Chapter

Nursing Implications in the ECMO Patient

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Abstract

Effective care and positive outcomes of the extracorporeal membrane oxygenation (ECMO) patient necessitate optimal interdisciplinary management from the healthcare team, including expert care from specially trained registered nurses (RNs). It is incumbent upon the RN caring for the ECMO patient to excel in both time management and assessment skills, as this population often demands care delivery at the pinnacle of intensive care unit (ICU) acuity. Astute and nuanced monitoring of neurological status, bleeding risk with potential (often massive) transfusions, poor hemodynamics, and integrity of the ECMO pump itself are only the few specialized areas of focus that must share priority with traditional nursing considerations involving the critically ill, such as prevention of pressure injuries and bloodstream infections. These high-intensity medical foci must be balanced with ethical considerations, as the ultimate goal of returning the patient to their normal life is not always possible. These demands highlight the dynamic proficiency of the RN caring for the ECMO patient. The following chapter will highlight the importance of specialized nursing care in the critically ill patient supported with ECMO.

Keywords: ECMO patient necessitates, interdisciplinary management, importance of specialized nursing care

1. Introduction

The patient requiring extracorporeal membrane oxygenation (ECMO) for any etiology is almost always managed in the intensive care unit (ICU) and requires care around the clock, which is delivered by a collaboration of physicians, nurses (RNs), respiratory therapists, perfusionists, and many others. Close collaboration between care providers is crucial, particularly between the RN managing hemodynamic medication infusions and the ECMO specialist managing the pump. RNs provide extensive, holistic care for ICU patients and their families, much of it geared toward traditional, clinical care with the additional implications of ECMO therapy, which requires additional specialized training. Acuity, unpredictability, and heavy resource requirements of the ECMO patient, especially when initiating therapy, can necessitate unusual and innovative staffing models, which rely on flexibility and often extra hours and shifts to accommodate individual patient and unit needs.

RNs are essential to the delivery of optimal healthcare and play an integral role in the care of patients admitted to the ICU, so it is important that, when staffed well, RNs reduce the risk of inhospital mortality anywhere from 14 to 36% [10, 29].

A recent expert consensus suggests RN-to-ECMO patient ratios should be at least 1:1 or 1:2 to deliver safe and quality patient care [33]. A recent survey found that RNs were allocated 1:1 in nearly 60% of ECMO centers internationally when also monitoring and intervening on the ECMO circuit [9]. This chapter will further discuss the nursing implications involved in the care of the ECMO patient, the RN's role in prevention of associated complications, and the importance of the holistic approach required at the bedside.

2. Nursing implications for cannula site management

Nursing care should include monitoring of the ECMO circuit as nurses and associated staff, such as respiratory therapists and perfusionists, are at the bedside with the patient continually. ECMO cannulae require the same, if not more, attention that any peripheral or central venous catheter would, including assessment for erythema, purulence, adequacy of securement, and dressing integrity. It is significantly important to monitor for fixation of the ECMO cannulae. Initial placement of ECMO cannulae is usually confirmed by echocardiography and the position reaffirmed by radiographs [19]. Thus, ensuring the securement and stability of the cannulae by routine and repeated physical assessment is integral, as misplaced cannulae, loose sutures, or distant lashing straps can lead to specific complications such as inadequate flows or cannula dislodgment [28]. Ideal placement of lashing straps and appropriate securement of cannulae can be seen in **Figure 1**.

It is particularly important for the nurse and other bedside clinicians to be mindful of the integrity of the pump, as mispositioning of cannulae or hypovolemia can result in end-organ injury [11]. Suction events involve disruption of flow secondary to venous collapse onto the drainage cannula and can result in thrombus formation [11]. The occurrence of thrombi in the pump or oxygenator can be recognized by a visible thrombus, an increasing pressure decrease across the oxygenator, or a low post-oxygenator pCO_2 [11].

Figure 1.
Appropriate lashing strap distance demonstrating safe securement and appropriate tension on the ECMO cannulae.

