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*Case Report*

# Extracorporeal Membrane Oxygenation in Pregnancy and the Postpartum Period: Two Case Reports and Narrative Review

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## Abstract

In recent times, extracorporeal membrane oxygenation is increasingly employed in pregnant and postpartum patients with severe cardiopulmonary failure. This article presents two illustrative cases from our tertiary care center, highlighting the complexities of obstetric extracorporeal membrane oxygenation management. These cases are described within a synthesis of recent systematic reviews, registry data, and large case series focusing on maternal and fetal outcomes, extracorporeal membrane oxygenation modality impacts, timing of intervention, complication profiles, and anesthetic considerations. The concordance and contrasts between these cases and the existing literature underscore the evolving indications, improving survival rates, and critical perioperative management issues. Emphasis on multidisciplinary care and planning remains essential to optimize outcomes in this unique patient population.

**Keywords:** VA ECMO; VV ECMO; amniotic fluid embolism in early pregnancy; TRALI after massive transfusion; vaginal delivery after cesarian (VBAC)

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## 1. Introduction

Survival rates for extracorporeal membrane oxygenation (ECMO) in pregnancy differ substantially depending on modality. Recent studies report maternal survival around 84% with venovenous (VV) ECMO compared to approximately 63–78% with venoarterial (VA) ECMO in obstetric patients [1,2]. This difference reflects the divergent indications and physiologic goals of each approach: VA-ECMO is primarily used for profound cardiogenic shock or cardiac arrest, providing both circulatory and respiratory support, while VV-ECMO is reserved for severe isolated respiratory failure with preserved cardiac function [3].

Over the past two decades, utilization of ECMO in obstetric populations has increased markedly, accompanied by substantial reductions in mortality. National data from the United States demonstrate a dramatic rise in obstetric ECMO use alongside a decline in mortality from nearly 74% to under 32% [4]. Similar trends have been observed in

international cohorts, including a nationwide Israeli study, in which ECMO was used predominantly in the postpartum period and was associated with improving survival [5]. These epidemiologic shifts underscore both the growing recognition of ECMO as a viable rescue modality in pregnancy and the need for institutional expertise and infrastructure to manage these high-risk patients [4,5].

We present two distinct cases from opposite ends of the ECMO spectrum: VA-ECMO for amniotic fluid embolism after cardiac arrest, and VV-ECMO for profound respiratory failure following transfusion-related injury. Both cases were managed in our tertiary center with close collaboration among obstetrics, anesthesiology, critical care, cardiology, and cardiothoracic surgery. By contrasting these modalities as applied in peripartum critical care, we explore the different pathophysiologic circumstances driving their use and the implications for both immediate and long-term maternal outcomes.

In addition, we conducted a targeted narrative review of the contemporary literature to provide context for our institutional experience, emphasizing updated maternal and fetal survival rates, major complication profiles, evolving management strategies, and key physiologic challenges.

## 2. Methods

### *2.1. Targeted Narrative Review Structure*

We conducted a targeted narrative review of the literature on ECMO in pregnancy and the postpartum period. We searched PubMed from January 2000 to December 2024 using combinations of the terms "extracorporeal membrane oxygenation," "ECMO," "pregnancy," "postpartum," "obstetric," and "peripartum." We prioritized systematic reviews, meta-analyses, national registry studies, and larger case series reporting maternal and fetal outcomes, indications, and complications, as well as key guidelines and narrative reviews on ECMO anticoagulation and anesthetic management of pregnant patients with cardiovascular disease. Reference lists of included articles were screened to identify additional relevant reports.

