SYSTEMATIC REVIEW AND META-ANALYSIS

Extracorporeal Life Support in Pregnancy: A Systematic Review

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BACKGROUND: The use of extracorporeal life support (ECLS) has expanded to include unique populations such as peripartum women. This systematic review aims to (1) quantify the number of cases and indications for ECLS in women during the peripartum period reported in the literature and (2) report maternal and fetal complications and outcomes associated with peripartum ECLS.

METHODS AND RESULTS: This review was registered in PROSPERO (CRD42018108142). MEDLINE, Embase, and CINAHL were searched for case reports, case series, and studies reporting cases of ECLS during the peripartum period that reported one or more of the following outcomes: maternal survival, maternal complications, fetal survival, and/or fetal complications. Qualitative assessment of 221 publications evaluated the number of cases, clinical details, and maternal and fetal outcomes of ECLS during the peripartum period. There were 358 women included and 68 reported fetal outcomes in cases where the mother was pregnant at the time of cannulation. The aggregate maternal survival at 30 days was 270 (75.4%) and at 1 year was 266 (74.3%); fetal survival was 44 (64.7%). The most common indications for ECLS overall in pregnancy included acute respiratory distress syndrome 177 (49.4%), cardiac failure 67 (18.7%), and cardiac arrest 57 (15.9%). The most common maternal complications included mild to moderate bleeding 66 (18.4%), severe bleeding requiring surgical intervention 48 (13.4%), and intracranial neurologic morbidity 19 (5.3%). The most commonly reported fetal complications included preterm delivery 33 (48.5%) and neonatal intensive care unit admission 19 (27.9%).

CONCLUSIONS: Reported rates of survival in ECLS in pregnant and postpartum women are high and major complications relatively low.

Key Words: extracorporeal circulation ■ extracorporeal membrane oxygenation ■ pregnancy and postpartum
comprehensive search of ECLS in the pregnant and postpartum periods, to define the reported indications as well as maternal and fetal survival, and to identify associated complications.

METHODS

This systematic review was registered in PROSPERO (CRD42018108142) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were reviewed and maintained when performing this systematic review. This study was exempt from institutional review board approval as a systematic review of published literature. The authors declare that all supporting data are available within the article and its online supplementary files.

Literature Search

A comprehensive literature search was performed on September 11, 2018 for this systematic review using OVID MEDLINE (1946-), Elsevier Embase (1947-), and EBSCOhost CINAHL (1937-) databases from time of inception to capture studies regarding ECLS in the pregnant and postpartum periods with no limit placed on language or date of publication, but studies that describe the use of ECMO in children were excluded. A selection of sentinel articles was used to generate search terms and test retrieval in all of the databases. The complete searches can be found in Data S1.

Study Selection

After the search was completed, 2 authors (E.E.N., A.N.C.) reviewed each abstract independently for consideration of full text review. The same 2 authors independently reviewed the full text articles for inclusion in the systematic review. A search using the Web of Science from February 28 through March 1, 2019 identified the articles in the bibliographies as well as citations of the selected articles and were also screened for inclusion. An additional study was found through preexisting subject knowledge and included. Once final articles were selected, data were extracted by one author (E.E.N.) and validated by another (A.N.C.). Google Translate was used for non-English texts and information was collected from adequately translated articles for those that met inclusion criteria. Any discrepancies were resolved by discussion. Figure 1 depicts a flowchart of study selection.

Case reports, case series, meeting abstracts, correspondences, and any other type of study that reported one or more of the following were included: maternal survival, fetal survival, maternal complications, and/or fetal complications with the use of ECLS during pregnancy or within the postpartum period (the first 42 days after delivery). Studies in which the patients did not clearly undergo ECLS, underwent cardiopulmonary bypass for cardiac surgery only, or underwent immediate cardiac mechanical support (e.g., left ventricular assist device, biventricular assist device) were excluded. Cases in which initiation of extracorporeal support was unclear were reviewed by 2 authors (E.E.N., M.E.B.) for inclusion and those where initiation was more than 42 days postpartum were excluded.

The following criteria were used for exclusion of studies: patients who were not pregnant or more than 42 days postpartum, studies not reporting either maternal or fetal outcomes, nonhuman studies, non-English studies without adequate translation, editorials, narrative review articles, and systematic review articles. Articles that were excluded after full text review were recorded with reasons for exclusion. If more than one reason for exclusion was identified, articles were excluded based on the following hierarchical order: nonhuman experiment or unrelated to ECLS; unable to obtain full text or full English translation; review article or systematic review; commentary/editorials without original results; ECLS not performed; patient not pregnant; no ECLS outcomes reported; unable to differentiate outcomes from nonpregnant patients; patient >42 days postpartum; duplicate studies or overlapping cohorts.

Nonstandard Abbreviations and Acronyms

| Acronym (Abbreviation) | Description                  |
|------------------------|------------------------------|
| ARDS                   | acute respiratory distress syndrome |
| ECLS                   | extracorporeal life support |
| ECMO                   | extracorporeal membrane oxygenation |

What Is New?

- With the increasing medical complexity of women of childbearing age, the potential for catastrophic complications of pregnancy may call for advanced therapies including extracorporeal life support.

What Are the Clinical Implications?

- Venovenous and venoarterial extracorporeal support may be implemented for a variety of severe cardiopulmonary conditions in pregnant patients with reasonable success and safety for mother and fetus.

CLINICAL PERSPECTIVE

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Interpretation of Data

Data were collected for indication; maternal demographics; gestational age; timing, duration, and type of ECLS; and maternal and fetal morbidity and mortality. Maternal information collected included age, gravidity/parity, disease process, ECLS duration, complications, and mortality. Obstetrical information was collected for gestational age and delivery type. Fetal information was collected for gestational age at delivery, preterm delivery, neonatal intensive care unit admission, complications, and mortality. ECLS information was collected for support type (venoarterial, venovenous, or both [venoarterial+venovenous]), duration, and indication. For cohort studies, the mean age, gravidity and parity, gestational age, and duration on ECLS were recorded. One author collected the data (E.E.N.) and the second author (A.N.C.) reviewed each study and confirmed the data. Discrepancies in the data were resolved by discussion, and if still unresolved, a third author (M.E.B.) reviewed for resolution. Authors of published articles with incomplete information were contacted by e-mail and/or telephone for further information.

Gravidity and parity was defined as described in reports on hospital admission. Vaginal deliveries included spontaneous vaginal deliveries and operative vaginal deliveries. Deliveries prior to 37 weeks were considered preterm deliveries. Any delivery prior to 32 weeks was considered to have been admitted to the neonatal intensive care unit whether or not it was explicitly stated, in accordance with the American Academy of Pediatrics guidelines on levels of neonatal care.12 Fetal outcomes were reported for patients who underwent ECLS while pregnant; fetal outcomes from patients who underwent ECLS immediately postpartum, postpartum, or unknown timing relative to delivery were not included. Ectopic pregnancies were not counted toward fetal mortality. Maternal cases <24 weeks with a fetal loss were reported as a spontaneous abortion and were not included in the preterm delivery count. Spontaneous abortions that occurred prior to ECLS were not included in fetal mortality. Therapeutic abortions were included in fetal mortality if the termination occurred on ELCS for maternal indications or if abortion was performed because of catastrophic fetal injury.

Figure 1. Flowsheet for study inclusion/exclusion. Flow diagram of search results and study selection.
incurred due to ECLS. Fetal survival was reported within the outcome only if it was explicitly stated in the study.

Patients were classified as being antepartum, immediately postpartum, or postpartum. Antepartum patients were those cannulated and initiated on ECLS prior to delivery. Immediately postpartum cases were identified as those patients who were cannulated and initiated on ECLS within 24 hours of delivery. Postpartum cases included patients who were cannulated and initiated on ECLS >24 hours after delivery but within 42 days of parturition. Cases that were identified as postpartum but did not have a clear time frame of <24 hours of delivery were included in the postpartum category. Indications for ECLS were noted based on case reports; some patients had multiple indications for ECLS. Patients with underlying ischemic, structural, or valvular heart disease were defined as having heart disease as well as cardiac failure as the indication for ECLS.

Mechanical support was identified as venoarterial, venovenous, or both as described in the study. Extracorporeal carbon dioxide removal, extracorporeal arteriovenous carbon dioxide removal, interventional lung assist membrane, and percutaneous extracorporeal lung assist supports were included with venovenous therapies. Cases in which the patient underwent cardiopulmonary bypass and had been previously initiated on ECLS or underwent post-cardiopulmonary bypass ECLS were included. Duration of ECLS was reported for all patients regardless of survival. Survival was reported within 30 days of discontinuation of ECLS therapy as the aim of this study is to evaluate the rescue survivability of ECLS; additional deaths within 1 year were also reported separately. Complications included mild to moderate bleeding (qualitatively described as mild to moderate and/or the need for transfusion without invasive intervention), severe bleeding (requiring surgical or endoscopic interventions), vascular complications (limb ischemia, pseudoaneurysm, wound infection), intracranial morbidity (hypoxic brain injury, intracranial hemorrhage, hemiplegia, cerebral infarct), deep vein thrombosis, and other neurologic morbidity (peripheral neuropathy, cognitive dysfunction, need for rehabilitation after discharge, myoclonic epilepsy, amnestic disorder). Some patients had multiple complications.

Quality Assessment
Because of the low level of evidence and high risk of bias, case reports and case series were not assessed for the level of quality. Given the limited information presented, meeting abstracts and correspondence were also not assessed for level of quality.

RESULTS
Overall, 2116 studies were identified and reviewed and 221 studies met inclusion criteria. Table S1 contains the complete list of articles included and description of the studies and patients. These papers were published between 1974 and 2019. Figure 2 depicts the increasing rate of reporting of cases. Table 1 reports

Figure 2. Case reports by year of publication.
Results of the case reports by year of publication. MSR indicates the maternal survival rate for each time period described.
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Table 1. Patient Characteristics

| Total Patients, n (%) | Maternal count | 358 (100) |
|-----------------------|----------------|-----------|
| Antepartum cases with fetal outcome | 68 (19.0) |
| Average maternal age, y (SD) | 29.5 (6.1) |
| Median gravity/parity (range) | 2/1 (G3P0–G9P8) |
| Median gestational age (SD) | 24 wk (6.2) |
| Interquartile range | 6.14 wk |
| Stage of pregnancy, n (%) | | |
| Antepartum | 81 (22.6) |
| Immediate postpartum | 69 (19.3) |
| Postpartum | 126 (35.2) |
| Uncategorized | 82 (22.9) |
| Delivery type, n (%) | | |
| Vaginal | 67 (18.7) |
| Cesarean | 158 (44.1) |
| Dilation and extraction | 5 (1.4) |
| Not reported | 128 (35.8) |
| Deliveries on extracorporeal membrane oxygenation, n (%) | 35 (9.8) |
| Extracorporeal life support indications, n (%) | | |
| Acute respiratory distress syndrome | 177 (49.4) |
| Cardiac failure | 67 (18.7) |
| Cardiac arrest | 57 (15.9) |
| Peripartum cardiomyopathy | 45 (12.6) |
| Pulmonary arterial hypertension | 28 (7.8) |
| Amniotic fluid embolism | 27 (7.5) |
| Pulmonary embolism | 17 (4.7) |
| Heart disease | 14 (3.9) |
| Septic shock | 11 (3.1) |
| Asthma | 7 (2.0) |
| Malignancy | 7 (2.0) |
| Takotsubo cardiomyopathy | 6 (1.7) |
| Pheochromocytoma | 5 (1.4) |
| Spontaneous coronary artery dissection | 3 (0.8) |
| Aspiration pneumonitis | 2 (0.6) |
| Trauma | 2 (0.6) |
| Distributive shock | 1 (0.3) |
| Propofol infusion syndrome | 1 (0.3) |
| Hemorrhagic shock | 1 (0.3) |
| Diffuse alveolar hemorrhage | 1 (0.3) |
| Pulmonary alveolar proteinosis | 1 (0.3) |
| Interstitial lung disease | 1 (0.3) |
| Sickle cell crisis | 1 (0.3) |
| Aortic dissection | 1 (0.3) |
| Transfusion related acute lung injury | 1 (0.3) |
| Cerebral venous thrombosis | 1 (0.3) |
| Pulmonary hemorrhage | 1 (0.3) |
| Cystic fibrosis | 1 (0.3) |
| Dengue fever | 1 (0.3) |

(Continued)

Table 1. Continued

| Total Patients, n (%) | Extracorporeal membrane oxygenation cannulation mode, n (%) | | |
|-----------------------|-------------------------------------------------|------------------|
| Venoarterial | 145 (40.5) | Venovenous | 96 (26.8) |
| Both venoarterial and venovenous | 19 (5.3) | Not reported | 98 (27.4) |
| Maternal overall survival at 30 d, n (%) | 270 (75.4) | Antepartum | 65 (18.2) |
| Immediate postpartum | 58 (84.1) | Postpartum | 85 (67.5) |
| Timeframe unspecified | 62 (75.6) | Maternal overall survival at 1 y, n (%) | 266 (74.3) |
| Maternal complications, n (%)† | | Mild to moderate bleeding | 66 (18.4) |
| Severe bleeding requiring surgical intervention (laparotomy, hysterectomy) | 48 (13.4) |
| Intracranial neurologic morbidity | 19 (5.3) |
| Vascular complications (extremity ischemia, infection) | 14 (3.9) |
| Deep ven thrombosis | 10 (2.8) |
| Other (peripheral neuropathy, need for rehabilitation on discharge, hyperbilirubinemia, reperfusion injury, bradycardia with cannulation) | 22 (6.1) |
| Fetal survival, n (%) | 44 (64.7) |
| Fetal complications, n (%)† | | Preterm delivery | 33 (48.5) |
| Neonatal intensive care unit admission | 19 (27.9) |

*Some cases had multiple indications for ECLS.
†Some cases had multiple complications.

the patient characteristics. There were a total of 358 cases of ECLS during the peripartum period reported. The maternal survival at 30 days was 270 (75.4%) patients; maternal survival at 1 year was 266 (74.3%). Of the 358 cases, there were 210 (58.7%) cases that described the fetal outcome. There were 81 cases where the mother was on ECLS during pregnancy; of these cases, 68 (84.0%) had fetal outcomes reported. Fetal survival reported for patients who underwent ECLS during the antepartum period was 44 (64.7%) patients.

The most common indications for ECLS overall in pregnancy included ARDS 177 (49.4%), cardiac failure 67 (18.7%), and cardiac arrest 57 (15.9%). Table 2 reports the survival of patients based on indication for ECLS. The most common maternal complications included mild to moderate bleeding 66 (18.4%), severe bleeding requiring surgical intervention 48 (13.4%), and intracranial neurologic morbidity 19 (5.3%). There were 18 (5.0%) patients who had peripheral neurologic deficits or required rehabilitation resulting in an intact neurologic maternal survival of 245 (68.4%).

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The average duration of ECLS was 17.9 days and monoarterial in 7 cases (5.6%), and unknown in 19 (15.1%). In 63 (50%), venovenous in 37 (29.4%), venovenous+venoarterial in 22 (17.4%) and severe bleeding 18 (14.3%). Cannulation was venoarterial included mild to moderate bleeding 17 (13.5%) and severe bleeding 7 (8.6%). Complications included cardiac arrest 39 (31.6%), cardiac failure 4 (4.2%). A smaller percentage of patients (5.3%) had both venoarterial or venovenous at different times during the peripartum period and this was most frequently used for cardiac arrest (28.3%), cardiac failure (26.2%) or peripartum cardiomyopathy (25.5%). Venovenous cases were on average longer in duration (average 18.8 days) and the vast majority were indicated for ARDS 74 (77.1%) followed by asthma 6 (6.2%), and percutaneous extracorporeal lung assist 1 (0.2%). Extracorporeal life support indications and outcomes separated by indication for extracorporeal support.

Table 2. Extracorporeal Life Support Indications and Outcomes

| Indications                          | Total, n (%) | Survival, n (%) |
|-------------------------------------|--------------|-----------------|
| Acute respiratory distress syndrome | 177 (49.3)   | 141 (79.7)      |
| Cardiac failure                     | 67 (18.7)    | 52 (77.6)       |
| Cardiac arrest                      | 57 (15.9)    | 50 (87.7)       |
| Peripartum cardiomyopathy           | 45 (12.5)    | 36 (78.3)       |
| Pulmonary arterial hypertension     | 28 (7.8)     | 14 (50)         |
| Amniotic fluid embolism             | 27 (7.5)     | 14 (51.9)       |
| Pulmonary embolism                  | 17 (4.7)     | 11 (64.7)       |
| Heart disease                       | 14 (3.9)     | 11 (78.6)       |
| Septic shock                        | 11 (3.1)     | 10 (90.9)       |

Outcomes separated by indication for extracorporeal support.

There were 81 (22.6%) cases in the antepartum period, 69 (19.3%) cases in the immediately postpartum period (<1 day), and 126 (35.2%) cases in the postpartum period (1–42 days). There were 82 (22.9%) cases that could not be classified into a defined time period. The most common antepartum indications were ARDS 53 (65.4%), cardiac failure 8 (9.9%), pulmonary arterial hypertension 7 (8.6%), and cardiac arrest 7 (8.6%). Complications included mild to moderate bleeding 27 (33.3%) and severe bleeding 7 (8.6%). Cannulation was venovenous in 46 (56.8%), venoarterial in 21 (25.9%), venovenous+venoarterial in 5 (6.2%), and unknown in 9 (11.1%). The average duration of ECLS was 10.8 days. Maternal survival was 65 (80.2%), fetal survival was 44 (64.7%). The most commonly reported fetal complications included preterm delivery 33 (48.5%) and neonatal intensive care unit admission 19 (27.9%). Fetal neurologic complications included intraventricular hemorrhage 2 (2.9%), ventriculomegaly 1 (1.5%), ventriculomegaly/cerebral ischemia 1 (1.5%), and asphyxia with therapeutic hypothermia 1 (1.5%).

