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# Cardiovascular Complications Related to the Use of ECMO in Cardiac Surgery

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## INTRODUCTION

ECMO (Extracorporeal Membrane Oxygenation) is an extracorporeal oxygenation technique that involves the use of a specialized membrane to oxygenate the blood and remove carbon dioxide out of the body. It is commonly used in critically ill patients with severe respiratory or cardiac failure to provide life support while waiting for organs to recover normal function.1

There are two main types of ECMO: VV-ECMO and VA-ECMO. VV-ECMO is used for patients with severe respiratory failure and focuses on oxygenation of the blood, while VA-ECMO is used for patients with heart failure or circulatory problems and focuses on supplying oxygenated blood to the body.1,2

Prolonged use of ECMO can lead to complications and damage to the body, such as vascular injury, metabolic disturbances, bleeding, infections and organ failure. Furthermore, the risk of these complications increases with the length of time of ECMO use and with the presence of pre-existing risk factors in the patient.3

Despite the associated risks, ECMO has proven to be an effective tool in the treatment of critically ill patients with severe respiratory or cardiac failure. Studies have shown that ECMO can improve survival in patients with acute lung disease and in patients who have suffered cardiac arrest.4

## VASCULAR LESIONS

The use of ECMO in patients can result in a variety of vascular injuries that can have serious consequences for the patient's health. These injuries can result from insertion of the catheter, manipulation of the catheter during ECMO use, or removal of the catheter at the end of treatment.5

Vascular injuries related to ECMO use can be of different types, such as thrombosis, bleeding, obstructions or stenosis. Thrombosis can occur in the catheter or at the site where the catheter is inserted, which can lead to obstruction of blood flow. Obstruction of blood flow can result in decreased oxygen delivery to organs, which can lead to ischemic injury or cell death. In addition, thrombosis can cause clot migration to other organs, which can lead to serious complications such as pulmonary embolisms or late strokes depending on the length of the procedure.5

Bleeding is a potentially serious complication related to ECMO use in patients. These hemorrhages can occur at the catheter insertion site, at the cannula anastomosis site, or in other areas of the body, such as the lungs or brain.5 Bleeding can result from injury to the blood vessel during catheter insertion, injury to the vascular endothelium due to blood flow pressure, or a decrease in the blood's ability to clot due to prolonged use of anticoagulants.6

The severity of bleeding can range from mild blood loss to massive, life-threatening hemorrhage. Hemorrhages can cause a decrease in circulating blood volume and thus decrease perfusion of vital organs such as the brain, heart and kidneys. In addition, hemorrhages can generate clots that can cause embolisms in other organs, such as the lungs or brain.6. Prevention of bleeding related to ECMO use is essential and may include measures such as careful selection of the catheter insertion site, frequent surveillance of the insertion site, monitoring of anticoagulant levels, adjustment of blood flow, and administration of clotting factors in the event of severe bleeding.6

Stenoses are the result of injury to the vascular endothelium due to blood flow pressure or catheter pressure. These injuries can lead to increased production of scar tissue, which can result in stenosis or narrowing of the blood vessel diameter.6. Stenoses can reduce blood flow to organs, which can lead to decreased perfusion and function of the affected organ. In addition, stenoses can lead to increased vascular resistance,

which can result in increased blood pressure and increased workload for the heart.6

**METABOLIC**

Metabolic complications are a common concern related to ECMO use in patients. Metabolic complications may include acid-base balance disturbances, alterations in electrolyte levels, and liver dysfunction.7

Acid-base balance disturbances can result from hypoxemia, hypercapnia and the administration of intravenous solutions during ECMO therapy. These disturbances may result in metabolic acidosis or alkalosis and may have a negative effect on organ function.8

The use of ECMO in patients can cause a variety of changes in the acid-base balance in the body. In general, ECMO is associated with a decrease in carbon dioxide (CO2) in the blood due to the removal of CO2 by the ECMO machine. This can lead to respiratory alkalosis in patients. In addition, ECMO can affect acid-base balance through disruption of normal blood flow and blood circulation in the body. ECMO can increase the production of lactic acid in the body, which can lead to lactic acidosis.8

Interruption of normal blood flow during ECMO use can also affect the body's ability to maintain acid-base balance, which can lead to metabolic acidosis. In addition, ECMO can affect kidney and liver function, which can lead to changes in acid and base levels in the body.8,9