### *2.2. Case 1—VA-ECMO for Amniotic Fluid Embolism with Cardiac Arrest*

#### 2.2.1. Patient Information and Initial Presentation

A 26-year-old multigravida woman, gravida 4, para 1-0-2-1 (G4P1021), at approximately 38 weeks' gestation presented in spontaneous labor without known structural cardiopulmonary disease. Her medical history was notable for variegate porphyria, preeclampsia, hereditary spherocytosis, and a prior pregnancy complicated by fetal macrosomia delivered by normal spontaneous vaginal delivery. On hospital day of delivery, she developed sudden seizure-like activity on the labor floor, followed by acute cardiovascular collapse with pulseless electrical activity (PEA). Fetal monitoring showed profound terminal bradycardia. Given the abrupt intrapartum deterioration with neurologic symptoms and cardiovascular collapse, amniotic fluid embolism (AFE, anaphylactoid syndrome of pregnancy) was strongly suspected. Advanced cardiovascular life support (ACLS) was initiated immediately. While she was being transferred to the operating room (OR), she became pulseless on the OR table and chest compressions were continued. A perimortem/emergent cesarean delivery was performed within minutes of arrest. Return of spontaneous circulation (ROSC) was achieved after approximately 30 min of CPR and multiple doses of epinephrine. During resuscitation she rapidly developed disseminated intravascular coagulation (DIC), manifested by diffuse oozing from venipuncture and surgical sites, prolonged coagulation parameters on point-of-care testing, and hemodynamically significant obstetric hemorrhage. A massive transfusion protocol (MTP) was activated with high-volume replacement of packed red blood cells, plasma, platelets, and cryoprecipitate.

Her pre-event hemoglobin was 8.4 g/dL. The neonate was delivered with depressed Apgar scores but improved over the first 10 min of life and was admitted to the neonatal intensive care unit for management of perinatal depression and prematurity-related risks.

#### 2.2.2. Pre-ECMO Evaluation and Decision-Making

Immediately after ROSC, arterial blood gas (ABG) analysis demonstrated severe mixed respiratory–metabolic acidosis and poor systemic perfusion, with a pH of 7.18 and lactate of 12.2 mmol/L. Despite ongoing resuscitation, high-dose vasopressor and inotropic support, and maximal ventilatory settings, she remained in profound shock. A subsequent ABG obtained just prior to ECMO cannulation showed pH 7.13, $PaCO_2$ 77 mmHg, $PaO_2$ 58 mmHg on 100% $FiO_2$, ionized calcium 1.98 mmol/L, glucose 339 mg/dL, and lactate 9.9 mmol/L, consistent with refractory circulatory collapse and severely impaired oxygen delivery. Bedside transesophageal echocardiography (TEE) revealed a markedly dilated right ventricle with severely reduced function and a relatively underfilled, partially collapsed left ventricle, without evidence of large pulmonary embolus. This pattern was compatible with acute right-sided failure and pulmonary vascular obstruction in the context of suspected AFE. Given periarrest physiology, persistent lactic acidosis, escalating vasopressor requirements, and echocardiographic evidence of acute right ventricular failure, a multidisciplinary team—including cardiothoracic surgery, anesthesiology, critical care, and obstetrics—concluded that conventional therapy had failed. In view of the predominantly cardiogenic shock phenotype with concomitant severe hypoxemia, venoarterial extracorporeal membrane oxygenation (VA-ECMO) was selected as rescue therapy to provide both immediate hemodynamic support and augmented systemic oxygen delivery.

#### 2.2.3. ECMO Cannulation, Management, and Anticoagulation

Under TEE and ultrasound guidance, peripheral VA-ECMO was initiated as extracorporeal cardiopulmonary resuscitation (ECPR) via percutaneous cannulation of the left femoral vein and left femoral artery, using a Cardiohelp pump. A 24 Fr multistage venous drainage cannula was advanced from the left femoral vein into the right atrium, and a 17 Fr arterial return cannula was positioned in the left femoral artery. Initial circuit settings provided approximately 4.35 L/min of blood flow with 100% circuit $FiO_2$ and a sweep gas flow of 5 L/min, targeting full cardiopulmonary support, restoration of mean arterial pressure, normalization of arterial oxygen saturation, and reduction in $PaCO_2$ while avoiding left ventricular overdistension.

To maintain distal limb perfusion, a 5 Fr distal perfusion catheter was placed into the left superficial femoral artery. Despite the presence of active DIC and brisk pelvic and surgical bleeding, a 5000-unit bolus of unfractionated heparin was administered prior to cannulation, followed by a low-dose heparin infusion during the initial VA-ECMO run, with intensity carefully titrated in response to ongoing hemorrhage and serial coagulation studies.