The most common immediately postpartum indications included cardiac arrest 39 (56.6%), cardiac failure 16 (23.2%), and amniotic fluid embolism 15 (21.7%). Complications included mild to moderate bleeding 17 (24.6%) and severe bleeding 8 (11.6%). Cannulation was venovenous in 53 (76.8%), venoarterial in 6 (8.7%), venovenous+venoarterial in 4 (5.8%). The average duration of ECLS was 5.5 days and maternal survival was 58 (84.1%).

The most common postpartum indications were ARDS 50 (39.7%), peripartum cardiomyopathy 32 (25.4%), and cardiac failure 24 (19.0%). Complications included mild to moderate bleeding 17 (13.5%) and severe bleeding 18 (14.3%). Cannulation was venoarterial in 63 (50%), venovenous in 37 (29.4%), venovenous+venoarterial in 7 cases (5.6%), and unknown in 19 (15.1%). The average duration of ECLS was 17.9 days and maternal survival was 85 (67.5%).

**DISCUSSION**

In this study, we found an overall 30-day survival rate of 75.4% (n=270) for mothers requiring ECLS and a survival rate of 64.7% (n=44) for fetuses exposed to ECLS. However, our fetal survival rate is limited by missing fetal outcomes and lack of long-term follow-up. Complications associated with ECLS in pregnant patients were consistent with the general population including bleeding, deep vein thrombosis, and vascular complications. The indications for ECLS and cannulation methods varied based on the timing relative to delivery. From the few reviews published to date, the survival rate for pregnant patients undergoing ECLS has been significantly higher than the overall survival with adult ECLS for pulmonary (59%) or cardiac (43%) causes with reported maternal survival rates ranging from 70% to 80% and reported fetal survival rates 65% to 72%. Despite concerns that pregnant or immediately postpartum women may be at risk of bleeding...
complications and/or at risk for thromboembolic phenomenon in the immediate postpartum period, our findings do not reflect this concern and suggest that the conditions leading these women to require ECLS may be reversible and in fact, more amenable to mechanical support than the standard adult ECLS. Mild to moderate bleeding complications were noted in 18.4% (n=66) of cases and severe bleeding requiring operation was present in 13.4% (n=48) of cases; this was comparable to the reported range in other adults studies ranging from 28% to 32%.13–15 Deep vein thromboses and vascular complications were uncommon at 2.8% (n=10) and 3.9% (n=14) respectively and comparable to the ranges reported for limb ischemia in other adult populations, 2% to 14%.13–15,17 Collectively, our findings demonstrate that pregnant patients had more favorable survival than prior reported rates for the general population with similar rates of complications.13–15,17 These patients represent an overall younger, healthier group who are more likely to have ECLS for acute, reversible indications than the general population of ECLS cases and our findings reflect this underlying favorability for better outcomes.

Survival varied depending on the indication for ECLS. Women who were cannulated for cardiac arrest had a survival rate of 87.7%; comparing this with a population-based study on maternal cardiac arrest that reported a 58.9% survival suggests that ECLS may have a role in improving clinical outcomes in this context.18 Neurologically intact survival for patients who undergo extracorporeal cardiopulmonary resuscitation has been reported at 28.5%, in this study it was found to be 78.9% with neurologic deficits including hemiparesis 1 (1.8%), limb motor deficits 2 (3.5%), hand weakness 1 (1.8%), and need for rehabilitation on discharge 2 (3.5%).19 The current literature regarding amniotic fluid embolism reports a wide range of survival from 39% to 89%.20–22 This review found an overall survival of 51.9% (n=14), consistent with the current literature; however, the rate of neurologically intact survival was 74% (n=20) compared with 15% in previously reported literature.20 Pulmonary arterial hypertension has a very poor prognosis in pregnant women and prior case series have reported very poor survival rates with ECLS (16.7%); however, our study reported a survival of 50% (n=14).23 Several reports of antepartum placement of venous and arterial sheaths for potential rapid initiation of ECLS in patients with severe pulmonary arterial hypertension suggest that these anticipatory interventions may improve outcomes in these high-risk patients.24,25

Table 3. Cannulation Outcomes

| Cannulation Type | Total, n (%) | Venoarterial+Venovenous | Total, n (%) |
|------------------|-------------|-------------------------|-------------|
| **Venoarterial** |             |                         |             |
| Indications      |             |                         |             |
| Cardiac arrest   | 41 (28.3)   | Cardiac arrest          | 6 (31.6)    |
| Cardiac failure  | 39 (26.9)   | ARDS                    | 6 (31.6)    |
| Peripartum cardiomyopathy | 37 (25.5) | Cardiac failure          | 4 (21.1)    |
| Duration         | 6.9 d       | Duration                | 13.9 d      |
| Maternal survival| 105 (72.4)  | Maternal survival        | 14 (73.7)   |
| Maternal complications |         |                         |             |
| Mild to moderate bleeding | 29 (20.0) | Mild to moderate bleeding | 6 (31.6) |
| Severe bleeding  | 23 (15.9)   | Severe bleeding         | 5 (26.3)    |
| Intracranial complications | 10 (6.9) | Vascular complications  | 3 (15.8)    |
| **Venovenous**   | 96 (26.8)   |                         | 98 (27.4)   |
| Indications      |             |                         |             |
| ARDS             | 74 (77.1)   | ARDS                    | 83 (84.7)   |
| Asthma           | 7 (7.3)     | Cardiac failure         | 20 (20.4)   |
| Cardiac failure  | 4 (4.2)     | Cardiac arrest          | 7 (7.1)     |
| Duration         | 18.8 d      | Duration                | 12.7 d      |
| Maternal survival| 77 (80.2)   | Maternal survival        | 74 (76.3)   |
| Maternal complications |         |                         |             |
| Mild to moderate bleeding | 29 (30.2) | Mild to moderate bleeding | 4 (4.1)    |
| Severe bleeding  | 12 (12.5)   | Severe bleeding         | 8 (8.2)     |
| Intracranial complications | 6 (6.3) | Deep vein thrombosis    | 5 (5.1)     |

Indications and outcomes separated by cannulation type. ARDS indicates acute respiratory distress syndrome.
We separated peripartum patients who underwent ECLS into 3 time periods and observed that there were different indications and survival rates for advanced mechanical support at different stages of pregnancy. The majority of cases during the antepartum period were for cases of ARDS and roughly one-third of those patients delivered while on ECLS. The decision to deliver the neonate versus continue ECLS in these patients is one that requires multidisciplinary discussion and is made on an individual basis depending on the disease process, evolution of illness, institutional experience, and expert opinion. Notably, survival in the immediately postpartum group was highest at 84.1% (n=58). The higher risk of bleeding in the immediately postpartum group (mild to moderate bleeding 17 [24.6%] and severe bleeding 18 [26.1%]) may not be surprising given the number of cases associated with amniotic fluid embolism and postpartum hemorrhage, 2 pathologies known to induce coagulopathy and hyperfibrinolysis. Of the 3 groups, postpartum ECLS had the longest average duration of support and lowest survival rates.

Cardiac arrest was the most common indication in the immediately postpartum period and many of these reports are cases of extracorporeal cardiopulmonary resuscitation, defined as application of venoarterial ECMO during cardiopulmonary resuscitation. The 57 cases of cardiac arrest in this review had very favorable survival (87.7%) compared with the general adult population survival with extracorporeal cardiopulmonary resuscitation (29%).16 These findings support consideration and use of extracorporeal cardiopulmonary resuscitation in pregnant and immediately postpartum patients as an advantageous group.

Our study has several limitations. These results may be confounded by publication bias as authors may be more likely to report favorable outcomes than poor ones. It may be that the current literature is unduly optimistic with successful cases being overrepresented but could also be underreporting of uneventful but successful cases. Another limitation is that the current data come from case reports and case series. We considered estimating our outcomes using 95% CIs; however, we did not have an unexposed population without ECLS in order to compare our outcomes. Additionally, when calculating CIs to estimate a risk/proportion, there is also the underlying assumption that the observations come from the same population with the same “true” risk and that these are randomly drawn from the population. We rejected this assumption as there is likely to be publication bias when synthesizing results from case reports and case series. Sample size limitations were also a major concern in the consideration of fitting a random effects model. Therefore, we included only the proportion of what is reported in the literature in our sample. There were 4 (1.1%) cases in which the authors noted maternal deaths more than 30 days postpartum that were included to estimate a 1-year maternal survival, however, outcomes at 1 year were not uniformly followed nor reported and this may be an underestimation. We are unable to draw any conclusions about maternal survival over time because of the limited reports prior to 2009. However, the contemporary reports from 2009 to 2019 have a maternal survival rate of 75%. Prospective and detailed reporting with multicenter collaboration may help to better elucidate the use of ECLS in pregnancy including indications, complications, outcomes, and best management strategies for this unique population.

The findings of this study are encouraging but one also has to consider the long-term functional outcomes in these patients. Although studies suggest that patients who have undergone ECMO are able to achieve reasonable physical and neuropsychologic recovery, functional deficits may persist.26–30 This is an important consideration in this young population as they may benefit from targeted medical or psychosocial rehabilitation.31 Intracranial neurologic morbidity occurred in 5.3% (n=19) of patients and overall neurologically intact survival in this study was 68.4% (n=245). These findings suggest a lower incidence of poor neurologic outcome and mortality compared with other ECMO studies that cite neurologic morbidity in up to 16.0% of patients.17,19,32,33 Another limitation to this study is the lack of information on fetal outcomes as they were only reported in 84.0% (n=68) of antepartum cases. With these data alone, it is challenging to accurately predict the fetal risk portrayed with maternal ECLS. Prospective studies may better elucidate the association of maternal and fetal outcomes with ECLS use during pregnancy.

These limitations notwithstanding, our findings prompt providers to consider the use of ECLS during the peripartum period as a potentially lifesaving intervention for patients with cardiac and/or respiratory failure. Centers that manage high-risk pregnancies, particularly those that include women with congenital heart disease, cardiovascular disease, and/or severe respiratory illness, should be prepared to initiate and manage patients with ECLS in the event of a devastating cardiopulmonary event during the peripartum period.

CONCLUSIONS

ECLS in the peripartum period has been successfully utilized with a maternal survival rate of 75.4% and should be considered in catastrophic cardiopulmonary conditions. Pregnancy brings a set of challenges and unique considerations for ECLS. At present, there are no formal guidelines to lead physicians to best manage these patients and future directions of research include optimal anticoagulation strategies, choice of cannulation sites, fetal monitoring, and/or method and timing of delivery. Future studies may want to assess long-term
outcomes of neonates born to women who underwent ECLS during the antepartum period. Moving forward, to more clearly assess outcomes, an emphasis should be made on reporting all cases of ECLS in pregnancy in a prospective manner with more granular case details to establish an inclusive assessment of outcomes and complications in this unique population.

ARTICLE INFORMATION
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Disclosures
None.

Supplementary Materials
Appendix S1–S3
Tables S1–S3
References 7, 8, 23, and 34–250

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SUPPLEMENTAL MATERIAL
Data S1.

Full search terms

ECMO in pregnancy searches

Ovid MEDLINE search for the sentinel articles

("23268668" or "23942727" or "22922930" or "28719429" or "28195885" or "25819202" or "29739630" or "27056763" or "26758056" or "27881700" or "26942349" or "25248040" or "19019293" or "26307595" or "26825433").ui.

Ovid MEDLINE; Ovid MEDLINE In-Process & Other Non-Indexed Citations; Ovid MEDLINE Epub Ahead of Print (800 results on September 11, 2018)

(exp pregnancy/ or exp pregnancy complications/ or exp obstetric surgical procedures/ or exp maternal health services/ or postpartum period/ or (c-section* or caesarean* or cesarean* or childbirth* or labor or labors or labour* or maternal or mother* or obstetric* or peri-partum or peripartum or post-natal or postnatal or postpartum or postpartum or pregan* or pre-natal or prenatal).tw.) and (exp extracorporeal membrane oxygenation/ or (ecmo or extra-corporeal or extracorporeal).tw.) not ((exp adolescent/ or exp child/ or exp infant/) not exp adult/)

Elsevier Embase.com (963 results on September 11, 2018)

('maternal care'/exp OR 'obstetric operation'/exp OR 'obstetrics'/exp OR 'perinatal care'/exp OR 'perinatal period'/de OR 'pregnancy'/exp OR 'pregnancy disorder'/exp OR 'prenatal care'/exp OR 'prenatal period'/de OR caesarean*:ab,ti OR 'c-section':ab,ti OR 'c-sections':ab,ti OR cesarean*:ab,ti OR childbirth*:ab,ti OR labor:ti OR labors:ti OR labours:ti OR maternal:ab,ti OR mother*:ab,ti OR obstetric*:ab,ti OR 'peri-partum':ab,ti OR peripartum:ab,ti OR 'post-natal':ab,ti OR postnatal:ab,ti OR 'post-partum':ab,ti OR postpartum:ab,ti OR pregnan*:ab,ti OR 'pre-natal':ab,ti OR prenatal:ab,ti) AND ('extracorporeal oxygenation'/exp OR ecmo:ab,ti OR (((extracorporeal OR 'extra-corporeal') NEAR/3 (support OR membrane OR oxygenation)):ab,ti)) NOT ('juvenile'/exp NOT 'adult'/exp)

Clarivate Web of Science (992 results on September 11, 2018)

TS=(ECMO OR extracorporeal OR "extra-corporeal") AND TS=("c-section" OR "c-sections" OR caesarean* OR cesarean* OR childbirth* OR labor OR labors OR labour* OR maternal OR mother* OR obstetric* OR peripartum OR "peri-partum" OR "post-natal" OR postnatal OR postpartum OR "post-partum" OR pregnan* OR "pre-natal" OR prenatal)

EBSCOhost CINAHL (325 results on September 11, 2018)