It is important to closely monitor acid-base levels in patients during ECMO use to detect and treat any acid-base imbalances that may arise. Treatments may include administering sodium bicarbonate to correct an acidosis and reducing ECMO airflow to correct an alkalosis. Regular monitoring of electrolyte levels, such as potassium and calcium, may also help prevent changes in acid-base balance.10,11

Alterations in electrolyte levels can occur due to administration of intravenous fluids and solutions, loss of fluids and electrolytes through the ECMO circuit, and renal dysfunction. Alterations in electrolyte levels can lead to a number of complications, including neuromuscular dysfunction, heart rhythm disturbances, and renal dysfunction.12

Liver dysfunction is another common metabolic complication related to ECMO use. Liver dysfunction can result from hepatic ischemia, drug administration, and the systemic inflammatory response associated with the underlying disease. Hepatic dysfunction can result in decreased bile production and toxin elimination, which can lead to accumulation of toxins in the body.13

Liver dysfunction is a common complication in patients undergoing ECMO. Liver dysfunction can be caused by several reasons, including hepatic hypoperfusion during ECMO support, toxin accumulation, and medication use.13

Hepatic hypoperfusion occurs when hepatic blood flow is reduced during ECMO, which can lead to a decreased supply of oxygen and nutrients to the liver. This can lead to liver damage and dysfunction. In addition, hepatic hypoperfusion can decrease the liver's ability to remove toxins from the body, which can also lead to liver dysfunction.14

**ORGANIC DYSFUNCTION**

Cardiac dysfunction is a common complication in patients undergoing ECMO and can be caused by several factors. ECMO use can adversely affect normal heart function due to prolonged exposure to high doses of catecholamines, additional workload on the heart, and decreased coronary blood flow.15

Prolonged exposure to high doses of catecholamines, which are released by the body in response to ECMO, can cause additional stress on the heart, which can lead to cardiac dysfunction. In addition, increased blood pressure due to ECMO can increase the workload on the heart, which can lead to cardiac dysfunction.15

In addition, decreased coronary blood flow due to ECMO can result in decreased oxygen delivery to the heart muscle, which can lead to cardiac dysfunction. Cardiac dysfunction can lead to decreased cardiac output and decreased perfusion of vital organs.16

Regular monitoring of cardiac function and reducing the use of catecholamines and other medications that may be toxic to the heart may help prevent cardiac dysfunction in patients undergoing ECMO.17

Pulmonary dysfunction is one of the main indications for ECMO use in critically ill patients. However, prolonged use of ECMO can also lead to pulmonary complications in itself. A condition called ECMO-induced lung injury (EILI) has been described, which may include a variety of pathological changes in the lungs, such as inflammatory infiltrates, alveolar hemorrhages and pulmonary edema.18

In addition, blood flow through the ECMO circuit may affect pulmonary function. Positive airway pressure used to provide ventilatory support can reduce pulmonary blood flow and increase the risk of barotrauma, while low tidal volume ventilation can lead to atelectasis. In addition, hypercapnia (excess carbon dioxide in the blood) can occur if the level of ventilatory support provided by ECMO is not adequate for the patient's needs.18

Pulmonary complications related to ECMO use can have significant consequences on patient recovery. In addition to prolonging the duration of ECMO support, they may require additional treatments such as mechanical ventilation and may increase the risk of secondary respiratory infections. It is important to carefully monitor patients' pulmonary function during ECMO use and adjust ventilatory support as needed to minimize the risk of pulmonary complications.19

**INFECTIOUS COMPLICATIONS**

In a study of 50 patients, 20 patients presented 23 infectious complications: 16 were bloodstream infections, with

coagulase-negative staphylococcus being the predominant isolate (there were 2 cases of candidemia). Age, cannulation site, cannulation site, severe coagulopathy and surgical interventions during care were analyzed as risk factors for infectious complications, but no significant differences were found. The duration of ECLS was significantly longer in patients with infectious complications (8.91 vs. 5.91 days; P = 0.039). There were no significant differences in pediatric intensive care unit (PICU) length of stay or survival.(20)

Another study of 75 ECMO patients found that 20 had developed NI (infection rate 26.7%); a total of 58 pathogens were isolated, including 43 strains of gram-negative bacteria (74.1%) and 15 strains of gram-positive bacteria (25.9%). Multidrug-resistant strains were highly concentrated and were shown to be mainly Acinetobacter baumannii , Pseudomonas aeruginosa and coagulase-negative staphylococci. The incidence of NI was related to the duration of ECMO support therapy and total length of hospital stay, and the differences were statistically significant ( $P < 0.05$). A prolonged period of ECMO support prolonged hospital stay, but did not increase the mortality rate. However, an elevated lactic acid level increased the mortality rate in this study population (21).

