



PATIENT TREATMENT USING EXTRACORPOREAL MEMBRANE OXYGENATION IN NURSING PRACTICE

PACJENT LECZONY METODĄ POZAUSTROJOWEGO UTLENOWANIA KRWI W PRAKTYCE PIELĘGNIARSKIEJ

Aleksandra Jaworska-Czerwińska^{1, 2, a}, Małgorzata Nartowicz^{3, b}, Elżbieta Bernaciak^{1, 2, c}, Bogusława Serzysko^{4, d}, Karolina Juraszek^{5, 6, e}

¹ Chair of Gastroenterology and Nutrition Disorders, Faculty of Health Sciences, Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University in Torun (Poland)

² Department of Clinical Anaesthesiology and Intensive Care, 10th Military Research Hospital and Polyclinic, Bydgoszcz

³ Chair and Clinic of Oncological Surgery, Faculty of Health Sciences, Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University in Torun (Poland)

⁴ Silesian Center for Heart in Zabrze, Department of Cardiology of Congenital Heart Defects and Electrotherapy with the Department of Pediatric Cardiology of the Medical University of Silesia in Katowice

⁵ Department of Physiotherapy, Collegium Medicum in Bydgoszcz, Nicolaus Copernicus University in Torun, Poland

⁶ Eskulap Hospital in Osielsko, Rehabilitation Center, Poland

^a <https://orcid.org/0000-0002-1718-8439>

^b <https://orcid.org/0000-0003-0658-6041>

^c <https://orcid.org/0000-0001-8944-1387>

^d <https://orcid.org/0000-0003-0005-4714>

^e <https://orcid.org/0000-0002-8493-0576>

DOI: <https://doi.org/10.20883/pielpol.2019.38>

ABSTRACT

Extracorporeal membrane oxygenation (ECMO), which is nowadays increasingly used in the treatment of patients, remains an advanced and invasive method, at risk of many complications and adverse events, at the same time increases the chance to save patients' health and life. On the other hand, indications for the use of extracorporeal methods of supporting vital functions are characterized by multiplicity and their constant widening. Nevertheless, the application of these procedures requires extensive knowledge and high qualifications not only among doctors and perfusionists, but also among nurses. Continuous improvement of qualifications by nurses is necessary to ensure patient's safety as well as the highest quality of treatment and care for the patient.

For many years, a lot of attention has been paid to the use of personalized treatment, which is the most beneficial for the patient, even if it requires transporting the patient to a more qualified center, where it will be available. Places are created throughout Poland, centers where the use of ECMO is possible. The importance of a mobile ECMO is also growing, which allows the described therapy to be used while the patient is being transported to the appropriate center.

KEYWORDS: nursing care, intensive care, respiratory insufficiency, circulatory failure.

STRESZCZENIE

Pozaustrójowe utlenowanie krwi (ECMO), które jest współcześnie coraz częściej wykorzystywane w leczeniu pacjentów, pozostaje metodą zaawansowaną i inwazyjną, obciążoną ryzykiem wielu powikłań i zdarzeń niepożądanych, jednocześnie zwiększa szansę na uratowanie zdrowia i życia pacjentów. Z drugiej strony, wskazania do zastosowania pozaustrójowych metod wspomagania funkcji życiowych charakteryzuje mnogość oraz ciągłe ich poszerzanie. Nie mniej jednak, stosowanie tych procedur wymaga dużej wiedzy i wysokich kwalifikacji nie tylko wśród lekarzy i perfuzjonistów, ale również wśród pielęgniarek. Ciągłe podnoszenie kwalifikacji przez pielęgniarki jest konieczne, aby zapewnić bezpieczeństwo pacjenta, a także jak najwyższą jakość leczenia i opieki nad chorym.

Od wielu lat przykładą się bardzo duża wagę do stosowania leczenia spersonalizowanego, które jest najkorzystniejsze dla pacjenta, nawet jeśli wymaga ono transportu chorego do ośrodka bardziej wykwalifikowanego, gdzie będzie ono dostępne. W całej Polsce tworzy się miejsca, ośrodki, gdzie stosowanie ECMO jest możliwe. Rośnie również znaczenie mobilnego ECMO, które umożliwi stosowanie opisywanej terapii jeszcze w trakcie transportu chorego do właściwego ośrodka.

SŁOWA KLUCZOWE: opieka pielęgniarska, intensywna terapia, niewydolność oddechowa, niewydolność krążeniowa.