There are additional considerations that the nurse caring for the ECMO patient will need to exercise specific to the therapy. Disruption of innate circulatory flow secondary to ECMO can result in limb ischemia. Thus, it is important to monitor limbs, especially those distal from cannulation sites. Clinical judgment, pulse palpation, and Doppler sonography of limb vessels are effective tools for this purpose [28]. Another modern tool for monitoring tissue oxygenation in lower extremities in ECMO patients is near-infrared spectroscopy [28]. The nurse may also note that clinicians will often place distal perfusion catheters to help prevent or treat distal limb ischemia, as demonstrated in **Figure 2** [28]. Harlequin syndrome can present in patients with venoarterial (VA) cannulation, where the heart has recovered but the lungs are still poorly functioning. The hallmark assessment finding for this is upper extremity cyanosis [28].

Vessel perforation may take place on insertion; but, symptoms may not present immediately [28]. The most serious complication is a large retroperitoneal hematoma; but, considerable local bleeding at the insertion site is also possible, and site assessment, as well as assessment of the abdomen, flanks, and inguinal areas for ecchymosis, hypotension, and acutely worsening anemia, is necessary [28]. Additional assessment findings may include bulging or swelling at the insertion site, most consistent with pseudoaneurysm. Mild insertional hematomas may be mitigated and controlled by application of manual pressure, with subsequent monitoring of flows and distal pulses, both of which are imperative for clinical safety.

Infection is an associated risk of ECMO therapy as well and linked to greater likelihood of mortality. In one study, patients on ECMO experienced an overall mortality of 68.3:75.6% in patients with infections and 67.1% in patients without infections [30]. The use of steroids in acute respiratory distress syndrome (ARDS) or adrenal insufficiency, body temperature control, and multiple blood transfusions after cardiac operations for coagulopathy during ECMO can interfere with the presentation of infection in patients undergoing ECMO [30]. Thus, routine inspection and care of all invasive lines, including ECMO catheters, become integral. Implementing standard decolonization practices set forth by the nurse's institution is appropriate for ECMO catheters, such as antimicrobial scrubs and occlusive dressings.

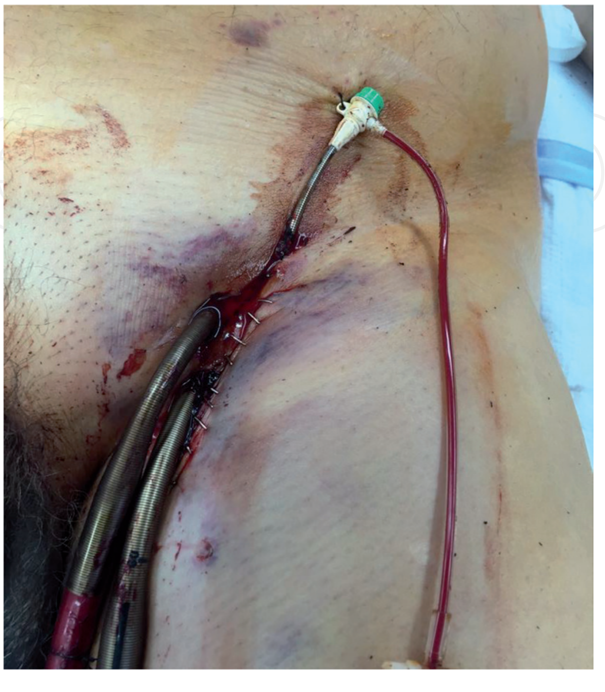

Figure 2.
Left femoral artery perfusion catheter in place providing flow from the arterial ECMO cannula to the left lower extremity.

