what extent this has affected the treatment of non-COVID ECMO patients.

Methods: Inpatient data from January 2019 to December 2020 from the Federal Statistical Office of Germany were analysed. Non-COVID-19 Patients > 18 years with ECMO were included using the appropriate international statistical classification of diseases and related health problem codes (ICDs) and process keycodes (OPSs) and divided into a pre-pandemic (2019) and pandemic cohort (2020).

Results: A total of 12 926 ECMO runs between January 2019 and December 2020 were analysed. In the pre-pandemic cohort 6 776 ECMO, of which 4 543 veno-arterial (VA) and 2 495 venovenous (VV) are performed. The pandemic cohort decreased by 9.2% (n=626), resulting in a total of 6 150 Cases (4 444 VA; 1 956 VV). The hospital mortality decreased from 61.1% to 59.9% ($p = 0.16$). Between the pre-pandemic and pandemic cohort no statistically significant change was shown for the age (59.5; SD=13.8 vs. 59.3; SD=13.7

years) and the Elixhauser Score (18.97; SD=9.7 vs. 18.94; SD=9.78). The length of stay decreased from 25.1 (SD=32.1) to 24.2 (SD=31.2) days between the pre-pandemic and the pandemic cohorts.

Conclusions: Despite the pandemic, there was only a 9.2% decrease in the non-COVID ECMO cases. There was no significant change in the age and the disease severity indicating that there was no triaging in the sense of preferring only younger and less ill patients.

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Mortality prediction in extracorporeal membrane oxygenation patients: A systematic review

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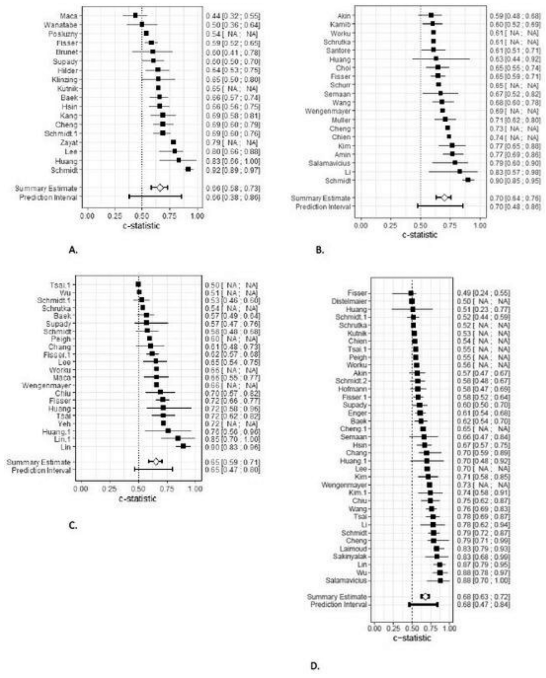
Objectives: Early prognostication should aid in the allocation of extracorporeal membrane oxygenation (ECMO) to those who benefit most. We aimed to summarize and assess the performance of existing mortality prediction models for patients receiving ECMO support for refractory cardiogenic shock and/or pulmonary failure.

Methods: Original articles presenting a multivariable (≥2 predictors) model aimed at prediction of all-cause mortality in adult patients (>18 y) who received ECMO for refractory circulatory and/or pulmonary failure. Also, re-development and external validation studies were included. Discriminatory ability was evaluated by pooling of reported c-statistics of external validation studies.

Results: Out of 4915 articles screened, 98 studies describing 58 different models fulfilled the inclusion criteria. The majority of predictors were assessed before ECMO initiation. The models' derivation cohort sizes ranged from 17 to 4175 patients. None of the derived models met the generally accepted Prediction Model Risk Of Bias Tool (PROBAST) criteria of good quality. This was mainly due to small sample sizes leading to low event-per-predictor variable (EPV), increasing the risk of over-fitting and inflated performance measures. Only 14 (24%) models were externally validated. For these models, the model performance was better in derivation cohorts than in external validation cohorts (c-statistic ranged 0.602 – 0.970 vs. 0.440 – 0.920 for individual models, respectively). General-purpose disease severity scores predicted mortality fairly in ECMO (pooled c-statistic (95%CI): 0.68, (0.63 – 0.72) for SOFA and 0.65, (0.59 – 0.71) for APACHE II). The SAVE and RESP score were derived from the largest ECMO-patients cohorts and were most frequently validated externally (pooled c-statistic (95%CI): 0.70, (0.64 – 0.76) and 0.66, (0.58 – 0.73), respectively), as displayed in figure 1.



Conclusions: Caution is warranted using these models, especially for decision support in individual patients and timing of ECMO initiation.

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4 Point Safety Bundle as a measure to reduce risk of cannulae migration

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Objectives: Safety of ECMO cannulae is paramount to ensure patient safety and guarantee the ideal conditions are in place to fulfil the purpose of ECMO therapy, including appropriate blood flow to achieve the patient hemodynamics and oxygenation desired. Cannulae migration has been identified as one of the most serious complications whilst on ECMO. We aimed to develop a method where cannulae safety was achieved in a consistent, practical, measurable method that would include a multidisciplinary team approach. The application of this bundle would reduce the risk of cannula migration

and, simultaneously, promote an early identification when it occurs.

Methods: In a multidisciplinary approach, bundle developed based in 4 safety aspects. **Sutures** – Minimum of 3 non-absorbable sutures, well tight and positioned at the proximal area of the cannula, including insertion site. **Dressing** – A clear chlorhexidine based dressing covering the insertion site that allows cannula visualization and measurement. Performed at a minimum of 7 days by ECMO nurse and following ECMO dressing guidance. **Cannula holder device** – appropriate holder according if femoral or jugular cannula approach. One device per cannula, well secured and above knee to allow safe mobilization. **Clamps** – Securing the cannulae in bed allowing enough slack for changes of position in bed.Cannulae position measurement (from insertion site to end of coil) should also be performed and documented every 4 hours/when mobilization.

Results: Bundle implemented and adherence audited weekly at ECMO rounds. 4 Points safety followed at all times. No further incidents of cannulae migration. Two episodes of inappropriate suturing identified and escalated promptly. Cannula measurement compliance improved from 35% to 98% of occurrences in a period of 6 months.

Conclusions: Cannulae safety is vital for ECMO therapy and patient safety. The development and implementation of a 4 Point Cannulae Safety bundle has reduced incidents related to cannulae migration and, simultaneously, has allowed an early identification of concerns which led to a prompt resolution. This bundle has also strenghted the ECMO nurse confidence in escalating any issues when identified and promoted multidisciplinary team collaboration.

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Profound leukopenia prior to veno-venous ECMO as a predictor of poor outcomes

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Objectives: Profound leukopenia is associated with increased mortality in acutely ill patients and is incorporated into scores which predict in-hospital mortality. However, white blood cell count (WBC) is not a component of scores typically used to predict mortality in patients requiring veno-venous extracorporeal membrane oxygenation (VV ECMO). Our goal was to assess profound leukopenia as a predictor of poor outcomes for patients being considered for VV ECMO support.

Methods: This was a retrospective chart review of adult patients in a single academic center supported with VV ECMO over a 6 year period. We included patients with profound leukopenia (WBC </= 1 $x10^3$/mL) at the time of cannulation. We compared in-hospital mortality to the predicted mortality using pre-cannulation Respiratory ECMO Survival Prediction (RESP) scores.

Results: We identified 8 patients with WBC </= 1 $x10^3$/mL at the time of cannulation. The mean age was 44.2 years (SD=13.0) and half were female. The median WBC prior to cannulation was 0.60 (IQR=0.4,0.7). The mean hospital length of stay was 21 days (SD=21) and the mean time on ECMO was 192 hours (SD=219). The median RESP score was 0.5 (IQR=-2.5,2.5). Two (25%) patients survived to hospital discharge. However, based on the RESP scores, the median predicted survival rate was 57% (IQR=45,66) for the entire cohort and 57% (IQR=33,57) for the non-survivors. The 2 surviving patients had predicted survivals of 57% and 76%. Of note, the cause of death of all non-survivors was multisystem organ failure and septic shock. The mean hospital length of stay was 13.0 days (SD=15.6) for non-survivors and 44.0 days (SD= 19.8) for survivors, and the mean time on ECMO was 134 hours (SD= 206) and 365 hours (SD=205) respectively.

Conclusions: Profound leukopenia appears to be associated with high mortality in patients supported with VV ECMO for respiratory failure. As most current predictive VV ECMO survival scores do not incorporate white blood cell counts, pre-cannulation WBC count should be considered in the decision to cannulate.

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Factors associated with acute kidney injury in patients receiving extracorporeal membrane oxygenation

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Objectives: To identify factors associated with acute kidney injury (AKI) in patients receiving extracorporeal oxygenation (ECMO).

Methods: Retrospective cohort study, realized in an adult intensive care unit (ICU) with patients older than 18 years receiving ECMO, from 2012 to 2020. The criteria for definition and classification of AKI were the Kidney Disease Improving Global Outcomes (KDIGO). For the analysis of associated factors, a multiple logistic regression model was developed, and the significance level adopted for the analyzes was 5%.

Results: The sample consisted of 84 individuals, of which 62 developed AKI (73.8%), and the most prevalent stage of AKI was 3 (82.2%). The factors associated with AKI in the multiple model were fluid overload (OR: 7.18; 95%CI: 1.56, 32,91; p = 0.011), SOFA escore (OR: 1.44; 95%CI: 1.14,1.81; p = 0.002) and the time between admission to the ICU and start of ECMO (OR: 1.11; 95% CI: 1.00, 1.23; p = 0.004).

Conclusions: Factors associated with the development of AKI were fluid overload, SOFA score and time between admission to the ICU and the start of ECMO. Thus, the continuous assessment of the volume status, together with organ dysfunctions and the time of initiation of therapy must be closely monitored due to its impact on renal function.

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How safe is extracorporeal membrane oxygenation in thoracic surgery? A high-volume single center experience

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Objectives: Extracorporeal membrane oxygenation (ECMO) is an important tool in modern thoracic surgery to establish functional operability. Complications associated with the use of ECMO are frequently described in the literature and are not only observed in ARDS patients but also with prolonged use in the perioperative setting. In the present work, the complications associated with the perioperative use of ECMO in thoracic surgery to establish functional operability are presented.

Methods: We conducted a retrospective analysis of all patients who received veno-venous ECMO (VV ECMO) to establish functional operability at the Ibbenbueren General Hospital in Germany between February 2015 and February 2021. 90-day mortality rate represented the primary outcome. ECMO-related complications were analyzed retrospectively.

Results: A total of 397 patients were identified. Of these, 333 patients received a low-flow VV ECMO mode (group 1), whereas high-flow VV ECMO mode was implemented in 64 patients (group 2). Mean ECMO duration was 6±1 days (1-25 days) in group 1 compared to 7±2 days (1-74 days) in group 2. In the overall cohort, 90-day mortality was 8.5% (33 patients). 23 patients died in group 1 and 10 patients in group 2. Mean ICU stay was 8±1 days (1-33 days) in group 1 vs. 10 ±2 day (1-111 days) in group 2. ECMO-related complications were thoracic bleeding with re-do procedures (27 patients, 6.8%), cannulation site infections (3 patients, 0.8%), and disseminated intravascular coagulation (21 patients, 5.2%). Circuit change after prolonged use was necessary for 26 patients (6.5%). Limb ischemia or cannulation site bleeding were not observed.

Conclusions: Application of VV ECMO for establishing functional operability in thoracic surgery represents an effective and safe procedure with acceptable mortality and morbidity. VV ECMO instituted by a specialized team has a role in reducing ECMO-related complications and management of postoperative complications. In general, VV ECMO has significantly reduced complications compared to veno-arterial ECMO and should be frequently considered for thoracic surgery in respiratory compromised patients.

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Functionality assessment of ECMO ultrasound-guided cannulation training simulators

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Objectives: Extracorporeal membrane oxygenation (ECMO) support requires extensive and regular clinician training to help maintain skills acquisition. Particularly for ECMO initiation, including cannulation, bench-top medical simulation training offers a cost-effective alternative to animal-based training. We have previously developed advanced simulators for ECMO ultrasound-guided cannulation training with the aim of replicating the tactility and ultrasound compatibility of human tissue. This study aimed to evaluate the suitability for training and functionality of these simulators using functional task alignment (FTA) analysis.

Methods: To evaluate the functionality of the simulators, fourteen task items were identified by experts. The items assessed the realism of the ultrasound and the needle insertion experiences while performing the

vascular access procedure. The evaluation process was in the form of FTA questionnaires; in which clinicians rated the performance of the simulators on a five-point scale (1- performs exactly like a human 2- performs very closely to human 3- neutral 4- doesn't perform like a human but adequate for simulation 5- inadequate for simulation). The study recruited 40 clinicians attending the cannulation course at the Alfred hospital, Melbourne/Australia in which ultrasound-guided cannulation is one of the main training sessions. The frequency distribution of responses for each item was calculated.

Results: The simulators were scored 1 and 2 for the overall ultrasound experience by 44.7% and 31.6% of the participants, respectively. As for the needle insertion experience, 61.1% of the participants scored the overall needle insertion experience simulators 1 and 2. The simulators lacked functionality in providing realistic skin puncture and resistance. The vessels (arteries) tactility upon needle insertion also scored lower; 3, 4 and 5 by 55.3% of participants.

Conclusions: Feedback from the majority of participants (72.2%) scored the overall usability of the simulators for training 1 and 2, exactly like human or close to human, suggesting the developed simulators are suitable for ECMO ultrasound-guided cannulation training. Future designs will increase functionality by addressing the skin layer realism to replicate skin resistance to needle insertion. Additionally, vessels compressibility (vein vs. artery) will be included.

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A case study on the impact of active rehabilitation supported with veno-venus extra corporeal membrane oxygenation (VV-ECMO) with a patient with profound hypoxaemia

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Objectives: A case study of an adult male supported with VV ECMO for 63 days following presumed vaping induced acute respiratory distress syndrome (ARDS). Our aim is to highlight successful rehabilitation in a patient despite profound hypoxaemia and demonstrate the positive impact rehabilitation made to his recovery.

Methods: The patient was awake, spontaneously breathing via a tracheostomy whilst supported with VV ECMO. Rehabilitation commenced on day 16 of ECMO support, at which point arterial PaO2 was consistently measured at less than 8kPa with a FiO2 0.98 via tracheostomy mask and ECMO support at 5.7L/min flow, FiO2 100% and sweep 8.On day 32, PaO2 decreased to lower than 5kPA and rehabilitation was paused due to concerns of muscle activity related oxygen consumption. The risks and benefits of rehabilitation were reviewed and it was proposed that rehabilitation could be recommenced providing the patient was haemodynamically stable, co-operative and irrespective of the measured PaO2. Rehabilitation included transferring to the chair, bed and chair pedals, standing and stepping practice. Remarkable improvement was observed after day 55 with great improvement in PaO2, chest x-ray, improvement in the patients overall muscle strength and physical condition resulting in ECMO decannulation at day 63.

Results: The patient participated in daily rehabilitation sessions for 51 days. There were no adverse events due to hypoxaemia during rehabilitation. The patients CPAx score increased from 0 to 18 with the patient standing to transfer out to the chair. The patient's arterial PaO2 did not decrease further during rehabilitation, but at times increased after rehabilitation.

Conclusions: Daily active rehabilitation was successfully undertaken in an awake patient supported with VV ECMO at times of sustained and profound hypoxaemia (PaO2 < 5 kPa). The patient was able to actively participate in rehabilitation and made great progress despite the theoretical risk of increased oxygen consumption.

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A reflection on the evolving role of active rehabilitation and physiotherapy with COVID-19 patients supported with VV-ECMO

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Objectives: In March 2020 little was known about COVID-19, greater numbers of patients were requiring admissions to the Intensive Care Unit (ICU) for respiratory failure and acute respiratory distress syndrome (ARDS), resulting in an increased requirement for Extra Corporeal Membrane Oxygenation (ECMO) support.

Methods: At the height of the pandemic our ICU cared for 21 COVID-19 patients requiring Veno-Venus (VV) ECMO simultaneously. One of the biggest challenges we experienced as a Physiotherapy and multidisciplinary team was around the risk versus benefits of rehabilitation and the optimal time to commence rehabilitation. Previously rehabilitation was not commenced until patients were awake and orientated, with stable levels of

ECMO and ventilator support, acceptable ABGs on less than maximal ECMO and ventilator support.

Results: Patients supported by ECMO due to COVID-19 did not present in a similar way to other conditions we have experience with. As a team we had to 'think outside the box' with regards to rehabilitation. We often started rehabilitation with patients that did not meet our previous criteria, including those who required higher levels of ventilator support and maximal VV ECMO support to maintain adequate gas exchange. As a team we adapted our sessions for our patients ever changing needs managing there oxygen requirements, work of breathing and fatigue. To date we have safely rehabilitated 69 patients supported on ECMO for COVID-19 and experienced no adverse events during rehabilitation.

Conclusions: This patient group changed our way of thinking about rehabilitation, questioning our predetermined understanding of the physiological demands of rehabilitation and patient suitability for exercise. As a team we have been able to reflect and challenge our previous ECMO rehabilitation limits while continuing to safely deliver ECMO rehabilitation. As we continue to work with COVID-19 patients requiring ECMO we continue to improve our practice to support patient's progress and goals.

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Impact of routine ECPR service on the availability of donor organs

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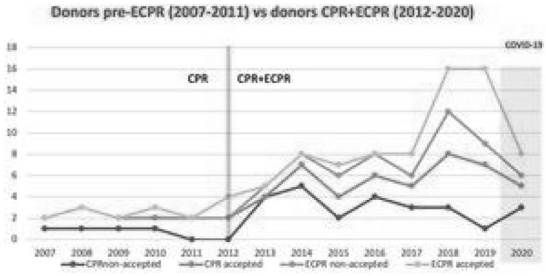
Objectives:
Introduction;

In refractory cardiac arrest, extracorporeal cardiopulmonary resuscitation (ECPR) may increase the chance of survival. However, in brain death or donation after cardiac death scenario, ECPR may provide an important source of organ donors. We hypothesized that 1/ the implementation of ECPR into the daily routine of a high volume cardiac arrest centre might increase the availability of organ donors, and 2/ ECPR might assure the same long-term function of donated organs as non-ECPR care.

Methods: We retrospectively evaluated the pre-ECPR (2007–2011) and ECPR (2012–2020) periods in terms of donors recruited from the out-of-hospital cardiac arrest population. We assessed the number of donors referred, the number of organs harvested, and their one- and five-year survival.



Results: In the pre-ECPR period, 11 donors were referred, of which 7 were accepted. During the ECPR period, the number of donors increased to 80, of which 41 were accepted. The number of donated organs in the respective periods was 18 and 119, corresponding to 3,6 vs 13,2 ($p = 0.033$) organs per year harvested. One-year survival of transplanted organs was 94.4% vs 99.2% and five-year survival was 94.4% vs 95.9%, in relevant periods. Survival of organs obtained from donors after CPR and ECPR at one year (98.8% vs 97.8%) and five years (89.5% vs 88.9%) was the same. Graft failure was not the cause of death in any single case.