( MH "Extracorporeal Membrane Oxygenation" OR TI (ECMO OR extracorporeal OR "extra-corporeal") OR AB (ECMO OR extracorporeal OR "extra-corporeal") ) AND ( MH ( "pregnancy+" OR "pregnancy complications+" OR "pregnancy outcomes+" ) OR TI ( "c-section" OR "c-sections" OR caesarean* OR cesarean* OR childbirth* OR labor OR labors OR labour* OR maternal OR mother* OR obstetric* OR peripartum OR "peri-partum" OR "post-natal" OR postnatal OR postpartum OR "post-partum" OR pregnan* OR "pre-natal" OR prenatal) OR AB ("c-section" OR "c-sections" OR caesarean* OR cesarean* OR childbirth* OR labor OR labors OR labour* OR maternal OR mother* OR obstetric* OR peripartum OR "peri-partum" OR "post-natal" OR postnatal OR postpartum OR "post-partum" OR pregnan* OR "pre-natal" OR prenatal) )
| Study (Author, Year) | Type of Study | Delivery Type | Indication | Disease Process/Indication | ECLS Type | ECLS Duration (days) | Maternal Complications | Maternal Mortality | Fetal Complications | Fetal Mortality |
|----------------------|---------------|---------------|------------|---------------------------|-----------|---------------------|-----------------------|------------------|-------------------|------------------|
| 34 Abbal 2014        | Case report   | C/S           | ARDS       | 31 year old G2P1 at 22 weeks with ARDS due to H1N1, 3 days after delivery underwent ECLS | VV        | 13                  | None                  | No               | Preterm delivery at 24 weeks, NICU admission | Yes              |
| 35 Abid Memon 2018   | Case report   | C/S           | PAH, cardiac arrest | 20 year old at 26 weeks with PAH, Von Willebrand’s, worsening PAH, post-delivery PEA s/p CPR onto VA | VA        | 24                  | Pericardial effusions, pericardial window, hemoptysis requiring bronchoscopy and cauterezation, trach | No               | Preterm delivery at 26 weeks, NICU | No               |
| 36 Agerstran d 2016  | Single center retrospective review (Columbia) | N/A           | ARDS (17), cardiac arrest (3), PE (2), AFE (2), PAH (1) | ARDS in 17 (flu 6, PNA 2, aspiration 3, TRALI 6, non-pulmonary sepsis 2), ECPR in 3, PE in 2, AFE in 2, PAH in 1; Antepartum in 4 patients, Postpartum in 14 | VV in 14, VA in 1, VAV in 3 | Median 6 days | ECMO related bleeding complications in 6 (DIC), 4/13 c/s cases had intraabdominal bleeding, 1 limb ischemia resulting in BKA, cannula associated DVT in 5 | 2/18 | 1 miscarriage after cannulation at 18 weeks, 2 miscarriages prior to ECMO cannulation; median GA 32 weeks | 4/18 |
| 36 Agerstran d 2016  | Single center retrospective review (Columbia) | C/S           | PAH        | Patient at 34 and 6/7 weeks with PAH requiring VV support then septic shock requiring VA, antepartum 3 days | VV then VA | 24                  | DIC, abdominal compartment syndrome, VV 12d then VA for 12d | N/A              | N/A               | N/A              |
| 36 Agerstran d 2016  | Single center retrospective review (Columbia) | C/S           | ARDS       | Patient at 28 and 5/7 weeks with H1N1 ARDS, antepartum 16 days | VV        |                     | Preeclampsia, DIC, bleeding | N/A              | N/A               | N/A              |
| Study | Type | Center | Diagnosis | Outcome | ECMO | N/A | NICU |
|-------|------|--------|-----------|---------|------|-----|------|
| 36. Agerstran d 2016 | Single center retrospective review (Columbia) | C/S | ARDS | Patient at 26 and 3/7 weeks with H1N1 ARDS developed renal failure, septic shock, delivered on ECMO c/s, preeclampsia, DIC, multisite bleeding | VV | 6 | N/A | N/A |
| 36. Agerstran d 2016 | Single center retrospective review (Columbia) | C/S | ARDS | Patient at 32 weeks with ARDS due to urosepsis, antepartum 7 days | VV | 0.70833 | DIC, renal failure, intracranial hematoma | Yes | N/A | N/A |
| 37. Alamo 1995 | Case series | VD | PPH, ARDS | 28 year old at 32 weeks with hypertension c/b fetal distress, forceps delivery, PPH, DIC, preeclampsia and ARDS | VV | 2 | Yes | N/A | N/A |
| 38. Alyamani 2018 | Case report | C/S | ARDS | 38 year old G9P8 at 30 and 3/7 weeks with sarcoidosis with ARDS, alveolar hemorrhage, cannulated antepartum | VV | 14 | Preterm delivery at 31 weeks, NICU | No | None | No |
| 39. Amancio 2017 | Case report | C/S | ARDS | 30 year old G1P0 at 27 weeks with H1N1 ARDS with hypoxemic respiratory failure cannulated antepartum | VV | 9 | Enterobacter PNA | No | None | No |
| 9. Anselmi 2015 | Case report and systematic review | C/S | ARDS | 32 year old G1P0 at 28 weeks with influenza ARDS | VV | 12 | Transient maternal peroneal nerve paralysis, C/S after decannulation | No | None | No |
|   | Arlt 2009 | Case report | C/S | PE, cardiac arrest | 27 year old with massive PE with PEA, given tPA, ECMO transported with hand-held system, underwent emergent hysterectomy and pulmonary thrombectomy under ECMO and remained on ECMO 4 days postop | VA | 4 | Vaginal and endotracheal bleeding after thrombolysis, emergency hysterectomy | No | N/A | No |
|---|-----------|-------------|-----|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|----|
|   | Barbalic 2016 | Case report | D&E | PPH, ARDS | 39 year old at 21 weeks with PPROM with miscarriage, D&E with PPH, atony, hysterectomy subsequent DIC, ARDS, hemodynamic instability, hypoxemia | N/A | 8 | Intraabdominal hemorrhage requiring multiple laparotomies and evacuations, hemolytic anemia | No | IUFD prior to ECLS | N/A |
|   | Barnes 2018 | Case report | C/S | ILD | 24 year old at 31 weeks with RA associated ILD with pulmonary vasculitis with emergent C/S requiring ECMO | N/A | 6 | Multiple infections, colitis, PNA, cardiac arrest in setting of refractory hypoxemia 56 days after ECLS | Yes | Preterm delivery at 31 weeks, NICU | No |
|   | Bartlett 1974 | Case series | VD | AFE, cardiac failure | 29 year old at 31 weeks with IUFD IOL c/b AFE and DIC | VA | 12 | PNA with gram negative septicemia, necrotizing pneumonitis | Yes | IUFD prior to ECLS | N/A |
|   | Bataillard 2016 | Case series | C/S | PE | 35 year old at 27 weeks with acute PE with RV dilation, hemodynamic instability and hypoxia | VA | 10 | Groin wound infection | No | Preterm delivery at 31 weeks, NICU | No |
|   | Bataillard 2016 | Case series | N/A | PE, cardiac arrest | 26 year old at 10 weeks with PE with cardiac arrest requiring resuscitation - later delivered a healthy baby at 37 weeks | VA | 4 | Groin wound infection treated with antibiotics, R external iliac thrombus | No | N/A | No |
|   | Bautista 2018 | Case report | C/S | PAH, cardiac failure | 18 year old at 24 weeks with pulmonary hypertension due to chronic venoocclusive disease | VV | 10 | Worsening after VV ECMO decannulation, lung transplant rejected, hemodynamic instability | Yes | IUFD at 24 hours | Yes |
| Reference          | Study Type    | Methodology | Diagnosis | Age | Gestation | Maternal Conditions | sDIC | ECMO | Mechanical ventilation | Infection | Intrauterine hemorrhage | Outcomes |
|--------------------|---------------|-------------|-----------|-----|-----------|---------------------|------|------|-------------------------|-----------|-----------------------|----------|
| Bellissima 2011    | Case series   | N/A         | ARDS      | 31  | N/A       | 31 year old pregnant patient with H1N1 with ARDS | N/A  | H1N1 with ARDS | No         | N/A                   | N/A      |
| Benetis 2016       | Case report   | C/S         | Septic shock, ARDS | 18  | 26 weeks | 18 year old G1P0 at 26 weeks with sepsis due to endometritis from staph aureus and enterobacter, C/S at 26 weeks c/b DIC, pulmonary edema, hemodynamic instability then hysterectomy developed ARDS, cannulated on PPD# 4 | VA   | 22     | Bleeding at cannulation site, hematoma infection, hemotherax, repeat thoracotomies, sepsis, subclavian artery rupture, R hand numbness | No         | Preterm delivery at 27 weeks, NICU | No       |
| Besnier 2013       | Case report   | C/S         | PPCM, cardiac arrest, Takotsubo | 32  | 38 weeks | 32 year old at 38 weeks for urgent C/S for prolapsed cord under general anesthesia, VT then cardiac arrest s/p shock LV failure (EF 17%) requiring ECMO, Takotsubo | VA   | 7      | Bleeding requiring surgical evacuation | No         | N/A                   | N/A      |
| Beurther et 2013    | Prospective study ECMO rescue team | N/A   | PPCM      | 3   | patients report with PPCM | 3 patients report with PPCM | VA   | N/A   | 2/3                    | N/A       | N/A                   | N/A      |
| Biderman 2017      | Retrospective review | VD | Cardiac failure | 36  | 33 weeks | 36 year old with toxic shock due to GAS on PPD# 4 | VA   | 8.5   | DIC                     | No         | N/A                   | No       |
| Biderman 2017      | Retrospective review | C/S | AFE       | 41  | N/A      | 41 year old with AFE | VA   | 4     | DIC, tracheotomy         | No         | N/A                   | No       |
| Biderman 2017      | Retrospective review | C/S | AFE       | 41  | N/A      | 41 year old with AFE | VA   | 6     | DIC, tracheotomy         | No         | N/A                   | No       |
| Biderman 2017      | Retrospective review | VD | ARDS      | 37  | 13 weeks | 37 year old at 13 weeks with ARDS due to H1N1 | VA then VV | 16   | DIC, tracheotomy; VA 7 d then VV for 9 | Yes        | SAB                   | Yes      |
| Biderman 2017      | Retrospective review | C/S | Cardiac failure | 30  | 33 weeks | 30 year old at 33 weeks with infectious PNA | VA   | 32    | Tracheotomy             | Yes        | N/A                   | No       |
| Study | Type | Gestation | Diagnosis | Age | Initial Management | Outcome | Mortality | ECMO Duration | Complications |
|-------|------|-----------|-----------|-----|--------------------|---------|-----------|---------------|---------------|
| 50Biderman 2017 | Retrospective review | VD | Septic shock, ARDS | 30 year old at 20 weeks with infectious PNA (h flu) | VA | 3 | Tracheotomy | No | Died 3 days into ECLS | Yes |
| 50Biderman 2017 | Retrospective review | C/S | Septic shock, ARDS | 19 year old with septic shock ARDS diffuse peritonitis PPD# 2 | VA | 11 | Tracheotomy | No | N/A | No |
| 50Biderman 2017 | Retrospective review | C/S | Septic shock, ARDS | 22 year old with infectious PNA PPD# 7 | VA | 20 | Tracheotomy | Yes | N/A | No |
| 50Biderman 2017 | Retrospective review | VD | Cardiac failure, heart disease | 38 year old with critical MS c/b cardiogenic shock, LV failure, pulmonary edema on PPD# 1 | VA | 20 | N/A | No | TAB at 12 weeks prior to ECLS | Not counted as mortality |
| 50Biderman 2017 | Retrospective review | VD | Cardiac failure | 40 year old with cardiogenic shock, LV failure on PPD# 5 | VA | 6 | N/A | No | N/A | No |
| 50Biderman 2017 | Retrospective review | C/S | AFE | 31 year old woman with AFE | VA | 0 | Death | Yes | N/A | No |
| 51Bok 2014 | Case report | VD | ARDS | 44 year old at 23 weeks with cryptogenic organizing PNA, VV ECMO then listed for lung transplant, stillbirth at 23 weeks | VV | 13 | Waited for lung transplant | No | SAB at 23 weeks | Yes |
| 52Bouabdal laoui 2017 | Case series | VD (7) C/S (3) | PPCM | 10 patients at average GA at 38 weeks with PPCM | VA | Peripher al support (all fem-fem) median 3 days, Central support 51 days | Pulmonary edema (2), bleeding at cannulation site (1), limb ischemia (1) and infection at cannulation site c/b septic shock (1), on dialysis before ECMO in 30% | 5/10 | N/A | N/A |
| 53Bowkalo w 2011 | Case report | VD | ARDS | 24 year old G4P2 at 20 and 6/7 weeks with H1N1 ARDS | N/A | 28 | Died | Yes | SAB at 21 weeks | Yes |
| 54Bruch 2013 | Case report | VD | PE, cardiac arrest | 31 year old G1P0 at 19 weeks PE circulatory shock requiring CPR, ECLS and thrombectomy, stillbirth at 19 weeks requiring D&C | VA | 5 | Bleeding requiring transfusions | No | SAB on ECMO | Yes |
| Reference          | Study Type  | Delivery Method | Diagnosis                          | Description                                                                                                    | Dose | Outcome       | Follow-Up          |
|--------------------|-------------|-----------------|------------------------------------|----------------------------------------------------------------------------------------------------------------|
| **55Cerene et al. 1977** | Case report | VD              | Aspiration pneumonitis, ARDS       | 32 year old with ARDS due to gastric aspiration during forceps delivery c/b cardiovascular collapse               | VA   | 4.95833       | Mild bleeding at insertion site | No                  |
| **56Chambers et al. 2018** | Case report | N/A             | Sickle cell crisis                 | 20 year old G1P0 at 25 and 3/7 weeks with sickle cell with acute chest syndrome, cannulated postpartum              | VV   | Blood transfections | No                  | Preterm delivery No |
| **57Champion et al. 2017** | Case report | C/S             | PPCM                               | 30 year old at 34 weeks with TTP c/b HELLP and sepsis with salmonella, PPCM day on PPD# 4                        | VA   | 18            | Renal failure, discharged after 45 days | No                  |
| **58Chao et al. 2016**    | Case series | VD              | ARDS                               | 35 year old G1P0 at 16 weeks with viral PNA with hypoxemic respiratory failure                                    | VV   | 9             | No                  | SAB at 16 weeks Yes |
| **58Chao et al. 2016**    | Case series | C/S             | PPCM                               | 29 year old G1P0 at 34 weeks with PPCM s/p C/S sent home on diuretics and digoxin but returned 1 month later requiring mechanical ventilation and pressors so put on ECMO found to have EF 18% | VA   | 8.5           | No                  | Preterm delivery at 34 weeks No |
| **59Chehab et al. 2015**  | Case report | C/S             | PPCM                               | 23 year old at 35 weeks with PPCM EF<15% within 1 week of delivery                                              | VA   | Major hemorrhage, multiorgan failure, hemothorax, cannula dislodgement | Yes                  | Preterm delivery at 35 weeks N/A |
| **60Chillcott 1995**      | Case report | VD              | ARDS, sepsis                       | 20 year old G1P0 at 26 weeks with staph aureus septicemia, hypoxemia, ARDS underwent extracorporeal CO₂ removal on PPD# 16 | ECCO₂ (VV) | 47            | Impaired skin integrity, pulmonary bleeding, HSV PNA, trach, hyperbilirubinemia, proteus and enterobacter PNA, oxygenator changes | No                  | Preterm delivery at 26 weeks, NICU, IVH No |
| Reference | Study Type | C/S Location | C/S Diagnosis | PPD | Week of Gestation | Cause of Death | TAB | NICU Admission | NICU Outcome |
|-----------|------------|--------------|---------------|-----|------------------|----------------|-----|----------------|--------------|
| Cho 2006  | Case report | C/S          | PAH, cardiac failure | 4  | 38 weeks         | HIT, thrombocytopenia, required IVIG, massive pulmonary hemorrhage, discovered to have aberrant right PA | No  | N/A            | No           |
| Choi 2016 | Case report in commentary | C/S          | Cardiac arrest | 4  | 30 weeks         | Hemolysis, need for blood transfusion, dialysis, discharged 1 month post arrest | No  | Pre-ECMO fetal demise | Not counted as mortality |
| Chuang 2015 | Case report | C/S          | PE, cardiac arrest | 2  | 2 days after admission | Burn injuries from resuscitation in ED, staph and influenza infections, discharged day 43 | No  | N/A            | N/A          |
| Clark 1991 | Case series | N/A          | ARDS          | 2  | 12 weeks         | Blood transfusions | No  | TAB at 15 weeks due to concern for fetal anomalies incurred from ECLS | Yes          |
| Clifford 2018 | Case report | C/S          | Asthma        | 6  | 23 and 1/7 weeks | VAP with moraxella and MSSA, influenza A | No  | IUGR           | No           |
| Coscia 2012 | Case series | VD           | ARDS, malignancy | 8  | 24 weeks         | Died 53 days after admission from AML complications | No  | Unclear outcome, spontaneous preterm delivery at 24 weeks, NICU admission | N/A          |
| Couroubl e 2011 | Case report | VD           | ARDS          | 9  | 23 weeks         | Multiple transfusions, epistaxis during ECMO run, staph bacteremia after decannulation | No  | None           | No           |
| **Crawford 2015** | Case report | C/S | ARDS | 37 year old G1P0 at 21 weeks with influenza A ARDS c/b HELLP with newly diagnosed LAM and DAH | VV | 14 | Had lung biopsy for LAM during ECMO run | No | Preterm delivery at 24 weeks, NICU, respiratory/nutritional support | No |
| **Creanga 2010** | Case series | C/S | ARDS | 26 year old at 32 weeks with H1N1 ARDS mechanically ventilated, C/S in ICU for maternal distress and hypotension, PNA and ARDS, septic shock, transferred for ECMO on PPD# 12 | VV | | Yes | Preterm delivery at 32 weeks, death | Yes |
| **Cunningham 2006** | Case report | VD | ARDS | 33 year old at 24 weeks with ARDS requiring ECMO then post-cannulation 3 days developed HELLP | VV | 3 | Renal failure, 3 days after d/c ECMO vaginal bleeding and spontaneously delivered fetus at 25 weeks | No | Preterm delivery at 25 weeks, intubated to NICU and RDS | No |
| **Dabas 2018** | Case report | C/S | Heart disease, cardiac arrest | 32 year old with d-TGA s/p Mustard with RV dysfunction s/p C/S c/b cardiac arrest, CPR and ECMO support | VA then VV | 3 | N/A | No | N/A | No |
| **DiLorenzo 2016** | Case report | C/S | Cardiac failure, heart disease | Patient at 33 weeks with MV regurgitation due to prosthetic valve thrombosis with NYHA Class III HF planned C/S after VA ECMO and MV replacement, ECMO in OR immediately before c/s | VA | 2 | None | No | N/A | No |
| **Ecker 2012** | Case report | C/S | PPH, cardiac arrest | 43 year old multiparous woman at 36 and 4/7 weeks with placenta previa with bleeding went to emergency C/S, upon closing fascia became unstable, PEA arrest underwent CPR and ECMO cannulation | VA | 1 | Bleeding, hysterectomy, need for HD, encephalopathy | No | N/A | N/A |
| Reference | Type | Patients | Diagnosis | Patient Details | Source | Days | Treatment | Complications |
|-----------|------|----------|-----------|----------------|--------|------|-----------|---------------|
| Ellington 2011 | Case series | 2 ARDS | H1N1 ARDS | 32 year old with twin pregnancy c/b preeclampsia, PPD# 6 pulmonary edema EF 15% | N/A | 1/2 | BIVAD, ECMO, IABP | None |
| Erb 2013 | Case report | 1 PPCM | | 32 year old G1P0 at 37 weeks with twin pregnancy c/b preeclampsia, PPD# 6 pulmonary edema EF 15% | N/A | 1.5 | None | No |
| Evans 2014 | Case report | 1 SCAD, cardiac failure | | Patient with ACS on PPD# 14 diagnosed with SCAD to the LAD with EF 15-20% s/p CABG with failure to wean from CPB | VA | 10 | Rehab | None |
| Ezri 2009 | Case report | 1 PPCM | | 32 year old at 7 weeks with ectopic pregnancy s/p lap salpingectomy c/b SVT, pulmonary edema, hypoxemia, severe LV dysfunction EF 10-15% on VA ECMO and IABP | VA | 7 | Coagulopathy, hemolysis, thrombocytopenia, transfusions, hypertension led to discovery of pheo, resected during that admission, d/c home with mild left leg weakness | No |
| Fabricius 2001 | Case series | 1 Aortic dissection | | 32 year old G1P0 at 39 weeks with C/S for fetal tachycardia, found to have type A dissection with cardiogenic shock | CPB then VA | 4 | None | No |
| Faerber 2018 | Case report | 1 PPCM | | 23 year old with PPCM 1 month after delivery | VA | 2 | PPCM EF 10% and unstable s/p VA ECMO to LVAD on day 2 (HM3) explanted 1 year later | No |
| Fang 2016 | Case report | 1 Cardiac arrest, AFE | | 35 year old at 36 weeks with C/S c/b PEA requiring CPR (2.5 hours) and transfer to ECMO center, likely AFE | VA | 2 | Cardiogenic pulmonary edema, pulmonary hemorrhage, AKI, shock liver, DIC, mild right hand motor weakness | No |
| #   | Author          | Year | Type          | Diagnosis                                      | Age | Duration | Procedure                                             | Outcome  | Additional Details                                                                 |
|-----|-----------------|------|---------------|-----------------------------------------------|-----|----------|-------------------------------------------------------|----------|-------------------------------------------------------------------------------------|
| 81  | Fayad           | 2007 | Case report   | Heart disease, cardiac failure                 | 31  | 1 week   | CPB then planned transition to ECMO for 9 days, VAP with pseudomonas then sepsis, died after ECLS decannulation | Yes      | Preterm delivery at 30 weeks, NICU respiratory support                              |
| 82  | Fernandes       | 2015 | Case report   | PE, cardiac arrest                             | 30  | 5/7 weeks | Intraperitoneal bleeding, DIC, massive transfusion Harlequin syndrome, R arm compartment syndrome after R axillary cannulation requiring fasciotomies; VA 33 hours, VV 81 hours | No       | N/A                                                                                 |
| 83  | Fernandes       | 2015 | Case report   | Malignancy, respiratory failure                | 24  |          | Refractory hypoxemia in setting of NSCLC               | Yes      | TAB at 22 weeks                                                                     |
| 84  | Firstenberg     | 2010 | Case report   | Septic shock, cardiac failure                  | 39  | 1 week   | Multiple wound debridements, bleeding,                 | No       | N/A                                                                                 |
| 85  | Fuchs           | 2017 | Case report   | ARDS                                          | 18  | 2/7 weeks | Preterm delivery at 36 weeks, respiratory support, NICU | No       | N/A                                                                                 |
| Study | Type | Case | Description | Feature | VA | Outcome | Notes |
|-------|------|------|-------------|---------|----|---------|-------|
| Futoran 1975 | Case series | C/S | AFE, PPH, cardiac failure | 28 year old G2P2 at 34 weeks with placental abruption s/p C/S, DIC hysterectomy massive transfusion, AFE | VA | 1.125 | Necrotizing bronchopneumonia, renal thrombosis, hemopericardium, hemothorax, brain and adrenal hemorrhage | Yes | Stillborn | Yes |
| Futoran 1975 | Case series | VD | Trauma, ARDS | 19 year old G1P0 at 32 weeks with auto accident, multiple injuries ruptured spleen, liver tear, rib fractures, PTX, ARDS, PNA, septicemia cannulated after delivery | VA | 14 | Iliac vein thrombosis, renal failure, septicemia | Yes | Died day 2 | Yes |
| Garcia-Aranda Dominguez 2017 | Retrospective review | C/S | PAH | Patient with severe PAH cannulated postpartum | VV | | Yes | N/A | N/A |
| Gattinoni 1980 | Case series | C/S | ARDS | 25 year old at 20 weeks with aplastic anemia, fetal demise s/p laparotomy, white out and ARDS | N/A | 1.625 | Pseudomonal peritonitis, septic shock 14 days after bypass | Yes | SAB at 20 weeks | Yes |
| Gauzer 2011 | Retrospective review | C/S | ARDS | 2 patients with H1N1 ARDS in third trimester | N/A | Both died | 2/2 | N/A | N/A |
| Gevaert 2011 | Case series | C/S | PPCM | 28 year old G3P1 with PPCM presented at 38 weeks, decompensated into cardiogenic shock with IABP placement c/b stillbirth via c/s, bedside ECMO cannulation and LVAD after 7 days | VA | 7 | VAP, bleeding at site of ECMO aortic cannula on day 1, d/c to home 37 days after admission and heart transplant 78 days post-LVAD | No | SAB at 38 weeks | Yes |
| Gijs 2018 | Case report | C/S | ARDS | 30 year old at 26 weeks with ARDS Influenza A c/b hypoxemia, seizure, intracerebral hemorrhage | VV | 12 | Microbleeds in brain, seizure | No | Preterm delivery at 26 weeks, NICU | No |
| #   | Author                  | Type               | Condition     | Case Description                                                                 | Procedure | Length | Complications                                                                 | Outcome | Additional Details                                                   |
|-----|------------------------|--------------------|---------------|----------------------------------------------------------------------------------|-----------|--------|--------------------------------------------------------------------------------|---------|---------------------------------------------------------------|
| 92  | Goto 2017              | Case series        | C/S           | Cardiac arrest                                                                   | VA        | 9      | DIC, coagulopathy, emergent hysterectomy, massive transfusion                  | No      | Preterm delivery at 36 weeks                                  |
| 93  | Grasselli 2012         | Case report and literature review | VD            | ARDS                                                                             | VV        | 13     | None reported                                                                  | No      | None                                                         |
| 94  | Greenberg 1995         | Case report        | VD            | ARDS                                                                             | ECCO2 (VV)| 28     | Bacterial sepsis c/b arrhythmia, ARDS, DIC, ischemic digits                    | No      | Preterm delivery, RDS, IVH, spastic quadriplegia, developmental delay |
| 95  | Grimme 2012            | Case report        | VD            | Pulmonary hemorrhage, cardiac arrest    | VV        | 5      | Hemothorax, tracheostomy, subsequent massive pulmonary hemorrhage              | No      | TAB bilateral ventriculomegaly, cerebral ischemia, counted toward fetal mortality |
| 96  | Guenther 2015          | Case report        | C/S           | AFE, cardiac arrest                                                              | VA        | 2.5    | Intraperitoneal bleeding, relaparotomy, renal failure, R hemiparesis, PEG, trach, d/c to rehab, neurologic deficits | No      | N/A                                                         |
| 97  | Guillaume 2013         | Retrospective study| N/A           | AFE                                                                               | VV        | 2/2    |                                                                                   | N/A     |                                                              |
| 98  | Halldorsdottir 2016    | Case report        | C/S           | Cardiac failure, heart disease                                                   | VA        | 3      | Weaned from CPB after MV replacement                                           | No      | None                                                         |