3. Skin integrity implications in ECMO patients

Hospital-acquired pressure ulcers (HAPUs) are seen often in the intensive care setting and continue to be a significant financial burden within the healthcare system. The costs range anywhere from $500 to $70,000 per pressure ulcer and can cause length of stay (LOS) to increase by as much as 11 days [26]. While incidence of pressure ulcer development ranges per hospital and patient population, in a database of 710,626 patients, an estimated 3.6% of all patients within the adult critical care and step-down units developed a HAPU [31]. In the acute care setting, a range from 0.4 to 12% has been found [31]. Within the cardiac surgery patients which comprise a portion of patients on ECMO, pressure ulcer incidence as high as 29.5% occurs [26]. The consequences of these pressure ulcers often include infection leading to sepsis, increased pain, further disability, and sometimes death [26]. Although general risk factors such as age, immobility, poor nutritional status, altered sensory perception, moisture, diabetes mellitus, vascular disease, and other comorbidities have been identified, patients receiving ECMO support are also at an increased risk for pressure ulcer development due to multiple factors unique to this population [7, 26]. If patients do undergo cardiothoracic surgery, factors that increase the likelihood of a HAPU include cardiopulmonary bypass time, vasopressor therapy, and body temperature while in the operating room [26]. While on ECMO support, hemodynamic instability related to turning can inhibit appropriate prevention measures, leading to higher incidence of skin breakdown. Nurses can experience apprehension related to routine turning due to the potential of accidental decannulation or risk of worsening hemodynamic instability. High doses of multiple vasopressors that are utilized in patients newly placed on ECMO can lead to decreased peripheral perfusion and have also been shown to increase risk of HAPU. These risk factors make it essential to establish a dedicated skin care regimen for patients receiving ECMO support to prevent HAPU.

Skin care goals for patients receiving ECMO support should largely be similar to any patient that is in the intensive care setting. "At-risk" patients are identified by using a standardized risk screening tool such as the Braden Scale score and treated with stratified skin care interventions implemented based on severity of risk. Patients with a Braden Scale score of 14 or less (moderate to high risk) receive maximum interventions [31]. Patients need to be turned and repositioned every 2 h as tolerated. Turns should be scheduled and require a multidisciplinary team to ensure patient safety (perfusionist or respiratory therapist to hold ECMO cannulas, nurse for lines, etc.). For patients who do not tolerate a full turn, such as those who are hemodynamically unstable on ECMO, specialty beds have been shown to be very effective in reducing HAPU [20]. These rotation and pressure redistribution beds can be set to rotate every 30 min to different ranges as patients tolerate. Even subtle and small frequent position changes have been shown to reduce HAPUs [7]. Many facilities also use fluidized repositioning devices to offload pressure [31]. Silicone gel adhesive dressings should be utilized when possible and can be applied on the sacrum, elbows, and heels. Specialized heel-protective boots can also be used if available. Nutritional status also has a significant impact on the body's ability to repair wounds. This makes dietitians an essential part of the treatment team to ensure these patients receive adequate nutrition in order to prevent skin breakdown and promote healing.

There are multiple factors all contributing to this patient population's increased risk of HAPU. Staff education, awareness, and motivation are essential in delivering the proper skin care measures in ECMO patients. When possible, a multidisciplinary skin care team can address each of the challenges present in this population to ensure that adequate prevention measures are being implemented.

4. Early mobility in ECMO

Early physical rehabilitation and mobility implemented in patients receiving ECMO support have been shown to significantly improve patient outcomes, including decreased LOS in the ICU and hospital, decreased rate of delirium, shorter durations of mechanical ventilation, decreased time to ambulation, increased function, and increased likelihood of returning home to family versus a rehabilitation facility [1, 36]. In spite of the obvious importance of early mobility in ECMO patients, there are limitations to this, particularly hemodynamic instability. The first 24–48 h after the initiation of ECMO are typically the most critical and often do not allow for aggressive physical therapy regardless of the type of ECMO. Most patients during this time are requiring the maximum amount of ventilatory and circulatory support. Eligibility for physical therapy is based upon hemodynamic stability and degree of mechanical and pharmacological support and is specific to each patient case.

Historically, a dual-lumen ECMO catheter would occupy one vessel, usually the internal jugular vein, and provide veno-venous (VV)-ECMO through one cannulation site, allowing bridge-to-transplant patients to participate in early mobility more easily. This was optimal for ambulation because both lower extremities were free and the patients were seen as less high risk for accidental decannulation. However, recently there has been a significant push to mobilize all types of ECMO patients whether they are bridge-to-transplant patients or bridge-to-recovery patients, despite the location and type of cannulation. Whatever the level of physical therapy the patient can tolerate, whether this is passive range of motion or ambulation in the hallway has been shown to improve patient outcomes [1]. Typically, VV-ECMO patients are more stable than VA-ECMO patients, and thus bedside nurses are more comfortable with early mobility in these patients. Patients on VA-ECMO with bi-femoral cannulation are some of the most difficult to ambulate. Fear of accidental decannulation, risk of hemodynamic instability, and lack of training in the physical rehabilitation of these patients have all been barriers to early mobilization. However, the study at the University of Maryland demonstrates that physical mobility is safely possible regardless of the type of ECMO or cannulation site [36].