Conclusions: Establishing a high-volume cardiac arrest/ECPR centre may lead to a higher number of potential and subsequently accepted organ donors. The length of survival of donated organs is high and comparable between ECPR vs non-ECPR cardiac arrest donors.

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Discrepant aPTT prolongation due to contact activation in extracorporeal circulatory devices: A case series

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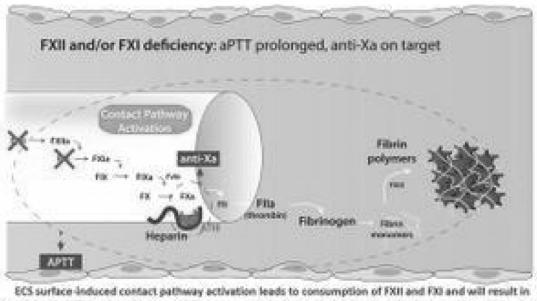
Objectives: Extracorporeal circulatory support (ECS) device surface-induced contact pathway activation with depletion of factors XII and XI will result in prolonged aPTT levels and subsequently a higher risk of subtherapeutic unfractionated heparin (UFH) dosages and device associated thrombosis. We propose combined aPTT and Heparin anti factor Xa assay (anti-FXa) measurement to assay heparin activity as the latter is

not influenced by surface-induced consumption of clotting factors.

Methods: We present three critically ill adult cases with device-induced coagulopathy, leading to discrepant high aPTT and on target anti FXa levels. Further dose monitoring of UFH was based on anti FXa activity, and not on aPTT

Results: An overview of the patient's demographics, used extracorporeal circulatory devices and clinical outcomes, as well as coagulation profile is provided in table 1:-



Conclusions: Anticoagulation in patients on ECS should be monitored by simultaneous measurement of anti-FXa levels to monitor the degree of heparinization and prevention of thrombosis, as well as aPTT levels for assessment of bleeding risk and possible coagulation factor deficiencies. Discrepancy between aPTT and anti-FXa level during UFH therapy should be interpreted within the clinical context.

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Implementation of a new emergency protocol and multidisciplinary training program following significant Extracorporeal Membrane Oxygenation (ECMO) circuit air entrainment

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Objectives: Air entrainment is a known complication of ECMO with significant air entrainment occurring in an average of 1.6% of Adult ECMO runs[1]. Our service has experienced three incidents of air entrainment during the last ten years, which is above average. Our most recent incident highlighted the challenges of de-airing a circuit with a significant amount of air, culminating in replacement of the entire circuit. Changes implemented after in depth review included:

- Circuit redesign to reduce entrainment
- Adaptation of our De-Airing Protocol
- An Emergency Circuit Replacement Protocol
- A multidisciplinary training programme to implement these changes

Methods: A simplified circuit was designed with minimal pigtails compared with our standard design. Our De-Airing Protocol was reviewed to move to circuit replacement in the context of overwhelming air entrainment. An Emergency Circuit Replacement Protocol was developed. A training programme involving didactic teaching and multidisciplinary simulation scenarios was targeted at ECMO specialists and Medical Staff. Simulation allowed enhancement of technical and non-technical skills. Training was repeated on multiple occasions to maximise capture. Anonymous feedback was obtained.

Results: Initial training was delivered to fifty-five individuals, 100% of the target group. Feedback was unanimously positive with the majority reporting increased confidence in managing this type of incident. Protocols were refined based on feedback.

Conclusions: Overwhelming air entrainment is a potentially fatal complication of VV ECMO. Circuit design changes will reduce human factor causes. Refinements to our protocols and our continued ongoing programme of multidisciplinary simulation training will improve patient safety further. We have shown the importance of continual review of policies and processes after critical incidents and ability to implement a team-based programme of training to mitigate against these incidents.

References[1]

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	Male 68 yo	**Male 82 yo**	**Male 72 yo**
ECS device	**VV-ECMO**	**VA-ECMO**	**Bi-Pella (CP + RP)**
Coagulation profile	On day 24 (of 76)	On day 24 (of 76)	On day 24 (of 76)
Heparin dose (U/kg/h)	14.8	14.1	12.8
aPTT (s) (ref: 25,1-36,5)	84.1 ↑	126.1 ↑	> 180.0 ↑
Anti-Xa (IU/mL) (target range)	0.27 (0.2-0.3)	0.42 (0.3-0.5)	0.38 (0.3-0.5)
Factor XI (%) (ref: 70-130)	60.5 ↓	33.9 ↓	20.2 ↓
Factor XII (%) (ref: 70-130)	53.6 ↓	17.9 ↓	29.0 ↓

Registry/Statistics/InternationalSummary.aspx (Accessed: 7th December 2021)

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Screening for delirium in patients requiring ECMO support using a purpose-designed app

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Objectives: Delirium is a serious complication in intensive care units (ICU), affecting up to 80% of mechanically ventilated patients, and is associated with higher mortality. The prevalence of delirium in ECMO patients is not well known, with reasons for this including a lack of suitable assessment tools for this cohort. Current tools to assess delirium in ICU, such as the Confusion Assessment Method for the ICU (CAM-ICU), are not optimal due to their low sensitivity and high dependency on assessors' expertise, resulting in nearly 75% of ICU patients not being assessed. Therefore, it is important to find a more sensitive tool that require no training to administer. A digital app (eDIS-ICU) was designed to enable accurate and assessor-independent screening for delirium. A pilot study investigating 29 ICU patients showed similar concordance between eDIS-ICU and CAM-ICU against gold standard assessment (75.9% vs 79.3%), with sensitivity of 86% (95% confidence interval [CI] = 81.5-100.0) versus 29% (95% CI = 5.1- 69.7 – $p < 0.05$), and specificity of 73% (95% CI = 81.5-100.0) versus 96% (95% CI = 75.1-99.8), respectively. This study aims to investigate the efficacy of the eDIS-ICU in patients specifically receiving ECMO.

Methods: An international, prospective, cohort study in five ICUs across three countries (Australia, Japan, and Estonia). Adult ICU patients with or without ECMO support will be assessed using three different test methods (eDIS-ICU, CAM-ICU and the gold standard diagnostic criteria: Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-V)). The primary outcome is the sensitivity of the delirium diagnostic tools against DSM-V criteria.

Results: We hypothesise that the sensitivity of eDIS-ICU will not be inferior to CAM-ICU in patients receiving ECMO.

Conclusions: eDIS-ICU could be a more routinely accessible tool that can reliably identify delirium in ICU patients requiring ECMO support.

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Extracorporeal membrane oxygenation – an Australian single centre experience

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Objectives: To report outcomes of extracorporeal membrane oxygenation (ECMO) performed in a low volume non-Metropolitan tertiary referral centre over 8 years and compare mortality with benchmarks.

Methods: Retrospective, observational cohort study of All patients who required ECMO support from the beginning of ECMO program in August 2012 up to July 2020. Data collected for each patient was used in the calculations of a predictive scoring system, to make an individual risk of death prediction for that patient and analysed against benchmark.

Results: Among 57 patients received ECMO between 2012 and 2020 and were included in the analysis, 22 (71%) survived to hospital discharge or transfer of 31 patients treated with V-V ECMO compared to (69%) in ELSO data over the last 10 years, nine deaths (29%) were observed, within the 95% CI (7–16) for the deaths predicted by the RESP score (p= 0.1). Eight (31%) survived to hospital discharge or transfer of 26 patients treated with V-A ECMO compared to (44%) in ELSO data over the last 10 years, eighteen deaths were observed, Within the 95% CI (14–23) for the deaths predicted by the SAVE score (p =0.154).

Conclusions: With careful patient selection, multidisciplinary approach, and stringent clinical governance structure, ECMO provision in single centre non-metropolitan hospital is able to achieve mortality outcomes comparable to benchmarks.

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Disparities in health care: A global update from the Covid-Critical Care Consortium (CCCC)

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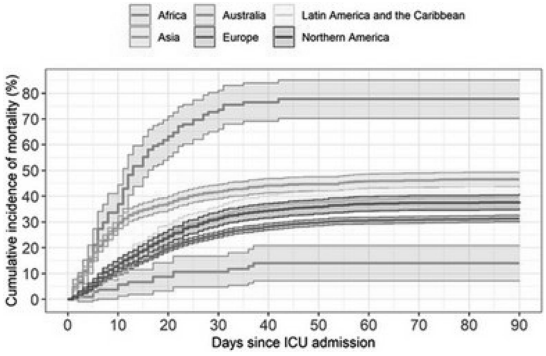
Objectives: To review of CCCC 6 continent data to assess differences in patient characteristics, practice and outcomes.

Methods: Data on 9,102 patients in CCCC intensive care units between 1 January 2020 and 30 October 2021 were analyzed for baseline characteristics, ICU practices and clinical outcomes by continent. Analysis comprised of descriptive statistics and cumulative incidence functions[NW1].

Results: Patients in Africa were younger, had higher respiratory rates, lower oxygen saturations, more invasive ventilation and higher mortality than other sites. An unexpected finding was BMI in African patients was similar to that of North America. The use of therapies such as mechanical ventilation or ECMO was variable.



Conclusions: Marked differences are noted between continents. Possible explanations may be in variability in access to care, triage practices, staffing limitations and access to therapies. An example is Africa, where ICU entry is triaged to require prior intubation. Addressing disparities across borders may improve outcomes. Sharing data such as provided by the CCCC can expedite findings to refine care, increase global caregiver interactions and knowledge sharing and help prioritize areas for future research to improve outcomes.

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The role of sunshine therapy in patients on extracorporeal membrane oxygenator

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Objectives: **Introduction**: Extracorporeal membrane oxygenation (ECMO) is considered an effective therapy for patients with end-stage respiratory diseases until a suitable organ becomes available. The concept of ''AWAKE ECMO'' was introduced to avoid complications often associated with long-term mechanical ventilation and prolonged immobility. Our institution has taken the ''AWAKE ECMO'' strategy one step further by including active rehabilitation and ambulation of patients awaiting lung transplant outside at the sun therapy area.

Methods: **Background:** Current evidence supports early mobilization and rehabilitation in awake ECMO patients and may be crucial in avoiding pre transplant weight and muscles loss. Pre-existing peripheral muscle dysfunction in chronic lung disease is one of the determinants of the postoperative impairment in physical status, suggesting a need for physical therapy and ambulation to optimize muscle strength and functional capacity during the pre-transplant period. In addition to rehabilitation, exposure to sunlight has been demonstrated to have a positive impact on patient's mental state and may promote outcomes and survival.

Results: Walking while waiting, our experience in ambulating patients with femoral ECMO cannulas in place appears safe and is undertaken following a rigorous pre-ambulation safety checklist. This includes an initial assessment of suitability and was created to ensure ECMO patients enjoy long periods of time outside in the sun therapy area, where they can enjoy the presence of their family and pets.

Conclusions: Taking the concept of awake ECMO patient one step further, the goal of sunshine therapy sessions are to improve patients' experience and the sense of wellbeing induced by more sunlight while awaiting lung transplantation. The ambulatory ECMO program became a standard of practice at our institution and has been demonstrated to be safe and effective when undertaken with proper planning, resources, and execution.

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ECMO during pregnancy and peripartum period: 12 years of experience in a tertiary care center

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Objectives: Extracorporeal membrane oxygenation (ECMO) is being increasingly used in critically ill

Characteristic	Africa	Asia	Australia	Europe	Latin America/ Caribbean	North America	Total
Age (range)	51 (44 to 57)	56 (46 to 65)	60 (48 to 69)	63 (54 to 71)	60 (46 to 69)	60 (49 to 71)	61 (51 to 70)
BMI (range)	31.1 (27.0 to 38.5)	24.3 (23.1 to 27.7)	27.7 (24.7 to 33.0)	28.7 (26.0 to 32.3)	28.6 (25.9 to 33.4)	31.0 (26.5 to 36.4)	28.3 (25.3 to 32.6)
Female (%)	81/173 (47)	461/1395 (33)	39/110 (35)	1660/5659 (29)	176/562 (31)	473/1203 (39)	2890/9102 (32)
Admission Respiratory rate, breaths/minute (range)	36 (24 to 44)	25 (22 to 30)	28 (22 to 33)	24 (20 to 30)	25 (20 to 32)	24 (20 to 30)	24 (20 to 30)
Admission O2 saturation, % (range)	87 (78 to 92)	94 (90 to 97)	93 (90 to 95)	93 (88 to 96)	90 (84 to 95)	93 (88 to 96)	93 (88 to 96)
PaO_2:FiO_2[a] (ICU first 24hours; (range)	90 (68 to 125)	88 (60 to 148)	128 (96 to 205)	108 (76 to 158)	109i (77 to 160)	97 (66 to 153)	103 (71 to 154[ )
Invasive MV (%)	172/173 (99)	805/1395 (58)	56/110 (51)	4417/5659 (78)	483/562 (86)	867/1203 (72)	6800/9102 (75)
Intubated prior/ within 24 h of ICU admission (%)	171/172 (99)	637/805 (79)	40/56 (71)	3,720/4,417 (84)	416/483 (86)	683/867 (79)	5,667/ 6,800 (83)
Hospital mortality (%)	115 (66.5)	591 (42.4)	14 (12.7)	1741 (30.8)	212 (37.7)	426 (35.4)	3099 (34)

patients with respiratory or cardiac failure. Nowadays there is still lack of evidence of increased survival of obstetric patients supported with extracorporeal technology. Data on ECMO use in pregnancy or peripartum period remains scarce. The aim of the study was to review ECMO use in pregnant or postpartum women in our institution.

Methods: We reviewed the data of all patients supported with ECMO in our institution from January 1, 2009 to December 31, 2021. Patients who were pregnant at the time of cannulation or up to 4 weeks after the delivery were identified. Clinical characteristics and outcomes, maternal and fetus, were analyzed.

Results: During 12 years period 384 patients were supported with ECMO in our institution. Among them 4 women were supported during peripartum period. The mean age of them was 30.5 (range 29-35 years). Two women were pregnant at the time of ECMO initiation, both of them delivered while on support. No major bleeding complications were observed during the delivery. In three cases indication for support was respiratory distress syndrome, in one case ECMO was used due to severe pulmonary embolism occurring 2 hours following cesarean delivery. The median duration of the extracorporeal support was 271 hours (range 153-390). VV ECMO was used in 3 cases, in one case VAV configuration was used. All 4 women survived to hospital discharge. The fetus survival was 50%. Stillbirth occurred in one case, the other neonate died the same day after the delivery.

Conclusions: ECMO can be life saving for obstetric patients during pregnancy or early postpartum period.

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Systemic Inflammatory Response Syndrome (SIRS) after VA-ECMO: In-hospital outcomes and risk factors

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Objectives: Systemic inflammatory response (SIRS) is often present in the post-decannulation phase from ECMO. Its impact on the patient's immediate prognosis has not been fully elucidated. The present study aims to illustrate the in-hospital prognosis of post-decannulation SIRS.

Methods: Patients treated with veno-arterial ECMO who were successfully weaned from mechanical support were identified. Post-ECMO SIRS phenomenon was defined as the occurrence of 2 out of 3 of the following criteria: fever, leukocytosis, and escalation of vasopressors. The patients were divided in two groups according to the absence (no-SIRS) or its occurrence (SIRS).

Results: Among 28 patients successfully weaned from VA-ECMO, 16(57%) had SIRS; most of them (8/16; 50%) received mechanical support as ECPR during PCI for acute myocardial infarction. Although high in both groups, patients with SIRS had the highest absolute

white blood cells (WBC) count at decannulation (14.16±6.63 vs. 21.23±8.34; no-SIRS vs. SIRS; p = 0.021) and delta WBC >25% (33% vs. 94%; no-SIRS vs. SIRS; p = 0.001). The patients with SIRS also had higher liver enzimes values at decannulation. Death in intensive care unit (ICU) occurred in 2/12 patients in no-SIRS (17%), while in SIRS patients occurred in 4/16 (25%).

Conclusions: SIRS after VA-ECMO is a common feature, especially in whom received VA-ECMO as ECPR. Although not statistically significant, mortality in the SIRS group occurred twice as frequently as in no-SIRS. The use of early culture and blood culture swabs and targeted antibiotic therapy likely led to a dampening of mortality in the group with SIRS.

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ECLS in trauma: A single-center review

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Objectives: Globally, trauma is a leading cause of death in young adults. The use of extracorporeal life support (ECLS) in the trauma population has been described since the 1970s, yet the overall consensus on treatment remains controversial due to the limited research published. The aim of this study is to look at the 30-day survival of all the ECLS trauma patients at our center between 1997-2019, comparing NISS and ISS scores.

Methods: We performed a retrospective cohort analysis of all trauma patients receiving ECLS support at the Karolinska University Hospital, Stockholm, Sweden between 1997-2019.

Results: During the study period 56 trauma patients received ECLS support. 84% of the patients were male and the mean age was 29.4 years. Overall 60% of the patients were decannulated alive, and nearly half (50%) of the patients survived to be discharged from the hospital. Only 1 patient was deemed to have died due to ECMO. All patients (n=28) that were alive at discharge were still alive 30 days post discharge and 23 patients (41%) are still alive today. The most common cause of death was cerebral injury (n=10), followed by hemorrhage (n=5) and cerebral anoxia (n=4). Overall the patients had a mean NISS of 46.41±17.10, and a mean ISS of 43.75±16.73.

Conclusions: The majority of patients suffered multitrauma with high NISS scores which are associated with a significant mortality. An overall survival of > 40% in our data supports that of data from other trauma centers and advocates for the use of ECMO in the severely ill trauma patient, predominantly those with severe acute respiratory distress syndrome.

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Extracorporeal life support for acute coronary syndrome complicated with cardiogenic shock requiring PCI: The impact of the shock team on outcomes

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Objectives: To verify the impact on intra-hospital survival of the "Shock Team" in the decision to use Veno-arterial ECMO (VA-ECMO) as support in patients with acute coronary syndrome (ACS) in cardiogenic shock (CS), requiring percutaneous revascularization (PCI).

Methods: Consecutive patients who from July 2013 to September 2020, presented to our Center for SCA and CS candidates for primary PCI, supported with VA-ECMO, were considered. The Shock Team is composed of the Hemodynamic Cardiologist, Clinical Cardiologist, Anesthesiologist, Cardiac Surgeon and Perfusionist. Over the years, the shared pre- or intra-procedural decision of how to mechanically support the circulation or not in patients with CS has been implemented. The retrospective analysis of consecutive patients has as primary end-point the frequency of Shock Team training, from the analysis of the conditions in which VA-ECMO was implanted, i.e. semi-elective (ECLS - Extracorporeal Life Support) or emergency (ECPR - Extracorporeal Cardio-Pulmonary Resuscitation), followed by the rate of weaning and survival from VA-ECMO.

Results: Twenty-three patients (19 males, median age 63 years, range 59-66 years) were supported with femoral-femoral VA-ECMO. The Shock Team was formed in 11 cases. When Shock Team was formed (Group 1), VA-ECMO was implanted as ECLS in 7/11 cases, in the remaining as ECPR. In Group 2 (no pre-procedure Shock Team consultation), VA-ECMO was implanted as ECPR in 11/12 cases (92%) and intra-procedure. Pre- or intra-procedural IABP was implanted in all patients in Group 2. In Group 1, intra-hospital survival was 9/11 cases (82%) and in Group 2 3/12 cases (25%), in most of the latter with no possibility of weaning.