**Legend:**
- **C/S:** Cesarean section
- **VD:** Ventilation
- **VA:** Venous access
- **VV:** Venous venous
- **ECCO2:** Extracorporeal membrane oxygenation
- **ECLS:** Extracorporeal life support
- **PEA:** Pulseless electrical activity
- **R:** Right
- **MV:** Mechanical ventilation
- **CPB:** Cardiopulmonary bypass
- **PPD:** Postpartum depression
- **TAB:** Transcutaneous abdominal banding
- **AF:** Accidental fetal death
| #   | Author       | Year | Case Type | Condition | Age | Ethnicity | Race | BP | ECMO Duration | Complications |
|-----|--------------|------|-----------|-----------|-----|-----------|------|----|--------------|---------------|
| 99  | Hamdan 2017  | N/A  | PPCM      | 25 year old with PPCM EF 15-20%, VA ECMO to LVAD within 3 weeks postpartum | VA 4 | None      | No   | N/A | N/A          |               |
| 100 | Hansen 2012  | N/A  | Heart disease, cardiac failure, sepsis | 38 year old with septic shock for retained POC, D&C before IABP and then VA ECMO, then papillary muscle rupture, 2 days ECMO before MV replacement | VA 2 | Severe AI went back to OR on POD9 | No   | N/A | N/A          |               |
| 101 | Hara 2017    | C/S  | PAH       | 32 year old G2P1 delivered at 37 weeks with PAH with c/s c/b acute RV failure after delivery requiring cannulation | VA 2 | None      | No   | Normal APGARs | No            |               |
| 102 | Herrero 2018 | C/S  | PAH       | 30 year old G4P3 delivered at 32 and 4/7 weeks with group 1 PAH during pregnancy, worsening heart failure s/p c/s under general anesthesia c/b severe R sided failure cannulated 7 days postpartum | VA 9 | Yes       | Preterm delivery at 32 weeks, NICU admission | N/A |               |               |
| 103 | Hill 1974    | N/A  | AFE, cardiac failure | 26 year old with AFE | VA 1.125 | Massive DIC, septicemia | Yes | N/A |               |               |
| 104 | Ho 2009      | C/S  | AFE, cardiac arrest | 33 year old G4P2 delivered at 38 weeks with placenta previa with bleeding went to emergency C/S for chest tightness, fetal bradycardia c/f AFE, PEA arrest underwent CPR and ECMO cannulation | VA 0.16667 | Placenta previa/accreta and AFE c/b bleeding requiring hysterectomy, ECMO for 4 hours then ICU stay c/b ARDS and L sided weakness likely from ischemic event, d/c to rehab | No   | None | No            |               |
| Reference     | Type                  | Diagnosis          | Age | SE         | Condition                                      | VA  | NICU  | Outcome                                      | Notes                                   |
|--------------|-----------------------|--------------------|-----|------------|------------------------------------------------|-----|-------|---------------------------------------------|-----------------------------------------|
| Ho 2014      | Case report           | C/S, PE, cardiac   | 37  | 6          | Hemoperitoneum, need for UAE, no long term sequelae |     | No    | N/A                                         | N/A                                     |
| Holzgrafe fe 2010 | Observationa l study | N/A, ARDS          | 3   | 1/3        | 1 baby died after 18 days of mom ECMO treatment   |     | N/A   | N/A                                         | N/A                                     |
| Hou 2012     | Case series           | N/A                | 4   | 2/4        | DIC, massive transfusion, discharged home         |     | No    | N/A                                         | N/A                                     |
| Hsieh 2000   | Case report           | C/S, cardiac arrest| 34  | 2          | DIC, massive transfusion, discharged home         |     | No    | N/A                                         | N/A                                     |
| Huang 2017   | Retrospective         | N/A                | 4   | 2          | 2 patients with official ECMO related bleeding    |     | Yes   | N/A                                         | N/A                                     |
| Huang 2017   | Retrospective         | C/S, AFE           | 39  | 2          | TAE, central hypothermia                           |     | No    | Preterm delivery of twins at 34 weeks      | N/A                                     |
| Huang 2017   | Retrospective         | VD, PPH, cardiac   | 41  | 2          | Subtotal hysterectomy, ex-lap internal bleeding   |     | No    | N/A                                         | N/A                                     |
| Huang 2017   | Retrospective         | VD, PPH            | 34  | 0.41667    | TAE                                              |     | Yes   | N/A                                         | N/A                                     |
| Huang 2017   | Retrospective         | VD, cardiac failure| 33  | 4.75       | Subtotal hysterectomy, 18 hours VA ECMO then LVAD |     | No    | N/A                                         | N/A                                     |

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| Study | Type                  | Size | Diagnosis             | Details                                                                 | Outcome          | ECMO Type | Duration | Other Complications                                                                 |
|-------|-----------------------|------|-----------------------|--------------------------------------------------------------------------|------------------|------------|----------|-------------------------------------------------------------------------------------|
| Huang 2017 | Retrospective observational study | C/S | PPH, cardiac arrest   | 34 year old G2P1 delivered at 39 weeks with PPH after c/s due to uterine atony, DIC, TRALI, abruption, required CPR for 1 min, Postpartum 4h | No               | VA, VV     | 2        | TAE, Bakri, massive transfusion, VA 10 hours, VV 33 hours                           |
| Huang 2017 | Case report             | N/A | Malignancy, respiratory failure | 38 year old at 16 weeks with mediastinal mass, lymphoma c/b high airway pressures VV then PEA and VA ECMO | No               | VV then VA | VV then PEA so VA, ECMO duration of days |
| Hur 2011     | Case report             | N/A | ARDS                  | 29 year old at 32 and 4/7 weeks with H1N1 ARDS                           | Yes              | N/A        | N/A      | Died                                                                                |
| Imaeda 2016  | Case report             | N/A | Septic shock, cardiac failure | 24 year old multiparous woman delivered at 32 weeks with septic shock due to GAS with severe cardiomyopathy EF 10% | No               | VA         | 7        | Renal failure                                                                     |
| Isbir 2014   | Case report             | N/A | PPCM, cardiac arrest   | 29 year old delivered at 31 weeks with PPCM EF 25%, sternotomy for concert for aortic dissection, IABP, cardiac arrest, VA ECMO in OR | No               | VA         | 2        | None                                                                                |
| Itagaki 2014 | Case report             | VD  | PPH, cardiac arrest, cardiac failure | 25 year old G2P2 delivered at 41 weeks with PPH, DIC prior to ECMO, Vfib arrest s/p shock recovered from DIC but PPD# 2 severe LV failure with hypoxic respiratory failure | No               | VA         | 3        | Required transfusions but no major bleeding, discharged from ICU day 10            |
| Ius 2015     | Single center retrospective review | C/S | ARDS                  | 31 year old G2P2 with respiratory failure requiring urgent c/s cannulated PPD# 1 | Yes              | VV         | 13       | Intraabdominal bleeding following c/s requiring repeat laparotomies, dialysis, tracheostomy, died 3 weeks after ECMO wean |