The patient developed differential upper-body hypoxemia consistent with "north–south" syndrome. In response, the circuit was revised from VA-ECMO to a veno-arterial-venous (VAV) configuration with placement of an additional 17 Fr return cannula in the right internal jugular (RIJ) vein to augment oxygen delivery to the cerebral and coronary circulations. When a right subdural hematoma (SDH) was subsequently identified on neuroimaging, systemic heparin infusion was discontinued, and subsequent anticoagulation decisions were individualized to balance the competing risks of intracranial and obstetric hemorrhage against circuit thrombosis.

As biventricular function recovered and cardiogenic shock abated over the ensuing days, the need for arterial circulatory support diminished. The configuration was revised from VAV to pure venovenous (VV) ECMO by removing the arterial limb and maintaining

the 24 Fr multistage drainage cannula in the left femoral vein with return via the 17 Fr RIJ cannula. VV-ECMO support was then progressively weaned as pulmonary function improved, and the patient was successfully decannulated from VV-ECMO on 10/28.

#### 2.2.4. Clinical Course, Complications, and Outcome

Following initiation of VA-ECMO, there was rapid improvement in hemodynamics and acid–base status, with rising mean arterial pressures, decreasing vasopressor requirements, and down-trending lactate levels over the first 24–72 h. She remained intubated, sedated, and mechanically ventilated, with daily echocardiographic assessments demonstrating gradual recovery of right and left ventricular function. Her early post-cannulation course was complicated by ongoing coagulopathy and hemorrhage, necessitating continued transfusion support. In addition to bilateral internal iliac artery embolization for uterine/pelvic bleeding, she developed a right subdural hematoma with midline shift and radiographic evidence of a right middle cerebral artery (MCA) territory infarct and bilateral anoxic brain injury. Acute kidney injury progressed to oliguric renal failure requiring continuous renal replacement therapy (CRRT).

As cardiogenic shock abated and ventricular function improved on serial TEE, her ECMO configuration was sequentially stepped down—from VA to VAV to address north–south syndrome, and then to VV-ECMO once adequate native cardiac output and perfusion were restored—before complete decannulation. VV-ECMO was maintained during this recovery phase to provide ongoing respiratory support while minimizing arterial afterload and embolic risk.

Over time, CRRT was converted to intermittent hemodialysis (iHD) as her hemodynamics stabilized. Because of prolonged ventilator dependence and neurologic injury, a tracheostomy was performed. During her extended ICU stay, she experienced several infectious complications, which were managed with targeted antimicrobial therapy. Despite these challenges, her neurologic status gradually improved: she progressed from coma to purposeful responses, and ultimately to the ability to participate actively in physical, occupational, and speech therapy. VV-ECMO was successfully weaned once gas exchange improved and lung mechanics stabilized. She was subsequently liberated from mechanical ventilation, and her tracheostomy was decannulated. After transfer from the ICU to a step-down unit, she continued to make steady functional gains with multidisciplinary rehabilitation. She was discharged to inpatient rehabilitation and then home with ongoing outpatient therapy.

The neonate required NICU admission for respiratory support and close monitoring related to perinatal depression and prematurity-associated considerations but survived to discharge.

### *2.3. Case 2—VV-ECMO for TRALI-Associated ARDS in the Postpartum Period*

#### 2.3.1. Patient Information, Hemorrhage, and Respiratory Failure

A multiparous woman gravida 6, para 3-1-1-4 (G6P3114) with a history of anemia and obesity at approximately 40 weeks' gestation presented for vaginal delivery. She underwent an initially uncomplicated vaginal birth, but her postpartum course was complicated by retained placenta on postpartum day (PPD) 0. She was taken emergently to the operating room, where placenta accreta was diagnosed, necessitating exploratory laparotomy, total abdominal hysterectomy, bilateral salpingectomy, and left oophorectomy.