Conclusions: In our case series, periprocedural Shock Team in patients with CS, allowed the establishment of mechanical support to the circulation in a semi-elective manner, with successful PCI and was associated with high survival. In contrast, in those in whom VA-ECMO is implanted as ECPR due to lack of shared decision, high intra-hospital mortality is observed. We therefore recommend in patients with ACS and CS the presence and consultation of the pre-procedural Shock Team.

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Maternal and neonatal outcomes of critically Ill pregnant women with COVID-19: Experience from Kuwait's national COVID-19 Center

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Objectives: The impact of severe COVID-19 infection on maternal and fetal outcomes is not well known. Our objective was to evaluate maternal and fetal outcomes of pregnant women admitted to the intensive care unit (ICU) in Kuwait's national COVID-19 center.

Methods: We conducted a retrospective chart review of all pregnant women who tested positive for SARS-CoV-2 and were admitted to the ICU at Jaber Al Ahmad Hospital between April 5th to September 4th, 2021. Baseline characteristics, ventilatory support, Extracorporeal Membrane Oxygenation (ECMO), ECMO complications and maternal and neonatal mortality until hospital discharge were evaluated.

Results: 408 female patients were admitted to the ICU, 87 (21.3%) were pregnant. Baseline characteristics include a median maternal age of 34 years (Interquartile range, IQR 30-37), a median gestational age of 29 weeks (IQR 25-33), and a median APACHE 2 score 13 (IQR 19-22). Pre-existing conditions include hypertension, asthma and diabetes, however a large majority of the patients were previously healthy (62%). 14 (16.1%) patients needed low flow oxygen, 23 patients (26.4%) required high flow oxygen, while 50 patients (57.5%) required mechanical ventilation. 8 (16%) patients were proned before delivery, and 28 (56%) were proned after delivery. 28 patients (56.0%) needed ECMO. The median ventilator days were 20 days (IQR 8-39), while median duration of ECMO was 27 days (IQR 18-37). 10 patients (11.5%) died in ICU, with 9 of them having been on mechanical ventilation. Overall maternal survival to hospital discharge was 89% and fetal survival rate was 84%.

Conclusions: When compared to non-pregnant patients in our ICU, pregnant women, including those on ECMO, had a better survival rate whilst neonatal mortality was significant. Further studies are required to identify factors associated with these outcomes. In the meantime, pregnant women should still be considered a high-risk population and should be prioritized for vaccinations.

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Comprehensive simulation based ECMO course – national education program in Poland

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Objectives: We present the 3 years activity of the first National Education Center for Artificial Life Support in Poland.The overarching goal of the proposed program is: Development of knowledge and skills and consolidation of doctors' awareness in the area of availability and safe use of medical technologies, which guarantee the survival of patients in the life-threatening states, in the course of acute either respiratory or circulatory failure, after exhaustion of conventional therapy as a standard of medical treatment resulting from evidence-based knowledge.

Methods: Because the ECMO therapy organizational model is complex and expensive, we prepared an authorship course program of "Artificial Life Support with ECMO" endorsed by ELSO and created the Department of Artificial Life Support and Patient Safety in University Center of Medical Simulation. The project passed the

qualification of POWR.05.04.00-IP.05-00-006/18 national competition and received funding from the Polish Ministry of Health in the amount of: 2750000 USD (PLN 10,974,708.60).Project: The project was implemented in 2019-2021 by the Medical University of Karol Marcinkowski in Poznań and includes the creation of a "Department of Artificial Life Support and Patient Safety" equipped with didactic and simulation tools. The program was dedicated to 264 physicians specializing in anesthesiology and intensive care, cardiac surgery, cardiology, thoracic surgery, vascular surgery, transplantology, emergency medicine and other physicians in trainee from all over Poland.

Results: In 261 participants there was 53.7% man and 46.3% women, with domination in 31-40 years old group. 66.8% of physicians was anesthesiologists or intensivists with mainly more than 5-year clinical experience, 56.1% of all had no ECMO – extracorporeal membrane oxygenation experience. In all detailed aspects of cognitive, behavioral and technical assessment marked improvement was observed after the course. The pre-course knowledge ECMO theory in the pre-course test was 10.9 out of 15 (76.0%). The results of post-course test were significantly higher than before training and mean score increased to approximately 12 points (85.3%). There was significant improvement after the course in all cognitive, behavioral, and technical self-assessments.

Conclusions: The implementation of the program allows to create specialized ECMO centers and specialized ECMO teams that can result in measurable benefits for Polish population.

Pediatric - Cardiac failure

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"ECMO" miracle or a device 15-year experience at pediatric cardiac intensive care unit. Prince Sultan Cardiac Centre, Riyadh, Saudi Arabia

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Objectives: Extracorporeal membrane oxygenation (ECMO) is a form of life support which is used for babies, children and adults with life-threatening pulmonary or cardiac failure (or both) when no other form of treatment has been or is likely to be successful. ECMO is essentially a Modification of Cardiopulmonary bypass circuit which is used routinely in cardiac surgery. Our objective is to share our 15 year experience of patients on ECMO support and their outcome at our hospital.

Methods: We analyzed retrospectively 140 patients who required ECMO support between 2007 – 2021. Our patients were supported by Veno Arterial ECMO. 60% of these patients were less than 1 year old. 80% of the patients required ECMO for low Cardiac output post cardiac surgery. Other indications were respiratory failure or ECP-R. We reviewed the patients profiles for indications, complications and in hospital outcomes and predictors for mortality.

Results: Our overall ECMO survival rate is 40%. The main cause of death was multi-organ dysfunction, sepsis, bleeding, thrombotic or neurological complications

Conclusions: The success of ECMO depends on right patient selection, timely intervention, dedicated and motivated team work and protocol based daily management.

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Veno-Arterial extra-corporeal membrane oxygenation support for acute fulminant myocarditis in pediatric patients

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Objectives: Acute Fulminant Myocarditis (AFM) in paediatric patients is a potentially life-threatening condition, though relatively uncommon. We aimed to evaluate the outcome of paediatric patients who received veno-arterial extra-corporeal membrane oxygenation (VA ECMO) support due to refractory cardiogenic shock in acute fulminant myocarditis at our Institution.

Methods: This is a retrospective single-centre analysis from 2005 to 2021. Inclusion criteria were VA ECMO support, age <18 years and diagnosis of AFM through endomyocardial biopsy. All clinical and biochemical data were reviewed. Follow-up data were gathered by last out-patient clinic visit and were complete and up-to-date in all.

Results: We included ten patients (40% female). Median age was 15.2 years (IQR 1.86-17), 4 (40%) were <3-year-old. Pre-implant (<72 hours) cardio-pulmonary resuscitation was carried out in 4 patients (40%). VA ECMO implant was performed under general anaesthesia in all. Central cannulation was performed in 6 (60%) patients,

while 4 (40%) cases received peripheral cannulation: 3 through the femoral vessels and one by common carotid artery and femoral vein. Histologic diagnosis was viral myocarditis in 90% of the patients while giant-cell AFM was reported in a single case. The most common post-operative complications were acute kidney injury (50%), hepatic dysfunction (30%) and bleeding (30%). Median hospital length-of-stay was 26.5 days (IQR 17-35.2). The median duration of support was 6.5 days (IQR 2.7-12.2). Successful weaning-off support was achieved in 60% of cases, one patient underwent heart transplant. In-hospital mortality was 30%, cause of death was multi-organ failure in 2 patients and anoxic brain injury in one. Median follow-up was 80 months (IQR 0.3-119). Among hospital survivors no late deaths or recurrent hospitalisations due to heart failure were observed.

Conclusions: In our cohort, VA-ECMO support allowed a reasonable survival in extremely critical patients. Those who recovered cardiac function showed a favourable long-term outcome.

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Extracorporeal membrane oxygenation following pediatric cardiopulmonary bypass: A retrospective review on predictors and outcomes at Birmingham Children's Hospital

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Objectives: Considering the vast increase in post-operative paediatric ECMO, defined indicators for initiating ECMO still remain controversial, with limited research into perfusion parameters. This study aimed to assess whether perfusion parameters can indicate the necessity for post-operative ECMO and whether patient outcomes are determined by ECMO duration and the reasons for requiring post-operative ECMO.

Methods: A retrospective study of Birmingham Children's hospital data was undertaken between 2008-2020. Data was collected for 101 ECMO patients, and 3 appropriate control patients were selected who did not require post-operative ECMO. Comparison was undertaken for all ECMO vs control patients, and between surgical procedure sub-groups. ECMO patients were also divided into the reason for requiring ECMO including low cardiac output syndrome, extracorporeal cardiopulmonary resuscitation, failure to separate from bypass, and respiratory failure to assess short- and long-term outcomes. Duration of ECMO was compared with short-term outcomes.

Results: The post-operative ECMO rate was 2.3% with a survival rate of 51.5% within the study. Bypass time was significantly longer for ECMO patient's vs control patients (162.59 and 105.01 minutes respectively, $p<0.001$), as well as arrest and x-clamp time (24.33 and 17.61 minutes respectively $p = 0.012$, and 80.09 and 64.61 minutes respectively, $p = 0.002$). The initial and final lactate on bypass were significantly increased in ECMO patient's vs control patients (3.25mmol/L and 2.44mmol/L respectively, $p<0.001$, and 6.55mmol/L and 4.51mmol/L respectively, $p<0.001$). Final base excess was more negative in ECMO patients than control patients at -4.88mmol/L and -3.62mmol/L respectively ($p =0.002$). Similar results were seen for surgical procedure sub-groups. Duration of ECMO increased mortality after 151 hours. ECPR had poorer survival rates compared to LCOS and FTSB however, there was no difference between long-term survival.

Conclusions: Overall, perfusion parameters can significantly indicate ECMO requirement. Duration and circumstances for requiring ECMO can impact on short-term outcomes, however, do not affect long-term outcomes.

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Continuous flow ventricular assist devices in children – how to bridge the gap the HVAD left behind?

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Objectives: In 2021 distribution of the left ventricular assist device (LVAD) Medtronic HVAD^{TM} (HVAD) was discontinued due to increased neurological events and mortality in adults. We aim to provide insights into our experience with the larger LVAD system Abbott HeartMate 3^{TM} (HM3) in children below 50kg who would have previously been treated with HVAD.

Methods: We collected data on three patients who received a HM3 at our centre: Patient 1 was a 13 year-old boy (39kg, 147cm) with severe anthracyclin-induced cardiomyopathy after osteosarcoma treatment. Patient 2 was a 12 year-old boy (31kg, 150cm) and patient 3 a 10 year-old girl (45kg, 149cm) who both suffered from rapidly progressing dilated cardiomyopathy, and were on extracorporeal life support since few days after diagnosis.

Results: HM3 implantation was successful in all patients, with primary sternal closure in patients 2 and 3, and delayed sternal closure after two days in patient 1.

Patient 1 then experienced a problematic course, as the right ventricle (RV) was unable to pump the minimum 2.5 L/min cardiac output required for HM3. Although this relative RV impairment was in itself not clinically evident, the concomitant HM3 difficulties with continuous, distressing HM3 alarms significantly hampered clinical progress, leading to implantation of a temporary RVAD and numerous complications. After 3.5 months the patient was discharged home with the HM3. In patients 2 and 3 the course on HM3 was uneventful with transfer from ICU to a regular ward within two weeks. None of the three patients experienced adverse neurological events. Finally, patients 1 and 2 received a heart transplantation 21 months and 5 weeks after HM3 implantation, respectively. Patient 3 demonstrated certain myocardial recovery, allowing for LVAD explantation after 7 weeks.

Conclusions: Under the prerequisite of sufficient RV function (cardiac output > 2.5 L/min), HM3 is a satisfactory alternative to HVAD in children and young adolescents.

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Survival of children and adult congenital heart patients bridged to heart transplant with ECMO and VAD at a single center

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Objectives: To determine whether the use of mechanical circulatory support and type of support was a risk factor for death in pediatric congenital, pediatric acquired, or adult congenital heart patients who later received a heart transplant.

Methods: We retrospectively reviewed 183 patients with pediatric congenital, pediatric acquired heart disease, and adults with congenital heart disease who received heart transplant at our institution from 2011 to 2021. The primary outcome was mortality. We compared patients based on whether or not they received mechanical circulatory support (MCS). Statistical analysis was conducted using a Chi-Square test.

Results: Our cohort included 89 pediatric patients with congenital heart disease, 66 pediatric patients with acquired heart disease, 25 adults with congenital heart disease, and 3 pediatric re-transplants. 34 patients were supported with VAD only, 4 with ECMO only, 13 patients underwent ECMO to VAD conversion, 5 with VAD and history of ECMO, and 127 patients received no MCS. Mean age was 10.01 $\pm$ 11.66, mean weight was 33.44kg $\pm$ 32.37. Five-year survival was 88.5% for all patients, 88.1% for no MCS, 94.1% for VAD only, 75% for ECMO only, 92.3% for ECMO + VAD conversion, and 80% for VAD with history of ECMO. At the five-year mark, there was no statistically significant difference in mortality between the group with no MCS compared to the VAD group (p=.716493), the ECMO only group (p=.544878), the ECMO converted to VAD group (p=.515797), or the VAD with history of ECMO group (p=.715805).

	All patients	Alive	Dead, all patients	1 year survival, %	5 year survival, %
All Tx	183	158	25	93.9	88.5
No MCS	127	109	18	92.9	88.1
VAD only	34	30	4	94.1	94.1
ECMO only	4	3	1	75	75
ECMO + VAD conversion	13	12	1	92.3	92.3
VAD + history of ECMO	5	4	1	80	80

Conclusions: In our cohort there was no statistically significant difference in survival between patients who received no MCS or were supported with VAD and ECMO. Considering the difference in illness severity between these two groups this is an important observation.

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Use of ECMO to restore hemodynamic stability before ventricular assist device implantation in pediatric patients

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Objectives: To review our experience of bridge to bridge concept consisting of initial veno arterial (VA) extracorporeal membrane oxygenation (ECMO) to durable longer term mechanical circulatory support (LTMCS) in paediatric patients.

Methods: All children supported by LTMCS from Jan 2014 to July 2020 were included in the study. Patients were allocated to 2 groups; Group I – bridged with ECMO before conversion to LTMCS and Group II – supported on LTMCS directly. Demographic, diagnostic, haemodynamic and outcome data was collected from our electronic database and patient registry. Descriptive statistics were used for demographic and diagnostic data while comparative outcomes were analysed using Wilcoxon rank sum, Mann-Whitney and $\chi 2$ testing. Significance level was set at a p value < 0.05 except while comparing biological parameter where Bonferroni correction was applied and a p value of < 0.004 was set.

Results: 65 children were implanted with LTMCS for refractory heart failure. Commonest diagnosis was dilated cardiomyopathy 73.9% Group I, 69.1% Group II. 6(26%) patients in Group I were less than 2 years of age

compared to 6(14.3%) in Group II. 10(65%) weighed less than 15 kgs in Group 1 compared to 22 (52.3%) in Group II. In 23 children ECMO was initiated prior to LTMCS (Group I) ; LTMCS as first line strategy (Group II, n=42). In Group I 19 (82.6%) were receiving mechanical ventilation and inotropic support prior to initiation of ECMO. Cardiopulmonary resuscitation was required in 10 (43.4%). Atrial Septostomy was performed in 5 (21.7%). Median time on ECMO prior to LTMCS was 216 (IQR 145-385) hours. The need for Biventricular support in Group I was 8 (34.7%) vs 6 (13.9%) p = 0.09 in Group II. The median duration on LTMCS in Group I was 118 (58.75- 249.25) vs 82(18-148) days; p = 0.03. Following LTMCS implantation 20 (87%) vs 34 (74.4%) p = 0.83, were bridged to transplant.

Conclusions: In our experience use of ECMO prior to LTMCS implantation in children with cardiogenic shock does not worsen outcomes compared to direct implantation.

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Acute myocarditis after use of propofol

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Objectives: We report a care of a 3-year-old , previously healthy girl, weight 14 Kg. She went through a dental procedure under general anaesthsia and developed a clinical complication. The drugs used were propofol (3 mg/kg) and sevoflurane(CAM 0,8-1,0). After anaesthesia she started with symptoms : dyspnea, diffuse snore, wheezes and hypoxemia. Supplemental oxygen was provided and bronchodilator therapy, without success. Troponin levels were very elevated and acute hemodynamic deterioration occurred , leading to a cardiogenic shock. The transthoracic echocardiograaphy (TTE) showed a ejection fraction (EF) of 20%. She was treated with mechanical ventilation as well as inotropic agents (VIS 200). Because of the impaired clinical course, a extracorporeal membrane oxygenation assistance was started (VA - ECMO) with cervical cannulation and 120ml/kg/min flow. She was treated with ECMO for 6 days, using also Epinefrine 0,02 mcg/kg/min, milrinone 0,7 mcg/kg/min and sodium nitroprussiate 2 mcg/kg/min. TTE was daily performed and showed improvement of myocardial contractility after the fourth day of assistance, with EF of 26%. In the sixth day of ECMO, hemodynamic parameters had improved, with better results in TTE: VTI of 10, EF of 42%. After that, the patient underwent decannulation and the cervical vessels were fixed. Inotropic agents were withdraw and the patient remained stable

Methods: Case report

Results: The patient underwent decannulation and the cervical vessels were fixed. Inotropic agents were withdraw and the patient remained stable.

Conclusions: Propofol should be used with caution for sedation in critically ill children and adults. In cases of severe myocarditis, ECMO VA can be used with excellent results.

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ECPELLA (ECMO with Impella) use following e-CPR (extracorporeal cardiopulmonary-resuscitation) in a pediatric adolescent under the institutional adult shock program

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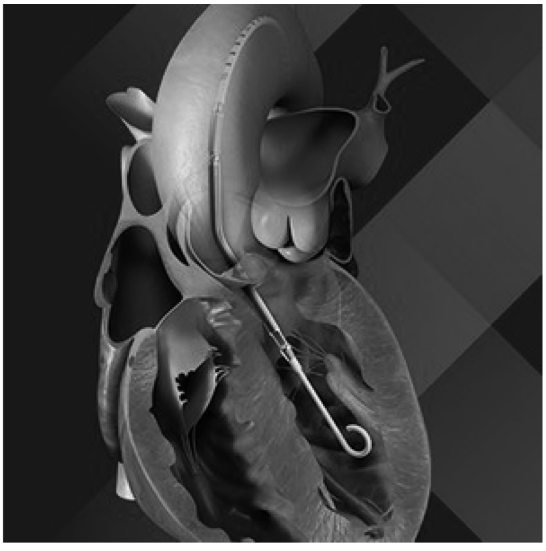
Objectives: To describe concomitant use of Impella* pump support in paediatric cardiogenic shock (CGS) following e-CPR (extracorporeal cardiopulmonary-resuscitation) with institutional adult shock program.

Methods: Case report of an adolescent who suffered out-of-hospital cardiac arrest (CA) and refractory CGS.