**COAGULOPATHIES**

A systematic review showed that most patients were treated for acute respiratory distress syndrome or cardiogenic shock. The median duration of ECMO without anticoagulants was 4.75 days. ECMO circuit thrombosis and patient thrombosis occurred in 27 (13.4 %) and 19 (9.5 %) patients, respectively. Any bleeding and major or "severe" bleeding were reported in 66 (32.8 %) and 56 (27.9 %) patients, respectively. Forty patients (19%) died. Although limited mainly by retrospective data and inconsistent reporting of results (22).

One cohort, on the other hand, showed the following results: of the 149 ECMO episodes (111 VA ECMO and 38 VV ECMO) performed in 147 adults, 89 episodes (60 %) were complicated by at least one hemorrhagic event. The most frequent sources of bleeding were: ECMO cannula (37 %), hemothorax or cardiac tamponade (17 %) and otorhinolaryngology (16 %). Intracranial hemorrhage occurred in five (2.2 %) patients. Hemorrhagic complications were independently associated with worse survival [adjusted hazard ratio (HR) 2.17, 95 % confidence interval (CI) 1.07-4.41, P = 0.03]. Longer activated partial thromboplastin time (aPTT) [adjusted odds ratio (OR) 3.00, 95 % CI 1.64-5.47, P <. 0.01], APACHE III score [adjusted OR 1.01, 95 % CI 1.01-1.02, P = 0.01] and ECMO after surgery [adjusted OR 3.04, 95 % CI 1.62-5.69, P < 0.01] were independently associated with an increased risk of bleeding occurrence. A similar association between bleeding and higher aPTT was found when nonsurgical ECMO VA was considered separately (23). Bleeding sites can include cannula insertion sites, recent surgical incisions, vascular access sites, lung, gastrointestinal tract, mouth, nose, chest cavity, abdominal cavity and brain. Massive bleeding in the brain, the most feared hemorrhagic complication, can be rapidly fatal because it occurs in a rigid enclosed space, is difficult to drain, and cannot be stopped by direct pressure at the bleeding site. Pulmonary hemorrhage can cause irreversible lung damage. Management must be rapid and precise to avoid fatal bleeding. Conversely, etiologies of thrombosis include elevated fibrinogen and factor VIII levels, heparin resistance, and platelet activation. Achieving the optimal balance of anticoagulation to prevent bleeding and thrombosis in ECMO patients is extremely complex. Hemostasis experts must be part of an institutional ECMO team and be continuously available for immediate management (24).

**CONCLUSIONS**

The use of ECMO (extracorporeal membrane oxygenation) is an advanced life support technique used in patients with severe respiratory and/or cardiovascular failure. Despite its benefits, the use of ECMO may also be associated with various systemic harms that can affect the functioning of multiple organs and body systems.

First, prolonged ECMO use may increase the risk of disseminated intravascular coagulation (DIC), a condition in which small blood vessels become clogged with clots, which can lead to reduced blood flow and tissue damage in different organs. In addition, the ECMO circuit can also activate the coagulation cascade and increase the risk of arterial and venous thrombosis.

Another common side effect of ECMO use is systemic inflammatory response, which can be caused by activation of the immune system and release of inflammatory cytokines. This inflammatory response can lead to cellular and tissue damage, affecting different organs and body systems.

ECMO use can also affect the functioning of the cardiovascular system, causing hypotension, arrhythmias and ventricular dysfunction. In addition, prolonged exposure to extracorporeal circulation can cause lung, kidney and liver damage, which can affect the body's ability to eliminate wastes and maintain proper metabolic balance.

Although the use of ECMO can be a vital resource for the treatment of critically ill patients, it can also be associated with multiple side effects and systemic damage that must be monitored and treated appropriately to minimize its negative impact on the patient's health.

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