The surgery was complicated by massive postpartum hemorrhage with hemorrhagic shock requiring activation of a massive transfusion protocol (MTP) and extensive blood product administration. Urology was consulted intraoperatively to assess the lower urinary tract; retrograde pyelography demonstrated bilateral ureteral ligation with no contrast

passage beyond the pelvic brim on either side. Because of ongoing hemodynamic instability and coagulopathy, the abdomen was packed and left open with placement of a negative-pressure wound therapy system, with plans for delayed abdominal closure and staged re-explorations.

In the hours following hemorrhage control and transfusion, the patient developed rapidly progressive hypoxemic respiratory failure. Chest radiography revealed extensive bilateral air-space opacities with air bronchograms, predominantly in the right upper and central left lung fields, and a left-greater-than-right pleural effusion—findings consistent with severe non-cardiogenic pulmonary edema. In the setting of recent massive transfusion, these findings were most compatible with transfusion-related acute lung injury (TRALI), though transfusion-associated circulatory overload (TACO) was also considered.

Despite lung-protective mechanical ventilation with high $FiO_2$, elevated positive end-expiratory pressure, and adjunctive measures including deep sedation and neuromuscular blockade, her gas exchange remained critically impaired. An arterial blood gas immediately prior to ECMO consideration showed pH 7.17, $PaCO_2$ 75 mmHg, $PaO_2$ 51 mmHg (on 100% $FiO_2$), lactate 7.0 mmol/L, ionized calcium 0.79 mmol/L, and ionized magnesium 0.26 mmol/L—consistent with severe hypercapnic and hypoxemic respiratory failure with evolving global hypoperfusion. Her $PaO_2/FiO_2$ ratio remained < 60 mmHg, meeting criteria for severe ARDS. Prone positioning and inhaled pulmonary vasodilators were discussed; however, ongoing hemodynamic lability, immediately preceding major abdominal surgery with an open abdomen, and high hemorrhagic risk significantly limited the feasibility and safety of several conventional rescue interventions.

#### 2.3.2. ECMO Decision-Making and Cannulation

Given refractory hypoxemia, persistent hypercapnia, and signs of early multiorgan dysfunction despite maximal conventional support, a multidisciplinary team—including critical care, anesthesiology, cardiothoracic surgery, and obstetrics—elected to initiate venovenous ECMO for isolated respiratory failure. Bedside transthoracic echocardiography demonstrated preserved biventricular systolic function without evidence of cardiogenic shock, supporting VV- rather than VA-ECMO as the most appropriate modality.

Under ultrasound and fluoroscopic guidance, VV-ECMO was established using a dual-site approach with a 23-Fr Medtronic single-stage cannula in the right femoral vein and a 25-Fr Medtronic multistage return cannula in the left femoral vein. Initial blood flow and sweep gas settings were titrated to achieve adequate systemic oxygenation and carbon dioxide clearance, allowing for transition to ultra-lung-protective ventilatory settings with very low tidal volumes, reduced driving and plateau pressures, and moderate PEEP.

#### 2.3.3. Anticoagulation and Bleeding Complications

Given the patient's recent massive transfusion and ongoing coagulopathy, anticoagulation was initially held at the time of cannulation. Once surgical hemostasis became more reliable, a continuous unfractionated heparin infusion was initiated at reduced doses, with target aPTT in the range of approximately 50–70 s (or equivalent ACT/anti-Xa levels), in an effort to mitigate circuit thrombosis while minimizing additional hemorrhage. This approach mirrors the broader controversy in obstetric and postpartum ECMO regarding optimal anticoagulation intensity and monitoring, particularly in patients with high hemorrhagic risk.

During her ECMO course, she required multiple additional procedures, including pelvic angiographic embolization for residual hemorrhage, urologic interventions for bilateral ureteral ligation (initially managed with bilateral nephrostomy tube placement), and subsequent delayed ureteral reimplantation with stent placement. Each intervention

demanded close coordination between the surgical teams and the ECMO/critical care service, with dynamic adjustments of heparin dosing and ECMO flow around operative windows. Anticoagulation was frequently reduced or temporarily held peri-procedurally and then carefully re-titrated once surgical hemostasis was reassured, while maintaining vigilant surveillance for circuit clotting and thromboembolic complications.

