Management of Extracorporeal Membrane Oxygenation for Obstetric Patients: Concerns for Critical Care Nurses

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Critical care nurses are faced with many challenges, and one that is particularly stressful is caring for obstetric patients. This care can become more complex when the obstetric patient requires extracorporeal membrane oxygenation. It is imperative that critical care nurses have knowledge about this unique population, the expected physical changes of pregnancy, and the management of extracorporeal membrane oxygenation. Obstetric patients present unique challenges, and care is focused on the woman and her family. The purpose of this paper is to provide information for critical care nurses regarding care of obstetric patients who receive extracorporeal membrane oxygenation. (*Critical Care Nurse*. 2019;39[2]:e8-e15)

Consider 3 sample cases. In case 1, a 26-year-old, white woman who gave birth to a healthy male newborn 7 days ago is admitted to the emergency department with shortness of breath, tachypnea, hypotension, and rales on auscultation of the posterior lung fields. She is cold, clammy, and her oxygen saturation is less than 90%. She has pitting edema in her bilateral lower extremities and states that she has become progressively worse since she gave birth. She is diagnosed with postpartum cardiomyopathy and progresses to fulminant heart failure. In case 2, a 35-year-old Hindu woman had cardiopulmonary arrest immediately following the birth of a healthy, male newborn. She gave birth at 40 weeks' gestation and had mild hypertension during pregnancy but no other medical concerns. After an extensive workup, she is diagnosed with amniotic fluid embolism. In case 3, a 24-year-old woman with influenza A (H1N1) is admitted to the intensive care unit (ICU) at 28 weeks' gestation. As the day progresses, her oxygen requirements increase, and her condition becomes increasingly unstable.

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What connects these cases? Eventually these patients were placed on extracorporeal membrane oxygenation (ECMO) and were cared for by critical care nurses. Each patient presented differently with confounding stressors that required the critical care nurse to respond quickly and to apply clinical knowledge efficiently.

Each day, critical care nurses are faced with challenges and unexpected crises that include life and death situations. Notification that an obstetric patient is being admitted to the ICU, especially one who requires ECMO, is sure to be received with stress and emotion. Extracorporeal membrane oxygenation is a mechanical support system that is used when a patient is in imminent risk of death from severe respiratory or cardiac failure or as an adjunct to cardiopulmonary resuscitation.[1] Extracorporeal membrane oxygenation is a viable option for use with complex patients, but it is a support therapy and should be reserved for those who have reversible conditions. It is not intended to be used for life support for a prolonged period.[1]

In 2013, Senanayake et al[2] reported that among different facilities, the overall rates of admission to the ICU for obstetric patients varied from 0.04% to 4.54%. These patients may present with respiratory failure due to embolism, infectious processes such as the flu, and cardiac failure due to cardiomyopathy and thus the need for ECMO. According to the Extracorporeal Life Support Organization, 37 231 adult patients, including obstetric patients, underwent treatment with ECMO worldwide; 38% to 66% of patients survived after placement, and 29% to 59% of patients survived for discharge or transfer.[3] Patients who received ECMO for respiratory failure were most likely to survive, and those who received ECMO adjunct to cardiopulmonary resuscitation were least likely to survive.[3]

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According to the Centers for Disease Control and Prevention,[4] in the United States, the ratio of pregnancy-related deaths has steadily increased from 7.2 deaths per 100 000 live births in 1987 to a high of 18.0 deaths per 100 000 live births in 2014. Considerable racial disparities exist connected to pregnancy-related death. The Centers for Disease Control and Prevention also reported that during 2011 to 2014, pregnancy-related mortality ratios were 12.4 deaths per 100 000 live births for white women and 40.0 deaths per 100 000 live births for black women. The leading causes of pregnancy-related death in the United States in order of most prevalent to least prevalent are as follow: cardiovascular disease (CVD, 15.2%), non-CVD (14.7%), infection or sepsis (12.8%), hemorrhage (11.5%), cardiomyopathy (10.3%), thrombotic pulmonary embolism (9.1%), cerebrovascular accidents (7.4%), hypertensive disorders of pregnancy (6.8%), amniotic fluid embolism (5.5%), and complications related to anesthesia (0.3%).[4] Any of these conditions could be a potential indicator for the use of ECMO. In the United States more than 2700 women die each year because of obstetric complications.[4] Given these sobering statistics, the purpose of this article is to educate the reader about normal physiological changes that occur during pregnancy and conditions that can result in the need for ECMO among obstetric patients and to increase critical care nurses' awareness of the physical and psychosocial factors that are associated with the use of ECMO in obstetric patients.

