Nursing Experience of a Patient Undergoing VV-ECMO After Cardiopulmonary Resuscitation

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Abstract

We report a case of a patient who received VV-ECMO after cardiopulmonary resuscitation. The patient experienced cardiac arrest caused by hypokalemia and underwent cardiopulmonary resuscitation and electrical defibrillation. Postoperatively, the patient regained spontaneous heart rate, but myocardial injury had already occurred. Combined with hypertension, severe pulmonary infection, and other factors, acute left heart failure was triggered. Increased left heart load led to elevated pulmonary circulation pressure, ultimately resulting in pulmonary edema. The alveolar epithelium sustained further damage on top of the existing infectious injury, ultimately leading to severe cardiopulmonary dysfunction. After assessment by the ECMO team, VV-ECMO was implemented. Scientific application of the nursing process was used to deliver nursing interventions including therapeutic nursing, observational nursing, daily living nursing, rehabilitation nursing, and psychological nursing, which effectively prevented related complications and enabled successful rehabilitation and discharge. The scientific nursing process is crucial for ensuring patient prognosis, successfully improving quality of life, and facilitating return to normal social life.

Full Text

Nursing Experience of a Patient Undergoing VV-ECMO After Cardiopulmonary Resuscitation

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Abstract

This report describes the nursing care of a patient who underwent venovenous extracorporeal membrane oxygenation (VV-ECMO) following cardiopulmonary resuscitation (CPR). The patient experienced cardiac arrest secondary to severe hypokalemia and required CPR with electrical defibrillation. Although spontaneous circulation was restored, myocardial injury had already occurred. Compounded by hypertension and severe pulmonary infection, the patient developed acute left heart failure, which increased left ventricular preload and pulmonary circulation pressure, ultimately resulting in pulmonary edema. The alveolar epithelium sustained further injury superimposed on the existing infectious damage, leading to severe cardiopulmonary dysfunction. After evaluation by the ECMO team, the decision was made to initiate VV-ECMO. Systematic nursing interventions—including therapeutic care, monitoring, daily living support, rehabilitation, and psychological care—were implemented using a scientific nursing process. These measures effectively prevented complications and facilitated successful recovery and discharge. The application of a scientific nursing protocol proved critical for ensuring patient prognosis and improving quality of life, enabling the patient's successful reintegration into normal social life.

Keywords: hypokalemia, cardiac arrest, post-CPR, severe pneumonia, VV-ECMO

Introduction

Electrolyte and acid-base imbalances are common clinical conditions with complex relationships to cardiac arrest risk, broadly categorized into two aspects: they may serve as precipitating factors for cardiac arrest, or they may represent pathophysiological states that accompany the CPR process [1]. Hypokalemia primarily results from reduced potassium intake or excessive potassium loss. In children, gastrointestinal losses from severe diarrhea and vomiting represent the most important cause, whereas in adults, renal losses predominate, commonly seen with prolonged diuretic use or certain renal diseases.

Cardiac arrest, also known as "sudden death," constitutes one of the most dangerous cardiovascular conditions in clinical practice. Prompt initiation of CPR after onset is essential to save the patient's life and prevent catastrophic outcomes. Following resuscitation, high-quality nursing care is crucial to ensure CPR effectiveness, improve success rates, and achieve optimal prognostic outcomes [2]. However, conventional nursing measures have limited efficacy in improving patient prognosis, necessitating continuous improvement and refinement of nursing strategies to enhance care effectiveness and promote better recovery.

Extracorporeal membrane oxygenation (ECMO), introduced in 1970, is a respiratory and cardiac support technology derived from traditional cardiopulmonary bypass (CPB) techniques [3]. As a form of extracorporeal life support system based on CPB, ECMO offers numerous advantages beyond simple circulatory support, including the ability to support respiratory function in patients with respiratory failure and rapidly improve circulatory failure and hypoxemia in patients with cardiopulmonary failure. ECMO can be classified into two modes based on vascular access: venoarterial (V-A ECMO) and venovenous (V-V ECMO). VV-ECMO drains blood from a central vein, oxygenates it, and returns it to a central vein, providing only gas exchange function. As extracorporeal circulation technology continues to advance and medical treatments become increasingly interdisciplinary, ECMO has assumed a critically important role in the rescue and treatment of critically ill patients, including those undergoing non-cardiac surgery [4].

On May 2, 2023, the Trauma ICU of the First Affiliated Hospital of Hainan Medical College admitted a patient who developed severe pulmonary infection following cardiac arrest secondary to hypokalemia and required VV-ECMO treatment. Through meticulous care by the medical team, the patient recovered well and was successfully discharged. We report our nursing experience as follows.