#### 2.3.4. Clinical Course, Weaning, and Outcome

Over approximately 3.5 weeks (about 25 days) of VV-ECMO support, the patient's oxygenation and lung mechanics gradually improved. Serial chest radiographs showed progressive resolution of the bilateral infiltrates. Imaging demonstrated well-aerated lungs with no pleural effusion or pneumothorax and no acute cardiopulmonary abnormality, with markedly improved bilateral aeration compared with admission films.

As pulmonary function recovered, ECMO blood flow and sweep gas were decreased incrementally while native ventilator support was cautiously increased. Objective criteria for decannulation included sustained improvement in $PaO_2/FiO_2$ ratio on low-to-moderate ventilator support, acceptable plateau pressures, and maintenance of adequate gas exchange during stepwise ECMO flow-reduction trials. Once these thresholds were met, she was successfully decannulated after roughly 25 days of VV-ECMO support.

Post-decannulation, she remained in the intensive care unit for further ventilator weaning, renal support, and rehabilitation. Renal function improved sufficiently to allow for transition from continuous renal replacement modalities, when used for volume and solute management, to intermittent hemodialysis as needed. Her open abdomen was gradually managed with repeat explorations and eventual fascial closure once hemodynamics and coagulation normalized.

She was subsequently transferred to a step-down unit for continued recovery and physical, occupational, and nutritional rehabilitation. By the time of hospital discharge, she had regained good functional status without documented need for supplemental oxygen at rest, and follow-up imaging demonstrated no major residual parenchymal abnormalities. Formal pulmonary function testing, when performed in outpatient follow-up, did not reveal significant obstructive or restrictive defects, and she reported no major long-term dyspnea or exercise intolerance.

Because VV-ECMO was initiated in the postpartum period, fetal considerations did not factor into management. Nevertheless, this case underscores the extreme hemorrhagic risk and complex perioperative coordination required for postpartum ECMO in the setting of TRALI-associated ARDS and highlights the feasibility of prolonged VV-ECMO support with tailored anticoagulation in a high-risk postpartum patient.

## 3. Discussion

Our two cases reflect broader trends in ECMO utilization among pregnant and postpartum patients. National and international data demonstrate a marked rise in the use of ECMO in obstetric populations over recent decades, paralleled by substantial improvements in survival. In a large U.S. administrative analysis, Taha et al. [4] showed that obstetric ECMO utilization increased by roughly 145% every four years between 1999 and 2014, while mortality associated with obstetric ECMO decreased from nearly 74% in earlier eras to less than 32% in more contemporary practice [4,5]. This improvement likely reflects advances in patient selection, multidisciplinary experience, and ECMO technology, as well as earlier recognition of severe cardiopulmonary failure [1–3].

### *3.1. Utilization Trends and Epidemiology*

Registry-level data from the Extracorporeal Life Support Organization (ELSO) reinforce these trends. Ramanathan et al. [6]. analyzed 280 peripartum ECMO patients and reported overall maternal survival of approximately 70%, which was comparable to or slightly better than outcomes in nonpregnant adults receiving ECMO for similar indications; survival improved over time, and higher mortality was observed among patients requiring extracorporeal cardiopulmonary resuscitation (ECPR), atypical circuit configurations, or renal replacement therapy [7]. van den Bosch et al. [8] using more than 5.3 million pregnancy-related hospitalizations from 2010 to 2016, identified 59 women who received ECMO (incidence 1.1 per 100,000 hospitalizations) and found an in-hospital mortality rate of 30.5%, with cardiogenic shock as an independent predictor of death [8]. A recent review of cardiac arrest situation in the peripartum period supports that this is a rare event (1 out 100,000) and that in most described cases, return on spontaneous circulation is obtained without requiring ECMO. In this recent paper, only 14 of the 87 cardiac arrest cases described received ECMO support and the majority survived with good physiological status [9].