Results: A healthy 15-year-old schoolboy (75kg,BSA 2.0m^2) collapsed at home with VF (ventricular fibrillation). He was resuscitated with CPR-Defibrillation& LUCAS device implementation till return of spontaneous circulation on arrival at local hospital, then referred to our center. Upon arrival at our paediatric ICU, he sustained two VF arrests, underwent e-CPR with defibrillation& percutaneous cannulation via left groin(19Fr femoral artery, 23Fr femoral vein). V-A ECMO with 3.55LPM flow on CardioHelp system- established by 10 minutes from onset of in-hospital CA. Echocardiography showed severe biventricular impairment. Coronary angiogram showed normal coronary arteries, LV end-diastolic pressure of 22mmHg. No aortic regurgitation.

Participating disciplines included adult shock program& paediatric cardiac intensive care teams; the interdisciplinary consensus was to implant a trans-femoral micro-axial blood pump (Impella®2.5, Abiomed) to unload LV whilst provide continuous forward flow. Patient remained on 4.3LPM flow with combination of peripheral V-A ECMO plus Impella®-pump support (ECPELLA). Anticoagulation management- as per institutional protocol. With serial echocardiographic evidence of contractility improvement, de-escalation proceeded to explantation of mechanical circulatory support by 91 hours. 18F Manta closure device was deployed via left femoral artery and Proglide with angioseal via right femoral artery for haemostasis on decannulation. Patient was extubated on day 5 with intact neurology& no other end-organ complications; investigations are ongoing to identify cause of recurrent VF.



Conclusions: Collaborative effort between paediatric ICU and adult shock services with ECPELLA use can positively optimise outcome of refractory CGS in adolescent children when implemented by a highly experienced multi-disciplinary team.

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COVID-19 and severe myocarditis in the infant: A case report

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Objectives: COVID-19, disease caused by the SARS-Cov-2 virus, emerged in 2019. Non-respiratory manifestations have been described in infants and adults. This report intends to describe the clinical presentation of an infant with severe myocarditis.

Methods: Infant, female, 11 months old, previously healthy, presented in Emergency with prostration, pallor and moaning on 08/22/20, without previous flu symptoms. She had signs of circulatory shock, underwent volume expansion, started vasoactive amines, antibiotic therapy and intubation. An echocardiogram (ECO) was performed – LV dysfunction, ejection fraction (LVEF) 29%. Immunoglobulin was administered and transferred to the Pediatric ICU , started on corticosteroids, aspirin and enoxaparin. Exams: SARS-CoV-2 IgG+/IgM+ serology, Pro-BNP 335,439pg/mL and D-dimer 1337.15ng/mL; Normal CRP, Ferritin and ESR. She presented clinical and echocardiographic improvement, LVEF 61%, amine suspension and extubation. Was discharged from hospital on 09/09/21. Echocardiogram 2 months after discharge showing dilated cardiomyopathy with LVEF 42%. On 01/13/21, readmitted with respiratory failure and shock, need for intubation and vasoactive amines. ECHO on 01/16/21, FEVE 10%. Transferred to P-ICU on 01/18/21. During transport, she had 2 cardiac arrests. Admitted with Pro-BNP 247,121pg/mL, ECHO and cardiac magnetic resonance imaging with dilated cardiomyopathy with LV systolic dysfunction, LVEF 15%, with no pattern of inflammation or fibrosis. She underwent LVAD implantation (PedVas)and was referred by aeromedical transport for heart transplantation but evolved with progressive improvement in LV function, with support being suspended after 21 days of assistance

Results: Case report.

Conclusions: Cardiac involvement secondary to SARS-COV-2 is described as a clinical manifestation of COVID 19 in cases related or not to SIM-P. There is a variety of mechanisms involved and related to direct myocardial injury by the virus or by an abnormal immune response. In the case reported, there was an evolution to dilated cardiomyopathy after myocarditis, with significant LV remodeling and heart failure profile 3 by INTERMAC

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Thrombocytopenia and morbidity in pediatric post-cardiotomy veno-arterial extracorporeal membrane failed to wean from cardiopulmonary bypass

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Objectives: Platelets play an important role in hemostasis. Thrombocytopenia after cardiopulmonary bypass (CPB) is

associated with increased morbidity and mortality. Many studies have focused on platelet count and function as thrombocytopenia is common during extracorporeal membrane oxygenation (ECMO). This study explores the effects of the maximum single-day platelets drop percent and the duration of platelets drop on complications and outcomes in ECMO failed to wean from CPB.

Methods: We retrospectively analyzed 65 pediatric post-cardiotomy patients (aged <18 years) who directly transitioned from CPB to ECMO, from January 2010 to June 2020. They were divided into survivors (n = 34) and non-survivors (n = 31) according to in-hospital mortality. We compared the incidence of various complications and outcomes between groups. Furthermore, we examined the associations between the maximum single-day platelets drop percent and the duration of platelets drop during ECMO, morbidity and blood product transfusion.

Results: The maximum single-day platelets drop percent had predictive value for hemolysis and circuit change; the duration of platelets drop could predict hemolysis, severe acute kidney injury (AKI) and neurological dysfunction. Moreover, the correlations between them and peak plasma-free hemoglobin, peak serum creatinine, transfusion of red blood cell, platelets and fresh frozen plasma and chest-tube drainage were significant. Multivariate logistic regression analysis identified that the maximum single-day platelets drop percent was positively correlated with hemolysis, and the duration of platelets drop was positively associated with AKI. Blood product transfusion, circuit change, hemolysis, AKI, and neurological dysfunction distinctly increased the in-hospital mortality.

Table. Clinical management and outcomes

Variables	Survivors (n=34)	Non-survivors (n=31)	P value
Management			
Median flow rate (mL/min)	650.0 (500.0, 800.0)	695.0 (515.0, 1002.5)	0.430
Median pump speed (rpm)	2650.0 (2505.0, 2813.8)	2747.5 (2482.5, 2900.0)	0.297
Chest-tube days	9.0 (5.0, 12.2)	7.6 (5.2, 11.0)	0.590
Chest-tube drainage (mL/kg)	79.9 (45.3, 121.4)	110.2 (51.3, 185.9)	0.156
Platelets-related parameters			
Platelet nadir ($\times 10^9$/L)	38.0 (28.8, 54.3)	29.0 (23.0, 41.0)	**0.034**
maximum single-day platelets drop percent (%)	54.1 (40.2, 64.2)	60.0 (43.2, 76.3)	0.299
duration of platelets drop (days)	3.0 (2.0, 4.0)	4.0 (3.0, 6.0)	**0.001**
Transfusion			
RBC transfusion (mL/kg)	106.6 (70.6, 152.6)	181.8 (137.9, 254.5)	**0.001**
PLT transfusion (mL/kg)	35.3 (6.3, 53.8)	53.7 (26.1, 76.9)	0.081
FFP transfusion (mL/kg)	42.4 (23.5, 66.5)	72.7 (41.7, 104.3)	**0.006**
Complications			
Major bleeding	21 (61.8)	23 (74.2)	0.304
Circuit change	2 (5.9)	9 (29.0)	**0.019**
Change time (h)	83.5 (75.0, 92.0)	73.0 (52.5, 108.5)	0.727
1st ECMO system duration (h)	95.0 (89.0, 126.5)	129.0 (77.0, 163.0)	0.214
Hemolysis	9 (26.5)	20 (64.5)	**0.003**
Peak pFHb (mg/dl)	30.0 (20.0, 50.0)	70.0 (40.0, 110.0)	**<0.001**
AKI-3	18 (37.5)	30 (62.5)	**<0.001**
Peak serum creatinine (μmol/L)	66.6 (52.7, 90.8)	152.7 (105.2, 221.4)	**<0.001**
Neurological dysfunction	0 (0.0)	7 (100.0)	**0.004**
Nosocomial infection	14 (38.9)	22 (61.1)	**0.024**
Hyperbilirubinemia	13 (50.0)	13 (50.0)	0.804
Peak total bilirubin (μmol/L)	36.2 (27.4, 64.7)	47.7 (35.5, 69.9)	0.105
Outcomes			
ECMO duration (h)	100.6 (90.8, 129.8)	148.0 (115.0, 213.0)	**0.001**
Successfully weaned from ECMO	34 (100.0)	13 (41.9)	**<0.001**
Hospital stay (d)	51.0 (39.0, 86.3)	32.0 (16.0, 46.0)	**0.005**
ICU stay (d)	33.5 (23.8, 49.5)	14.0 (6.0, 41.0)	**0.044**
Ventilation time (h)	544.5 (273.0, 887.3)	231.0 (144.0, 898.0)	**0.037**

Note: Continuous data are presented as median (interquartile range) and categorical data as n (percent).
UFH, unfractionated heparin; RBC, red blood cell; PLT, platelet; FFP, fresh frozen plasma; pFHb, peak free plasma hemoglobin; ECMO, extracorporeal membrane oxygenation; AKI, acute kidney injury; ICU, intensive care unit.

Conclusions: The platelets drop contributed to hemolysis and AKI in pediatric post-cardiotomy ECMO failed to wean from CPB. Various complications occurred together with thrombocytopenia during ECMO, leading to poor prognosis. We need more scientific evidence, in the future.

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Learning curve and technical/clinical changes in VA pediatric ECMO: Single centre experience

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Objectives: Improving results are correlated only with technical/clinical innovations or even with a different ECMO team approach?

Methods: In a previous study we analyzed twenty years of VA-ECMO (1998-2019) 84 patients, in these last two years (2020-21) we added 15, total 99 patients, we registered a lower median weight, from 6 to 4 kg, and median age from 6 to 3 months. The incidence of different diagnoses doesn't change significantly: **49,5%** post CEC, 7% after HT, 16,5% CM, **8,5%** Myocarditis, **7,8%** CHD, **3,5%** cardiac arrest for others procedures,**6,8%** other.We divided the first 20 years into three periods: A (1998-2005; 8 pt): first generation centrifugal pumps, silicon membrane oxygenators B (2006-2011; 36 pt); anticoagulation protocol, hollow fiber oxygenators, introduction of magnetic levitation pump C (20012-2019: 46 pt); VAD program In the last 2 years nothing changed in our protocols, but we registered an increased number of pt, **7,5**/year, no Covid related, and extended indications for smaller patients, 4 of them under 3 kg.

Results: ECMO survival was **60,8%** and at discharge **44,7%**, there was significant improvement of survival between the first and second period, p=0,003 and second and third, **p=0,03,** influenced by anticoagulation protocol, **p=0,03,** hollow-fiber oxygenator, **p=0,03** and magnetic levitation pump, **p=0,02.** Survival data of the last 2 years had the same improving trend of the third period, **66,6%** and 53%. Decreased of surgical revisions and transfusions in the 3 periods: revisions/day **(p=0,0007)** and transfusions/Kg/day **(p=0,001)**, was due to anticoagulation protocol **(p=0,001)**, hollow fiber oxygenator **(p=0,0016)**, and magnetic pump **(p=0,003, p<0,0001)**. VAD protocol improved the survival of transplant after ECMO **(p=0,001)** and in a multivariable model showed to have a protective effect on ECMO outcome **(OR=0,46, p=0,19)**.

Conclusions: Technical/clinical changes in ECMO implantation and management of course influenced the outcome of patients, VAD program gave a future to a lot of them, but in the last two years a more confident approach with this device permitted us to consider ECMO as an effective life-saving procedure and to extend the indications to more patients.

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Influence of left ventricular unloading on pediatric veno-arterial extracorporeal life support outcomes

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Objectives: The effectiveness of veno-arterial extracorporeal life support (V-A ECLS) in treating neonatal and pediatric patients with complex congenital cardiac disease (CHD) and requiring cardio-circulatory assistance is well known. Nevertheless, the influence of left ventricle (LV) distension and its countermeasure, namely LV unloading, on survival and clinical outcomes in neonates and children treated with of V-A ECLS needs still to be addressed. Therefore, the aim of the current study is to determine the effects of LV unloading on in-hospital survival and complications in neonates and children treated with of V-A ECLS.

Methods: The clinical outcomes of 90 CHD pediatric patients under 16 years of age supported with V-A ECLS for post-cardiotomy cardiogenic shock (CS) in a tertiary center were retrospectively reviewed, particularly in relationship with the presence or absence of an active LV unloading strategy.

Results: The patient cohort included 90 patients (age range 19,6±339,8 months, 64,4% males), 42 of whom were vented with different techniques (38 with atrial septostomy or left atria cannula, 2 with cannula from LV apex, 1 with intra-aortic balloon pump and 1 with pigtail across aortic valve). Unloading strategy significantly increased the in-hospital survival (OR= 2.74, CI 1.06-7.08; p= 0,037). On the contrary, extracorporeal cardiopulmonary resuscitation decreased the related survival (OR= 0.323, CI 1.09-0.96; p= 0,041). The most common complications were infections (28,8%), neurological injury (26%) and bleeding (25.6%). However, these did not differently occur in venting and no-venting groups

Conclusions: In pediatric CHD patients supported with V-A ECLS for post-cardiotomy CS, the LV unloading strategy was associated with increased survival.

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Clinical profile and factors associated with in-hospital mortality after extracorporeal membrane oxygenation in neonates and children with acute myocarditis/cardiomyopathy: A single-centre 14-year experience

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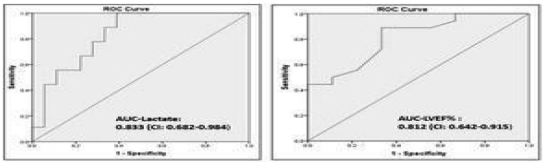
Objectives: To study clinical profile, biochemical and echocardiographic factors associated with in-hospital mortality in children treated with veno-arterial extracorporeal-membrane-oxygenation (V-A ECMO) for acute myocarditis or cardiomyopathy.

Methods: Retrospective review of electronic notes over 14-year period (Jan2008-Jan2022) at a tertiary paediatric cardiorespiratory intensive care unit. Inclusion criteria: age <16 years, diagnosis of acute myocarditis or cardiomyopathy (CMP), and need for V-A ECMO support.

Results: Twenty-six children (median age 16 months, range 12 days-15.5 years) received V-A ECMO for cardiogenic shock, with diagnosis of DCM(n=15), HCM(n=1) or acute myocarditis(n=10). 5 (19%) received E-CPR (extracorporeal-cardiopulmonary-resuscitation). Interventions for left heart unloading included transcatheter balloon atrioseptostomy (BAS)(n=5), BAS with atrial flow regulator(n=2) and transfemoral implantation of Impella® device (n=1). 10 (37%) received renal replacement therapy(RRT). Time to decannulation was shorter with concurrent RRT(122 vs 206 hours, p = 0.04). 3 children died. 23(88.5%) survived to intensive care discharge, with 18 (69.5%) to decannulation and 5 to transplant centre transfer (TCT) on ECMO. No significant difference between survivors

and non-survivors in pre-ECMO troponin-I or B-natriuretic peptide levels. Causes of death: multiorgan failure(n=2),and intracerebral haemorrhage(n=1). In ROC-analysis to predict in-hospital mortality or need for TCT, the AUCs of pre-ECMO lactate and left ventricle ejection fraction(LVEF) were 0.833(95% CI, 0.682-0.984, p<0.01) and 0.812(95% CI, 0.642-0.915, p<0.01) respectively. Pre-ECMO lactate level of 8.75mmol/L and LVEF of 17% were cut-off points for mortality. E-CPR was a risk factor for mortality(p =0.02).



Conclusions: In our cohort, in-hospital mortality for children with acute myocarditis or CMP needing V-A ECMO is 11.5%. V-A ECMO provided bridge to hospital survival without transplant in 69.5%, and bridge to TCT in 19%. Pre-ECMO risk factors for mortality or need for transplant referral were lactate >8.75mmol/L, LVEF <17% and need for E-CPR.

Pediatric - Difficult cases

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Massive spontaneous pneumomediastinum associated with bronchiolitis and ARDS treated with veno-venous ECMO in an 11-month-old infant

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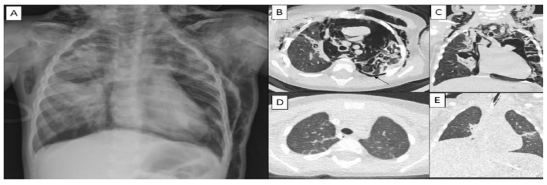
Objectives: Spontaneous pneumomediastinum (SPM) is a rare entity with usually good outcomes. It is classified into primary or secondary, depending on the existence of an underlying disease.To the best of our knowledge, we report here the first case of massive secondary SPM associated with severe bronchiolitis treated by ECMO in an infant.

Methods: An 11-month-old infant was admitted in the cardiac PICU with bronchiolitis and a massive secondary spontaneous pneumomediastinum with pseudo tamponade. Careful non-invasive ventilation partially improved oxygenation without preventing evolution towards a paediatric ARDS.The decision was to intubate, place a mediastinal surgical drain, and run a veno-venous extracorporeal membrane oxygenation (ECMO). Outcome was favorable and the ECMO weaning was achieved at day-8.



A: Chest X ray showing massive pneumomediastinum and subcutaneous emphysema
B and C: Injected thoracic CT scan showing SPM and mediastinal structures dissection, the black arrow indicated the suspected left pneumothorax
D and E: Control thoracic CT scan at day-7 ECMO run showing complete recovery except partial alveolar condensation of the inferior right lung

Results: The gas tamponade made it challenging to put the infant on mechanical ventilation and to run the ECMO. Femoral cannulation was performed percutaneously and jugular cannulation surgically because subcutaneous emphysema made the echo-guidance impossible. It was successfully managed by a specialized multidisciplinary team.

Conclusions: Even if a vast majority of secondary spontaneous pneumomediastinum have good outcomes, malignant forms associated with ARDS can lead to a life-threatening situation. In such situation, ECMO is feasible and can be safely run.

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Repeated extracorporeal cardiopulmonary resuscitation in a child with anomalous origin of the left coronary artery

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Objectives: We present the case of a 5-year-old girl with a history of anomalous left coronary artery from the right coronary sinus and subsequent ischemic cardiomyopathy. She developed arrhythmogenic cardiac arrest and required extracorporeal cardiopulmonary resuscitation via femoral cannulation. The left heart was vented via trans-catheter atrial septostomy. On day 3 of ECMO she suffered a left middle cerebral artery embolic stroke and emergent trans-arterial thrombectomy was performed. After neurologic recovery, she underwent left coronary artery unroofing and transition to Berlin Heart EXCOR left ventricular assist device, as her right heart function appeared to be preserved. On post-op day 19, she experienced ventricular fibrillation, resistant to defibrillation. She was recannulated for ECPR via the right neck vessels. The Berlin heart LV cannula was used

as a vent and the aortic cannula was connected to the arterial limb of the ECMO circuit. The heart was then successfully defibrillated. On day 29 of her second ECMO run she was taken back to the OR and RVAD cannulation was added. She was decannulated from ECMO and supported with BiVAD for 5 months.

Methods: Case presentation and follow up

Results: The patient was rehabilitated and mobilized prior to her successful heart transplant. At follow up, 6 months after her first extracorporeal cardiopulmonary resuscitation, she has a slight limp and is intellectually intact.

Conclusions: Important lessons learned:
1. Even though the right heart appeared to be preserved the arrhythmogenic, myopathic left heart remained and biventricular assist from the outset would have prevented a second cardiac arrest.
2. Percutaneous mechanical thrombectomy may be very effective in ECMO – related thromboembolism.
3. The second run of ECPR could have been done using the Berlin Heart LVAD aortic cannula as the arterial ECMO cannula, draining from a jugular cannula and preserving the carotid, then connecting the LV cannula as a vent.