Many institutions who have an established ECMO program have developed a dedicated multidisciplinary team highly trained in the initiation of physical therapy for ECMO patients [36]. These teams typically include a physical therapist, one to two critical care nurses, a perfusionist or respiratory therapist, and a critical care attending physician. When assessing for eligibility, it is helpful to have a standardized screening tool [36]. The University of Maryland developed a protocol for the initiation of ECMO physical therapy [36]. The initial screening was composed of two parts: a medical screening and a physical therapy assessment [36]. The medical screening criteria included hemodynamic stability specific for each patient, coagulopathy: no bleeding at the cannulation site, stable ECMO flows with RN activities, a RASS goal of −1 to 0 with a range (−2 to +2), and stability of cannulation position [36]. The physical therapy assessment included vital signs, assessment of mental status, ECMO flow remaining stable (hip flexion with femoral cannulated lower extremities), and documented ECMO cannulation position [36]. If both of these screens were passed, then the patient met the criteria for further rehabilitation as tolerated [36]. The common physical therapy progression included bed activities/bed mobility such as passive range of motion and resistive training [36]. If that was well tolerated, then patients progressed to the edge of bed activities including balance training and pre-transfer activities [36]. Following this were sit-to-stand transfers, standing and pre-gait activities, and lastly ambulation [36]. Stabilization devices to secure the ECMO cannulas are recommended before physical therapy is initiated [1]. Adjustments on the sweep gas flow rates and increased oxygenation settings can be used during physical therapy based on clinician assessment [1].

In the aforementioned study, 167 of the 254 patients supported on ECMO received physical therapy [36]. One hundred and thirty-four of those patients had at least one femoral cannula, while 66 patients had two, 44 of which were on VA-ECMO and 39 of whom were on VA-ECMO with bi-femoral cannulas. Only five patients had a dual-lumen catheter. Only three minor events were recorded during physical therapy: one episode of hypotension and two episodes of arrhythmias. Of the patients who received physical therapy, 109 patients survived hospital discharge, and 26 of those patients were discharged home. The patients who received physical therapy while on ECMO scored higher on their ICU mobility scale (IMS) than the ones who only received physical therapy after decannulation [36]. It is important to note that this was only possible due to a dedicated team of individuals specifically trained for the initiation and completion of physical therapy and mobility in ECMO patients and that the resources necessary to develop this type of team may not exist at all institutions who utilize ECMO support [36].

The Society of Critical Care Medicine developed the ABCDEF (**A**ssess, prevent, and manage pain; **B**oth spontaneous awakening and breathing trials; **C**hoice of analgesia and Sedation; **D**elirium assess, prevent, and manage; **E**arly mobility and exercise; **F**amily engagement/empowerment) bundle as an ICU Liberation Collaborative [25]. A recent study measured the success of this bundle on over 15,000 patients spread across 68 academic, community and federal intensive care units. Patients who received more of the ABCDEF bundle each day showed lower delirium rates, less use of physical restraints, decreased length of mechanical ventilation, avoidance of ICU readmission, increased instances of being discharged to home, and ultimately decreased mortality rates [25]. The significance of this bundle is that it can be applied to every ICU patient regardless of their diagnosis, including the ECMO patient population. Implementing the ABCDEF bundle on ECMO patients potentially increases the likelihood of returning to their baseline function sooner.

5. Nursing implications for detection and prevention of systemic complications related to ECMO

The use of ECMO is accompanied by a myriad of potential complications across multiple body systems that are considered calculated risks upon initiation of therapy; however, without it, mortality may increase in conditions like severe acute heart failure [32]. A recent, international, randomized controlled trial (RCT) also suggests a potential mortality benefit with the use of ECMO in severe acute respiratory distress syndrome (ARDS); however, it was found to not be statistically significant [8]. There is abundant literature surrounding the complications of ECMO; but, despite these risks, survival to hospital discharge is greater than 50% [4, 12]. In one recent meta-analysis, the most frequently reported complications associated with ECMO include acute kidney injury (AKI), bleeding, and infection [6]. Specialized RNs have knowledge and understanding of potential complications related to ECMO therapy and can assist with early detection through critical thinking, performing frequent assessments, and reporting them through an open dialog with the team of providers involved.