Systematic reviews corroborate that ECMO has transitioned from an extraordinary salvage measure to an increasingly standardized rescue therapy in this population. Sebastian et al. [10] synthesized 213 peripartum ECMO cases reported between 1990 and 2020 and found that 28.2% of patients were cannulated in the third trimester and 32.9% postpartum, reflecting a predilection for use in late pregnancy and the puerperium [10]. In this cohort, maternal survival was 79.3%, with a live-birth rate of 73.7%. More recent meta-analysis by Lu et al. [2] pooling 30 studies and 1460 peripartum ECMO patients, reported mean maternal survival of 74% and fetal survival of 73%, again with clear signals of improving outcomes over time [2].

Experience from other health systems is consistent with these observations. A nationwide Israeli cohort of 28 obstetric ECMO patients (64% VV-ECMO, 32% VA-ECMO, 4% V-AV) reported maternal and fetal survival of 89% and 100%, respectively, with most cases occurring in the postpartum period and respiratory failure (predominantly COVID-19 ARDS) as the leading indication [5]. These epidemiologic data contextualize our two cases within a broader landscape in which obstetric ECMO is being used more frequently, with progressively better maternal outcomes when implemented in experienced centers.

### *3.2. Indications and Modality Selection*

The spectrum of indications for ECMO in pregnancy and the postpartum period includes severe ARDS (from viral pneumonia such as H1N1 or COVID-19, aspiration, TRALI, and other causes), peripartum cardiomyopathy, massive pulmonary embolism, sepsis with refractory shock, amniotic fluid embolism (AFE), and other forms of decompensated cardiogenic shock [7]. ARDS is consistently the most common indication, accounting for nearly half of cases in several large series and systematic reviews, whereas pulmonary embolism, peripartum cardiomyopathy, and sepsis comprise the bulk of cardiac or mixed cardiopulmonary presentations [10].

Case 1 exemplifies the use of VA-ECMO as rescue therapy for fulminant cardiogenic shock and cardiac arrest in suspected AFE, where simultaneous circulatory and respiratory support are required. This presentation aligns with disease-specific data: a recent meta-analysis of 79 AFE patients treated with VA-ECMO reported a maternal survival rate of 72%, with about 6% of survivors sustaining major neurologic sequelae, supporting VA-ECMO as a rational rescue modality in this catastrophic condition. Our patient's rapid cannulation after intraoperative arrest and subsequent myocardial recovery mirror the approach de-

scribed in these reports and in broader registries where AFE and cardiogenic shock due to peripartum cardiomyopathy or pulmonary embolism are leading VA-ECMO indications [1].

Case 2 demonstrates VV-ECMO for isolated severe respiratory failure in the postpartum period after massive hemorrhage and TRALI, in the setting of preserved biventricular function. This is consistent with contemporary practice patterns, in which VV-ECMO is the predominant modality for ARDS and noncardiogenic respiratory failure, whereas VA-ECMO is reserved for patients with circulatory collapse or mixed cardiopulmonary failure [11]. In Malfertheiner et al.'s [11] multicenter series of 60 peripartum ECMO patients, 77% received VV-ECMO—most commonly for influenza-related ARDS—and 23% VA-ECMO for pulmonary embolism, peripartum cardiomyopathy, and other cardiac indications. Maternal survival was 94% in the VV-ECMO group versus 71% in the VA-ECMO group [11].

Across meta-analyses aggregating more than 1400 obstetric ECMO patients, overall maternal survival is approximately 74%, with VV-ECMO consistently associated with higher survival (≈84%) than VA-ECMO (≈63%). Sebastian et al. [3]. and others have not always demonstrated a modality–survival association in smaller pooled cohorts, but when larger datasets such as Lu et al. [2] are considered, a clear advantage for VV-ECMO emerges [3,7]. Single-center series parallel these findings; for example, Lankford et al. [1] reported maternal survival of 72% in 21 peripartum ECMO patients, with particularly favorable outcomes among those treated with VV-ECMO for ARDS and some centers reporting VV-ECMO survivals approaching 90–94% [1]. Our two cases are aligned with these modality-specific trends: both patients survived, and the VV-ECMO case underscores how respiratory support alone can be lifesaving when cardiac function is preserved.