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Endobronchial valve placement for the treatment of persistent air leak in a pediatric patient with COVID-19 on ECMO: A case report

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Objectives: Bronchopleural fistulas, resulting in persistent air leaks, are reported in 1-2% of adult patients with COVID-19 induced ARDS. Thus far, they have not been reported in pediatric patients presenting with COVID-19, but with more children recently affected, they may become more prevalent. For a patient on ECMO, while a common initial approach is to reduce or discontinue positive pressure, when the air leak is severe, this can be ineffective. Further, if the air leak persists, weaning off ECMO may pose as a challenge, as effective tidal volume and gas exchange may be impacted.

Methods: A previously healthy but obese (BMI:45) and unvaccinated 17-year-old girl required emergency intubation in an outside hospital for severe hypoxemia due to COVID pneumonia, and she was transferred to our Pediatric Intensive Care Unit. The day after, she developed a right sided pneumothorax that initially resolved after chest tube placement. Her ARDS progressively worsened (OI: 42), and she was cannulated onto VV ECMO. No further air leak was noted from her chest tube until three weeks into her ECMO course, when a continuous air leak developed and persisted despite efforts to decrease ventilatory pressures.

Results: CT scan and bronchoscopy confirmed the presence of a bronchopleural fistula in the right middle lobe. Despite clearing of her lung field over time, loss of tidal volume from the fistula precluded successful ECMO weaning. After discussion with interventional pulmonology, a 9mm endobronchial valve was placed under bronchoscopic visualization to the right middle bronchus. The air leak immediately resolved, and within 24 hours, adequate tidal volume and gas exchange were present, and she was able to wean off ECMO successfully. She was discharged to rehab and then to home.

Conclusions: When all other non-invasive methods were unsuccessful, placement of an endobronchial valve was a safe and minimally invasive method to treat a bronchopleural fistula in a pediatric COVID-19 patient on ECMO and allowed for successful decannulation.

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Concurrent COVID19 pneumonia and systemic inflammatory syndrome in a two week old requiring ECMO

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Objectives: Initially, newborns seemed to be relatively spared from severe COVID-19. However, with the emergence of the B.1.617.2 (Delta) variant hospitalization rates among children aged 0-4 years increased by 10-fold by the middle of August 2021. We present a case of a 2-week-old previously healthy preterm, twin, male infant who developed severe COVID-19 pneumonia, subsequent acute respiratory distress syndrome (ARDS), and an inflammatory syndrome requiring VA – ECMO support for 22 days.

Methods: A retrospective chart review was performed after successful weaning from ECMO. Parental permission for a case report was obtained in compliance with institutional standards.

Results: Multiple challenges were encountered during this patient's 22 days on ECMO. Rising markers of inflammation (LDH, Ferritin, D-dimer, CRP, ESR, troponin) made us concerned for multi-system inflammatory syndrome (MIS) in the setting of pneumonia. This complicated our treatment plan and led to a limited trial of immunomodulating agents in a baby with concurrent viral pneumonia. Dexamethasone,

IVIg, and Anakinra were used. After treatment with these agents, clinical improvement began with a slowly clearing chest x-ray (Table 1 and 2) and weaning of ECMO flows. He developed seizures concerning for stroke in the setting of stable markers of coagulation, necessitating faster weaning and earlier ECMO decannulation than desired. Imaging studies showing extensive change to the lung architecture and ultimately required tracheostomy placement.

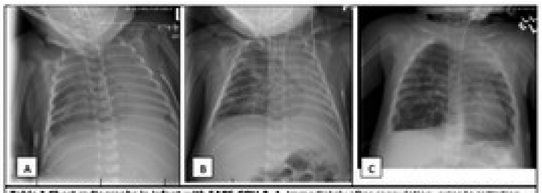

Table 1 Chest radiographs in infant with SARS-COV-2. A. Immediately after cannulation, prior to initiation of rest ventilator settings. B. Immediately prior to decannulation after bronchoscopy and aggressive pulmonary toilet. C. Most recent film as of Jan 2022 with tracheostomy in place.

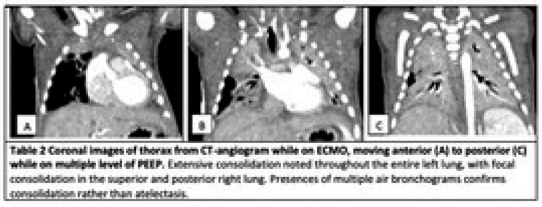

Table 2 Coronal images of thorax from CT-angiogram while on ECMO, moving anterior (A) to posterior (C) while on multiple level of PEEP. Extensive consolidation noted throughout the entire left lung, with focal consolidation in the superior and posterior right lung. Presences of multiple air bronchograms confirms consolidation rather than atelectasis.

Table 3 Coronal images of chest CT two months after ECMO decannulation, scrolling anterior (A) to posterior (C). Severe hyperinflation of the right lung, with expansion across midline of the chest anteriorly. Loss of lung architecture is seen with extensive air trapping.

Conclusions: Severe COVID19 in infants remains a rare condition. Most infants have mild symptoms and recover completely. Unfortunately, some develop severe illness requiring extracorporeal life support. These infants can be successfully managed on ECMO during their acute crisis. The presents of a what appears to be a concurrent hyperinflammatory syndrome presents additional management challenges, but use of immunomodulating agents should be considered in infants.

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ECMO support in diabetic ketoacidosis

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Objectives: We share our experience of ECMO support in a patient with Diabetic Ketoacidosis and challenging ECMO course.

Methods: Previously well 10 year old girl presented to a district general hospital as first presentation of diabetes with severe DKA (ph 6.7 & Glucose 30). Besides metabolic derangement she was in refractory shock with compromised distal perfusion. DKA treatment was commenced as per British Society for Paediatric Endocrinology and Diabetes.She had severe acidosis and metabolic derangement for more than 24 hours. Despite aggressive fluid resuscitation and vasoactive support, she continued to deteriorate with spiralling cardiovascular collapse. ECMO support was instituted for refractory shock with multi-organ failure. We opted for central cannulation (anticipating high ECMO flow / cardiac output requirement) and optimum cannula sizes. With good ECMO flow we could achieve sufficient systemic and peripheral perfusion. However, it was clear that one leg remained pale with compromised perfusion. She had multiple interventions aiming to restore perfusion to this ischaemic leg during ECMO run – (clot removal from femoral and popliteal artery, then fasciotomies, resulting in persistent challenges with anticoagulation vs bleeding). She was decannulated successfully after 9 days. She had septic deterioration with cardiovascular collapse requiring CPR which necessitated a second ECMO run, again through central cannulation. Due to ongoing concerns of leg ischaemia, she first had below knee and subsequently above knee amputation. We had significant challenges with bleeding in the stump and when ECMO was weaned this was without any circuit anticoagulation.

Results: After two ECMO runs, multiple interventions for an ischaemic leg and a six week stay on PICU, she was discharged. She was communicating well and appropriately.

Conclusions: This was a challenging case of DKA needing ECMO support, complicated with leg ischaemia. Would an earlier amputation have had a better outcome and prevented the need for a second ECMO run?

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PPHN on ECMO - a bridge to diagnosis and treatment

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Objectives: Aetiology of Persistent Pulmonary Hypertension of the Newborn (PPHN) can be uncertain at presentation. We share our experience of an unusual case.

Methods: A term baby girl was born by elective C-section after an uneventful pregnancy and delivery. She became cyanosed at 6hrs of age requiring maximal ventilatory support including iNO but her saturations remained in low 70's. Echocardiogram demonstrated evidence of high pulmonary pressures and the Right Pulmonary Artery (RPA) was not visualised. As

oxygenation became increasingly challenging she was transferred to the regional ECMO centre. Maximal inotropy was required to achieve pulmonary blood flow and post-ductal SaO2 40%. Although the diagnosis was unclear and CT imaging was planned, she was in extremis and was supported with VA ECMO via neck cannulation.

Results: Cardiac CT confirmed an abnormal origin of RPA from innominate artery. A large duct in the usual position connected to the LPA, arising from the main pulmonary artery. She was shunting right to left through an ASD. ECMO support enable a cardiac catheter intervention on Day 7 achieving good flow to the RPA. A massive pulmonary haemorrhage followed reperfusion of the right lung, which settled after 12 hours. She was successfully decannulated after 19 days. A definitive corrective surgery (RPA unifocalisation, VSD closure, fenestrated closure of ASD) was performed in the follow-up admission.

Conclusions: This is an unusual case of a structural cardiac condition, successfully supported with ECMO for definitive diagnosis and treatment

Pediatric - Nurse

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Caring for a pediatric patient during the process of organ donation after circulatory death. Experiences from intensive care nurses' perspective. Protocol for a systematic review

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Objectives: The aim is to research if there is any documented evidence of experience from the ICUnurse's perspective in the organ donor process of a potential pediatric DCDpatient. Objectives

- Identify, analyze and appraise the available evidence pertaining the ICUnurses' experiences from the caring process in the DCDprocess when caring for the pediatric patient.
- Identify, analyze and appraise the available evidence pertaining the ICUnurses' perspective of identifying and caring the pediatric DCDpatient.
- Identify gaps in the evidence pertaining the pediatric DCDprocess and ICUnurses' perceptions of the process. Upcoming gaps will be valuable in the further process of implementation.

Methods: Following research question will be used: Is the ICUnurse inducted to the process of DCD when it comes to identifying and caring a potential pediatric DCDpatient?
A qualitative approach following PEO will be used:
P – Population – ICUnurse
E – Exposure – Pediatric DCDprocess
O – Outcome – Identify the ICUnurses' experiences in the caring process of a potential pediatric DCDpatient
Eligibility criteria: ICUnurses working with pediatric patients at ICUs worldwide, including ECMO-ICU. Focus is experiences from the ICUnurses' perspective when caring for a potential pediatric DCDpatient. All qualitative *peer review* studies/articles will be included.

Results: This review can be helpful during the upcoming implementation- and education process of DCD worldwide. ICUnurses' perspective of experiences when caring for a pediatric DCDpatient are today an unexplored area and findings, no matter what they are, will be important information in the implementation process. A report with all earlier documented evidence in this sensitive topic will therefore have a great value for a further implementation for ICUnurses' and may be a sucessful framework for future secureness when working with DCD.

Conclusions: DCD in pediatric intensive care is a new way to manage the donor process in Sweden. The topic of interest is to see if the complicated, and in many ways multidimensional caring process are documented in studies worldwide before an implementation in Sweden. In case of finding evidence from other instances worldwide, result will be helpful during the education of DCD.

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Single-patient data meta-analysis on awake extracorporeal life support strategy applied to pediatric population: Feasibility and safety correlated to sedation weaning, extubation and physiotherapy

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Objectives: Over the last decade, the Adult Critical Care community has rapidly increased its consensus towards Awake Extracorporeal Life Support (ECLS) in conjunction with early active mobilization. The pediatric critical care

community is following the evidence reported so far, and it has been increasingly applying the innovative strategy to children. This review summarizes available independent, single patient data for the pediatric population regarding Awake ECLS, physiotherapy presentation, and correlated outcomes.

Methods: A literature search was carried out up to December 2021. Inclusion criteria were pediatric Awake ECLS with/without physiotherapy; Primary outcome was survival to hospital discharge, secondary outcomes were ECLS duration, extubation during ECLS, Intensive-Care-Unit length-of-stay.

Results: Nineteen manuscripts articles were included, with 65 patients (male n=27/57, 47%) undergoing Awake ECLS. Age range was from neonates (n=9) to adolescents (from 2 days to 17 years-old). Veno-Venous ECMO was used in 41 (63%) children, Veno-Arterial ECMO in 18 (27.7%), and 6 (9.2%) had other ECMO configurations.Exclusive neck ECMO cannulation was reported in 78.5% (n=51) of cases. Successful extubation during ECLS was identified in 60% (n=39) of patients, while in 24.6% (n=16) tracheostomy was performed. Patient status was declared awake by authors in 96.9% (n=63/65) of cases. Physiotherapy was reported in all confirmed awake: unspecified physical activity (n=32, 50.8%), mobilization in bed (n=15, 23.8%) and ambulation (n=14, 22.2%). Complications were described in 60.3% (n=35/58) of patients, the majority related to hemorrhagic (36.2%) and mechanical (15.5%) issues, and the need of reintubation (17.2%). Survival to hospital discharge was described in 81.5% (n=53) children.

Conclusions: Awake ECLS strategy supported with early active physiotherapy can be applied in the pediatric population from neonatal age. Ambulation was achieved in pediatric and adolescent patients. Further studies are needed to evaluate safety and efficacy of early physiotherapy during Awake ECLS and better define suitable patient selection.

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Single-patient data meta-analysis on awake extracorporeal life support strategy applied to adult population: Feasibility and safety correlated to sedation weaning, extubation, and physiotherapy

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Objectives: More frequently, the Extracorporeal Life Support (ECLS) community has been adopting the approach aiming to free patients from a sedated and unconscious cognitive state, or from invasive mechanical ventilation, to allow more active participation in mobilization and social interaction. This review summarizes available independent single patient data for the adult population regarding Awake ECLS, physiotherapy treatment, and correlated outcomes.

Methods: A literature search was carried out from inception to December 2021. Inclusion criteria were adult Awake ECLS with/without physiotherapy, with patient status clearly declared as awake. Primary outcome was survival to hospital discharge, secondary outcomes were ECLS duration, extubation during ECLS, Intensive-Care-Unit length-of-stay.

Results: Fifty-three articles were selected, which included 74 patients (male 46/74, 62%; age range 18-80 years) undergoing Awake ECLS. Veno-Venous ECMO was used in 39 (52.7%) cases, Veno-Arterial ECMO in 31 (41.9%) and 4 (5.4%) cases had other ECLS configurations. Exclusive neck ECLS cannulation was reported in 40.6% (n=28/69) of cases. Successful extubation during ECLS was identified in 74.3% (n=52) of adults, while in 15.7% (n=11) tracheostomy was performed. Physiotherapy was reported in all: unspecified physical activity (n=21/61, 34.4%), mobilization in bed (n=6/61, 9.8%), standing (n=13/61, 21.3%) and ambulation (n=21/61, 34.4%). Complications were present in 58.2% (n=32/55) of reported cases, the majority related to pulmonary (18.2%), mechanical (12.7%), and hemorrhagic (10.9%) issues. No need of reintubation occurred. Survival to hospital discharge was described in 86.5% (n=64/74) adults.

Conclusions: The adult population appears to be achieving satisfactory results with the Awake ECLS strategy implementation, despite the complications occurred and the presence of femoral ECLS cannula configuration in more than half of patients. Ambulation was achieved by one third of patients, even with peripheral vessel cannulation. Further studies are needed to evaluate the safety and efficacy of early physiotherapy during Awake ECLS and better define suitable patient selection.

Pediatric - Perfusion

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Lowering of vancomycin dosage in pediatric cardiac patients undergoing extracorporeal membrane oxygenation (ECMO)

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Objectives: Vancomycin is administered as prophylaxis in pediatric cardiac ECMO patients and in children with delayed sternal closure after bypass surgery. We want to determine the modern ECMO's role in vancomycin elimination.

Methods: An 8-year single-center retrospective cohort study of all children (0 -18 y) at the PCICU undergoing ECMO therapy. Critically ill children with delayed sternal closure post-cardiac surgery served as our control group.

Results: A total of 85 courses of ECMO (in 82 children) and 99 courses of delayed sternal closure (in 85 children) received vancomycin. Of all ECMO courses 79 were on v-a-ECMO and open chest cannulation, and 6 on v-v-ECMO and cervical cannulation. Renal replacement therapy received 19 children on ECMO and 9 controls. Median age was 141 [IQR: 10-874] and 30 [6-276] days and median weight was 4.6 [IQR: 3.3-11.3] and 3.7 [3.2-7.1] kg, respectively. Vancomycin's total daily dose in ECMO group was significantly lower than in controls with mean of 31.9 and 36.3 mg/kg/day, respectively ($p<0.05$). Vancomycin levels were slightly lower in ECMO group than in controls with 12.4 and 13.3 μg/ml, respectively ($p<0.05$). Regression analysis demonstrated significant difference in dynamics with greater reduction of vancomycin dose per day over the treatment course on ECMO compared to control group ($p<0.05$). Serum urea was only initially higher on day 0-2 and serum creatinine on day 0-1 on ECMO compared to control ($p<0.05$) and during the later treatment course with no significant difference. The vancomycin dose was associated with day on treatment, serum urea, creatinine, and ALAT. In-hospital cumulative mortality on ECMO was 49% (n=40). Our crude analysis revealed significant difference in the in-hospital death between ECMO and controls (OR: 9.2, $p<0.05$).

Conclusions: Timely therapeutic drug monitoring is mandatory, since Vancomycin elimination may be severely prolonged in ECMO patients even with mild kidney impairment.

Pediatric - Quality Improvement

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Development of pediatric multidisciplinary ECMO simulations: A novel educational program to enhance team communication and emergency preparedness

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Objectives: Pediatric extracorporeal membrane oxygenation (ECMO) is a high risk, low-volume technology. Infrequency of this technology and associated complications may translate to unfamiliarity of identification and management of potentially life-threatening events. Health care providers (HCP) involved in managing ECMO must be able to promptly identify and initiate management for such events. During the restructuring of our institution's ECMO program 2 years ago, we identified that the pediatric cardiac ICU team was composed of physicians and Advanced Nurse Practitioners (APNs) at different stages in their career and from different educational backgrounds, with varied levels of ECMO experience. Thus, the development of an ECMO training curriculum and simulation program for physicians and APNs was imperative due to its low-yield, high risk complications nature.

Methods: A multidisciplinary ECMO simulation program was implemented in a tertiary children's hospital. Over 18-months, simulations were conducted involving circuit and patient emergencies, teamwork and communication behaviors and technical skills. A survey was sent to participants following sessions to evaluate post-simulation confidence, lessons learned and potential barriers to implementation of necessary skills and behaviors.

Results: Ten simulation sessions occurred during implementation. Mean participants per session was 7 (range: 5-11). Eight PCICU attendings, four APNs, 54 RNs (PCICU/PICU), and 55 pediatric RTs attended. Tasks with highest self-reported increase in confidence were related to 1) diagnosis (tension pneumothorax, oxygenator failure, and ventricular tachycardia), 2) fluid administration and 3) early and efficient mobilization for ECPR. More than 90% of participants provided a task or behavior they would implement if a specific emergency was encountered in real-life. Real-life application did occur following simulations with participants reporting direct impact of training on their ability to perform the skill efficiently and correctly.

Conclusions: Implementation of ECMO multidisciplinary simulations provides structured opportunity for the team to learn and practice ECMO skills together. Ensuring competency of healthcare providers through implementation of such a program may improve patient safety through enhanced team communication, knowledge, and hands-on experience.