5.1 Renal and other intraabdominal complications

The incidence of acute kidney injury (AKI) has been reported as high as 80% of ECMO patients and is associated with a quadrupled mortality risk [13, 34]. Severe fluid overload is one of the major reasons that renal replacement therapy (RRT) is initiated in this population and is often performed through the ECMO circuit but can also be performed after the pump, which could lower the risk of air embolism not trapped by the oxygenator [34]. Fluid overload is independently associated with increased mortality, prolonged LOS, prolonged ventilator time, and prolonged ECMO time [13, 34].

This consideration can lead providers to assume earlier RRT for therapeutic fluid removal would reduce these comorbidities; however, there is little data to suggest the efficacy of this. In fact, studies suggest increased mortality in ECMO patients who require RRT during their time on pump [16, 37]. Of ECMO patients who suffer AKI, an estimated 46% of survivors require RRT after ECMO is completed [6]. The bedside RN can assist in early identification of AKI by monitoring urine output; measuring strict fluid intake and output; assessing serial serum chemistry values, particularly serum creatinine and trends of electrolyte dyscrasias; and identifying physical exam findings consistent with fluid overload.

Abdominal compartment syndrome (ACS) is a known complication of ECMO [3]. This can be caused by massive fluid overload, which can be necessary to keep ECMO flows appropriate (read aforementioned suction events) [3]. This significantly positive fluid balance is associated with generalized edema, pleural effusions, and ascites, all of which are known to be causes of ACS. ACS can also compress femoral cannulas, thus diminishing the effectiveness of the ECMO therapy [28]. Clinical assessments significant for the monitoring of abdominal compartment syndrome include physical monitoring of abdomen for tension, distention (diameter), discoloration, and, if the technology is readily available, measurement of intraabdominal pressure.

5.2 Hematological complications

Bleeding is the most frequent complication associated with ECMO and affects approximately 30% of the patients receiving the therapy [2]. Bleeding may occur secondary to primary injury such as trauma and surgery or as a result of ECMO itself. Disruption of the red blood cell membrane leads to hemolysis, which is a common complication of patients on ECMO [11]. SIRS and contact between the patient's blood and the ECMO circuit lead to activation of the coagulation cascade, affecting fibrinolysis, thrombin formation, and platelet function [2].

Large amounts of bleeding will cause losses and consumption of coagulation factors and platelets, leading providers to believe that a heparin overdose may be occurring, thus decreasing the heparin, leading to acute thrombosis of the ECMO circuit or in other places where blood flow may be stagnant [22]. Thrombosis is mainly associated with VA-ECMO and can occur in the atria, ventricles, upper and lower extremity deep vein thrombosis (DVT), pulmonary vasculature, brain, or the ECMO circuit [22]. Unfractionated heparin (UFH) is well known, easily monitored, and easily reversible, allowing its frequent use managing hypercoagulability in the ECMO patient. Institutional guidelines vary; but, systemic anticoagulation with UFH infusion to target aPTT between 50 and 70, with some variations [2]. Despite ease of use, UFH can be associated with complications such as heparin-induced thrombocytopenia (HIT), further contributing to bleeding [22]. Alternatives such as warfarin, lepirudin, or argatroban may also be used in lieu of UFH for anticoagulation in the event of HIT [2]. The ECMO patient provides a unique challenge for providers, who must balance hypercoagulability with coagulopathy with careful but aggressive, administration of blood product transfusions and anticoagulants.

It is clear that there is a litany of reasons the patient on ECMO may experience bleeding and bleeding often results in the need for transfusion. Adult patients on ECMO may require 2–3 units of packed red blood cells (PRBCs) and up to 14 units of plasma or cryoprecipitate daily [11]. Additionally, platelet counts of 45,000–60,000 count/μL are associated with mild to moderate bleeding [11]. Demands on bedside clinicians can be burdensome, as transfusion requirements have been reported to average 45 units of packed red blood cells transfused per adult ECMO patient [11].