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| #   | Author      | Year     | Study Type       | Type      | Patients | ARDS | Description                                                                 | ECMO | N/ST | Need | Preterm | Outcome                        |
|-----|-------------|----------|------------------|-----------|----------|------|----------------------------------------------------------------------------|------|------|------|---------|---------------------------------|
| 116 | Jacquens    | 2017     | Retrospective observational study | N/A       | 6 patients with ARDS in national database | N/A  | Patient case within series of patients with PAH; delivered then had RV failure requiring ECLS then heart/lung transplant | VA   | N/A  | No   | N/A     | N/A                            |
| 117 | Jais        | 2012     | Case series      | N/A       | PAH      | 20 year old G3P1 at 30 weeks with ARDS secondary to e.coli urosepsis with refractory hypoxemia for ECCO₂ removal | VA   | N/A  | No   | None    | Preterm delivery at 30 weeks, NICU No |
| 118 | Jandhyala   | 1994     | Case report      | VD        | ARDS     | 36 year old G3P1 at 30 weeks with ARDS secondary to e.coli urosepsis with refractory hypoxemia for ECCO₂ removal | PECLA (VV) | 1.83333 | None | No      | Preterm delivery at 30 weeks, NICU No |
| 119 | Janssen     | 2006     | Case report      | C/S       | ARDS     | 36 year old G3P1 at 30 weeks with ARDS secondary to e.coli urosepsis with refractory hypoxemia for ECCO₂ removal | PECLA (VV) | Renal failure, relaparotomy on POD2 | No   | Preterm delivery at 30 weeks, NICU No |
| 120 | Jo          | 2011     | Case report      | C/S       | PPCM     | 37 year old G4P0 at 37 weeks with PPCM with apical ballooning within 2 hours post C/S | VA   | 8    | None | No      | N/A                            |
| 121 | John        | 2012     | Case report      | C/S       | Cardiac failure, heart disease | Cardiac failure, heart disease | VV | 7    | None | No      | None                            |
| 122 | Ju          | 2018     | Case series      | C/S       | Septic shock, ARDS | Septic shock, ARDS | VV | 9    | Fingertip amputation due to ischemia | No   | TAB, twins                  |
| 122 | Ju          | 2018     | Case series      | VD        | PPH, cardiac failure | PPH, cardiac failure | VA | 6    | Hysterectomy, ligation of internal iliacs, DIC, massive transfusion, hematoma | No   | N/A            |
| 122 | Ju          | 2018     | Case series      | C/S       | Cardiac arrest | Cardiac arrest | VA then VV | 13 | Intraabdominal hematoma requiring washout | No   | N/A            |
| 122 | Ju          | 2018     | Case series      | C/S       | AFE, cardiac failure | AFE, cardiac failure | VA then VV | 10 | Hematoma, cognitive dysfunction | No   | N/A            |
| Study       | Type          | Procedure | Patient Details                                                                 | Procedure | Outcome                  | Mortality | Additional Details                                           |
|-------------|---------------|-----------|---------------------------------------------------------------------------------|-----------|--------------------------|-----------|-------------------------------------------------------------|
| Kapoor 2012 | Case report   | D&E       | 39 year old G2P1 at 22 weeks with PAH and RV failure, planned D&E but post-procedure decompensated, PEA and went on VA support | VA        | Underwent heart-lung transplant | No        | TAB at 22 weeks (prior to ECLS) Not counted as mortality  |
| Kaliyev 2015| Case report   | N/A       | 28 year old at 26 weeks with severe ARDS                                         | VV        | Blood transfusions       | No        | None No                                                     |
| King 2000   | Case report   | VD        | 29 year old at 25 weeks with asthma, PNA with ARDS with severe hypoxemia         | VV        | None                     | No        | Preterm delivery at 31 weeks, NICU No                      |
| Kinni 2018  | Case report   | N/A       | 20 year old at 24 weeks with hemoptysis, diffuse alveolar hemorrhage, microscopic hemangiomas | VV        | Worsening RV failure after VV, anatomical limitations to VA, pulmonary hemorrhage | Yes       | N/A N/A                                                     |
| Knapp 2016  | Case report   | C/S       | 30 year old patient 16 days postpartum with SCAD s/p multiple stents s/p CABG SVGs to LAD and circumflex | VA        | Post CABG BiV dysfunction EF 25% and moderate RV dysfunction | No        | N/A N/A                                                     |
| Ko 1998     | Case report   | C/S       | 37 year old G5P3 at 35 and 2/7 weeks with twins, placenta increta with bleeding and atony s/p UA ligation, methergine induced coronary vasospasm and pulmonary edema, LV EF 44% and arrhythmias on POD1 c/f postpartum MI | VA        | 4.16667                  | None      | No N/A N/A                                                  |
| Konstantinidis 2015 | Case report | N/A       | 35 year old at 37 weeks with idiopathic PAH with planned ECMO cannulation, unclear delivery but immediately after decompensated and was started on ECMO, BiV failure with RV pressure/volume overload | N/A       | 3                        | None      | No N/A N/A                                                  |
| #  | Author Year | Study Type | Outcome | Case Details | VA | L Hemiplegia in 1 patient | GA | Twins | No Twins | N/A | SAB at 21 weeks |
|----|-------------|------------|---------|--------------|----|--------------------------|----|-------|----------|-----|---------------|
| 130 | Kuan-Ying 2017 | Case series | N/A | PPH (3), AFE (1), PE (1) | VA | 1.25 | L hemiplegia in 1 patient | 4/5 | N/A | 5/5 |
| 131 | Kumar 2012 | Case report | C/S | PPCM | N/A | 5 | None | No | Twins | N/A |
| 132 | Krumnik 2006 | Case report | C/S | PPH, cardiac arrest, cardiac failure | VA | 1.5 | Myoclonic epilepsy, small visual field deficits | No | N/A | No |
| 133 | Kunsty 2010 | Case report | VD | ARDS | VV | 14 | Hemorrhagic bronchitis, cephalic vein thrombosis, pseudomonal infection | No | Preterm delivery at 24 weeks, NICU, respiratory support | No |
| 134 | Kutlesa 2011 | Case series | VD | ARDS | VV | 16 | Fetal death, hyperbilirubinemia, severe tracheal hemorrhage | Yes | Fetal death, ischemia | Yes |
| 135 | Law 2013 | Case series | C/S | PPCM, Takotsubo, cardiac arrest, pheo | VA | 1 | Myocarditis EF5% increased by day 4 to 25-30% (Takotsubo) | No | Preterm delivery at 32 weeks, NICU admission | N/A |
| 136 | Lee 1997 | Case series | VD | ARDS | VA to VV | 57 | Cannula dislodgment, bilateral tension hemopneumothoaces, bronchopleural fistulas, multiple explorations for | Yes | SAB at 21 weeks | Yes |
| Case series | Type | CA | ARDS/AFE/ARDS | 33 year old woman with varicella PNA c/b ARDS, cannulated PPD#3 | VV | 11 | Staph PNA and renal insufficiency | No | N/A | N/A |
|-------------|------|----|----------------|----------------------------------------------------------------|-----|----|------------------------------------|----|-----|-----|
| Lee 1997    | Case series | VD | ARDS           | 22 year old G3P2 at 40 weeks with PPH requiring multiple transfusions, TRALI with pulmonary edema | VA | 3  | None, discharged POD 33            | No | N/A | N/A |
| Lee 2008    | Case report | C/S | PPH, TRALI     | 26 year old G2P1 with operative vaginal delivery with forceps at term, AFE | VA | 1  | Hemorrhage, atony, AFE c/b PEA s/p hypogastric artery embolization, hysterectomy, RV dysfunction | Yes | N/A | N/A |
| Legrand 2013 | Case series | VD | AFE            | 30 year old at 32 weeks with splenic artery pseudoaneurysm rupture with hemoperitoneum, massive blood loss s/p coil embolization, return to OR for abdominal hemorrhage, cardiac arrest/pulmonary edema then ECMO, died hours later | N/A |     | Multiple organ failure, DIC        | Yes | N/A | N/A |
| Lemaire 2017 | Case series | N/A | Hemorrhage, cardiac arrest | 27 year old G2P0 at 40 and 6/7 weeks with vaginal delivery c/b manual removal placenta, PPH, atony, biventricular dysfunction requiring laparotomy/hysterectomy and intermittent CPR requiring ECMO support eventually regained function and d/c | VA | 5  | Post-operative IABP support; no neuro or cognitive deficit | No | N/A | N/A |
| ID   | Year       | Study Type | Event | Diagnosis | Age | Gestation | Cause | Route | Duration | Outcome | Mortality | Notes                  |
|------|------------|------------|-------|-----------|-----|-----------|-------|-------|----------|---------|-----------|------------------------|
| 141  | Li 2013    | Case report| C/S   | ARDS     | 28  | 33        | H1N1 ARDS c/b refractory hypoxemia, stat C/S then ECMO | VV    | 6      | Staphylococcus hominis catheter infection | No     | Preterm delivery at 33 weeks, NICU admission | No                     |
| 142  | Liu 2018   | Case report| VD    | ARDS     | 25  | 24        | H1N1 ARDS c/b fetal death on ECMO and vaginal delivery | VV    | 6      | IUFD, vaginal bleeding, uterine contractions, IOL and VD, weaned from mechanical ventilation | No     | IUFD at 24 weeks | Yes                   |
| 143  | Loizos 2017| Case report| N/A   | Cardiac failure, pheo, Takotsubo | 21  |          | pheochromocytoma, went for surgical termination of pregnancy, had HTN/bradycardia and pulmonary edema and then Takotsubo | VA    | 7      | LV dysfunction EF 10-15%, discharged 7 days later | No     | TAB - not counted for fetal mortality | Not counted as mortality |
| 144  | Lueck 2016 | Case series | C/S   | PPCM     | 34  | 35        | PPCM with hemodynamic shock, was on 10 days of ECLS prior to LVAD, eventually LVAD weaned after 612 days | VA    | 10     | None | No | N/A | N/A                     |
| 145  | Lund 2011  | Case report| VD    | PPCM     | 37  | 37        | G2P2 presented in acute CHF 8 days after delivery, intubated, EF 5-10% on ECMO for 4 days then LVAD | VA    | 4      | N/A | No | N/A | N/A                     |
| 146  | Lysenko 2014 | Case report | C/S  | ARDS    | 24  | 39 and 3/7       | H1N1 ARDS, C/S at 30w3d | VV    | 17     | None | No | Preterm delivery at 30 week, intubated, NICU admission | No                     |
| 147  | Marino 2018 | Case report| C/S   | PPH, AFE, cardiac arrest, PPCM | 34  | 38        | G2P1 at 38 weeks with cardiac arrest, uterine atony, DIC c/b PEA, AFE, LV EF 8%, VA ECMO with Impella | VA    | 7      | PPH with DIC, bilateral UAE, abdominal hemorrhage, renal failure, multiple laparotomies for bleeding and massive transfusion | No | N/A | N/A                     |
| Reference        | Type          | C/S | Condition                      | Description                                                                                                                                                                                                 | VA | ECMO | Complications | Preterm Delivery | Details                                                                 |
|------------------|---------------|-----|--------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|------|---------------|------------------|-------------------------------------------------------------------------|
| McDonald 2017    | Case report   | C/S | PE, cardiac arrest             | 22 year old at 36 weeks with PE c/b emergency C/S c/b instability with CPR for 65 min before ECMO cannulation                                                                                               | VA | 5    |               | No               | Preterm delivery at 36 weeks, acidotic, did not survive                 |
| McKennie 2001    | Case report   | C/S | SCAD, cardiac failure          | Patient at 36 weeks with SCAD, p/w chest pain developed seizure and hemodynamic collapse, emergency C/S with CPR, shocks then ECMO with EF <10%, had angioplasty with 6 stents placed                                 | VA | 3    | No complications | No               | None                                                                   |
| McNam 2010       | Case report   | C/S | ARDS                           | 21 year old G2P1 at 33 weeks with H1N1 complicated by PTX, hypoxia requiring ECMO on PPD#5, pulmonary hemorrhage requiring R middle lobectomy c/b bronchopleural fistula | VA | 28   | Pulmonary hemorrhage, generalized myopathy, neuro-rehabilitation     | No               | None                                                                   |
| Mendes 2012      | Case report   | N/A | ARDS                           | 42 year old woman with H1N1 ARDS 2 weeks postpartum                                                                                                                                                    | VV | 7    | None           | No               | N/A                                                                     |
| Meng 2017        | Retrospective | C/S | PAH                            | Patient at 31 weeks with PAH due to CHD or VSD/Eisenmenger cannulated PPD#4                                                                                                                              | VA | N/A | Yes            | Preterm delivery at 31 weeks, NICU admission                            |
| Meng 2017        | Retrospective | C/S | PAH                            | Patient at 34 weeks with PAH due to CHD or VSD/Eisenmenger cannulated PPD#3                                                                                                                              | VV then VA | 13 | VV 2d then VA 11d | Yes               | Preterm delivery at 34 weeks                                           |
| Study | Type                  | Procedure | Diagnosis                  | Timing                                                                 | Discharged to | Delivery Status | Cause of Death |
|-------|-----------------------|-----------|----------------------------|------------------------------------------------------------------------|---------------|-----------------|----------------|
| Meng 2017 | Retrospective review, 4 centers | C/S       | PAH | Patient at 35 weeks with PAH due to CHD or VSD/Eisenmenger, cannulated 2 days before delivery | VV then VA | 21              | No             |
| Meng 2017 | Retrospective review, 4 centers | D&E       | PAH | Patient at 13 weeks with idiopathic PAH | N/A          | N/A             | Yes            |
| Meng 2017 | Retrospective review, 4 centers | D&E       | PAH | Patient at 21 weeks with scleroderma, pulmonary HTN, cannulated PPD#8 | VA           | N/A             | Yes            |
| Meng 2017 | Retrospective review, 4 centers | C/S       | PAH, cardiac arrest, malignancy | Patient at 34 weeks with thrombotic disease from cancer, PEA arrest cannulated PPD#1 | VA           | N/A             | Yes | Preterm delivery at 34 weeks |
| Meng 2018 | Case report | D&E       | Heart disease, cardiac failure | 21 year old G1P0 at 22 weeks with Eisenmenger syndrome, VSD underwent planned D&E at 21 weeks for maternal risk c/b post-procedure respiratory decompensation | VV           | 3               | No             | D&E | Yes |
| Miessau 2015 | Case report | VD       | PPCM | 22 year old with severe cardiomyopathy EF <10% bridge to decision cannulated PPD 14 | VA then VV | 22              | No             | N/A | No |

Discharged home on PPD24 found dead at home on PPD89 - ultimately died but not while on ECMO, VV 15d then VA 6d