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Composition of thrombi in pediatric ECMO circuits

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Objectives: Despite anticoagulant therapy, thrombi regularly develop inside extracorporeal membrane oxygenation (ECMO) circuits of children. Thrombi that necessitate change of ECMO circuits can also embolize to the patients. The composition of these thrombi is unknown and scarcely investigated. Knowledge of thrombus composition might be helpful in developing targeted antithrombotic strategies to prevent thrombus formation. In this pilot study, we aim to investigate the composition of thrombi inside ECMO circuits after clinical use in children.

Methods: After clinical use in pediatric patients (<18 years), ECMO circuits were rinsed with buffer solution, visually inspected for thrombi and the location of thrombi was recorded. Thrombi were obtained from connector sites of pump, oxygenator, and oxygenator fibers and processed for paraffin embedding. Thrombi were stained with hematoxylin-eosin and examined via immunohistochemistry for presence of platelets (CD61) and Von Willebrand Factor (VWF). Scanning electron microscopy (SEM) was used to investigate the structures adherent to different surfaces of the circuit.

Results: Fourteen circuits from 11 patients (median age 1 day, 9 neonates, 12 veno-arterial ECMO) were studied. All circuits exhibited thrombi, especially in oxygenator and connection sites. CD61 staining showed platelet rich thrombi at the connection site (Fig 1); SEM showed activated platelets in the oxygenator and protein deposits at connector sites.

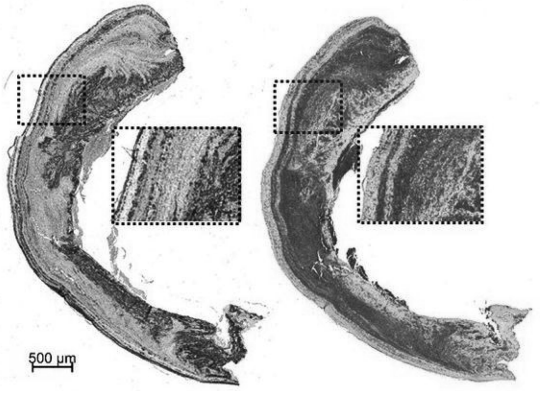

Fig 1. Histological images of connector site thrombosis. 2.5x magnification.

Conclusions: Despite anticoagulation, platelet rich thrombi develop in all ECMO circuits of pediatric patients, especially at connector sites and in the oxygenator. In this pilot study, a method has been developed to perform several techniques to evaluate the composition of those thrombi. These methods will be extended to VWF staining on additional slides. Pilot data suggest that antiplatelet therapy might be a valuable addition to current anticoagulant therapy.

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The lack of standardized reporting of coagulation research in pediatric extracorporeal membrane oxygenation studies: A systematic review

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Objectives: Extracorporeal membrane oxygenation (ECMO) involves complex coagulation management and frequent hemostatic complications. ECMO practice between centers is variable. To compare results between coagulation studies, standardized definitions and clear documentation of ECMO practice are essential. We assessed how study population, outcome definitions and ECMO-, coagulation- and transfusion-related parameters were described in pediatric ECMO studies describing hemostatic tests or outcome.

Methods: Embase, Medline, Web of Science, Cochrane Library and Google Scholar were searched and English original studies of pediatric ECMO patients describing hemostatic tests or outcome. Eligibility was assessed following PRISMA guidelines. Study population, outcome, ECMO-, coagulation- and transfusion parameters were summarized.

Results: 107 of 1312 records were included. Study population parameters most frequently included (gestational) age (79%), gender (60%) and (birth)weight (59%). Outcomes, including definitions of bleeding

(29%), thrombosis (15%) and survival (43%) were described using various definitions. Description of pump type, oxygenator and cannulation mode occurred in 49%, 45%, and 36% of studies, respectively. The main coagulation test (53%), its reference ranges (49%) and frequency of testing (24%) were the most prevalent reported coagulation parameters. The transfusion thresholds for platelets, red blood cells and fibrinogen were described in 27%, 18%, and 18% of studies, respectively.

Conclusions: This systematic review demonstrates a widespread lack of detail or standardization of several parameters in coagulation research of pediatric ECMO patients. We suggest several parameters which might be included in future coagulation studies. We encourage the ECMO community to adopt and refine this list of parameters and to use standardized definitions in future research.

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Two-page echocardiography guideline for pediatric ECMO: Is everything the same?

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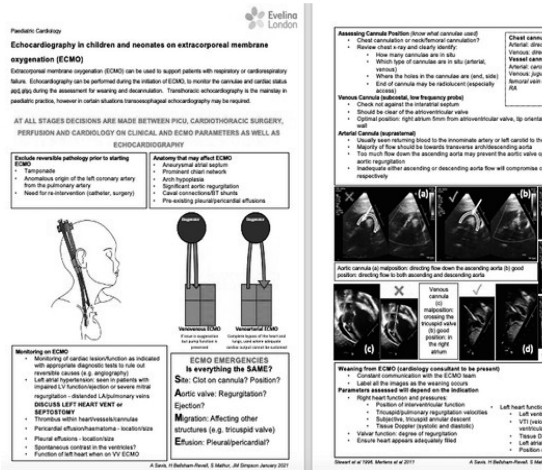
Objectives: Echocardiography for paediatric ECMO is complex, given the different modalities, cannula configurations diagnoses and such a wide age range. We sought to develop a simple two-page guideline to aid scanning that would help novices to paediatric ECMO and evaluate the effectiveness of this.

Methods: The Evelina London ECMO service covers a mixed patient population of cardiac and respiratory patients aged 0-16 years. Echocardiograms are performed by the physiology and cardiology team, with physiologists and trainees of mixed levels with varying degrees of echocardiographic and ECMO experience. To allow ease of use, particularly in an emergency, the guideline was developed to be no more than two pages.

Results: The two-page guideline was created (figure 1) using the published literature and authors' experience and was approved by the local guidelines committee. It re-enforces the multidisciplinary team approach, and that assessment is based on clinical parameters as well as the echocardiogram. It contains an overview of ECMO, and is divided into trouble shooting, emergency situations and weaning, with clear diagrams and pictures to illustrate clear points. Feedback from trainees reported satisfaction with the guideline with 100% reporting it as either extremely or very useful. The use of the acronym SAME for ECMO emergencies was also reported to be useful.



Conclusions: The two-page guideline was developed and has been in place providing a reference for all trainees and physiologists, regardless of their experience. The guideline emphasises the multi-disciplinary team approach and has been well received.

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The development of a UK and Ireland consensus document for early rehabilitation and mobilisation of neonatal and pediatric ECMO patients

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Objectives: Early rehabilitation and mobilisation (ERM) in adults receiving ECMO is well established, however the same is not the case for children. Rationale for ERM is multifaceted, including prevention of immobility related issues, maintenance of functional ability and avoidance of delirium. Despite increasing ERM in paediatric intensive care, current evidence for ERM of neonatal/paediatric ECMO patients is limited and there are no guidelines.We aimed to develop a consensus document to provide guidance for the implementation of ERM in neonatal and paediatric ECMO patients.

Study population	Outcome	ECMO circuitry	Coagulation management	Transfusion management
ECMO indication	Survival term	Type of pump and oxygenator	Main and additional coagulation tests with corresponding target ranges	Platelet transfusion threshold
Race and ethnicity	Definitions of bleeding and thrombosis	Type of tubing and coating	Device of coagulation tests	Fibrinogen transfusion threshold
Primary diagnosis groups	Definitions of hemolysis, sepsis and infection	Use of bridge or venous reservoir	Frequency of testing	Red blood cell transfusion threshold
Gender	Definition of ECPR and mechanical complications	Mode of cannulation and cannulation sites	Anticoagulant and anticoagulant dose	Antithrombin transfusion threshold
Weight	Definition of surgical interventions	Inclusion of distal perfusion catheter	Coagulation protocol and protocol around ECMO cannulation	
(Gestational) age	Duration of ECMO support	Prime fluid	Location of blood withdrawals	
In- and exclusion criteria		ECMO start and stop criteria		

Methods: Specialist physiotherapists from nine ECMO centres within the UK and Ireland established a consensus agreement for best practice. The centres were;

- Alder Hey Children's Hospital, Liverpool
- Birmingham Children's Hospital
- Children's Health Ireland at Crumlin, Dublin
- Evelina London Children's Hospital
- Freeman Hospital, Newcastle
- Glenfield Hospital, Leicester
- Great Ormond Street Hospital for Children, London
- Royal Hospital for Children, Glasgow
- The Royal Brompton Hospital, London

The document was developed in conjunction with the UK Paediatric Critical Care Society ECMO group and each centre's ECMO team was involved, together with other members of the multidisciplinary team (MDT). The document is based on extensive clinician experience and current evidence.

Results: A 20-page working document has been produced. The document covers key considerations and practicalities for completing ERM in this population and includes;

- MDT requirements
- Appropriate equipment
- Acuity levels and clinical status measurement
- Activity level guidance
- Safety and risk assessment
- Progression and goal setting

Risk assessment and safety checklist bedside tools are also included, and designed to be adapted as required to meet specific unit policies and protocols.

Conclusions: It is hoped that the development and publication of this document will promote ERM in neonatal and paediatric ECMO patients within the UK and Ireland. It aims to provide healthcare professionals with the appropriate resources and support to more confidently implement ERM. Future plans include collaboration with international colleagues to increase the applicability of the document to other countries.

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Blood stream infections during extracorporeal membrane oxygenation in neonates and children: A retrospective audit spanning 5 years

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Objectives: Blood Stream Infections (BSI) are an important complication of extracorporeal membrane oxygenation (ECMO) and can significantly impact on morbidity and mortality. Overall prevalence rates between 6 and 33% have been described in previous studies. We aimed to describe the epidemiology of significant bacteraemia during ECMO in a tertiary paediatric intensive care unit (PICU).

Methods: We conducted a retrospective analysis of all reported blood stream infections in patients undergoing ECMO between 1st January 2016 to 31st December 2020. Data collected included duration of ECMO, details of the infectious organism and survival to 30 days post decannulation.

Results: A total of 150 patients required ECMO during the study period and 169 ECMO runs were performed with a total of 1432 ECMO days. The median duration of ECMO was 6 days. A total of 48 blood cultures were identified in 40 patients, of which 17 organisms were deemed contaminants and 3 patients had sepsis prior to the ECMO cannulation. There were 16 episodes of a secondary BSI whilst on ECMO. Overall significant ECMO infection prevalence was 16.6% of the ECMO runs and the infection rate was 19.6 episodes per 1000 ECMO days. Overall survival to 30 days post ECMO decannulation was 61.3% (92/150). However, in the patients with an infection survival was only 47.5% (19/40).

Conclusions: Neonates and children undergoing ECMO are at high risk of infections and have a higher risk of mortality. Strategies and guidelines to prevent infections in this high-risk group remain a priority.

Pediatric - Respiratory failure

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VV-ECMO support as a late addition for infection-related respiratory failure in a 16-month old child

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Objectives: Late initiation of VV ECMO support, in a patient who has been supported with mechanical ventilation, for respiratory failure, has been shown to have poor results. Several papers have highlighted the unfavorable outcomes of previously ventilated patients, prior to initiating ECMO support, and the relative contraindication as shown in the latest ELSO guidelines, make such a decision difficult.

Methods: We present our successful effort, of supporting a 16month old child, with Human metapneumovirus (HMPV) infection. Our patient had been intubated and ventilated, with inotropic support for 10 days and a Murray score of 5, before commencing VV ECMO, with a 16F Avalon cannula, through the right jugular vein, with an open procedure.

Results: He was supported for 7 days, before emergency decannulation was performed, due to the presence of clots in the circuit. He was discharged home 10 days following decannulation.

Conclusions: Late initiation of VV ECMO support, in a patient who has been supported with mechanical ventilation, more than 7 days for respiratory failure, has been shown to have poor results, Despite our efforts with ventilatory and medical support, the use of VV ECMO came as a last resort. It was a successful outcome and the child is back into his normal activities.

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Mechanical ventilator setting during extracorporeal membrane oxygenation for pediatric acute respiratory distress syndrome: An European observational study

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Objectives: The main objective of the study was to first describe which settings are used for mechanical ventilation during ECMO for pediatric acute respiratory distress syndrome. The secondary objective of this study is to identify risk factors associated with poor prognosis or uncomplete recovery.

Methods: A retrospective observational study in five European centers. All children aged 1 month - 18 years supported by ECMO for refractory P-ARDS from January 2009 to December 2019 were included. Collected data were pre-ECMO clinical score invasive ventilation parameters before ECMO and at day 1, 3, 7 and 14 of assistance (positive end-expiratory pressure, mean pressure, plateau pressure, driving pressure), adjunctive therapies during ECMO (prone positioning, steroids, tracheostomy, bronchoscopy and cross-sectional imaging. Finally, we gathered outcomes parameters (survival rate, length of ECMO and invasive ventilation).

Results: We included 256 patients. Median oxygenation index and oxygenation saturation index were 37 and 24.7,

respectively. Half of the P-ARDS cases were viral pneumonia. Before ECMO implantation, prone positioning and neuromuscular blockers were used in 39% and 61% of the patients. Veno-venous ECMO was offered in 62%, and dual-lumen cannula was used in one quarter of VV ECMO cases. Preferential ventilator mode during ECMO was barometric setting during the whole study periode. Positive end-expiratory pressure (PEEP) and mean airway pressure were significantly different between centers. Prone positioning during ECMO remained limited (16%), recruitment maneuvers (2%), cross sectional imaging (8%), and tracheostomy (3%). Higher PEEP and higher mean airway pressure during the whole study period were associated with higher mortality.

Conclusions: Ventilatory setting during ECMO for acute respiratory distress syndrom are highly dependent on the center. Association between high PEEP and mean airways pressure with lower survival rate raise the question to define the best way to manage patients under ECMO for ARDS

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Risk factors associated with prolonged ECMO in children: A referral center cohorte study

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Objectives: This study aimed to investigate the characteristics and clinical outcomes of children supported with prolonged ECMO (≥28 days) for severe acute respiratory failure or cardiac failure.

Methods: We conducted a retrospective study in our referral center for ECMO between 2009 and 2020. All pediatric patients age from 28 days to 18 years-old supported with ECMO for ≥28 days were included. All neonatal indications for ECMO were excluded. We looked for pre-ECMO treatment such as mechanical ventilation settings, the use of prone positioning, nitric oxide, exogenous surfactant, neuromuscular blockers. We also gathered the ventilation settings at day 1, 3, 7, 14 and 21, outcome criteria as the median duration of ECMO, the length of invasive mechanical ventilation, the length of intensive care stays and the survival rate following intensive care discharge and 6 months after ICU discharge.

Results: On the 223 patients treated by ECMO during the study period, 14 (7%) patients underwent an ECMO run longer than 28 days. Median ECMO run duration was 44 days (28 – 122). Patients requiring a long ECMO run were younger (574 vs 1079 days), had a significantly lower PaO_2/FiO_2 ratio (51 vs 62, $p < 0.001$) and higher mean airways pressure (22 vs 18, p: 0.03). A lower tidal volume at day 7 of ECMO was significantly associated with long run (2.3 vs 4.6, p: 0.02). Higher FiO_2 requirement on oxygenator and mechanical ventilator were significantly associated with long-run ECMO at day 7 and 14. Patients having a long run were suffering from more bleeding and infectious complications. Half of the deaths for long run patients were related to palliative care. Survival rate was lower for patients having a long run.

Conclusions: Long run ECMO represent a minority of all case of ECMO. Ventilator parameters at day 7 of ECMO may help to identified theses runs. Early identification of early patients at risk of a long run could be useful to prevent bleeding complication and to prepare potential bridge to transplantation.

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It's not ACD but CAD: Implications for ECMO and palliation

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Objectives: Describe the clinical course of a neonate, supported with ECMO, who received a diagnosis of alveolar capillary dysplasia with misalignment of the pulmonary veins (ACD/MPV) and is now stable at home with a subsequent diagnosis of congenital alveolar dysplasia (CAD).

Methods: Clinical case, literature review.

Results: A term female infant, born after an uneventful pregnancy, was placed on VA ECMO for refractory hypoxia, persistent pulmonary hypertension (PPHN) and shock. After nine days she had improved so was trialed off VA ECMO but remained hypoxic so was placed on VV ECMO on day 10.A lung biopsy suggested ACD/ MPV and a microdeletion of the locus 17q23.1q23.3 was identified, a rare mutation associated with a clinical phenotype of neonatal death due to PPHN. Despite the poor prognosis of this patient, VV ECMO allowed us to demonstrate that gas exchange was adequate to trial off ECMO rather than palliate on ECMO. She was decannulated from ECMO and 10 days later extubated and discharged home in oxygen aged 37 days. Four months post-ECMO, she has been growing and developing well with minimal oxygen requirement. Re-evaluation of her case concluded that the histology was likely to be CAD, a condition which mimics ACD but has a better prognosis with some patients living into adulthood without lung transplant, if they survive the initial neonatal period.

Conclusions: A diagnosis of ACD/MPV is likely to result in redirection of care towards palliation which does not

allow for a longer assessment of the child's native lung function or for results of adjunctive investigations. This case demonstrates the potential for diagnostic uncertainty in this group of diseases and this child was benefitted by a considered wean off VV ECMO and is now thriving at home in minimal respiratory support.

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Covid-19 positive severe respiratory failure requiring VV-ECMO - the Southampton pediatric experience

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Objectives: We describe our series of 3 paediatric patients who presented during the third Covid-19 wave with acute severe respiratory failure in the context of a Covid infection . We looked at the demographics, time association with Covid infection, disease characteristics, treatment pathways, complications and outcomes.

Methods: Case reviews.

Results: Age range was 5 to 23 months. One female two males. No comorbidities. One mixed race, two Caucasian. Two patients were strikingly similar in their presentation: a clinical picture of unilateral,severe nectrotising pneumonia, PCR or culture positive for strep pneumoniae, with empyema and progressive endobronchial spread to the better lung resulting in hypoxic respiratory failure requiring ECMO. One patient had a clinical and radiological picture of Covid-19 pneumonitis. Two patients had associated air leaks. Treatment strategies changed as our understanding of the disease, and our own experience progressed. We consulted closely with other Paediatric ECMO centres both in the UK and in Canada, given the little collective experience we had of Covid-19 associated respiratory failure in young children, and the severity of disease in these patients. All three received VV ECMO. Mean run length 15.3 days (7-30). Complications were: 1 X sepsis with DIC requiring circuit change, 1 X cannula thrombus. Anticoagulation was not straight forward, possibly associated with the well described pro - thrombotic state in Covid -19. All patients survived with good recovery of lung function and were discharged self ventilating in air with no ongoing morbidity to date.

Conclusions: We have experienced two distinct clinical pictures of severe respiratory failure associated with Covid -19 infection, requiring VV ECMO support in very young children with no comorbidities. Disease progression was rapid and one patient required a long ECMO run. All three patients survived with good outcomes.

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Awake ECMO in oncological child affected by COVID-19

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Objectives: COVID 19 originated in Wuhan (China), taking global proportions. Since the beginning of the pandemic, there has been a constant search for treatments capable of changing outcomes and the course of the disease. In pediatrics, we face difficulties with various clinical manifestations. Extracorporeal membrane oxygenation (ECMO) is an important tool for supportive care, especially in patients with severe hypoxemia.