### *3.3. Complications: Hemorrhage and Thrombosis*

Hemorrhagic complications are among the most frequent and clinically consequential adverse events in obstetric ECMO, occurring in roughly one-third of patients in contemporary series and meta-analyses [1]. Bleeding may manifest as surgical-site hemorrhage, hemoperitoneum, intracranial hemorrhage, uterine atony with postpartum hemorrhage, or significant cannulation-site bleeding, and is frequently exacerbated by disseminated intravascular coagulation (DIC), massive transfusion, or obstetric interventions performed in close proximity to cannulation.

Our VA-ECMO case was complicated by DIC and massive transfusion in the setting of AFE, necessitating hysterectomy, pelvic embolization, and complex hemostatic management, while our VV-ECMO case required repeated procedures for pelvic bleeding and urologic injuries in the context of postpartum hemorrhage and coagulopathy. These scenarios illustrate the complex interplay between obstetric pathology, surgical re-exploration, and ECMO-related anticoagulation described throughout the literature. At the same time, thrombosis—including oxygenator and circuit clotting, deep vein thrombosis, and systemic embolic events—remains a constant threat, particularly when anticoagulation intensity is intentionally lowered to mitigate bleeding [9].

Unfractionated heparin remains the standard anticoagulant in most ECMO programs, but its dosing is less predictable in the ECMO setting, and excursions outside the therapeutic range are common. This has fueled ongoing debate regarding optimal monitoring strategies—activated clotting time (ACT), activated partial thromboplastin time (aPTT), anti-Xa levels, or combinations—and how best to incorporate adjunctive therapies such as antithrombin supplementation or direct thrombin inhibitors (e.g., bivalirudin, argatroban) in patients with heparin resistance or heparin-induced thrombocytopenia [1]. Experience with direct thrombin inhibitors in pregnancy is limited to case reports, and pregnancy itself is a hypercoagulable state with altered pharmacokinetics, further complicating anticoag-

ulation management. In both of our patients, anticoagulation was initially withheld or minimized in the face of active bleeding, then cautiously up-titrated as surgical and obstetric hemostasis improved—an approach consistent with expert reviews but highlighting the absence of high-quality, obstetric-specific data to guide anticoagulation protocols.

### *3.4. Maternal and Fetal Outcomes; Timing of Delivery*

Maternal outcomes with peripartum ECMO are encouraging across heterogeneous indications, but fetal and neonatal outcomes are more variable and are closely tied to gestational age at cannulation, underlying maternal pathology, and the timing of delivery relative to ECMO initiation [1,10]. Lu et al. [2] reported an average fetal survival rate of 73%, with survival strongly associated with later gestational age. Hrymack et al. [9] analyzing 37 pregnant ECMO patients in the Chinese ECLS registry, found fetal survival rates of 0% in the first trimester, 14% in the second, and 78% in the third trimester, despite maternal survival of 80% with VV-ECMO and 56% with VA-ECMO [9]. Similarly, Aissi et al. [12] observed that, among women with ARDS due to H1N1 or COVID-19, fetal survival was significantly higher when ECMO was initiated after emergency delivery (92%) than when pregnancy was continued on ECMO (55%), whereas maternal survival was similar regardless of timing.

Contemporary analyses also suggest that when pregnancy is maintained during ECMO and delivery occurs after maternal stabilization, fetal survival can approach 66–nearly 100% in selected series, whereas survival is lower (≈40–50%) when delivery occurs before ECMO or very early during the ECMO run [6]. Prematurity, rather than ECMO itself, appears to be the principal driver of neonatal morbidity and mortality; common complications include respiratory distress syndrome, the need for NICU admission, and sequelae of extreme prematurity.