Preterm delivery at 35 weeks

D&E

Upper extremity DVT POD 8, discharged on POD35

Dialysis, MARS for shock liver, severe respiratory failure after TAH, tracheostomy; underwent OHT 103 days after TAH implantation; VA unclear, VV 12 days then rescue 10 days (22 days of VV support after TAH)
| Study ID  | Type of Study | Case Report/CASE SERIES | Diagnosis | Clinical Details | VA | Comments |
|----------|----------------|-------------------------|-----------|----------------|----|----------|
| 154Mikami 2018 | Case report | C/S | PPCM | 38 year old G3P2 at 35 and 6/7 weeks with PPCM EF10% given IABP and ECMO prior to C/S | VA | 8 | Uterine bleeding s/p Bakri, TAE, hysterectomy No | Preterm delivery at 35 weeks, neonatal asphyxia, therapeutic hypothermia, NICU No |
| 155Mita 2017 | Case report | C/S | Cardiac arrest, pheo | 29 year old G4P1 at 37 weeks with C/S complicated by hemodynamic collapse, concern for AFE admitted to ICU, PEA with CPR then IABP+ECMO found to have pheochromocytoma | VA | 6 | DIC, renal failure, rhabdomyolysis; pheo resected on POD70, left ICU and discharged 142 days postpartum no neurologic deficits No | N/A N/A |
| 7Moore 2016 | Case report, Systematic review | N/A | ARDS, cardiac failure | 25 year old G2P1 at 18 weeks with hantavirus cardiopulmonary syndrome | VA | 3 | Bleeding requiring transfusion No | Preterm delivery at 35 weeks No |
| 156Morsolini 2017 | Case series | C/S | PAH | Patient with PAH | VA | 1.08333 | SVC and PA thrombosis No | Preterm delivery No |
| 156Morsolini 2017 | Case series | C/S | ARDS | Patient with H1N1 | VV | 31 | Gastrointestinal bleeding, fetal IVH No | Preterm delivery, IVH, discharged No |
| 156Morsolini 2017 | Case series | C/S | Heart disease, heart failure | Patient with mitral prosthesis thrombosis | VA | 1.5 | PNA No | Preterm delivery No |
| 156Morsolini 2017 | Case series | C/S | PAH | Patient with PAH | VA | 0.91667 | Uterine bleeding, discharged POD22 No | Preterm delivery No |
| 157Nair 2011 | Retrospective observational study | VD (S) VAVD (2) C/S (S) | | 5 spontaneous, 2 VAVD and 5 C/S (3 after ECMO, 1 after ECMO started, 1 prior to ECMO), all postpartum patients were within 1 week of delivery | N/A | | Preterm birth average 31 weeks |
| 157Nair 2011 | Retrospective observational study | ARDS | | 34 year old at 26 weeks with H1N1 ARDS cannulated antepartum | VV | 18 | No N/A No |
| 157Nair 2011 | Retrospective observational study | ARDS | | 22 year old at 13 weeks with H1N1 ARDS cannulated antepartum | VV | 2 | No N/A No |
| Reference | Study Type            | Diagnosis | Age | Gestation | cannulation location | cannulation location | Event | Outcome |
|-----------|-----------------------|-----------|-----|-----------|----------------------|----------------------|-------|---------|
| Nair 2011 | Retrospective observational study | ARDS     | 23 year old | 21 weeks | VV | 11 | No | N/A | No |
| Nair 2011 | Retrospective observational study | ARDS     | 33 year old | 23 weeks | VV | 5 | Uterine bleeding | No | Stillborn | Yes |
| Nair 2011 | Retrospective observational study | ARDS     | 42 year old | 20 weeks | VV | 20 | Pulmonary bleeding | No | Stillborn | Yes |
| Nair 2011 | Retrospective observational study | ARDS     | 39 year old | 26 weeks | VV | Multiple bleeding sites | Yes | N/A | No |
| Nair 2011 | Retrospective observational study | ARDS     | 29 year old | 30 weeks | VV | 20 | Intracranial bleeding | Yes | N/A | No |
| Nair 2011 | Retrospective observational study | ARDS     | 27 year old | patient with H1N1 ARDS | VA to VV | 17 | Limb ischemia, ECMO cannula bleeding | Yes | N/A | No |
| Nair 2011 | Retrospective observational study | ARDS     | 29 year old | patient with H1N1 ARDS | VV | 10 |  | No | N/A | No |
| Nair 2011 | Retrospective observational study | ARDS     | 23 year old | patient with H1N1 ARDS | VV | 27 | Pulmonary bleeding | Yes | N/A | No |
| Nair 2011 | Retrospective observational study | ARDS     | 27 year old | patient with H1N1 ARDS | VV | 15 | ECMO cannula bleeding | No | N/A | No |
| Nair 2011 | Retrospective observational study | ARDS     | 32 year old | patient with H1N1 ARDS | VA to VV | 12 | Limb ischemia, fasciotomy | No | N/A | No |
| Nair 2017 | Case report | VD | PAH, cardiac failure | 29 year old patient with PAH, hemoptysis, RV failure cannulated PPD#11 | VA then VV | VA then VV ECMO after lung transplant, d/c 1 month post-transplant | No | N/A | N/A |
| Study | Study Type | Delivery | Diagnosis | Mother's Age | Diagnosis Details | Ventilation | ECMO Days | Notes | Preterm Delivery | NICU Admission |
|-------|------------|----------|------------|--------------|-------------------|-------------|------------|-------|-----------------|----------------|
| Naqi 2018 | Case report | VD | PPCM | 32 year old patient with ALL s/p chemo with LV EF 15% and RV thrombus, IOL and delivery c/b acute DVT and PE, edema to ECMO bridge to transplant | VA | 60 | Multiple circuit changes, heart transplantation on day 60 | No | N/A | No |
| Neurath 1993 | Case report | C/S | ARDS | 32 year old patient at 26 weeks with ARDS due to malaria cannulated PPD# 17 | ECCO2 (VV) | 12 | Tracheotomy, 11 week hospital stay | No | Preterm delivery at 26 weeks, NICU admission | No |
| Ngatchou 2012 | Case report | N/A | ARDS | 28 year old G2P1 at 32 weeks with urosepsis with e.coli c/b ARDS | VV | 2 | None reported | No | N/A | N/A |
| Noah 2010 | Case series | C/S | ARDS | 23 year old at 32 weeks with ARDS due to s. aureus p/w hemoptysis intubated emergency c/s worsening status despite NO | VV | 23 | Hemothorax, PTX, CVVH, MARS | No | N/A | N/A |
| O'Gara 2009 | Case report | C/S | Malignancy, heart failure | 28 year old at 32 and 4/7 weeks with mediastinal mass s/p pericardial window, depressed LV EF on ECMO day 7, later underwent sternotomy and diagnosed with lymphoma | VA | 9 | Sternotomy for biopsy, underwent chemo while on ECMO, later hospital course c/b seizures, candida fungemia, d/c to rehab then home; of note, she died 10 months later | No | Preterm delivery at 32 weeks, NICU | No |
| Pagel 2009 | Case report | C/S | Cardiac arrest | 24 year old at 24 weeks with Brugada syndrome c/b difficult to control VT episodes, multiple ICD shocks starting at 20 weeks, had arrest requiring shocks and emergency C/S | VA | 3 | Groin re-exploration and pseudoaneurysm | No | Preterm delivery at 24 weeks, NICU | No |
| Panarell o 2010 | Case series | C/S | ARDS | H1N1 ARDS, ECMO mean 16 days; 1 patient delivered on ECMO | N/A | Mean LOS 37 days | No |
| Panarell o 2010 | Case series | N/A | ARDS | 38 year old at 25 weeks with H1N1 ARDS | N/A | 16 | Study mean LOS was 37 days | No | Preterm delivery at 25 weeks, NICU | No |
|   | Author          | Year | Study Design | Mortality | GADJ | NICU Admission | Cause of Mortality | ECMO Type | Study Mean LOS (days) | NICU Admission | Cause of NICU Admission |
|---|----------------|------|--------------|-----------|------|----------------|-------------------|------------|-----------------------|----------------|--------------------------|
|165 | Panarell o 2010 | Case series | N/A | ARDS | 31 year old at 33 weeks with H1N1 ARDS | N/A | 16 | Study mean LOS was 37 days | Preterm delivery at 33 weeks, NICU | No | Preterm delivery at 33 weeks, NICU |
|166 | Panarell o 2010 | Case series | N/A | ARDS | 23 year old at 39 weeks with H1N1 ARDS | N/A | 16 | Study mean LOS was 37 days | Preterm delivery at 33 weeks, NICU | No | Preterm delivery at 33 weeks, NICU |
|166 | Panarell o 2011 | Case report | C/S | ARDS | 38 year old at 25 weeks with H1N1 ARDS cannulated antepartum | VV | 35 | C/S at 30 weeks to improve pulmonary mechanics, GI bleed requiring endoscopic intervention | Preterm delivery at 30 weeks, intracranial hemorrhage, intubation, NICU | No | Preterm delivery at 30 weeks, intracranial hemorrhage, intubation, NICU |
|167 | Park 2014       | Case report | C/S | PPCM | 34 year old G2P1 at 37 weeks with PPCM EF 39% worsening HF planned VA ECMO prior to C/S due to concern to abrupt decreased cardiac output | VA | 6 | None | NICU admission, respiratory support | No | NICU admission, respiratory support |
|168 | Parkins 2007    | Case report | C/S | ARDS | 16 year old G1P0 at 32 weeks with influenza ARDS | VV | 13 | Emergency C/S due to ineffective ECMO flow rate from uterine compression, infections, renal failure, mild anoxic brain injury, pancreatitis, polyneuropathy | Preterm delivery at 32 weeks, NICU admission | No | Preterm delivery at 32 weeks, NICU admission |
|169 | Paruchuri 2018  | Retrospective cohort | N/A | ARDS | Limited details but reported 2 patients with no mortalities | N/A | | | | No | N/A |
|170 | Patel 2017      | Case report | C/S | Distributive shock | 34 year old G1P0 with preeclampsia c/b distributive shock postpartum, laparotomy, liver dysfunction listed for liver transplant supported with VV ECMO | VV | 9 | Liver transplant done while on ECMO, discharged home day 43 | N/A | N/A |
|171 | Patroniti 2011  | Case series | N/A | ARDS | Patient at 22 weeks with H1N1 ARDS | N/A | | | | No | N/A |
| Reference | Study Type | N/A | Diagnosis | Details | ECMO | No/N/A | N/A | N/A | N/A |
|-----------|------------|-----|-----------|---------|------|--------|-----|------|------|
| 172Patrut 2015 | Case report | C/S | ARDS | 32 year old woman at 26 weeks with H1N1 severe ARDS, C/S 1 day after decannulation | VA | 8 | No | Preterm delivery at 27 weeks, NICU admission | Yes |
| 173Pechulis 2014 | Case report | N/A | ARDS | 24 year old woman with H1N1 ARDS c/b prolonged ECMO | VV | 72 | No | N/A | N/A |
| 174Pekka 2013 | Case report | C/S | PE, cardiac failure | Patient with massive PE 21 days postpartum, RV failure used as bridge to decision (medical management in this case) | VA | 2 | None | No | N/A | N/A |
| 175Perdue 2018 | Case report | N/A | ARDS, cardiac failure, septic shock | 24 year old patient 2 days postpartum with septic shock from GAS c/b hypotension, ARDS, cardiomyopathy EF <10% | VA | 4 | None | No | N/A | No |
| 176Pereira 2018 | Case report | C/S | Pulmonary alveolar proteinosis | 21 year old patient at 32 weeks with pulmonary alveolar proteinosis c/b hypoxia, VV ECMO done postpartum for BAL | VV | None | No | Preterm delivery at 32 weeks, NICU admission | N/A |
| Reference | Study Type | Cohort | N/A | ARDS | 18 patients with H1N1 ARDS | N/A | IUFD at 21 weeks in one case, preterm delivery at 34 weeks and NICU admission but survived | 4/18 | IUFD at 21 weeks, Preterm delivery at 34 weeks and NICU admission | N/A |
|-----------|------------|--------|-----|------|--------------------------|-----|---------------------------------|------|---------------------------------|-----|
| Pham 2013 | Case report | C/S    | N/A | ARDS | 25 year old G2P1 at 21 weeks with hyperemesis gravidarum with aspiration pneumonitis, ARDS | VV  | C/S 5 weeks after ECMO | No   | Preterm delivery at 26 weeks, NICU, RDS | No  |
| Phillips 2017 | Case report | C/S    | PPH, cardiac arrest | 22 year old with PPH s/p VF with CPR, pulmonary edema with IABP and ECMO | VA  | Lamellar dural hematoma, abdominal bleeding requiring ex-lap, transfer to floor on day 13 | No   | N/A | N/A |
| Piatrovich 2018 | Case report | N/A    | Propofol infusion syndrome, cardiac arrest | 20 year old woman with status epilepticus treated with propofol, developed PRIS with VT/Vfib went onto ECMO | N/A | Cerebral artery infarct attributed to cardiac embolism | No   | N/A | N/A |
| Piraheli 2012 | Case report | C/S    | Trauma, ARDS | 25 year old patient at 28 weeks with GSW to R chest, fetal bradycardia s/p c/s, lung lacerations, massive transfusion c/b ARDS | VA  | Renal failure, no ECMO complications | No   | Preterm delivery at 28 weeks, NICU | Yes |
| Plotkin 1994 | Case report | C/S    | ARDS | 37 year old patient at 23 weeks with H1N1 ARDS | VV  | Critical illness polyneuropathy, d/c to rehab, transfusions required | No   | Stillborn | Yes |
| Power 2011 | Case series | N/A    | ARDS | 23 year old patient at 32 weeks with respiratory distress due to pedunculated tracheal tumor, underwent tumor debulking on PPD#1 with precautionary VV ECMO cannulation - lobular capillary hemangioma | VV  | Bleeding during tracheal tumor resection, VV ECMO rescue | No   | Preterm delivery at 32 weeks, NICU admission | No  |
| Reference   | Study Type | Event | Diagnosis | Patient Details | ECMO | Cannulation | Organ Failure | Complications | Outcome | NICU | Sedation |
|-------------|------------|-------|-----------|-----------------|------|-------------|--------------|---------------|---------|------|----------|
| Rabin 2012  | Case report | C/S   | ARDS      | 22 year old patient with postpartum wound infection c/b ARDS with prolonged respiratory failure, traction bronchiectasis, lung transplant on CPB after 155 days | VV   | 155         | None         | No            | N/A     | N/A |
| Rademaker 2010 | Case report | C/S   | PPCM, heart disease, heart failure | 36 year old woman at 39 weeks with PPCM, severe ischemic heart disease, s/p multiple stents cannulated PPD#2 | N/A  | 4           | PNA, extubated and decannulated, however day 17 condition worsened and found to have total LV necrosis | Yes | N/A | N/A |
| Radsel 2018 | Case report | VD    | ARDS      | 29 year old G1P0 at 23 weeks with H1N1 ARDS | VV   | 10          | Decannulated on day 5 then recannulated, preterm labor, critical illness polyneuropathy, trach, rehab | No | Preterm delivery at 25 weeks, NICU, intubated, BPD, NAS from maternal sedation | No |
| Raley 2015  | Case report | C/S   | Asthma    | 18 year old patient at 37 weeks with status asthmaticus, hypercarbic respiratory failure s/p C/S with elevated airway pressures for AVCO₂ removal | AVCO₂ (VV) | 3           | None         | No            | N/A     | N/A |
| Ramirez 2018 | Case report | N/A   | PPCM      | 29 year old G2P1 at 23 weeks with cardiomyopathy EF 25%, giant cell myocarditis c/b IUFD, IABP and ECMO | VA   |             | Uterine bleeding requiring transfusions, ectopy | No | IUFD at 23 weeks | Yes |
| Rein 2014   | Case report | VD    | ARDS      | 38 year old woman delivered at 37 weeks with postpartum ARDS due to influenza B, MRSA | N/A  |             | ARDS, multiple organ failure, transferred for ECMO but no details of cannulation or duration | Yes | NICU | No |
| Case ID     | Type          | Diagnosis       | Details                                                                 | Intubation | Mechanism/Location | Outcome  |
|-------------|---------------|-----------------|-------------------------------------------------------------------------|------------|--------------------|----------|
| 190Reytmann 2006 | Case report  | C/S  | PPH, cardiac arrest, cardiac failure | 36 year old G2P1 at 37 weeks with C/S for twins developed PPH cardiac arrest with EF<10% CPR x2 hours then ECMO | VA         | 6.25               | No       |
|             |               |                 |                                                                         |            |                    | One twin went to NICU for acidosis | No       |
| 191Riddell 2004 | Case report  | C/S  | ARDS                        | 33 year old at 37 weeks with C/S for twins and HELLP c/b hypoxemia, hypotension, ARDS transfer for ECMO on PPD3 | VA         | 21                 | Yes      |
|             |               |                 |                                                                         |            |                    | N/A      |
|             |               |                 |                                                                         |            |                    | No       |
| 192Rievert 2015 | Case series  | C/S  | Cardiac failure, pheo, Takotsubo | 25 year old patient presented with hypertensive crisis, emergency c/s c/b Takotsubo cardiomyopathy secondary to pheo, pulmonary edema | VA         | None               | No       |
|             |               |                 |                                                                         |            |                    | None     |
|             |               |                 |                                                                         |            |                    | No       |
| 193Robbins 2015 | Case report  | C/S  | Asthma                      | 30 year old at 16 weeks with asthma, pneumococcal PNA respiratory failure | VV         | 9                  | No       |
|             |               |                 |                                                                         |            |                    | Preterm delivery at 36 weeks | N/A      |
| 194Roberts 2010 | Case report  | C/S  | ARDS                        | 27 year old G3P1 at 24 weeks with H1N1 ARDS                            | VV         | 17                 | No       |
|             |               |                 |                                                                         |            |                    | None     |
| 195Rodriguez Chaverri 2018 | Case report  | N/A  | PPCM                         | 33 year old woman with postpartum biventricular dysfunction          | VA         | 7                  | No       |
|             |               |                 |                                                                         |            |                    | N/A      |
| 196Roncon-Albuquerque 2012 | Case series  | C/S  | ARDS                        | 36 year old woman with H1N1 ARDS cannulated on PPD#13                | VV         | 39                 | Yes      |
|             |               |                 |                                                                         |            |                    | N/A      |
| Study | Study Type | C/S | Condition | Case Details | ECMO Type | VM | Outcome | Notes |
|-------|------------|-----|-----------|--------------|-----------|----|---------|-------|
| Rubin 2013 | Case report | C/S | PE, cardiac failure | 38 year old G2P0 at 25 and 3/7 weeks with hypoxia, hypotension, seizure-like activity underwent emergent C/S found to have RV straight, PE with failed suction thrombectomy c/b DIC and shock then put on VVA ECMO | VVA | 8 | DIC prior to ECMO, abdominal compartment syndrome requiring bedside laparotomy and hematoma evacuation | No Preterm delivery at 25 weeks, NICU |
| Sakamoto 2018 | Case report | C/S | Heart disease, cardiac arrest | 36 year old G2P1 at 38 weeks with history of WPW s/p cardiac arrest, VF s/p ACLS, perimortem C/S to ECMO | N/A | 3 | Cardiac dysfunction, postpartum bleeding, coagulopathy | No Hypoxic encephalopathy, NICU |
| Sakanas hi 1994 | Case report | C/S | Heart disease, cardiac failure | 32 year old with postpartum dyspnea 33 days after delivery, R heart failure, hypoxemia, Eisenmenger's | VA | 3.66667 | None during ECLS, died 57 days after decannulation of sudden cardiac arrest | No N/A N/A |
| Salazar 2017 | Retrospective review | N/A | Dengue | 31 year old at 30 weeks with preeclampsia, induced labor at 30 w, postpartum c/b refractory thrombocytopenia and hypoxemic respiratory failure requiring MV and ECMO found to have dengue | VV | 1.5 | Bradycardia during cannulation | Yes N/A N/A |
| Satoh 2002 | Case report | C/S | PAH, cardiac failure | 33 year old G1P0 at 18 weeks with PAH with mean 70s and worsening of symptoms, termination of pregnancy on ECMO | VA | 19 | Coagulation of artificial lung requiring changing | Yes TAB, included in infant mortality |
| Scherrer 2012 | Case report | C/S | Heart disease, cardiac failure | 24 year old at 36 weeks with tachycardia induced CM secondary to chronic SVT, ECMO on PPD1 then RFA on ECMO successfully terminated rhythm | VA | 4 | Confusion, amnestic disorder, Sheehan's | No None No |
| Scriven 2009 | Case series | C/S | ARDS | 31 year old at 33 weeks with H1N1 ARDS | N/A | N/A | No Preterm delivery at 33 weeks | No |
| Author | Year | Type | C/S | Diagnosis | Age/Stage | Event | VV | Duration | Outcome | Notes |
|--------|------|------|-----|-----------|-----------|-------|----|----------|---------|-------|
| Seczynska 2014 | Case report | C/S | ARDS | 33 year old at 28 weeks with H1N1 ARDS cannulated PPD#9 | VV | 21 | Bilateral pneumothoraces, R hemothorax | No | Preterm delivery at 28 weeks prior to ECMO, NICU admission | N/A |
| Seidler 2016 | Case report | C/S | ARDS, malignancy | 29 year old at 29 weeks with respiratory distress, metastatic choriocarcinoma after c/s on PPD#2 | VV | 5 | None | No | Preterm delivery at 29 weeks, NICU | N/A |
| Sellami 2017 | Case report | N/A | PPCM | 29 year old with ectopic pregnancy s/p laparotomy c/b LV failure EF 20% myocarditis | VA | 15 | Discharged to rehab | No | Ectopic pregnancy | N/A |
| Seong 2018 | Case report | VD | Cardiac arrest | 32 year old at 39 weeks with SROM c/b seizure and hypotension then CPR, VT, LV dysfunction, DIC plan for ECMO 1 hour after arrest | VA | 1 | Massive transfusion, DIC (AFE) | No | None | No |
| Seth 2018 | Case report | N/A | Asthma | 32 year old G2P1 at 23 weeks with status asthmaticus, hypoxic respiratory failure | VV | N/A | | No | N/A | No |
| Shah 2014 | Case report | C/S | ARDS, cystic fibrosis | 22 year old at 29 and 5/7 weeks with influenza A, cystic fibrosis, hypercapnic respiratory failure requiring ICU cannulated 3 weeks after delivery | VV | 39 | Multiorgan failure, worsening CF plan to bridge to lung transplant however required inotrope and multiorgan failure; awake ECMO 3 weeks into ICU stay started as bridge to salvage lung transplant for CF, died after 60 days in ICU | Yes | Preterm delivery at 32 weeks, NICU admission | No |
| Shamsah 2017 | Case report | VD | PAH, cardiac arrest | 25 year old G2P1 at 26 weeks with pulmonary hypertension, heart failure s/p arrest during labor, delivered amidst CPR and ECMO cannulation | VA | 14 | Prepared for heart/lung transplant but abruptly decompensated and died after ECLS | Yes | Preterm delivery at 26 weeks, NICU | N/A |
| Study Reference | Study Design | Type | Week(s) of gestation | Diagnosis | Cause | Event | Minimal Bleeding | Preterm Delivery | Outcome |
|-----------------|--------------|------|----------------------|-----------|-------|-------|-----------------|-----------------|---------|
| Sharma 2015     | Case series, Systematic review | N/A  | 25 | ARDS | Patient at 25 weeks with mycoplasma ARDS | VV | 5 | Minor bleeding at trach and ECMO catheter site | No | N/A | No |
| Sharma 2015     | Case series, Systematic review | N/A  | 25 | ARDS | Patient on PPD#1 with influenza A ARDS | VV | 4 | Minor vaginal bleeding | No | N/A | No |
| Sharma 2015     | Case series, Systematic review | VD   | 34 | Cardiac failure | Patient at 34 weeks with cardiogenic shock likely viral | VA | 6 | STEMI, vaginal bleeding, clot in circuit | No | Preterm delivery at 34 weeks, stillborn | Yes |
| Sharma 2015     | Case series, Systematic review | N/A  | 34 | PPCM, ARDS | Patient on PPD#2 with peripartum cardiomyopathy ARDS unknown | VV | 6 | Minor vaginal and trach site bleeding | No | N/A | No |
| Shen 2009       | Case report | C/S  | 33 | AFE, cardiac arrest | 21 year old G2P1 at 33 weeks with AFE c/b PEA to ECMO | VA | 1 | None | No | Preterm delivery at 33 weeks | No |
| Shuang 2016     | Case report | C/S  | 35 | ARDS | 40 year old at 35 weeks with ARDS from H5N6 cannulated PPD# 2 | N/A | 46 | Multiorgan failure, pulmonary HTN, died on day 50 | Yes | N/A | N/A |
| Sim 2012        | Case report | C/S  | 26 | Cardiac failure, cardiac arrest | 28 year old at 26 weeks with refractory SVT with cardiogenic shock crashed to ECMO, had IUFD, had RFA, later c/s | VA | 7 | None reported | No | SAB at 26 weeks | Yes |
| Skolnik 2017    | Multicenter, retrospective cohort | N/A  | | AFE | 4 patients with AFE | VA | | 2 ECMO died within first few hours, 1 CPB died, 1 major 1 minor neurologic morbidity, not including CPB | 2/4 | N/A |
| Smiechowicz 2011| Case report | C/S  | 35 | ARDS, cardiac arrest | 37 year old with postpartum H1N1 ARDS (5 weeks PP) c/b PEA and hypercarbia requiring CO2 removal, required dialysis, discharged on day 24 | VV | 8.5 | Started CO2 removal x 6 days, then off for 36 h then resumed on day 8 for another 60 h | No | N/A | N/A |
| Study | Type | Week | Condition | Presentation | VAD | MPA | Survival | Preterm | NICU | IUFD | Notes |
|-------|------|------|-----------|--------------|-----|-----|---------|--------|------|------|-------|
| Smith 2009 | Case report | 38 weeks | PPH, PPCM | 19 year old G2P0 at 38 weeks with PPH requiring uterotonics, emergency hysterectomy, massive transfusions, TTE with LV EF 25%, bradycardic arrests requiring CPR, TEE EF <5%, external cardiac massage then VA ECMO | VA | 2.83333 | None | No | N/A | N/A |
| Stankiewicz 2011 | Case report | 37 weeks | ARDS | 23 year old at 37 weeks with H1N1 ARDS cannulated 12 days postpartum | VV | 26 | PTX, thoracotomy, replacement of oxygenator | No | N/A | N/A |
| Steinack 2017 | Case report | 5 weeks | Asthma | 25 year old at 5 weeks with status asthmaticus with hypoxic respiratory failure despite maximal medical therapy | VV | 2 | Retrochorial hematoma, resolved and went on to delivery healthy boy at 38 weeks; discharged 9 days later | No | None | No |
| Strecker 2012 | Case report | 24 weeks | Cerebral venous thrombosis, ARDS | 28 year old with cerebral venous thrombosis c/b R frontal lobe edema s/p craniectomy c/b ARDS cannulated 15 days postpartum | VV | 110 | Multiple infections | No | N/A | N/A |
| Su 2014 | Retrospective review | 30 weeks | PPCM | 32 year old at 30 weeks with PPCM in 3rd trimester, emergency c/s for maternal distress represented 1 month later after collapse | VA | 5 | None | Yes | Preterm delivery at 30 weeks, NICU admission | N/A |
| Su 2014 | Retrospective review | 34 weeks | PPCM | 27 year old at 34 weeks with PPCM in 3rd trimester, emergency c/s for maternal distress represented 1 month later after collapse | VA | 8.5 | None | No | Preterm delivery at 34 weeks | N/A |
| Takacs 2018 | Case report | 24 weeks | Cardiac arrest, ARDS | 21 year old G3P2 at 24 weeks with cardiac arrest with CPR, SROM during resuscitation, pulmonary contusions and ARDS | VA | 7 | SAB during collapse, DIC while on ECLS, possible due to IUFD so underwent IOL, IUFD prior to ECLS | No | Not counted in mortality |
| Study ID | Study Type | Site | Diagnosis | Clinical Details | ECMO | Outcome 1 | Outcome 2 |
|----------|------------|------|-----------|-----------------|------|-----------|-----------|
| Takeda 2012 | Case series | N/A | ARDS | Patient with H1N1 ARDS | VV | No | N/A |
| Tampo 2014 | Case report | N/A | PPCM | 32 year old G1P0 at 39 and 5/7 weeks with PPCM, LV EF 33% cannulated | VA | 5 | None | No | N/A | N/A |
| Theodorus 2015 | Case report | N/A | Asthma | 38 year old G1P0 at 16 weeks with status asthmaticus, hypercarbic respiratory failure | VV | 8 | Severe mucosal bleeding, small intracerebral hemorrhage | No | Ventriculomegaly | N/A |
| Tincres 2018 | Case report | C/S | AFE, ARDS, cardiac arrest | 35 year old G1P0 at 39 weeks with hypoxia, DIC, AFE c/b cardiac arrest, PPH, hysterectomy, ARDS, RV failure onto ECMO | VA | 4 | Hemorrhagic shock before ECMO from AFE | No | N/A | N/A |
| Ull 2017 | Case report | C/S | PPCM | 26 year old multiparous woman at 34 weeks with placenta previa increta, C/S with hysterectomy cannulated immediately postpartum | VV | 71 | PPCM with EF <20%, need for intermittent dialysis; made full recovery by 12 months | No | Preterm delivery at 34 weeks, NICU | No |
| Unterberg 2017 | Case report | VD | ARDS | 29 year old G1P0 at 38 weeks with HELLP c/b several intracerebral hemorrhage and coagulopathy s/p EVD c/b pseudomonal PNA and ARDS with refractory hypercapnia cannulated PPD# 9 | VV (iLA) | 42 | Severe neurological dysfunction, IVH, tracheostomy, rehab, 42 days ECMO then 10 additional days of iLA | No | NICU admission | No |
| Uribarri 2017 | Case series | N/A | ARDS | Patient with ARDS due to influenza A during pregnancy | VV | 2 | Bleeding | Yes | N/A | N/A |
| Study                  | Type       | Outcome | Case Details                                                                                     | Initial Management | ECMO Details | Outcome | Notes |
|-----------------------|------------|---------|-------------------------------------------------------------------------------------------------|--------------------|--------------|---------|-------|
| 229 Van Zwet 2016     | Case report| C/S     | 27 year old at 35 and 2/7 weeks who presented with respiratory distress, hypertensive crisis, fetal bradycardia -> emergency C/S with refractory hypotension, pulmonary edema and PEA x2, TEE with EF 20-25% to VA ECMO, found to have pheo removed 22 days after initial event | VA then VV         | VA 5 days, VV 2 days | No      | Preterm delivery at 35 weeks, intubated, NICU |
| 228 Veld-van Wingerden 2015 | Case report | VD      | 22 year old G5P3 at 18 weeks with ARDS due to strep pyogenes PNA/ARDS, pregnancy loss prolonged ECMO course cannulated after spontaneous abortion | VV                 | Enterococcus septicemia, massive hemothorax, pulmonary hemorrhage, circuit changed 5 times, trach, rehab | No      | SAB at 18 weeks | Yes |
| 231 Verroust 2007     | Case report| VD      | 29 year old G3P2 at 35 weeks with termination for porencephaly so ruptured membranes, 15 minutes later had cardiac arrest TTE with RV failure, delivered fetus within 1 hour then massive bleeding, transferred hospital, EF <15% went onto ECLS | VA                 | Bleeding prior to ECLS related to AFE | No      | N/A | Yes |
| 232 Visveswaran 2016  | Case report| C/S     | 31 year old at 23 weeks with sepsis c/b cardiomyopathy, LV dysfunction EF 25-30% treated with IV T3 | VV                 | None, discharged home on day 20 | No      | None | No |
| 233 Vitulo 2017       | Case series| C/S     | 31 year old at 32 weeks with pre-capillary PAH Group V, scheduled c/s c/b post-delivery cardiac arrest, RV dysfunction so went onto ECMO | VA                 | None | No      | Preterm delivery at 32 weeks, NICU admission | N/A |
| Study (Year) | Type | Event | Patient Details | Course of Treatment | Outcome | Comments |
|-------------|------|-------|----------------|-------------------|---------|----------|
| Vitulo 2017 | Case series | C/S | PAH | 31 year old at 32 weeks with pre-capillary PAH Group I, scheduled c/s with planned pre-incision ECMO | VA | 1 | Urgent re-laparotomy for bleeding on POD3, thought not to be related to ECMO | No | Preterm delivery at 32 weeks, NICU admission |
| Wall 2010 | Case report | N/A | Cardiac arrest | 39 year old G2P1 at 18 weeks with acute PEA, out of hospital arrest | VA | 3 | Compartment syndrome of lower extremity requiring fasciotomy, planned AKA but due to neurological damage withdrew care | Yes | Maternal PE at 18 weeks |
| Wang 2015 | Case report | VD | ARDS | 29 year old at 27 weeks with H7N9 ARDS | VV then VA | 19 | AF, heart failure, sepsis due to acinetobacter, PE; VV 4 days VA 15 days | Yes | SAB delivered 4 days after loss of fetal heart tones |
| Wei 2011 | Case report | C/S | PE, cardiac arrest | 36 year old G1P1 delivered at 37 weeks with PE with PEA, cardiac massage to ECMO then pulmonary thrombectomy | N/A | None | No | N/A | N/A |
| Weinberg 2011 | Case report | C/S | PAH, cardiac failure | 27 year old G4P3 at 31 weeks with chronic pulmonary thromboembolic disease with RV dysfunction, post C/S ECMO cannulated catheter thrombolysis and suction catheter embolectomy | VA | 4 | Renal replacement therapy, trach | No | Preterm delivery at 31 weeks, intubated, NICU |
| Welch 2010 | Case report | C/S | ARDS | 34 year old G2P1 at 21 weeks with ARDS due to H1N1 | VV | 19 | VAP, trach, severe weakness | No | Preterm delivery at 35 weeks |
| Wertasc 2017 | Case series | C/S | Cardiac arrest | Patient with prolonged AVNRT emergency C/S cardiac arrest cannulated immediately postpartum | VA | 10 | Brain bleed | Yes | N/A | N/A |
| Reference       | Type           | C/S | Diagnosis                          | Parameters                                                                 | Outcome 1 | Outcome 2 | Outcome 3 |
|-----------------|----------------|-----|------------------------------------|-----------------------------------------------------------------------------|-----------|-----------|-----------|
| Wertasing 2017  | Case series    | C/S | PE, cardiac arrest                  | Patient with massive PE with cardiac arrest s/p C/S cannulated immediately postpartum | VA        | Brain bleed | Yes       | N/A          | N/A          |
| Wertasing 2017  | Case series    | VD  | ARDS                               | Patient at 24 weeks with H1N1 ARDS                                          | VV        | Preterm labor at 26 weeks, NICU | No        | Preterm labor at 26 weeks, NICU | No            |
| Weyrich 2016    | Case report    | C/S | PPH, ARDS, cardiac arrest          | 36 year old G6PS at 38 weeks with uterine rupture, PPH, ARDS c/b bradycardia s/p CPR refractory hypoxemia cannulated on PPD# 10 | VV        | Bladder bleeding s/p coagulation, bacterial contamination of circuit, trach | No        | N/A          | No            |
| Williams 2008   | Retrospective review | N/A | ARDS, cardiac failure, HELLP       | 17 patients included for various indications including infectious (9), cardiac (4), HELLP (3) | N/A       | 4/17       | 3 patients on ECLS with pre-viable fetus and all died, 1 before ECLS, 1 maternal death, 1 IUFD during ECLS | 3/17          |
| Wise 2016       | Case report    | VD  | AFE, cardiac arrest                 | 34 year old G1P0 at 39 and 4/7 weeks with AFE, hemodynamic collapse with RDS, VAVD | VV then VA | 3          | None      | No            | None          |
| Yang 2007       | Case report    | N/A | PPCM                               | 18 year old at 40 weeks with desaturation during C/S, HTN, severe pulmonary edema, EF 18%, vaginal bleeding | VA        | 0.85714   | Vaginal bleeding | No                | N/A          | N/A          |
| Yang 2014       | Case report    | N/A | PE, cardiac arrest                  | 30 year old G4P1 at 36 and 5/7 weeks with massive PE c/b PEA given tPA underwent thrombectomy under ECMO | VA        | 7          | DIC, transfusions, intracranial hemorrhage | Yes | N/A          | No            |
| Case report | Year | Event | Patient Age | ECLS | Diagnosis | VAD | PCI | ECHOS | Interventions | Outcome | Complications |
|-------------|------|-------|-------------|------|-----------|-----|-----|-------|---------------|---------|---------------|
| Yeh 2013 | 245 | Case report | VD | Heart disease, cardiac failure | 25 year old on PPD# 7 with hypoxia found to have giant PDA and Eisenmenger | N/A | 30 | Multiorgan failure, pulmonary HTN | Yes | N/A | N/A |
| Young 2016 | 246 | Case report | C/S | PE, cardiac arrest | 39 year old on PPD# 0 from cesarean delivery with cardiac arrest s/p CPR found to have massive PE, RV dysfunction s/p ECMO then mechanical thrombectomy | N/A | 1 | Abdominal compartment syndrome, uterine bleeding, laparotomy, hospitalized for 6 weeks, d/c to PT | No | N/A | N/A |
| Zhang 2018 | 247 | Case series | C/S | PAH, heart failure | 22 year old G2P0 at 37 weeks with PAH cannulated postpartum | VA | Pulmonary hypertension crisis, HF | Yes | Neonatal distress, NICU | No |
| Zhang 2018 | 247 | Case series | C/S | PAH, heart failure | 25 year old G5P1 at 32 weeks with PAH cannulated postpartum | VA | Pulmonary hypertension crisis, HF | Yes | Preterm delivery at 32 weeks, NICU admission | No |
| Zhang 2018 | 248 | Case series | C/S | PAH | Patient on PPD# 0 with RV failure after delivery/oxytocin requiring ECMO | VA | Yes | Preterm delivery | No |
| Zhang 2018 | 248 | Case series | C/S | PAH | Patient on PPD# 0 with RV failure after delivery/oxytocin requiring ECMO | VA | Yes | Neonatal distress (NICU admission) | No |
| Zingel 2012 | 249 | Case report | C/S | PPCM | 30 year old G1P1 with PPCM 17 days postpartum, medically treated then IABP/ECMO | N/A | None, total ICU course was 14 days | No | N/A | N/A |
| Zykovka 2010 | 250 | Retrospective review | N/A | ARDS | 25 year old with H1N1 flu while pregnant | N/A | No | N/A | N/A |