Methods: This work aims at describing the case of an adolescent with COVID-19 pneumonia with respiratory failure and acute respiratory distress syndrome (ARDS), and to discuss the use of ECMO in an awake and extubated patient, as well as the challenges and advantages of this strategy.

Results: An adolescent with grade III anaplastic ependymoma in remission. He presented flu-like symptoms and syncope, being admitted to the ICU with respiratory failure and hemodynamic instability. The patient was intubated, and the administration of amines was initiated. He had a positive RT-PCR for COVID-19 and had refractory hypoxemia, with a PaO2 / FiO2 ratio of 98 and MV with optimized parameters. On the 7th day of illness and the 2nd day of MV, venovenous ECMO was started. 48h after ECMO was installed, the patient was extubated. During the run, he actively participated in his rehabilitation. Motor and respiratory physiotherapy, oral diet, and psychological follow-up were performed. The patient showed progressive pulmonary improvement and had no infectious complications. Decannulation took place on the 11th day of ECMO, and the patient was discharged from the hospital 13 days after removal of the machine.

Conclusions: Performing ECMO in patients without sedation and with spontaneous breathing is safely practiced and can reduce care-related morbidity and mortality. In the present case, we did not observe any associated complications. The non-use of continuous sedation makes it possible for the patient to be involved in care, to initiate early motor and respiratory rehabilitation, reducing the occurrence of delirium, length of hospital stay, use of vasoactive drugs, among other benefits.

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SARS-COV-2, MIS-C, hypoxemia and awake ECMO in a child

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Objectives: The systemic involvement due to SARS-COV-2, MIS-C, is a common form of disease manifestation in the pediatric population. Rarely, MIS-C is associated with respiratory dysfunction. The treatment choice is immunoglobulins, in addition to clinical support for critically ill patients.

Methods: Case report.

Results: An adolescent, previously healthy, female, 14 years old, was admitted to an emergency care unit due to respiratory failure associated with mild flu-like symptoms. Oxygen was started by mask, with no improvement in hypoxemia. She was intubated and sent to the ICU. The first COVID test was negative. In the following 12 hours, she developed progressive ventilatory worsening, despite the maneuvers performed (prone position, NO). Blood gas analysis with significant hypoxemia, PaO2 / FiO2 ratio of 82. Associated with worsening ventilation, hemodynamic deterioration requiring vasomotor support at moderate doses (noradrenaline 0.25 mcg/kg/min). Normal echocardiogram, without ventricular dysfunction. Pulmonary support was started with VV ECMO 18 hours after intubation, flow 60 ml/kg, Sweep 2, and FiO2 in the 100% oxygenator. Ultra-protective MV, PCV, DP 10, FiO2 30%, and RR 10 bpm were maintained. There was an improvement in blood gases, but the persistence of hemodynamic instability. Lactate 4.6, using noradrenaline 0.4 mcg/kg/min, without associated bacterial infection criteria. On the 3rd day of ECMO, she received immunoglobulin, 2g/kg. 6 hours after the end of the infusion, there was a hemodynamic improvement. Vasomotor medication was suspended on the 5th day of ECMO. The patient was extubated on the 6th day of ECMO and decannulated on the 8th day. She was discharged from the hospital 14 days after ECMO withdrawal, using anticoagulants via the enteral feeding tube.

Conclusions: The systemic involvement due to SARS-COV-2, MIS-C, is a common form of disease manifestation in the pediatric population. Rarely, MIS-C is associated with respiratory dysfunction. The treatment choice is immunoglobulins, in addition to clinical support for critically ill patients.

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ECMO support for severe ARDS in a newborn with SARS-CoV-2 perinatal infection

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Objectives: SARS-CoV-2 infection can have a wide spectrum of presentation. Pediatric patients rarely develop severe disease. The incidence of vertical infection is low and newborns are usually asymptomatic.

Methods: Case report.

Results: We present the case of a male newborn, 36 weeks gestational age, weighing 2.740 kg, without other pregnancy or labor complications. His father had been diagnosed with COVID-19 five days earlier, but his mother's PCR test at hospital admission was negative. One hour after birth, he became hypoxic with respiratory distress and was started on Biphasic nCPAP and antibiotics in the NICU. After 24 hours, he was intubated and on D4 started HFOV due to severe hypoxia without pulmonary hypertension. X-rays showed bilateral interstitial infiltrate.SARS-CoV-2 PCR was positive on D4 (newborn and mother). He was transferred to our ECMO center and maintained on HFOV with iNO and prone position for 10 to 16 hours per day. Assuming severe ARDS due to SARS-CoV-2 pneumonia, dexamethasone was prescribed. On D22, a tension pneumothorax was diagnosed and treated, but due to clinical deterioration with global respiratory failure and refractory hypoxia, VA ECMO was initiated on D23. Therewere no major complications during the ECMO run. Pulmonary function gradually improved after a second course of steroids, allowing successful weaning and decannulation after 51 days of support and extubation to NIV-NAVA on D74. the was transferred to the ward on D86 without any neurological deficits and discharged home on D128, with oxygen therapy and nCPAP during sleep.

Conclusions: To our knowledge, this is the first neonatal case of severe ARDS due to SARS-CoV-2 infection to need ECMO support. Case progression was very similar to that of adult severe COVID-19 pneumonia. Long-term ECMO is still a challenge in children, especially in this novel disease with unknown long term outcome.

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Association between PaO2 after ECMO initiation and mortality in neonates treated for refractory respiratory failure

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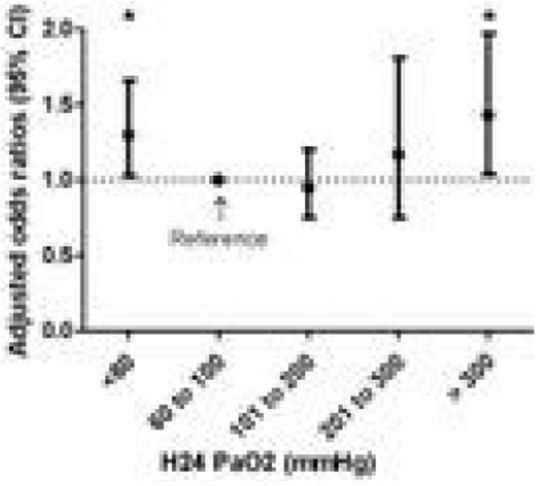
Objectives: Mortality among neonates supported by ECMO for respiratory indication remains high, close to 30%. Recent studies have shown the negative impact of hyperoxia in adult patients supported ECMO for respiratory failure and in children during cardiac surgery. Our objective was to investigate the association between PaO2 and 28-day mortality among newborns treated by ECMO.

Methods: Retrospective database analysis. All newborns <28 days supported by venovenous (VV) or venoarterial (VA) ECMO for respiratory indication reported to the Extracorporeal Life Support Organization (ELSO) between January 2015 and January 2020 were included. The PaO2 value closest to H24 after ECMO initiation was considered (H24 PaO2). H24 PaO2 was transformed into a discontinuous variable : <60 mmHg (hypoxemia), 60-100 (normoxia), 101-200 (moderate hyperoxia), 201-300 (mild hyperoxia) and > 300 (severe hyperoxia) considering normoxia as the reference. The association between H24 PaO2 and 28-day mortality was assessed using a multivariable logistic regression model including all clinically relevant variables.

Results:



We included 3,533 newborns (76.8% VA ECMO, median age 1 day [IQR, 1-3], median weight 3.2 kg [2.8-3.6]) from 198 ELSO centers. The median H24 PaO2 value was 85 mmHg [60-142] and 731 patients died (20.7%). After adjustment for all confounders, a U-shaped relationship between H24 PaO2 and 28-day mortality was observed (fig 1). This association was statistically significant for hypoxemia (aOR 1.30, CI95% 1.03-1.66, p = 0.031) and severe hyperoxia (1.43 CI95% 1.04-1.97, p = 0.028). In the VV ECMO subgroup the association was significant for hypoxemia (aOR 1.1, CI95% 1.03-3.18, p = 0.038) and moderate hyperoxia (aOR 1.98, CI95% 1.00-3.90, p = 0.049).

Conclusions: Hypoxia and severe hyperoxia are associated with 28-day mortality among neonates requiring ECMO for respiratory failure. Cautious PaO2 control should be considered after start of ECMO therapy.

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Hemolysis, plasma free hemoglobin and mortality in neonates receiving venovenous ECMO for severe respiratory failure: A prospective observational study

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Objectives: Hemolysis, defined as a plasma free hemoglobin (PFH) >50 mg/dl, has been associated with mortality and poor outcome in neonates receiving extracorporeal life support (ECLS). Among neonates receiving ECLS for respiratory failure, those with congenital diaphragmatic hernia have a high mortality of approximately 50%. Aim of this study was to investigate the kinetics of PFH and its association with outcome in CDH neonates during venovenous ECLS.

Methods: Sixty-two patients were prospectively enrolled. Venovenous ECLS was performed using a Medos DP3 pump with a Hilite 800LT oxygenator (Xenios AG). PFH was determined daily during ECLS using spectrophotometric testing. Hemolysis was defined as a PFH >50mg/dl. Group allocation according to occurrence of hemolysis.

Results: Hemolysis occurred in 50% during ECLS and in 33.9% within the first 7 days. Characteristics of patients with and without hemolysis are demonstrated in table 1. Mortality for neonates with hemolysis was 64.5% compared to 29% (p = .005). The ECLS duration was < 7d in 41.9%, 7-14 days in 25.8%, and > 14d 32.3%, with a mortality of 23.1%, 37.5%, and 85%, respectively. 19.2%, 50% and 90% of patients developed hemolysis within one, two, and > 2 weeks of ECLS, respectively. On univariate analysis hemolysis, ECLS duration >10 days, and prematurity <35weeks were significantly associated with mortality. On multivariate analysis,

only hemolysis remained significantly associated with death (HR: 2.72; 95%CI: 1.04-7.09, p = 0.041), but neither prematurity <35 weeks (HR: 1.32; 95%CI: 0.56-3.13, p = 0.523) nor ECLS duration >10 days (HR: 1.86; 95%CI: 0.80-4.31, p = 0.150).

	Group allocation		
Variables	No Hemolysis	Hemolysis	p-value
Sex, male	59.0%	51.8%	0.617
Gestational age, weeks	**38.0 [IQR 36.9-38.7]**	**36.6 [IQR 34.1-38.4]**	**0.028**
Prematurity <35 weeks	**6.5%**	**38.7%**	**0.002**
Left-Sided CDH	80.7%	77.4%	0.760
Liver-up CDH	71.0%	83.9%	0.231
13 French canula	**90.3%**	**64.5%**	**0.015**
ECLS duration, days	**7.5 [IQR 3.6-9.0]**	**16.8 [IQR 8.2-21.6]**	**<0.001**
Dialysis	6.5%	22.6%	0.073
Mortality	**29.0%**	**64.5%**	**0.005**
Weaning failure	**0.0%**	**38.7%**	**<0.001**

Conclusions: In our cohort, we observed a high rate of hemolysis during venovenous ECLS in CDH neonates which remained independently associated with mortality after correcting for confounders. For routine use it must be considered that preanalytical handling impacts PFH testing.

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Cerebral reperfusion injury in hypoxic arrest using a novel pediatric porcine model of extracorporeal cardiopulmonary resuscitation

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Objectives: Despite increased use of extracorporeal cardiopulmonary resuscitation (ECPR) in pediatric patients, neurologic injury remains one of the most severe consequences in survivors. Many risk factors have been implicated in neurologic injury following ECPR but methods to minimize injury from reperfusion, correction of hypoxia, and optimization of ECMO flow have not been clearly defined. We sought to establish a novel pediatric porcine ECPR model following a hypoxic arrest with varying strategies for correction of hypoxia.

Methods: 8-week-old piglets (5-10kg) underwent a hypoxic arrest following 7 mins of endotracheal tube occlusion. Cardiac arrest was confirmed with EKG and invasive hemodynamic monitoring. Following 20 minutes of CPR, veno-arterial ECMO support was established via cervical cannulation. In the hyperoxia group, oxygen delivery via the ECMO circuit was set at a sweep gas inlet O2 fraction (FsO2) of 1.0. In the normoxia group, FsO2 were initiated at 0.21 and titrated up to maintain arterial oxygenation saturations of 94-96%. Piglets were supported on ECMO for 4 hours and then sacrificed. Control piglets underwent ECMO without hypoxic arrest. Histopathology was used to evaluate the extent of ischemia and reperfusion injury primarily within the caudate and putamen areas of the brain.

Results: Eleven piglets underwent hypoxic arrest and were resuscitated using ECMO. Piglets were supported for 4 hours with minimal hemodynamic compromise. Those piglets that were resuscitated after an arrest with hyperoxia demonstrated severe ischemic-necrotic neurons in the putamen and caudate areas of the brain compared to controls. Those resuscitated targeting normoxia demonstrated mild injury compared to control (Figure 1).

Conclusions: We have established a reproducible pediatric porcine model of ECPR following hypoxic arrest. This model demonstrated differential brain injury following different strategies for hypoxia correction. This model will be used to study strategies to mitigate neurologic injury using various strategies to avoid reperfusion injury.

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Pediatric and neonatal Covid-19 pneumonitis: Deciding on candidacy for extracorporeal membranous oxygenation - a difficult dilemma

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Objectives: The experience of ECMO use in COVID-19 overwhelmingly comes from adult data. In comparison, there are few reported cases of infants with severe respiratory failure secondary to COVID-19 who have received ECMO. We describe four cases of infants with severe COVID-19 pneumonitis receiving maximal conventional therapy. The lack of data and experience of lung recovery in these patients makes case selection a challenge.

Methods: Case note review.

Results: We report four infants less than 12 months of age with COVID-19 pneumonitis on maximal respiratory therapy. Three developed recurrent pneumothoraces requiring multiple chest drain insertions. One had severe respiratory failure at birth following maternal COVID-19. This patient

diagnosed with COVID-19 within the first 24 hours of life. All cases were considered for ECMO. One was excluded as too premature and weight under 2kg. Both infants with severe pneumothoraces met the criteria for ECMO, but avoided cannulation due to a rapid improvement in their clinical condition after 7-10 days of ventilation.The fourth patient who had congenital COVID-19 pneumonitis proved the most difficult in decision making. After extensive discussion a decision was made to offer ECMO to allow time for immunomodulatory therapies. Whilst the chance of lung recovery was considered small due to the paucity of knowledge of lung recovery in this population it could not be excluded Of the four cases, two with severe pneumothoraces survived and discharged home. The patient receiving ECMO died due to lack of lung recovery. The remaining patient died.

Conclusions: Experience and decision making in neonatal and paediatric severe COVID-19 pneumonitis is limited by the small number of reported cases. Decision for ECMO in this population remains challenging.

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Expansion of an established cardiac ECMO programme to provision of VV-ECMO in a pediatric intensive care unit in the UK

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Objectives: We describe the expansion of our successful cardiac ECMO programme to provision of VV-ECMO. To date we have had four cases. We discuss the development of the service, disease characteristics, cannulation strategies, complications and outcomes.

Methods: In the UK, respiratory ECMO is provided by six centres, but in recent years the number of respiratory ECMO candidates has increased. In collaboration with our lead centres, we provided training and created guidelines to provide a safe VV-ECMO service moving forward. During each case, we had regular contact with them.

Results: Age range; one day-23 months. Three had pneumonia/pneumonitis, one PPHN. All patients with lung parenchymal disease were proned to promote self-recruitment whilst on rest ventilator settings, and had chest CTs to aid diagnosis, treatment strategies and timing of recruitment.Following the experience of Evelina Children's Hospital, we provided VV-ECMO via two single lumen Biomedicus cannualae. Our first child was initially cannulated VA via open cannulation but 24 hours later was successfully transitioned to VV. Our subsequent three children have all been placed on VV ECMO, irrelevant of vasoactive requirements. We used percutaneous cannulation in the latter three; proving to be safe, quick, and allowing for easy decannulation by an intensivist. Age and weight meant all had drainage via the right internal jugular (RIJ) and return via the femoral vein. With this set up, we achieved flows adequate for tissue oxygen delivery in all cases (ranging from 90mls/kg/min to 150mls/kg/min) and we had no significant recirculation issues. Complications: 1. persistent multi-organism bacteraemia, which required a circuit change. However this child was immunosuppressed with Anakinra for Covid-19 and immune dysregulation. 2. Apparent resistance to heparin before cannulation (Covid-19 positive -possibly creating a pro-thrombotic state), requiring three boluses to achieve ACT >250. In this same case, cannulation of the RIJ was complicated by an initial cannulation of the azygos vein. However, percutaneous cannulation was still possible on 2nd attempt.

Conclusions: There have been no neurological complications and all were successfully discharged home awaiting ECMO follow up.

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Early hemodynamic predictors of neonatal mortality after initiation of VA-ECMO in CDH

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Objectives: Little is known about the early prognostic markers in pediatric patients receiving extracorporeal membrane oxygenation (ECMO), especially in congenital diaphragmatic hernia (CDH). The aim of the present study was to determine the hemodynamic indicators that can predict mortality in newborn

infants with CDH on veno-artrial (VA) ECMO at an early stage.

Methods: We retrospectively reviewed the data of newborn infants who received VA ECMO as primary extracorporeal life support modality for isolated CDH from 2014 to 2021 in a single tertiary center. We compared perinatal characteristics, arterial blood gas analyses, and hemodynamic parameters including blood pressure (BP), and urine output over the initial 24h after ECMO implantation, between the survivors and the non-survivors.

Results: Among the 21 CDH patients who received VA ECMO, 10 patients (47%) survived. The perinatal characteristics including gestational age and the observed-to-expected lung area-to-head circumference ratio did not differ between the survivors and the non-survivors. In pre-ECMO baseline data, PaCO2 was significantly lower in survivors than in the non-survivors ($P<0.05$), but the oxygenation index did not differ between the groups. Although the ECMO flow rate, mean BP did not differ between the two groups, the pulse pressure at 24 hours post-ECMO was significantly lower in the non-survivors (10.6±5.1 mmHg) than in the survivors (19.3±6.1 mmHg) ($P = 0.002$). The mean 24h urine output was significantly lower in the non-survivors (4.5±1.3 mL/kg/h) than in the survivors (3.0±1.5 mL/kg/h) ($P = 0.024$).

Conclusions: The pulse pressure at 24h post-ECMO and urine output over the initial 24h post-ECMO were early hemodynamic indicators that predict mortality in newborn infants with CDH who underwent VA ECMO.

Pediatric - Other

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Dynamic platelets transfusion threshold in pediatric extra corporeal membrane oxygenation - giving less and gaining more

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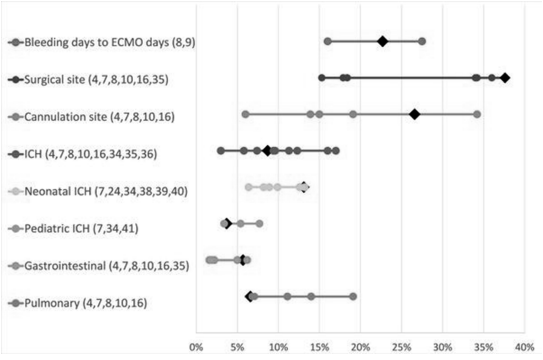
Objectives: Extracorporeal membrane oxygenation (ECMO) serves as cardiopulmonary replacement therapy in critically ill patients with respiratory or heart failure. It carries a significant, multi-faceted, risk of bleeding and is associated with profound thrombocytopenia. Most of the pediatric ECMO programs strictly follow the existing guidelines that recommend transfusing platelets when the count is less than 80,000-100,000 per cubic millimeter. Our practice has been to dynamically lower the platelets transfusion threshold based on the patients' illness acuity and bleeding risk to ~20,000 per cubic millimeter.