ECMO is a viable option for use with complex patients, but it is a support therapy and should be reserved for those who have reversible conditions.

Normal Physiological Changes in Obstetric Patients

The normal, physiological changes that occur during pregnancy and the postpartum period can elevate a woman's risk for complications that can result in the need for ECMO. For example, the hematologic, cardiovascular, and respiratory systems of a woman's body undergo profound changes to accommodate the growing fetus.[5] Normal changes in the hematologic system include a steady and progressive increase in plasma volume of up to 50%; a decrease in hemoglobin, hematocrit, and red blood cell count; and a decrease in platelet count.[5] Changes also occur in the coagulation systems of pregnant

women. During pregnancy and the postpartum period, women are at elevated risk for venous thromboembolism because levels of certain clotting factors increase as levels of endogenous anticoagulants decrease.[6] These alterations result in a hypercoagulable state in which clotting is more likely.[5,6]

Significant changes also occur in the cardiovascular and respiratory systems. The first change to occur is peripheral vasodilation, which leads to an increase in overall plasma volume. Systemic vascular resistance decreases by as much as 30%, and cardiac output increases by as much as 40% as a compensatory mechanism.[5] Initially, the increase in cardiac output is caused by enhanced stroke volume; however, as the pregnancy progresses, the increase in cardiac output is caused by increased heart rate.[7] Blood pressure decreases in the first and second trimesters of pregnancy and is lowest in the second trimester; it rises and returns to prepregnancy levels in the third trimester.[5]

During pregnancy, a profound increase in the demand for in oxygen is the result of a 15% increase in metabolic rate and a 20% increase in oxygen consumption.[5] An increase in tidal volume leads to maternal hyperventilation, which in turn leads to an increase in arterial Po_2, a decrease in arterial Pco_2, and a compensatory decrease in serum bicarbonate.[5] The increased demand for oxygen during pregnancy causes a chronic, respiratory alkalosis, which results in a normal state of compensatory metabolic acidosis.[5]

During pregnancy and the immediate postpartum period, women are at risk for amniotic fluid embolism, a rare but significant threat.

Conditions That May Lead to the Need for ECMO

Maternal mortality can be attributed to congenital and acquired CVD, hypertensive disorders of pregnancy, and embolic disorders.[8] Cardiovascular disease complicates 1% to 3% of all pregnancies; is the cause of 10% to 15% of maternal mortality cases; and includes heart failure, valvular disorders, and arrhythmia.[9] The increasing number of women with complications related to CVD during pregnancy and the postpartum period may be related to the increasing prevalence of CVD in women of childbearing age.[7] In addition to preexisting conditions or known CVD, pregnancy-related causes of heart failure include preeclampsia, peripartum cardiomyopathy, and amniotic fluid embolism. Heart failure in pregnancy occurs when cardiac ventricles are unable to handle the increased circulatory demands of pregnancy.[8] Peripartum cardiomyopathy is relatively rare, has unknown etiology, and is diagnosed within the final months of pregnancy or within 5 months of birth.[7]

Valvular disorders or valvular heart disease (VHD) can cause serious complications in women during pregnancy or the postpartum period. Valvular heart disease includes any complication that arises from damage or defects to 1 or more of the 4 heart valves.[7,9] Pregnancy can pose significant health concerns to women with substantial congenital or acquired VHD.[9] Even with advancements in diagnosis, medical and surgical therapies, and technology, pregnancy and the postpartum period can be complicated by significant adverse maternal and newborn outcomes for women with VHD.[9]