ECLS = extracorporeal life support; VD = vaginal delivery; VAVD = vacuum-assisted vaginal delivery; C/S = cesarean delivery, D&C = dilation and curettage; VV = venovenous; VA = venoarterial; NICU = neonatal intensive care unit; ARDS = acute respiratory distress syndrome; PAH = pulmonary arterial hypertension; PEA = pulseless electrical activity; CPR = cardiopulmonary resuscitation; PNA = pneumonia; TRALI = transfusion related acute lung injury; ECRP = extracorporeal cardiopulmonary resuscitation; PE = pulmonary embolism; AFE = amniotic fluid embolism; DIC = disseminated intravascular coagulation; BKA = below the knee amputation; DVT = deep vein thrombosis; GA = gestational age; PPH = postpartum hemorrhage; tPA = tissue plasminogen activator; D&E = dilation and evacuation; IUFM = intrauterine fetal death; ILD = interstitial lung disease; IOL = induction of labor; RV = right ventricle; PPRM = peripartum cardiomyopathy; VT = ventricular tachycardia; LV = left ventricle; EF = ejection fraction; GAS = group A streptococcus; SAB = spontaneous abortion; MS = mitral stenosis; TAB = therapeutic abortion; TTP = thrombotic thrombocytopenic purpura; HELLP = hemolysis, elevated liver enzymes, low platelets; ECO2 removal = extracorporeal carbon dioxide removal; HIT = heparin induced thrombocytopenia; IVIG = intravenous immunoglobulin; PA = pulmonary artery; PTE = pulmonary thrombectomy; ED = emergency department; TTE = transthoracic echocardiogram; IUGR = intrauterine growth restriction; AML = acute myeloid leukemia; iLA = interventional lung assist; LAM = lymphangioleiomyomatosis; DAH = diffuse alveolar hemorrhage; RDS = respiratory distress syndrome; d-TGA = dextro-transposition of the great arteries; MV = mitral valve; HF = heart failure; OR = operating room; HD = hemodialysis; BiVAD = biventricular assist device; IABP = intraaortic balloon pump; ACS = acute coronary syndrome; LAD = left anterior descending coronary artery; POD = post-operative day; CABG = coronary arterial bypass graft; SCAD = spontaneous coronary artery dissection; CPB = cardiopulmonary bypass; SVT = supraventricular tachycardia; AKI = acute kidney injury; VAP = ventilator associated pneumonia; NSCLC = non-small cell lung cancer; LVAD = left ventricular assist device; PTX = pneumothorax; IVH = intraventricular hemorrhage;
intraventricular hemorrhage; PEG = percutaneous endoscopic gastrostomy; POC = products of conception; POD = postoperative day; ICU = intensive care unit; UAE = uterine artery embolization; TAE = transcatheater arterial embolization; Vfib = ventricular fibrillation; SOB = shortness of breath; BIV = biventricular; SVG = saphenous vein graft; UA = umbilical artery; MI = myocardial infarction; pheo = pheochromocytoma; CHF = congestive heart failure; CHD = congenital heart disease; VSD = ventricular septal defect; MARS = molecular adsorbent recirculating system; TAH = total artificial heart; OHT = orthotopic heart transplantation; SVC = superior vena cava; ALL = acute lymphoblastic leukemia; CVVH = continuous veno-venous hemofiltration; NO = nitric oxide; ICD = implantable cardioverter defibrillator; LOS = length of stay; GI = gastrointestinal; BAL = bronchoalveolar lavage; VF = ventricular fibrillation; PRIS = propofol infusion syndrome; BPD = bronchopulmonary dysplasia; NAS = neonatal abstinence syndrome; AVCO₂ = extracorporeal arteriovenous carbon dioxide removal; MRSA = methicillin resistant staph aureus; WPW = Wolff-Parkinson-White syndrome; CM = cardiomyopathy; RFA = radiofrequency ablation; SROM = spontaneous rupture of membranes; CF = cystic fibrosis; STEMI = ST elevation myocardial infarction; TEE = transesophageal echocardiogram; AKA = above knee amputation; CRRT = continuous renal replacement therapy; HTN = hypertension; PDA = patent ductus arteriosus
Table S2. Cases of deliveries on ECMO (n = 35).