Methods: Retrospective chart-review study of all ECMO-supported patients in the cardiac intensive care unit of a tertiary pediatric center during a 10-year period.



Results: The analysis included 229 patients, of whom 97.4% had a platelet count < 100,000 per cubic millimeter at some point during their ECMO course. Average minimal daily platelets count was 9,600 per cubic millimeter, platelets were transfused on 28.5% of ECMO days, and 19.2% of patients did not receive platelets transfusion. Our patients did not require more blood transfusion or suffer more frequent hemorrhagic complications than described in the literature. The overall outcome of the patients was similar to other published cohorts.

Conclusions: In this single-center cohort study, we have shown that a restrictive "patient-tailored" rather than "goal-directed" platelets transfusion policy is feasible, as platelets exposure decreased with no excess blood transfusion or increase in bleeding complication rates. Our study calls for a prospective, randomized, controlled study examining outcomes of pediatric ECMO patients allocated to different platelet transfusion thresholds.

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Characteristics, outcomes and 30-day readmissions following pediatric ECMO in the United States: A nationwide readmissions database study

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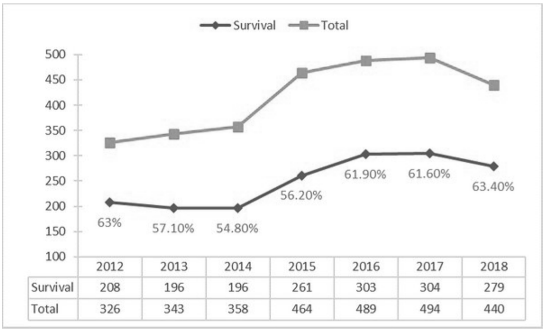
Objectives: Extracorporeal membrane oxygenation (ECMO) is an increasingly used mode of critical care support for pediatric patients with cardiac and/or respiratory failure refractory to conventional therapy. We report the characteristics, outcomes, trends and readmission rate for pediatric ECMO in the United States (US).

Methods: We extracted data from the Nationwide Readmission Database (NRD), a database designed to support national readmission analyses, for patients aged 1-18 years undergoing ECMO during index hospitalization between 2012-2018. Baseline demographics, comorbidities, characteristics, outcomes and trends were identified using their respective International Classification of Diseases (ICD) codes.

Results: Out of 897,117 index pediatric hospitalizations, 2,194 patients underwent ECMO (mean age 10.76 ± 5.02 years; 51.9% males). Of these 1,747 (59.9%) patients survived to hospital discharge, with a 30-day readmission rate of 51.6% among survivors. Cardiac conditions associated in ECMO patients were congenital heart disease (23.6%), cardiogenic shock (23.6%), and congestive heart failure (20.1%). The common respiratory associations were pneumonia (34.8%), sepsis (30.5%), and asthma (16.7%). Patients who survived were more likely to have diagnoses of myocarditis, conduction block, heart transplant failure, pneumonia, asthma and bronchiolitis. The common complications observed were acute kidney injury (53.7%), disseminated intravascular coagulation (23.2%), surgical site bleeding (13.2%), and cerebral infarction (8%). There was flat trend of yearly mortality (linear p-trend 0.5).

Conclusions: Pediatric ECMO is associated with significant mortality rates in the US, with the mortality trend over the years 2012-2018 showing a plateau. The high rates of 30-day readmissions among survivors is disconcerting. More research is needed to identify patients at high risk for mortality and readmission, to help target resources more efficiently and improve outcomes.



	2012	2013	2014	2015	2016	2017	2018
Survival	208	196	196	261	303	304	279
Total	326	343	358	464	489	494	440

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Population pharmacokinetics model of levosimendan and metabolites in neonates and children: The impact of ECMO support

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Objectives: Levosimendan is a calcium-sensitiver inotropic and vasodilatator agent. Its beneficial effect on the weaning of VA-ECMO support. In the light of pharmacological characteristics of levosimendan, OR 1855 and 1896 active metabolites, we hypothesized that ECMO may induce major increase of the volume of distribution in smaller patients, due to direct drug absorption into the circuit, haemodilution, and frequent administration of blood products fluids in this population.

Methods: From 20 patients receiving a total of 27 infusion of levosimendan (16/27 during ECMO support) we collected 240 blood samples. Levosimendan and metabolites were measured using liquid choromatography coupled with mass tandem spectrometry). We developed of pharmacokinetic (PK) model using non linear mixed effects modeling to perform dose-exposure simulations in children supported or not with ECMO.

Results: Most patients received a 0.2µg/kg/min infusion over 24h. Peak concentrations, AUC, elimination half time were significantly lower in patients supported with ECMO. Plasma clearance was significantly higher in the group of patient supported with ECMO (0.55±0.23 versus 0.33±0.21 l/kg/h). Of the clinical and biological characteristics included in the model, the "patient plasma volume" on "ECMO-circuit volume" ratio was the factor affecting mostly PK characteristics of levosimendan. Active metabolites OR1855 and OR1896 were detected respectively in 66% and 75% of the patients only, and PK characteristics of metabolites were primarily affected by levosimendan PK characteristics itself. Later results provided drug exposure simulations for various infusion posology and various body surface or ECMO-circuit volumes (figure 1).

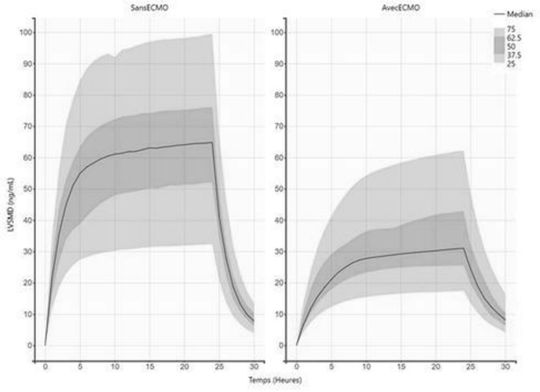

Figure: Example PK model of levosimedan plasma concentration after a 0.2µg/kg/min infusion over 24h in a 5 kg infant (left: no ECMO; right ECMO).

Conclusions: ECMO induces crucial alterations in levosimendan PK characteristics in smaller patients supported with ECMO. Further studies should define optimal regimen of levosimendan infusion in order to plan rigorous trial evaluating the effects of levosimedan in this special population.

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Carboxyhemoglobin as an early marker of mechanical complications during extracorporeal membrane oxygenation in children

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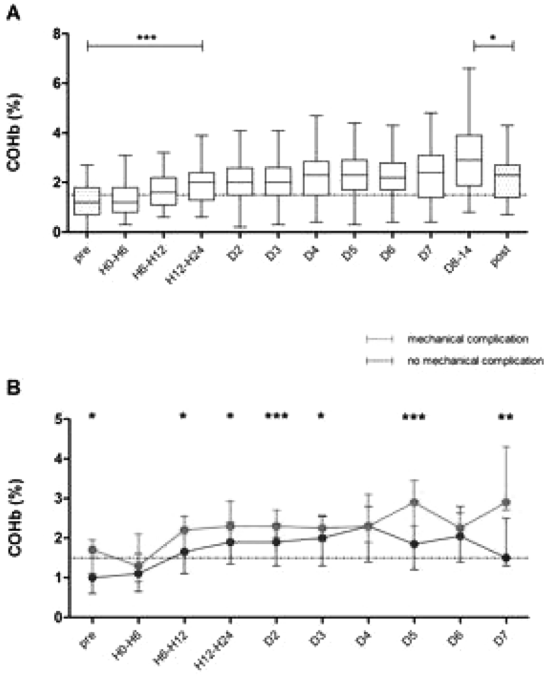
Objectives: Plasma free hemoglobin is the gold standard for assessing hemolysis during extracorporeal membrane oxygenation (ECMO). However, some concerns limit its routine use. Carboxyhemoglobin (COHb) is another known marker of hemolysis. Our objective was to clarify the clinical relevance of COHb monitoring during ECMO in children.

Methods: All children requiring ECMO from January 2018 to December 2021 at Nantes Hospital were considered for inclusion. In case of multiple ECMO runs, only data from the first episode were analyzed. Arterial COHb levels within 6 hours before initiation, during ECMO, and within 6 hours after ECMO weaning were collected. Pre-ECMO samples obtained in children with cardiopulmonary bypass were excluded. Children with underlying hemolytic anemia, without COHb data or supported less than 24 hours were also excluded. Mechanical complications were recorded prospectively, according to ELSO definitions.

Results: A total of 58 patients were included with a median ECMO duration of 97 hours [IQR, 71- 185]. COHb levels increased rapidly and significantly 12 hours after ECMO initiation (1.2% [0.7-1.8] versus 2.0% [1.3-2.4], p <0.001) and remained constant during the first seven days of ECMO (Fig1A). Mechanical complications occurred in 17/58 children (29%), with a median time of 88 hours [IQR 24-113] after the onset of ECMO. Pre-ECMO COHb levels were higher in children with mechanical complications as compared with those without (2.4 % [IQR 2.1-2.7] versus 1.9 % [IQR 1.4-2.3], p 0.02). COHb levels remained also significantly higher in mechanical complication group for a large majority of the time during ECMO (Fig 1B).



Conclusions: COHb levels increased during ECMO and were significantly higher in children with mechanical complications, suggesting that COHb may be useful as an early bedside indicator for the occurrence of mechanical complication associated with ECMO.

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Endogenous heparin-like substance in children on extracorporeal circulatory support devices anticoagulated with bivalirudin negatively affects laboratory monitoring

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Objectives: Bivalirudin is an effective alternative to heparin in pediatric extracorporeal life support (ECLS). The anticoagulant effect is usually monitored by activated partial thromboplastin time (aPTT), however, aPTT with heparinase (HPTT) is used at our institution with target range (TR) 60-80 sec, due to high incidence of endogenous heparin-like substance (HLS) among pediatric ECLS samples. The purpose of this study is to compare thrombin generation assay (TGA) with aPTT, HPTT, and bivalirudin concentration measured by plasma diluted thrombin time (dTT) values in HLS specimens.

Methods: Thirty samples from 12 pediatric patients on bivalirudin therapy during ECLS were collected and tested using aPTT, HPTT, and dTT on STAR-Max-analyser, TGA was evaluated on ST-Genesia-analyser (Diagnostica Stago) using STG-DrugScreen reagent. HLS was considered when aPTT/HPTT-ratio was >1.1. TGA variables were presented as ratio normalized by control reference plasma values. Statistical analysis was performed with Mann-Whitney U-test using MS Excel 2010; data is presented as mean±SD, with significance at $p<0.05$.

Results: We found that 63% of analyzed specimens had HLS, only aPTT was significantly higher in HLS-positive specimens, and the rate of bivalirudin concentration below TR (<0.7 μg/mL) was similar: 47% in HLS-positive and 36% in HLS-negative group. However, the incidence of presumably over-anticoagulated specimens by aPTT>80 sec was significantly higher in HLS-positive group (58% vs 18%, p =0.034), and in 4 of these 11 samples bivalirudin level was below TR (none in HLS-negative group). Interestingly, TGA showed paradoxical enhanced thrombin generation with non-significantly shorter lag-ratio and significantly higher peak-ratio.

Conclusions: Endogenous HLS could negatively affect bivalirudin monitoring by aPTT providing misleading information with supra-therapeutic aPTT values in specimens with bivalirudin concentration below TR. In addition, the thrombin generation appears to be enhanced in HLS specimens. Therefore, presence of HLS may increase thrombosis risk among ECLS patients.

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Heparin related anticoagulation practice and clinical outcomes in pediatric post-cardiotomy extracorporeal membrane oxygenation

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Objectives: There is no consensus on anticoagulation regimens in pediatric post-cardiotomy veno-arterial extracorporeal membrane oxygenation (VA-ECMO). Unfractionated heparin (UFH) dosage varies among patients under the same coagulation monitoring and targeting range. The study explores the factors influencing UFH dosage and the impact on clinical outcomes of UFH related anticoagulation practice.

Methods: The data of 85 children who received VA-ECMO support after cardiac surgery from January 2010 to December 2018 in Fuwai Hospital were retrospectively collected. Patients were divided into low-dose (<10U/kg/h, n=41) and high-dose (≥10U/kg/h, n=45) groups according to the median hourly heparin dose during ECMO. Clinical outcomes of this study included blood products transfusion, thrombocytopenia, hemolysis, bleeding, thrombotic events, ECMO duration, successful ECMO weaning rate, in-hospital mortality, ICU length of stay, total length of stay, and duration of mechanical ventilation.

Results: Multiple linear regression showed that pediatric ECMO prediction (PEP) score, lactate at ECMO implantation, and timing of systematic heparinization were significantly associated with heparin dosage. The low-dose group was exposed to higher-intensity red blood cell and plasma transfusions during ECMO. Compared with the high-dose group, children in the low-dose group had a significantly increased risk of thrombosis without an associated reduction in the risk of bleeding. Moreover, the low-dose group had higher in-hospital mortality. Univariate logistic regression analysis showed that low UFH dosage was risk factors for thrombosis [OR=3.522 (1.317, 9.417), P =0.012], hemolysis [OR=2.482 (1.037, 5.941), P =0.041], weaning failure [OR=3.187 (1.189, 8.547), P =0.021], and in-hospital mortality [OR=3.421 (1.398, 8.371), P =0.007].

Test variable	aPTT/HPTT-ratio	Bivalirudin, μg/mL	aPTT, sec	HPTT, sec.	Lag-ratio	Peak-ratio, %	ETP-ratio, %
HLS-negative (n=11)	1.05±0.04	0.90±0.45	72.5±6.8	69.4±7.9	2.7±1.5	67.8±8.1	68.1±11.3
HLS-positive (n=19)	1.25±0.16	0.87±0.50	84.7±17.0	67.2±8.1	2.5±1.1	76.7±8.9	70.2±12.0
p value	**n/a**	0.89	**0.031**	0.55	0.59	0.010	0.63

Conclusions: Heparin dosage during VA-ECMO after pediatric cardiac surgery was influenced by patients' characteristics at ECMO implantation, and timing of UFH initiation. Low heparin dosage increases the risk of thrombosis and mortality, as well as exposes to more blood product transfusion.

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Thirty years of non-cardiac neonatal extracorporeal membrane oxygenation from a regional program: Indications, survival and 4-year outcomes

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Objectives: To describe indications for and outcomes following neonatal non-cardiac ECMO used over 30 years at our centre.

Methods: During Era 1 (1989 to October 2000) ECMO was done in NICU based on oxygenation index, whereas in Era 2 (November 2000 to January 2018) ECMO was done in PICU based on clinical criteria. Eras were compared using two-tailed Fisher's Exact Test.

Results: There were 182 (16.5/year) patients in Era 1 and 44 (2.6/year) in Era 2, with similar birth weight, gestational age, CPR prior to ECMO (25% vs 23%), and male sex (46% vs 64%, p =0.04). In Era 2 a larger proportion had VA ECMO (71% vs. 48%, p =0.008), ECMO start after 48 hours of life (39% vs. 21%, p<0.0001), after the first week of life (25% vs. 3%, p<0.0001), required ECMO for sepsis (25% vs. 12%, p =0.03), and had a lethal condition (11% vs. 1%, p =0.004). In Era 2 a smaller proportion of neonates had ECMO for meconium aspiration (11% vs. 40%, p =0.0004) or hyaline membrane disease (0% vs. 7%, p =0.08). A similar proportion required ECMO for congenital diaphragmatic hernia (36% vs 35%). Mortality was higher in Era 2, 59% vs. 33% (p =0.002). Most deaths (85% and 78%) occurred before hospital discharge. Cerebral palsy (17% vs. 12%), seizure disorder (6% vs. 6%), FSIQ (83.3 (SD 22.1) vs 86.3 (SD 18.1)), VIQ (81.5 (21.6) vs 85.7 (17.9)), PIQ (84.5 (22.9) vs 86.9 (SD 28.3), FSIQ <70 (33% vs 18%, p =0.20), and disability free (72% vs 50%, p =0.13) were similar between eras. In Era 2 there were fewer with permanent sensorineural hearing loss (SNHL 0% vs. 40%, p =0.0008).

Conclusions: In Era 2 there were fewer patients/year, higher severity of illness, and more likely to have later onset respiratory failure, sepsis, and lethal conditions. These selection biases likely explain higher mortality in Era 2. Outcomes in survivors were similar. With attention to slower rates of bolus furosemide administration SNHL has been eliminated in Era 2.

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Demographic features of non-cardiac extracorporeal life support over 17 years in a regional referral centre

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Objectives: To describe the characteristics of a prospective cohort of children <6 years who underwent non-cardiac extracorporeal membrane oxygenation (ECMO) at the Stollery Children's Hospital in Alberta, Canada between January 1999 to December 2016.

Methods: Prospective inception cohort study. Descriptive statistics are given for the cohort and outcomes in survivors. Outcomes were assessed at 4.5 years old, including disability, intelligence quotients (IQ), visual-motor integration (VMI), and functional outcome (General Adaptive Composite (GAC)). IQ, VMI, and GAC scores are given as mean (standard deviation) and have population norms of 100 (15).

Results: 84 patients <6 years of age underwent non-cardiac ECMO in the study period; 48% male, 25% were < 29 days old at cannulation, and 13% were <7 days old. ECMO duration ranged from 6 hours to 55 days. Although 51 (61%) patients survived decannulation, 6 died following decannulation, with an in-hospital mortality of 39 (46%); mortality at 6 years of age was 42 (50%). The most

common indications for ECMO were viral or bacterial pneumonia (45%), sepsis (14%), pulmonary hypertension (11%), and drowning (6%). Pre-ECMO cardiac arrest occurred in 42%, 23 underwent ECPR and 10 required CPR on ECMO. Thirty patients (36%) were transported on ECMO to our centre. Patients were supported on veno-venous ECMO (30%), veno-arterial ECMO (56%), or both (14%). Of survivors, 40/42 (95%) had neurocognitive and functional outcomes determined at age 56.1 months. All outcomes were shifted to the left of population norms, with Full-Scale IQ 78 (20), Verbal IQ 78 (20), Performance IQ 79 (22), VMI 79 (21), and GAC 79 (19). Of the 40 survivors, 9 had motor disability, 3 had visual impairment, none had sensorineural hearing loss, and 2 had a seizure disorder.

Conclusions: There was a diverse presentation of patients who received non-cardiac ECMO in our referral centre. Long-term outcomes were favorable, although shifted to the left of population norms, with a minority of survivors having motor-disability. We hypothesize there are modifiable pre/on-ECMO variables associated with adverse outcomes that will be examined in future analyses.

Perfusion

EuroELSO 2022, Author Index

Perfusion
2022, Vol. 37(1S) 112–121

DOI: 10.1177/02676591211096716
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