Large transfusion volumes are independently associated with increased mortality [11]; despite this, anticoagulation remains the standard practice in patients undergoing ECMO due to thrombotic complications [2]. With the significant risk for bleeding and the subsequent need for anticoagulation, nursing can expect regular and repeated blood draws, transfusions, and anticoagulant titration to be a part of their daily practice in the care of the ECMO patient.

5.3 Infectious complications

A prospective, 1-day study identified approximately 50% of adult patients in over 1200 ICUs internationally whom were thought to have some form of infection, increasing ICU, and hospital mortality rates by over double that of patients without infection [35]. The literature suggests that from anywhere 13–26% of reported nosocomial infection rate in adults receiving ECMO (particularly VA-ECMO) is significantly associated with infection before initiation of ECMO, prolonged LOS, ECMO duration (particularly >10 days), and prolonged ventilator days [5, 14, 15, 30]. In the ICU patient, respiratory infections are most common; however, with the addition of ECMO, blood stream infections become most prominent [17, 35]. Other reported nosocomial events in ECMO patients include respiratory, urinary, and surgical site infections [17].

Care provided by the specialized RN remains inherently important in the prevention of infection, particularly when caring for lines and their cannulation sites with thorough hand, cannulation site, and patient hygiene and the application of impermeable site dressings. Protocols preventing ventilator-acquired pneumonia (VAP) are common practice and include interventions like hand hygiene, meticulous oral care with chlorhexidine gluconate solution, endotracheal tube cuff pressure control, and control of sedation [27]. Further management of routine line and cannulation site management are further discussed earlier in this chapter under Section 2.

5.4 Cardiopulmonary complications

Cardiopulmonary complications are often resultant of high left ventricular (LV) afterload, especially on prolonged ECMO (particularly VA-ECMO), which can lead to pulmonary edema [21]. Other cardiac sequelae include aortic valve regurgitation, biventricular failure, and LV thrombus which have been treated with a variety of modalities including intra-aortic balloon pump (IABP) and other percutaneous and surgical procedures to shunt elevated LV pressures [24]. Additional lung complications significantly associated with ECMO include pulmonary hemorrhage, hemorrhagic pulmonary infarct, pulmonary calcifications, and fibrinous pleuritis [18]. The bedside RN can assist with early detection of these complications by close assessment of vasopressor and inotrope requirements, endotracheal secretions, monitoring the ventilator for peak and plateau pressures, and ensuring daily chest radiographs and frequent echocardiograms which are ordered to monitor progression of cardiopulmonary disease.

5.5 Neurological complications

A study reviewing nearly 24,000 patients on ECMO revealed 10.9% of incidence of nearly equal prevalence of seizure, stroke, or intracranial hemorrhage (ICH) [23].

These patients who suffered ICH while on ECMO had increased mortality, while strokes and ICH alike both demonstrated increased LOS and increased likelihood of requiring placement in a skilled nursing facility (SNF) or long-term acute care hospital (LTACH) upon discharge [23]. Other sources suggest up to 50% of patients on ECMO demonstrate severe neurological sequelae [19]. Intracranial hemorrhage has been identified in as high as 40% of non-survivors of ECMO, and thrombotic events have been identified in approximately 15% of ECMO courses [2].

The clinical suspicion for stroke may be obscured in ECMO patients given the multitude of other systemic or metabolic derangements usually encountered in ICU patients [19]. The bedside RN becomes integral to monitoring subtle neurologic indicators such as pupilometer and bi-spectral index, which can read zero in the event of catastrophic neurologic injury.

6. Nursing implications in ethics and ECMO withdrawal

With the advent of advancing ECMO technology comes an expanded library for indications of use. VA and VV support are commonly being utilized for bridge-to-transplant and respiratory or cardiac failure. Additionally, ECMO therapy is being utilized as bridge to support the body through a medical emergency in the form of extracorporeal cardiopulmonary resuscitation (ECPR). With the introduction of high-tech innovation, critical care nursing frequently encounters stressors due to resource scarcity, increased workloads, and moral distress related to carrying out aggressive life-sustaining treatments that may conflict with the patient's best interests or maybe even personal preferences.