1. Clinical Data

Mr. Wang, a 44-year-old male, was admitted on May 2, 2023, with a two-day history of fever and 10 hours of progressive limb weakness. Two days prior to admission, he developed fever with a maximum temperature of 39°C, accompanied by nasal congestion and scant sputum production, without nausea, vomiting, abdominal pain, diarrhea, chest tightness, dyspnea, or pitting edema of the lower extremities. He received intravenous cephalosporin at a local clinic without improvement. Ten hours before admission, he experienced profound limb weakness, particularly in the lower extremities, preventing independent ambulation, though without loss of consciousness, prompting emergency transport via ambulance. In the emergency department, COVID-19 antigen testing was positive, and electrolyte panel revealed potassium of 1.78 mmol/L. The patient subsequently developed ventricular fibrillation and cardiac arrest. After five minutes of CPR and three electrical defibrillations, spontaneous circulation was restored. He was transferred to our unit for further management with admission diagnoses of: (1) post-cardiopulmonary resuscitation, (2) hypokalemia, and (3) arrhythmia. On admission, vital signs were: temperature 36.8°C, pulse 84 beats/min, respiratory rate 20 breaths/min, blood pressure 135/69 mmHg. The patient's family reported poor mental status, physical strength, appetite, and sleep since onset, though bowel and bladder function remained normal without significant weight change. He had been diagnosed with hyperlipidemia two years prior and took pravastatin regularly. He had experienced recurrent hypokalemia for the past year without treatment. He previously reported limb weakness after intravenous cephalosporin administration.

The patient was placed under 24-hour cardiac monitoring. He was conscious with an endotracheal tube connected to mechanical ventilation. On May 5, his condition deteriorated with declining oxygen saturation. Ventilator parameters were immediately adjusted. After achieving relative stability, he was transported to CT for evaluation, which revealed severe pulmonary infection. Oxygen saturation subsequently dropped again. Despite endotracheal suctioning, ventilatory support, prone positioning, and anti-heart failure measures, oxygenation remained uncorrectable. The Trauma ICU immediately convened a multidisciplinary team (MDT) discussion, determined that the patient met criteria for ECMO therapy, and after obtaining family consent, performed ECMO cannulation successfully. ECMO was initiated at 22:17 on May 5. Prone position ventilation was implemented on May 7. ECMO cannulas were removed at 18:47 on May 11. Post-decannulation vital signs remained stable. A nasojejunal tube was placed on May 12 for enteral nutrition support. The endotracheal tube was removed on May 16, with oxygen saturation maintained above 95%. The patient was transferred to the nephrology department on May 18 and discharged improved on May 28.

2. Nursing Care

2.1 Nursing Assessment Following ECMO initiation, the patient remained in a sedated state with a Richmond Agitation-Sedation Scale (RASS) score of -3. Self-care ability score was 0. Pressure injury risk assessment was 9, indicating extremely high risk. Deep vein thrombosis risk was high. Sputum was thick and difficult to aspirate. Nursing staff conducted comprehensive assessments, with handover reports covering coagulation status, consciousness, line management, and infection control.

Based on systematic assessments and scoring scales, the following nursing problems were identified: hypoxemia and carbon dioxide retention, ineffective airway clearance, risks of bleeding and thrombosis, risks of impaired skin integrity, infection, and unplanned extubation.

2.2 Nursing Objectives Based on assessment findings, nursing objectives were established. Acute phase objectives focused on ensuring oxygen delivery, improving gas exchange, and rapidly correcting hypoxemia and hypercapnia. Recovery phase objectives aimed to improve pulmonary function, prevent complications, and achieve successful weaning and extubation.

2.3.1 Ventilator Care The patient was admitted with an endotracheal tube in place. During mechanical ventilation, airway patency was maintained, ventilator function ensured, and cough and sputum production closely monitored with suctioning performed as needed. Oxygen saturation was continuously monitored, and blood gas analysis was repeated promptly to assess respiratory function. After ECMO cannulation, ventilator parameters were reduced. Prior to extubation, a spontaneous breathing trial was conducted, and extubation was performed only after successful completion.

2.3.2 ECMO Care Despite maximal ventilator support (assist-control mode, tidal volume 500 ml, FiO_2 100%, inspiratory time 1.2 s, respiratory rate 16 breaths/min), the patient's oxygen saturation remained at 80-85%. ECMO catheters were placed in the right internal jugular and right femoral veins with a gas flow of 4 L/min, oxygen concentration 100%, water bath temperature

37°C, rotational speed 3055 rpm, and blood flow 3.27 L/min. Hemodynamic changes, particularly heart rate, blood pressure, and urine output, were closely monitored. ECMO tubing was secured using the "high platform" method with red brick adhesive tape, and puncture sites were covered with maximum-area sterile transparent dressings. Line security was checked each shift, with prompt management of any loosening or curling. Protective restraints were applied, with regular assessment of skin condition, temperature, circulation, and dorsalis pedis pulses, along with provision of warmth [5]. On the sixth day after cannulation, the patient passed the ECMO weaning trial, and the ECMO circuit was removed. The right internal jugular and right femoral decannulation sites were observed for bleeding, with dressing changes performed as needed.

2.3.3 PICCO Care Cardiac output was measured via thermodilution every 8 hours (using ice-cold saline injection). Line patency was ensured with continuous pressure bag maintenance above 300 mmHg and flushing every 30-60 minutes. Strict aseptic technique was observed, and puncture sites were monitored for redness and bleeding.