| Study (Author, Year) | Delivery Type | Case details | ECLS Type | ECLS Duration (Days) | Maternal Complications | Maternal Mortality | Cause of Maternal Death | Fetal Complications | Fetal Mortality | Anticoagulation |
|----------------------|---------------|--------------|-----------|----------------------|------------------------|-------------------|------------------------|-------------------|----------------|----------------|
| Agerstrand 2016<sup>36</sup> | C/S           | Patient at 34.9 weeks with PAH requiring VV support then septic shock requiring VA, on ECMO for 3 days prior to delivery | VV then VA | 24 | DIC, abdominal compartment syndrome, VV 12d then VA for 12d | No | N/A | N/A | Yes | N/A |
| Agerstrand 2016<sup>36</sup> | C/S           | Patient at 26.4 weeks with H1N1 ARDS | VV | | ARDS, renal failure, septic shock, preeclampsia, DIC, multisite bleeding | No | N/A | N/A | N/A | N/A |
| Alyamani 2018<sup>38</sup> | C/S           | 38 year old G9P8 at 30.4 weeks with sarcoidosis with ARDS, alveolar hemorrhage | VV | 14 | Profuse bleeding after bronchoscopy, DVT after decannulation | No | N/A | Preterm delivery at 31 weeks, NICU | No | Anticoagulated with institutional goal PTT 45-55 |
| Bautista 2018<sup>46</sup> | C/S           | 18 year old at 24 weeks with PAH due to chronic venoocclusive disease | VV | 10 | Worsening after VV ECMO decannulation, lung transplant complicated by rejection, hemodynamic and respiratory failure | Yes | Died 1 day after decannulation of cardiopulmonary failure | IUFD at 24 hours | Yes | N/A |
| Biderman 2017<sup>50</sup> | VD            | 30 year old at 20 weeks with ARDS, infectious pneumonia with h. influenza and septic shock | VA then VV | 3 | Tracheotomy | No | N/A | Died 3 days into ECLS | Yes | Heparin started at time of cannulation - 5000 IU bolus then gtt titrated to patient condition |
| Biderman 2017<sup>50</sup> | VD            | 37 year old at 13 weeks with ARDS due to H1N1 | VA then VV | 16 | Disseminated intravascular coagulation (DIC), tracheotomy; VA 7 days then VV for 9 days | Yes | Sepsis, died after decannulation | SAB | Yes | Heparin started at time of cannulation - 5000 IU bolus then gtt titrated to patient condition |
| Bowkalow 2011<sup>51</sup> | VD            | 24 year old G4P2 at 20.9 weeks with H1N1 ARDS | N/A | 28 | Died | Yes | Multiorgan failure | SAB at 21 weeks | Yes | N/A |
| Bruch 2013<sup>54</sup> | CD            | 31 year old G1P0 at 19 weeks with PE and cardiac arrest requiring CPR, ECLS and thrombectomy, stillbirth at 19 weeks requiring D&C | VA | 5 | Bleeding requiring transfusions | No | N/A | SAB on ECMO | Yes | N/A |
| Name          | Year | Type | Age | PNA | Cause | Maternal complication | Route | ECMO Days | Coagulation | Delivery & Support | Outcome |
|---------------|------|------|-----|-----|-------|------------------------|-------|------------|-------------|-------------------|---------|
| Chao 2016      | 2016 | VD   | 35  | Y   | SAB   | 16 weeks with viral PNA causing hypoxemic respiratory failure, ARDS | VV    | 9          | No          | SAB at 16 weeks   | Yes     |
| Coscia 2012    | 2012 | CD   | 31  | N   | SAB   | 16 weeks with recent M3 AML developed hypoxemic respiratory failure c/b ARDS, spontaneously delivered 48 hours into iLA | iLA   | 8          | No          | Unclear outcome, spontaneous preterm delivery at 24 weeks, NICU admission | N/A     |
| Crawford 2015  | 2015 | C/S  | 37  | Y   | SAB   | 21 weeks with influenza A ARDS c/b HELLP with newly diagnosed LAM (lymphangioleiomyomatosis) and diffuse alveolar hemorrhage (DAH) | VV    | 14         | No          | Preterm delivery at 24 weeks, NICU, respiratory/nutritional support | No      |
| DiLorenzo 2016 | 2016 | C/S  | 37  | N   | SAB   | Patient at 33 weeks with mitral valve regurgitation due to prosthetic valve thrombosis with NYHA Class III HF planned c/s after VA ECMO and MV replacement, ECMO in OR immediately before c/s | VA    | 2          | None        | Preterm delivery at 24 weeks, NICU | N/A     |
| Jandhyala 1994 | 1994 | VD   | 20  | N   | SAB   | 30 weeks with ARDS secondary to e.coli urosepsis with refractory hypoxemia for ECCO\textsubscript{2} removal | VV    | 1.833333   | None        | Preterm delivery at 30 weeks, NICU | No      |
| Ju 2018        | 2018 | C/S  | 36  | Y   | SAB   | 21 weeks with twin pregnancy complicated by chorioamnionitis, septic shock | VV    | 9          | Fingertip amputation due to ischemia | Therapeutic abortion, twins | Yes |
| Kunstyr 2010   | 2010 | VD   | 26  | Y   | SAB   | 24 weeks with H1N1 ARDS | VV    | 14         | Hemorrhagic bronchitis, cephalic vein thrombosis, pseudomonal infection | Preterm delivery at 24 weeks, NICU, respiratory support | No |
| Lee 1997       | 1997 | VD   | 26  | Y   | SAB   | 17 weeks with varicella PNA ARDS | VA to VV | 57         | Cannula dislodgment, bilateral tension hemopneumothoaces, bronchopleural fistulas, multiple re-explorations for bleeding, right heart | Multiple organ system dysfunction | SAB at 21 weeks | Yes |

1. VV: Venovenous, iLA: Intrauterine life assistance, VA: Venae aorticae
2. N/A: Not available
3. SAB: Septic arthritis of bone
4. HF: Heart failure
5. ECMO: Extracorporeal membrane oxygenation
6. MV: Mechanical ventilation
7. NYHA: New York Heart Association
8. ECCO\textsubscript{2}: Extracorporeal CO\textsubscript{2} removal
9. PTT: Partial thromboplastin time
10. ACT: ACT (activated clotting time)
11. SAB: Septic arthritis of bone
12. PTA: Platelet transfusion
13. HELLP: Hemolysis, elevated liver enzymes, low platelet count
14. LV: Left ventricular
15. RV: Right ventricular
16. VA: Venae aorticae
17. VV: Venovenous
18. N/A: Not available
19. SAB: Septic arthritis of bone
20. NICU: Neonatal intensive care unit
21. ECMO: Extracorporeal membrane oxygenation
22. MV: Mechanical ventilation
23. NYHA: New York Heart Association
24. ECCO\textsubscript{2}: Extracorporeal CO\textsubscript{2} removal
25. PTT: Partial thromboplastin time
26. ACT: ACT (activated clotting time)
27. SAB: Septic arthritis of bone
28. PTA: Platelet transfusion
29. HELLP: Hemolysis, elevated liver enzymes, low platelet count
30. HF: Heart failure
31. LV: Left ventricular
32. RV: Right ventricular
33. PTA: Platelet transfusion
34. PTT: Partial thromboplastin time
| Author          | Year | Procedure | Age | Gestation | Diagnosis/Other Details                                                                 | Complications | Blood Flow | Duration   | No  | N/A | Note                                                                 |
|-----------------|------|-----------|-----|-----------|-----------------------------------------------------------------------------------------|---------------|------------|------------|-----|-----|----------------------------------------------------------------------|
| Lysenko        | 2014 | C/S       | 24  | 39.4 weeks| G1P0 at 39.4 weeks with H1N1 ARDS, cesarean delivery at 30 weeks 3 days                 | No            | VV         | 17         | None| N/A | Preterm delivery at 30 week, intubated, NICU admission                |
| Panarello      | 2010 | C/S       |     |           | H1N1 ARDS                                                                               | N/A           | None       |            |     |     | Discontinued heparin 5 hours before delivery and resumed 14 hours after delivery under GA - no bleeding or thrombotic complications |
| Meng           | 2017 | C/S       | 24  | 39.4 weeks| Patient at 35 weeks with PAH due to CHD/Eisenmenger, cannulated 2 days before delivery | No            | VV         | 21         | None| N/A | Postpartum day 89, unwitnessed cardiac arrest                         |
| Mikami         | 2018 | C/S       | 38  | 35 weeks  | Patient at 35 weeks with PAH due to CHD/Eisenmenger, cannulated 2 days before delivery | No            | VA         | 8          | Uterine bleeding s/p Bakri, transcatheter arterial embolization, hysterectomy | N/A           | No         | Unfractionated heparin to maintain ACT 180-200                      |
| Morsolini      | 2017 | C/S       | 38  | 31 weeks  | Patient at 31 weeks with PAH                                                             | No            | VA         | 1.083333   | SVC and PA thrombosis                                              | N/A           | No         | Low anticoagulation used with goal PTT 40-50, all had heparin gtt and it was held during c/s |
| Morsolini      | 2017 | C/S       | 38  | 31 weeks  | Patient at 31 weeks with PAH                                                             | No            | VA         | 31         | Gastrointestinal bleeding                                           | N/A           | No         | Low anticoagulation used with goal PTT 40-50, all had heparin gtt and it was held during c/s |
| Morsolini      | 2017 | C/S       | 38  | 31 weeks  | Patient at 31 weeks with PAH                                                             | No            | VA         | 1.5        | PNA                                                       | N/A           | No         | Low anticoagulation used with goal PTT 40-50, all had heparin gtt and it was held during c/s |
| Morsolini      | 2017 | C/S       | 38  | 31 weeks  | Patient at 31 weeks with PAH                                                             | No            | VA         | 0.916667   | Uterine bleeding                                                  | N/A           | No         | Low anticoagulation used with goal PTT 40-50, all had heparin gtt and it was held during c/s |
| Panarello      | 2010 | C/S       |     |           | H1N1 ARDS                                                                               | N/A           | None       |            |     |     | Low anticoagulation used with goal PTT 40-50, all had heparin gtt and it was held during c/s |

| Author          | Year | Case Type | Age | Gestation | Condition | Mode | Duration | Features | Anticoagulation | Outcome | Notes |
|-----------------|------|-----------|-----|-----------|-----------|------|----------|----------|-----------------|----------|-------|
| Panarello       | 2011 | C/S       | 38  | 25 wks    | H1N1 ARDS| VV   | 35       | Cesarean delivery at 30 weeks to improve pulmonary mechanics, active bleeding ulcer | No    | N/A   | On heparin for beginning of run, held for 2 hours prior to C/S then resumed 2 hours post-op with goal PTT 40-50 |
| Park            | 2014 | C/S       | 34  | G2P1      | PPCM EF 39% and worsening heart failure, planned VA ECMO prior to cesarean | VA   | 6        | None      | No              | N/A      | Held of anticoagulation until 3 days postpartum, then started nafamostat mesilate |
| Radsel          | 2018 | VD        | 29  | G1P0      | H1N1 ARDS | VV   | 10       | Decannulated on day 5 then recannulated, preterm labor, critical illness polyneuropathy, tracheostomy, discharged to rehabilitation | No    | N/A   | |
| Satoh           | 2002 | C/S       | 33  | G1P0      | PAH with mean PA pressure in 70s and worsening of symptoms; termination of pregnancy at 18 weeks on ECMO | VA   | 19       | Coagulation of artificial lung requiring changing | Yes   | Right heart failure | Therapeutic abortion | Yes |
| Shamsah         | 2017 | VD        | 25  | G2P1      | PAH, heart failure s/p arrest during labor, delivered amidst CPR and ECMO cannulation | VA   | 14       | Prepared for heart/lung transplant but abruptly decompensated and died | Yes   | Worsening PAH after ECLS | Preterm delivery at 26 weeks, NICU | N/A |
| Sharma          | 2015 | VD        | 34  |          | cardiogenic shock, likely viral etiology | VA   | 6        | STEMI, vaginal bleeding, clot in circuit | No    | N/A   | Preterm delivery at 34 weeks, stillborn | Yes |
| Sim             | 2012 | C/S       | 28  | G2P1      | SVT with cardiogenic shock crashed to ECMO, had IUFD, had RFA, later cesarean delivery | VA   | 7        | None reported | No    | N/A   | SAB at 26 weeks | Yes | N/A |
| Author     | Year | Delivery Type | Case Summary                                                                 | VAD | VAVD | SAB | IUFD Prior to ECLS | NICU Admission | Preterm Delivery at 32 weeks, NICU Admission |
|------------|------|---------------|-----------------------------------------------------------------------------|-----|------|-----|-------------------|----------------|---------------------------------------------|
| Takacs     | 2018 | VAVD          | 21 year old G3P2 at 24 weeks with cardiac arrest with CPR, rupture of membranes during resuscitation, pulmonary contusions and ARDS, received enoxaparin, developed IUFD and DIC | VA  | 7    | SAB during collapse, DIC while on ECLS, possibly due to IUFD so underwent IOL, VAVD, retained POC, subsequent D&C on ECMO | No             | N/A                                         |
| Vitulo     | 2017 | C/S           | 31 year old at 32 weeks with PAH, scheduled cesarean delivery with planned pre-incision ECMO | VA  | 1    | Urgent re-laparotomy for bleeding on POD3, thought not to be related to ECMO | No             | N/A                                         |
| Wang       | 2015 |VD             | 29 year old at 27 year weeks with H7N9 influenza ARDS | VV then VA | 19 Guest and sepsis due to acinetobacter, PE; VV 4 days VA 15 days | Yes | Pulmonary embolism 3 days after decannulation | SAB delivered 4 days after loss of fetal heart tones | Yes | N/A |
| Wertaschnigg | 2017 | VD            | Patient at 24 weeks with H1N1 ARDS | VV | None reported | No | N/A             | Preterm labor at 26 weeks, NICU | No | N/A |

ECLS = extracorporeal life support; VD = vaginal delivery, C/S = cesarean delivery, VV = venovenous, VA = venoarterial, iLA = interventional lung assist, SAB = spontaneous abortion, IUFD = intrauterine fetal death, NICU = neonatal intensive care unit, IVH = intraventricular hemorrhage; gtt = infusion; PTT = partial thromboplastin time; DIC = disseminated intravascular coagulation; ARDS = acute respiratory distress syndrome; DVT = deep vein thrombosis; PAH = pulmonary arterial hypertension; LAM = lymphangioleiomyomatosis; iLA = interventional lung assist; ECCO2 removal = extracorporeal carbon dioxide removal; HELLP = hemolysis, elevated liver enzymes, low platelet syndrome; MV = mitral valve; ACT = activated clotting time; PNA = pneumonia; CHD = congenital heart disease; IABP = intra-aortic balloon pump; PPCM = peripartum cardiomyopathy; SVC = superior vena cava; PA = pulmonary artery; EF = ejection fraction; CPR = cardiopulmonary resuscitation; STEMI = ST elevation myocardial infarction; TEG = thromboelastography; SVT = supraventricular tachycardia; RFA = radiofrequency ablation; IOL = induction of labor; VAVD = vacuum assisted vaginal delivery; POC = products of conception; D&C = dilation and curettage
Table S3. Cases that included cardiopulmonary bypass (CPB) (n = 11).

| Study (Author, Year) | Stage of Pregnancy | Postpartum Day | Delivery | Disease Process/Indication | ECLS Type | ECLS Duration (Days) | Maternal Complications | Maternal Mortality | Fetal Complications | Fetal Mortality |
|----------------------|--------------------|----------------|----------|-----------------------------|-----------|----------------------|-----------------------|-------------------|-------------------|-----------------|
| Arlt 2009\(^{40}\)  | Immediately postpartum | 0.166666667 | C/S | 27 year old with massive PE complicated by PEA given tPA, ECMO transported with hand-held system, underwent emergent hysterectomy and pulmonary thrombectomy under ECMO | VA | 4 | Vaginal and endotracheal bleeding after thrombolysis, emergency hysterectomy | No | N/A | No |
| Bruch 2013\(^{54}\)  | Antepartum | N/A | VD | 31 year old G1P0 at 19 weeks with PE and cardiac arrest requiring CPR, ECLS and thrombectomy, stillbirth at 19 weeks requiring D&C | VA | 5 | Delivered on ECMO, bleeding requiring transfusions | No | SAB on ECMO | Yes |
| Chuang 2015\(^{63}\) | Postpartum | 2 | C/S | 29 year old G1P1 with PE s/p cardiac arrest and CPR underwent PTE 2 days after admission | VA | 2 | Burn injuries from resuscitation in ED, staph and influenza infections, discharged day 43 | No | N/A | N/A |
| DiLorenzo 2016\(^{72}\) | Antepartum | N/A | C/S | Patient at 33 weeks with mitral valve regurgitation due to prosthetic valve thrombosis with NYHA Class III HF planned cesarean after VA ECMO and MV replacement, ECMO in OR immediately before delivery | VA | 2 | Delivered on ECMO | No | N/A | No |
| Evans 2014\(^{76}\)   | Postpartum | 14 | Not noted | Patient with ACS diagnosed with SCAD to the LAD with EF 15-20% s/p CABG with failure to wean from CPB | VA | 10 | Rehab | No | None | N/A |
| Fabricius 2001\(^{78}\) | Immediately postpartum | 0 | C/S | 32 year old G1P0 at 39 weeks had cesarean delivery for fetal tachycardia, found to have type A aortic dissection with cardiogenic shock | VA | 4 | None | No | None | No |
| Fayad 2007\(^{81}\)   | Postpartum | <7 days | C/S | 31 year old delivered at 30 weeks with post-rheumatic mitral stenosis, dilated RV had CPB then planned transition to ECMO | VA | 9 | Ventilator associated pneumonia with pseudomonas then sepsis, pre-operative renal failure | Yes | Preterm delivery at 30 weeks, NICU respiratory support | N/A |
| Authors | Year | Time | Delivery Method | Age | Diagnosis | ECMO | Outcome | Diagnosis | ECMO | Outcome |
|---------|------|------|----------------|-----|-----------|------|---------|-----------|------|---------|
| Halldorsdottir et al. | 2016 | Immediately postpartum | 0 | C/S | 29 year old G3P1 at 37 weeks with cardiogenic shock after cesarean delivery due to MV prosthesis thrombosis with severe hypoxemia, cannulated 2 hours postpartum | VA | Weaned from CPB after MV replacement, on ECMO before CPB | No | None | No |
| Hansen et al. | 2012 | Postpartum | 6 | D&C | 38 year old with septic shock for retained products of conception, underwent D&C before IABP and then VA ECMO, found to have papillary muscle rupture, had 2 days ECMO before MV replacement | VA | Severe aortic insufficiency, went back to OR on POD9 | No | N/A | N/A |
| Knapp et al. | 2016 | Postpartum | 16 | C/S | 30 year old with SCAD s/p multiple stents s/p CABG with saphenous vein grafts to LAD and circumflex | VA | Post-CABG biventricular dysfunction EF 25% | No | N/A | N/A |
| Wei et al. | 2011 | Postpartum | 2 | C/S | 36 year old G1P1 delivered at 37 weeks with PE and cardiac arrest, cardiac massage to ECMO then pulmonary thrombectomy | N/A | None | No | N/A | N/A |

ECLS = extracorporeal life support; VD = vaginal delivery, C/S = cesarean delivery, D&C = dilation and curettage, VV = venovenous, VA = venoarterial, SAB = spontaneous abortion, NICU = neonatal intensive care unit; PE = pulmonary embolism; PEA = pulseless electrical activity; tPA = tissue plasminogen activator; CPR = cardiopulmonary resuscitation; PTE = pulmonary thrombectomy; ED = emergency department; OR = operating room; ACS = acute coronary syndrome; LAD = left anterior descending coronary artery; POD = post-operative day; CABG = coronary arterial bypass graft; MV = mitral valve; SCAD = spontaneous coronary artery dissection