Arrhythmia can be caused by preexisting conditions such as cardiomyopathy, valvular disease, congenital changes, or by the pregnancy itself.[8] Pregnancy can cause ventricular or atrial arrhythmia in women with no prior history of cardiac problems.[8] Some causes of arrhythmia include changes in hormones, electrolytes (low potassium levels), and the autonomic system; preexisting cardiac disease; and hemodynamic instability.[8] Whether the CVD is caused by a preexisting condition or by the pregnancy itself, devastating outcomes for mother and/or newborn can occur.

Hypertensive disorders of pregnancy complicate approximately 10% to 15% of all pregnancies and include chronic hypertension, gestational hypertension, and preeclampsia.[7] Even though all of these conditions are considered hypertensive disorders of pregnancy, it is important for the critical care nurse to be familiar with the slight differences in the origins of each disorder. Chronic hypertension occurs in 1% to 5% of pregnancies and is defined as hypertension that is present before pregnancy, develops before 20 weeks' gestation, or persists more than 6 weeks after birth.[7] Gestational hypertension occurs in 5% to 10% of all pregnancies and is defined as the development of hypertension after 20 weeks' gestation, generally without the presence of proteinuria; it resolves within 6 weeks after birth.[7] Preeclampsia occurs in approximately 5% to 7% of pregnancies and is defined as the development of hypertension after 20 weeks' gestation. Preeclampsia differs from

gestational hypertension in that it requires the presence of clinically significant proteinuria (>0.3 g/d).[7]

Pregnancy is considered a hypercoagulable state; therefore, during pregnancy and the postpartum period, women are at significant risk for venous thromboembolism, which can present as deep vein thrombosis or as pulmonary embolism.[7] In addition, during pregnancy and the immediate postpartum period, women are at risk for amniotic fluid embolism (AFE), a rare but significant threat that occurs when amniotic fluid, fetal cells, hair, or debris enters the maternal bloodstream and generates a systemic, allergic reaction.[10] The incidence of AFE was reported to range from 1 in 8000 to 1 in 80 000 births; because of inaccurate diagnosis and inconsistent reporting, the true incidence is unknown.[10] Although maternal mortality rates related to AFE are high, "the infant survival rate is around 70%."[10] Early diagnosis (possibly attributable to identification of maternal risk factors, increased provider awareness, early recognition of maternal or fetal stress, and prompt resuscitation) and improved resuscitative interventions have resulted in significant reductions in mortality rates.[10] Amniotic fluid embolism is most significantly associated with induction of labor or multiple pregnancies.[11] Key signs and symptoms of AFE include shortness of breath, hypotension, hemorrhage, coagulopathy, and premonitory symptoms (numbness, tingling, agitation).[11] Although mortality rates have decreased, morbidity rates remain high, and complications include neurological impairment, cardiac failure, renal failure, and respiratory failure.[10] Researchers suggested ECMO as a therapy that could be used to successfully treat women with AFE.[10]

Considerations Related to the Care of Obstetric Patients Who Require ECMO

Early recognition of a patient's needs and the ability of an institution and its staff to provide ECMO support are vital to ensure positive outcomes. For critical care nurses, caring for patients who require ECMO takes into consideration physical factors, such as risk for thrombosis, bleeding, and infection, and psychosocial factors, such as maternal-infant bonding, family bonding, anxiety, and financial concerns (see Table).[12] Care for patients undergoing ECMO is labor intensive and requires a team of trained critical care physicians, cardiothoracic surgeons, respiratory therapists, nurse practitioners, critical care nurses, and ECMO specialists or perfusionists. The cardiothoracic surgeon places the cannulas, and the circuit is maintained by the ECMO specialist and the critical care nurse, who routinely monitor the circuit for problems, maintain circuit connections, and evaluate for cracks in tubing.[12] Mongero et al[13] found that a multidisciplinary team reduced delirium associated with sedation and functional impairment and improved overall quality of life at discharge for patients undergoing ECMO.