2.4 Wound and Puncture Site Care The patient had multiple vascular access devices (including ECMO and PICCO), with ECMO sheaths being particularly large-bore. Combined with post-cannulation anticoagulation, this increased complication risk. Puncture wounds were closely monitored for bleeding, hematoma, leg circumference, limb skin temperature, color, sensation, and dorsalis pedis pulses. Passive massage and limb movements were performed to prevent ischemia and thrombosis, with detailed handover reports.

The left internal jugular central venous catheter (CVC) removal site was disinfected with Type III iodophor and covered with sterile gauze. The left femoral arterial and right femoral venous catheter removal sites received routine sandbag compression for 4-6 hours. The patient could turn in bed after 12 hours to prevent discomfort, with 24 hours of immobilization. Daily dressing changes were performed, with monitoring for infection signs (redness, swelling, heat, pain). Prophylactic antibiotics were administered to prevent wound infection.

2.5 Environmental Requirements Laminar flow rooms effectively reduce nosocomial infection rates. Therefore, after catheter placement, patients should be transferred to single laminar flow rooms when possible, and invasive procedures should be minimized. The patient was placed in an isolation room. All entering medical staff wore isolation gowns, masks, and hats, practiced strict hand hygiene and aseptic technique, and limited room occupancy. Air disinfectants were placed in the room, and surfaces and floors were disinfected according to ICU environmental cleaning protocols, following the principle of one item per cloth, with regular bacterial cultures performed.

2.6 Complication Observation and Care **Bleeding and Thrombosis** ECMO therapy requires continuous heparin infusion for systemic anticoagulation to maintain circuit patency, creating high bleeding risk. Post-cannulation coagulation monitoring included ACT, APTT, and hemoglobin levels.

To prevent bleeding, coagulation status was monitored intensively during ECMO therapy (every 2 hours initially, then every 4 hours once stable). ACT was maintained between 160-200 seconds with timely communication with physicians. Platelet counts were maintained above (5-7) $\times 10^9$/L, with platelet or fresh frozen plasma transfusion when counts fell below this range [7].

During ECMO therapy, blood remains in a hypercoagulable state, predisposing to limb vessel and left heart thrombosis. Extremity temperature, color, sensation, and circulation were assessed hourly, particularly in both lower limbs. Swelling, cyanosis, or diminished/absent dorsalis pedis pulses raised suspicion for deep vein thrombosis. Additionally, ECMO tubing and oxygenator color were observed hourly for darkening to prevent thrombosis.

2.7 Skin Care To accelerate resolution of pulmonary infection, prone positioning was initiated on the second day after ECMO cannulation, making skin care particularly crucial. During prone positioning, the patient's head was supported by a 4000 ml replacement fluid bag placed obliquely under the face. Prior to turning, all pressure-prone areas were protected with foam dressings, and large cotton pads were placed under tubing to prevent medical device-related pressure injuries [8].

2.8 Sedation and Analgesia Management The patient was admitted with an endotracheal tube and received routine light sedation. After ECMO cannulation, deep sedation was used during the initiation phase to reduce patient stress and myocardial oxygen consumption. During the maintenance phase with concurrent prone position ventilation, moderate sedation was employed to prevent patient agitation.

2.9 Nursing Evaluation After ECMO decannulation, sedative doses were adjusted according to physician orders, achieving RASS scores of 0 to -1. Respiratory function was exercised, leading to early extubation.

3. Continuity of Care

After discharge, medical staff conducted regular telephone follow-ups to assess the patient's condition, emphasizing the importance of diet and timely electrolyte re-examination. During an August follow-up visit, all laboratory parameters were within normal ranges. Health education was reinforced, emphasizing the need for continued adherence.

Discussion

This patient was initially admitted for cardiac arrest secondary to hypokalemia, but the most severe problem during ICU stay was severe pulmonary infection with refractory hypoxemia despite maximal ventilatory support. After MDT discussion, ECMO therapy was initiated. This case placed higher demands on nursing staff. The medical team thoroughly understood the patient's condition through accurate assessment and education, achieving good cooperation from the patient and family. Post-cannulation care focused on equipment management, complication observation, and management to ensure optimal outcomes and reduce complications. ECMO patients have multiple lines, and prone position ventilation during ECMO therapy further increased nursing complexity. Ensuring patient safety during treatment was our top priority. Through literature review and adaptation to our unit's actual conditions, we implemented targeted nursing measures for skin protection, line securement, puncture site compression, and complication prevention, successfully avoiding adverse events, promoting rapid recovery, achieving successful ECMO weaning, and facilitating ICU discharge.

The *Chinese Expert Consensus on Sedation and Analgesia in Cardiac Intensive Care* [9] recommends different sedation strategies for different ECMO phases, with the principle of reducing patient stress to decrease myocardial oxygen consumption as the primary goal. Deep sedation is recommended during ECMO initiation, while moderate or light sedation is advised during the maintenance phase to reduce adverse events, and deeper sedation may be considered during the weaning phase to avoid patient stress responses [10].

Currently, our hospital has limited ECMO experience, with most nursing knowledge derived from literature and other institutions. We have established a dedicated ECMO team and hope to develop a comprehensive nursing protocol soon.

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Note: Figure translations are in progress. See original paper for figures.