Our experience mirrors these observations. In Case 1, emergent cesarean delivery during maternal cardiac arrest at term was clearly indicated because of immediate fetal compromise, and ECMO was initiated primarily for maternal salvage in the immediate postdelivery period. This scenario exemplifies situations in which delivery timing is dictated by maternal hemodynamic catastrophe and fetal bradycardia, leaving little opportunity to optimize neonatal maturity but occurring at a gestational age where neonatal survival potential is already high. In contrast, Case 2 involved ECMO in the postpartum period, eliminating fetal considerations but highlighting maternal risks related to postpartum hemorrhage, coagulopathy, and the need for ongoing surgical interventions.

Available data do not support a single prescriptive rule regarding the optimal timing of delivery for pregnant patients on ECMO. Decisions must be individualized within a multidisciplinary framework, balancing maternal stabilization (which may benefit from postponing delivery to allow for cardiopulmonary recovery) against fetal maturity and the risks of prolonged in utero exposure to severe maternal hypoxemia, acidosis, or hemodynamic instability. Our cases reinforce that obstetric ECMO management is highly context-dependent, and that both pre-ECMO and on-ECMO delivery can be appropriate depending on gestational age, fetal status, and maternal condition [7,9].

### *3.5. Anesthetic and Multidisciplinary Management*

Both cases underscore the necessity of a coordinated multidisciplinary team involving anesthesiology, critical care, cardiology, cardiothoracic surgery, maternal–fetal medicine, and, when applicable, neonatology and interventional radiology [6,9]. Complex decisions regarding cannulation strategy (peripheral vs. central; dual-site vs. dual-lumen VV), targeted flow rates in the context of pregnancy-related increases in cardiac output,

anticoagulation intensity, perioperative management for repeated surgeries, and timing of decannulation require frequent, structured communication among all disciplines [1,11].

Anesthetic management must account for altered pharmacokinetics and pharmacodynamics during both pregnancy and ECMO, hemodynamic fragility, and the dual goals of maternal safety and fetal well-being when pregnancy is ongoing [13]. Pregnancy-induced changes in volume of distribution, protein binding, and renal clearance affect sedatives, analgesics, and vasoactive agents, while the ECMO circuit itself can sequester highly protein-bound or lipophilic drugs, necessitating dose adjustments and therapeutic drug monitoring when feasible [9]. Additionally, pregnancy is associated with reduced functional residual capacity and increased oxygen consumption, making preoxygenation, ventilator-to-ECMO transitions, and peri-extubation planning particularly critical [2,3].

Our institutional approach—using intraoperative transesophageal echocardiography to guide modality selection and cannula positioning; employing tailored, dynamic anticoagulation strategies around major obstetric and surgical interventions; and closely coordinating ICU, operating room, and interventional radiology care—reflects recommendations from recent expert reviews and guidelines emphasizing formalized ECMO teams and obstetric–critical care collaboration [4,8,9].

## 4. Limitations

This report has several limitations. First, it describes only two cases from a single tertiary center and is inherently retrospective and descriptive, limiting generalizability. Second, we did not perform a systematic review; our literature summary is a targeted narrative synthesis and may have missed relevant reports, particularly unpublished or non-English-language data [2,10]. Third, we lack standardized long-term follow-up data on maternal cardiopulmonary function and on neurodevelopmental outcomes in the offspring, which are increasingly recognized as important sequelae after severe peripartum critical illness and ECMO support [1,6]. Finally, as with most obstetric ECMO reports, decisions regarding cannulation approach, anticoagulation intensity, and delivery timing were individualized rather than protocolized, precluding any causal inference about specific management strategies [3,4,6,8,10,13]. These limitations underscore the need for prospective, multicenter studies and standardized registries focused specifically on pregnant and postpartum ECMO patients.

## 5. Conclusions

ECMO has become an increasingly critical intervention for severe cardiopulmonary failure in pregnancy and the postpartum period. Our two hospital case reports, consistent with the contemporary literature, reinforce the improving maternal and fetal survival rates, the critical role of ECMO modality selection, and the complexity of anesthetic and multidisciplinary management required. Tailored care and timing of ECMO initiation and delivery planning is paramount. Prospective research and long-term outcome studies are urgently needed to consolidate best practices and address ongoing clinical uncertainties in this specialized field.

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