Daily management of these patients includes review and maintenance of mechanical ventilation. Currently, no standard guidelines exist for the management of

Table Nursing considerations for obstetric patients

Nursing considerations	Monitoring
Bleeding	Mental status changes Uterine bleeding Thrombocytopenia
Thrombosis	Limb ischemia Clots in ECMO circuit
Infection	Increased white blood cell count Fever or chills Drainage
Arrhythmias	Monitor telemetry Monitor electrolytes
Renal dysfunction	Urine output Monitor creatinine and serum urea nitrogen Evaluate for need for CRRT
Ventilator management	Suctioning Work of breathing Arterial blood gas results Lung protective ventilator settings
Delirium	Monitor for agitation and restlessness Mental status changes Level of consciousness
Mother-infant bonding	Infant visitation Family involvement Images of infant Assess and monitor for postnatal depression
Breast engorgement	Breastfeeding Management of discomfort through ice packs and snug-fitting bra or wrap
Psychosocial factors for family members and caregivers	Monitoring for anxiety Evaluation for needs from palliative care, spiritual care, or critical care social workers

Abbreviations: CRRT, continuous renal replacement theraphy; ECMO, extracorporeal membrane oxygenation.

mechanical ventilation.[14,15] Marhong et al[15] analyzed 141 individual responses from 283 centers across 28 countries, and only 27% of these centers reported the use of explicit, mechanical ventilation protocols for ECMO patients. Most of the centers (77%) reported that lung rest was the primary goal of mechanical ventilation; 9% of the centers reported that lung recruitment was the ventilation strategy.[15] Goals and settings are adjusted as the patient recovers and is able to breathe more independently.

Physical Considerations

Complications related to the use of ECMO include hematologic complications (thrombosis, bleeding), infection, renal dysfunction, and delirium.[16] Other hematologic complications include thrombocytopenia, acquired von Willebrand factor deficiency, and heightened risk for heparin-induced thrombocytopenia and disseminated intravascular coagulation.[16] Anticoagulation therapy is needed to prevent thrombosis, which occurs in 1% to 22% of patients who receive ECMO[16]; however, too much anticoagulant will result in bleeding. Currently, standardized guidelines for anticoagulation treatment do not exist, so policies vary among institutions.[12] Bleeding occurs in 5% to 79% of patients who receive ECMO.[16] In a review of literature on extracorporeal life support during pregnancy, Moore et al[17] found that in fatal hemorrhage cases, bleeding sites were intracranial or multiple sites, and in nonfatal cases, bleeding sites were uterine or pulmonary. Other bleeding problems included hemothorax, upper gastrointestinal hemorrhage, maternal intracranial hemorrhage, vaginal bleeding, and bleeding from the cannulation and tracheostomy sites.[17] Because of potential hematologic consequences and the positions and sizes of the cannulas, patients should be monitored for limb ischemia, which occurs in 13% to 25% of patients who receive venous-arterial ECMO.[16] Circulation in the extremities should be checked by monitoring for color, pulses, and capillary refill.

Renal dysfunction can occur as a result of the hypotension and poor renal perfusion seen in patients undergoing ECMO.

Infection occurs in 17% of 49% of patients who receive ECMO,[16] and bloodstream, respiratory, urinary tract, and catheter-related infections have been reported.[17] Maintaining sterile technique will help reduce the risk of infection, and the critical care nurse should monitor for signs and symptoms of infection.