ECMO is a costly, resource-intensive therapy requiring commitment from the patient, family, and multiple disciplines. The impact of caring for an ECMO patient puts a mental and physical strain, not only on the patient and family but the entire medical team involved in the patient's care. Providing the intense, complex nursing care impacts not only the nursing staff or ECMO provider but the entire nursing unit caring for the patient. Institutions employing the use of ECMO in treating complex, critically ill patients as one of their only means of survival must have a process that addresses the moral and ethical dilemmas that arise from caring for the critically ill. Common questions are "Who receives ECMO treatment?", "When should support cease?", and "What is the goal of therapy, *quantity* or *quality* of life?"

Allocation of nursing resources has become undoubtedly one of the most challenging aspects in caring for patients and families. Nursing staff ratios, complexity of patients, and the mental and physical impact on the bedside nurse become compounded when one critically ill patient draws a majority of a unit's resources. ECMO patients can begin their treatment with significantly unstable hemodynamic parameters requiring multiple blood transfusions, circulatory support with several vasoactive medications, and frequent lab draws pulling a majority of the nursing unit's resources for the care of one patient. This places an enormous burden on the nursing staff to be creative and flexible with patient care assignments. RN:patient ratios may be less than desirable, ultimately impacting the care provided to other patients on the unit as well. Everyone, from the unit manger to housekeeping, plays a hands-on role in supporting the entire unit as well as the ECMO care team.

How do we reduce some of the ethical or moral dilemmas nurses experience caring for complex, critically ill patients? Communication is the key in healthcare. An integral part of communication is developing and maintaining a team not isolated to healthcare workers but also including the patient and family. Early involvement of the palliative care team and social work is crucial to providing consistent support to the patient and family. Interdisciplinary daily rounds including the bedside nurse, family members, palliative care team, and social work are integral to find commonalities for all regarding goals of care. If conflict arises about treatment benefits or burden and the patient's best interest is no longer being served, support from the ethics committee can be beneficial to the family and healthcare team. These are just the foundation. In critical care nursing, it is important that the nursing staff's voice be heard. It is vital to recognize the nursing assessment of not just the patient but the situation and to be included in the decision-making that nurses are ultimately responsible for performing.

6.1 Withdrawal of ECMO therapy

Unfortunately, despite a team's best efforts, an ECMO patient may continue to decline, with multiple organ systems failing or a devastating systemic event. In such cases, withdrawing care may be imminent, and the question must be asked of the patient and family should be "is the patient's preference *quantity* or *quality* of life?" Can the patient make their wishes known? In the case of bridge-to-transplant, patients may be able to make their wishes known to their families and healthcare team. For the critically ill patient who is dependent on their family or the healthcare team for their medical decisions, is this truly representative of what the patient's wishes would be? Does conflict arise between the healthcare team and family regarding withdrawal of care? These questions are applicable in any situation involving ECMO; however, they cannot be answered algorithmically or methodically, as they need to be answered uniquely to each situation.

Nurses are in a unique position in healthcare. They are at the bedside for 8- or 12-hour shifts as most consistent patient advocate. They support and inform family members and build personal and emotional bonds with them. Although valuable, this rapport can be morally taxing to the bedside RN. As nurses witness a patient and families suffering during clinical decline, they begin to question the continued aggressiveness of care that likely will not benefit from treatment, thus causing moral distress to the nursing staff. Sadness, frustration, and anxiety felt by the nursing staff for prolonged periods of time can lead to staff burnout, job dissatisfaction, and decreased staff retention.

7. Conclusion

The ECMO patient is often the most critically ill within the hospital at any given moment, prompting highly trained bedside RNs as well as other healthcare providers, familiar with the therapy, to be readily available to provide the multifaceted care this population requires. In addition to routine ICU care, the ECMO patient necessitates additional monitoring due to associated risk factors assumed when being placed on pump. Medical, ethical, and emotional considerations exist and must be addressed regularly in order to provide the best care of this unique patient population. Despite high mortality associated with ECMO, the survivability continues to increase as time progresses and the bedside RN will continue to be responsible for vital functions in continuing that trend.

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