Renal dysfunction can occur as a result of the hypotension and poor renal perfusion seen in patients undergoing ECMO.[12] Patients who undergo ECMO usually experience decreased urine output related to acute kidney injury caused by multiple system organ failure, use of inotrope and vasopressors to support blood pressure and cardiac output, release of cytokines involved in inflammation, and activation of the complement system.[18] Patients may require continuous renal replacement therapy (CRRT), which is temporary renal replacement for fluid removal or solute clearance.[18] The CRRT tubing can be connected to the ECMO circuit to help improve gas exchange and remove volume.[19] Research on the combined use of ECMO and CRRT has primarily been conducted in pediatric patients, and less work has been done in the adult population.[18] However, in one study of 40 adult patients who received ECMO and CRRT, the mortality rate at 1 month was 80%; among the 8 survivors (20%), 3 patients required continuation of hemodialysis, and 5 patients were independent of dialysis at 30 days.[18]

Delirium is common in the ICU: it occurs in 32% to 87% of ICU patients and is associated with long-term intellectual problems, increased cost, and increased length of hospital stay.[12] Delirium can cause altered mental status and sleep deprivation that can heighten the anxiety of the patient's family.[12] The signs of delirium range from agitation, restlessness, and combativeness, to being slow to respond to stimuli, to little or complete loss of movement.[20]

When critical care nurses are knowledgeable about the signs of delirium, diagnosis can be made quickly and potential negative side effects can be reduced.[20] Delirium can be assessed using the Confusion Assessment Method for the Intensive Care Unit, which takes into consideration mental status changes, inadvertence, level of consciousness, and disorganized thinking.[21]

Delirium can be minimized by interrupting sedation daily, encouraging early mobility, structuring patient care activities such has bathing during day hours, and controlling light and noise at night to optimize the patient's sleep-wake cycle.[12] The Richmond Agitation-Sedation Scale can be used to minimize amount and depth of sedation needed.[21] With delirium, the risk that a patient

might remove or displace a cannula is a concern because of the potential for exsanguination or air embolism.[12]

Psychosocial Considerations

In addition to the potential, physical complications related to the use of ECMO, the critical care nurse must be aware of related psychosocial considerations, such as maternal-newborn bonding and family anxiety.[12] Maternal-newborn bonding is an emotional connection; interruption of this connection can have negative implications for the mother's mental health and the newborn's well-being.[22] In the ICU when a mother is critically ill, bonding, including touching and cuddling, can be difficult, limited, or even nonexistent. If a woman is unable to bond with her newborn in traditional ways, innovative strategies such as video conferencing can allow for visualization of the newborn and other children at home. Hutcheson and Cheeseman[23] described the use of the FaceTime application for parents who were separated from their newborns; based on feedback from parents, the program improved bonding. If the mother is stabilized, placing the naked infant on the mother so there is skin-to-skin contact facilitates bonding[22]; although no studies on ECMO patients using this method were found.

During the postpartum period, women with acute illness may experience anxiety or posttraumatic stress, including feelings of frustration and disempowerment.[24] Postpartum depression can negatively affect bonding[25] and can cause problems in relationships between the woman and those around her, including members of her support system.[26] Nonnenmacher et al[25] measured postpartum depression, bonding, and attachment style in women with depression and in healthy women. They found that the combination of depression and dual/disorganized attachment style may pose special risk for the developing mother-infant bond.[25] Also, new mothers may view their infant as burdensome and blame the infant for their health care problems.[26]

Critical care nurses also need to consider breastfeeding for obstetric patients after birth. Multiple, short- and long-term medical and neurodevelopmental benefits of breastfeeding have been documented.[27] For infants, breastfeeding improves outcomes related to various infections, sudden infant death syndrome and infant mortality, cognitive development, obesity, and diabetes.[27] For women, breastfeeding decreases postpartum blood loss, promotes more rapid involution of the uterus, and reduces the likelihood of postpartum depression.[27] Cumulative breastfeeding has been correlated with a reduction in breast and ovarian cancer.[27] However, breastfeeding may not be appropriate for critically ill women in the ICU. In 1997, Dauphinee and colleagues[28] described the information, skills, and resources necessary to assess, initiate, and maintain breastfeeding for critically ill women in the ICU who recently gave birth. They also provided strategies to assist with breastfeeding or pumping as desired.[28]

We were unable to identify any studies on breastfeeding in women who require ECMO. Comfort is a primary concern, especially if an ECMO cannula is placed in the chest. Health care providers do not always encourage breastfeeding for women with chronic illness because of concern that medications may be transferred through breast milk. In addition, in these patients, research by pharmaceutical companies cannot be conducted using clinical trials because of ethical considerations.[29] Spencer[29] suggested that health care providers refer to LactMed and the Infant Risk Center for the most current information on medications and human milk. After birth, if a woman is unable to breastfeed or pump, her breasts can become engorged and painful. Comfort measures for breast engorgement include ice packs; cold, raw cabbage leaves; and snug-fitting bras or wraps.[30]

Critical care nurses caring for patients who require ECMO have valuable resources in palliative care, spiritual care, and critical care social workers.

Critical care nurses can be a valuable resource for obstetric patients who require ECMO and their family, but little research in this area exists to support best practice. Skoog and colleagues[31] found that the incidence of anxiety in family members of patients in the cardiothoracic ICU can be as high as 80%. As long as 3 months after discharge, heighted anxiety in a family member can lead to negative psychosocial implications that manifest in what is referred to as post–intensive care syndrome-family.[31] Anxiety, separation of mother and infant, imposed visiting hours, other siblings, employment obligations, and expenses can all negatively affect bonding.[31]

Critical care nurses caring for patients who require ECMO and their family members have valuable resources in palliative care, spiritual care, and critical care social workers. Although long-term implications should be considered before initiation of ECMO, a palliative care

and/or spiritual care consult may be needed at a later point.[32] Unfortunately, not all hospitals offer palliative care services.[33] The palliative care team can identify goals to optimize patient care and enhance communication between the patient, family, and all members of the health care team.[32] Enhanced communication and coordination of care can help to mitigate anxiety related to current clinical outcomes and potential death.[32] The spiritual care social worker ensures that religious needs are being met, and the critical care social worker provides psychosocial support, facilitates communication, and provides resources during the hospital stay and for outpatient needs.[34]

Critical care nurses and health care providers in general may experience compassion fatigue related to interactions with the patient and family and in response to negative patient outcomes. Compassion fatigue includes emotional, physical, and psychological symptoms and can ultimately be the reason health care providers leave the profession.[35] More research is needed to enhance our understanding of compassion fatigue.

Conclusion

The cases presented at the beginning of this article require quick and decisive interventions. The patient in case 1, with postpartum cardiomyopathy and heart failure, may ultimately require additional mechanical support, a transplant, or may recover completely with no complications. The use of ECMO may save the life of the patient in case 2, who presented with a rare but potentially fatal complication following childbirth. Finally, for the patient in case 3, the use of ECMO may allow recovery from influenza A (H1N1) and the birth of a healthy newborn. All 3 cases are complex and challenging and reinforce the importance of knowledgeable and skilled critical care nurses.

The results of recent studies show that ECMO is an effective and relatively safe treatment for critically ill patients during pregnancy and the postpartum period. In a study of 18 peripartum patients who received ECMO,[36] 16 patients (88.9%) survived to hospital discharge. Two patients successfully gave birth while on ECMO, and no fetal complications were attributed to ECMO.[36] In a literature review, Moore et al[17] reported that 45 patients in 26 studies were treated with ECMO. Survival rates were 77.8% (35 of 45) for mothers and 65.1% (28 of 43) for fetuses. Outcomes for patients in the postpartum period were not included in this review.

It is crucial that patients who require ECMO are identified early and that an experienced and skilled team is involved in their care. The critical care nurse is at the bedside and will be the primary advocate for the patient, family, and newborn. As women continue to give birth later in life and increasing comorbidities complicate medical management, it is likely more obstetric patients will be admitted to the ICU. Education and training regarding this unique patient population should be incorporated at all facilities that provide ECMO so that staff members can respond confidently and competently. CCN

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None reported.

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