Introduction

Extracorporeal membrane oxygenation (ECMO) is a method that allows for sustaining the function of an inefficient heart and / or lung. It involves oxygenation of blood and elimination of CO₂ in the oxygenator by diffusion in accordance with the concentration gradient. For a proper exchange, it is necessary to ensure the appropriate blood flow through the device conditioned by the operation of the pump. It is a modern technology, more and more commonly used, often being the last chance to save a patient. For treatment with ECMO are qualified those patients who are waiting for a lung / heart transplant, treated for ARDS, among others, as a result of severe complications of influenza A(H1N1), in cardiogenic shock or in severe hypothermia [1, 2, 3]. It should be noted that in patients with extreme hypothermia in addition to cardiovascular and respiratory support, the possibility of fast heating is used. This possibility is provided by the heat exchanger, which is part of the ECMO construction. Nevertheless, it is an invasive method and is burdened with many dangerous complications that threaten not only health but also the lives of patients. Therefore, it should be used in specialized centers, where experienced staff, including nursing staff, with their knowledge and experience will ensure patient safety while using the described therapy [3].

The development of medicine and advanced medical technologies has caused that the use of specialized equipment guarantees the success of patient's treatment. The increasing use of extracorporeal support of life functions methods (ECLS, Extracorporeal Life Support), including extracorporeal oxygenation, forces the nursing milieu to permanently train and develop skills in the care of patients treated using these methods. Currently, ECMO therapy 'goes beyond' specialized centers of cardiology and / or cardiac surgery units, cardiac surgery departments and is increasingly used in intensive care units. The importance of mobile ECMO, which facilitates patient transport in a relatively easy way, is also growing, and it is planned to have at least one ambulance equipped with it in each of the provinces [4].

The aim of this work is to draw attention to the important role of a nurse while taking care of a patient treated with extracorporeal membrane oxygenation. Due to the short time of application and the innovativeness of the described method, the literature on the subject, especially covering Polish publications, is relatively poor, particularly in terms of standards and methods and processes of nursing. It is the creation and adherence to specific recommendations and guidelines that guarantee the success of patients' health and lives. Nurses working in units that provide highly specialized medical procedures, are people whose rapid reaction

capability and the ability to use advanced equipment guarantee the effectiveness of the therapy [3, 4].

The aim

The aim of this publication is to present important aspects of nursing care of a patient treated with the use of extracorporeal oxygenation of blood. This article presents the most important information about ECMO treatments, which was collected on the basis of a literature review. Particular attention has been paid to the aspects that guarantee the high quality of nursing care.

Extracorporeal membrane oxygenation

ECMO, also called extracorporeal blood oxygenation, is an advanced method treatment of patients with respiratory and / or circulatory insufficiency. As underlined the Extracorporeal Life Support Organization, 'ECLS is the use of mechanical devices to temporarily (days to months) support heart or lung function (partially or totally) during cardiopulmonary failure, leading to organ recovery or replacement' [5]. The basic elements of a modern ECMO device include: a set of cannulas, drains, a centrifugal pump, an oxygenator, a heat exchanger and additional modules – hemofilter and hemodiafiltration [3]. The brief characteristics and functions of listed elements are shown below.

Basic equipment:

- **a set of cannulas and drains:** depending on the method V-V ECMO, V-A ECMO (Veno-Venous ECMO, Veno-Arterial ECMO), venous and / or arterial cannulas are used. We distinguish the drainage cannula (using this cannula blood under the influence of gravity 'flows' into the device) and the return cannula (using this cannula, the blood put into motion by a centrifugal pump returns to the human body). A set of drains connects cannulas with a central unit - currently, they are available drains covered with heparin which prevents blood clotting in drains and drains with double light with the possibility of percutaneous implantation (not requiring vessels), which can be implanted, among others, by an experienced anesthesiologist;
- **centrifugal pump:** responsible for the return blood to the human body; the blood is set in motion by means of a rotating rotor in the magnetic field;
- **oxygenator:** (or oxidizer); responsible for oxygenation of extravasated blood and elimination of carbon dioxide from it by diffusion (at the border of blood-gas contact);

- **-heat exchanger:** allows to lower or raise blood temperature; the thermal energy carrier is water [3, 6, 7].

Additional modules:

- **hemofilter:** connected to a drainage system, allows hemofiltration to increase the hematocrit value in hypovolaemia and hemodilution
- **hemodiafiltration:** the main indications are primarily: metabolic acidosis, high levels of creatinine and urea, electrolyte disturbances, poisoning [8].

Initially, ECMO was used primarily in the treatment of newborns. Currently, it finds a lot of indications; that are constantly expanding. Nevertheless, the use of this method is the individual decision of the doctor / therapeutic team, who takes it based primarily on the clinical condition of the patient and the efficiency of the center in which the patient stays (organizational aspect). The most important qualifying criterion for the ECMO method is the ratio $\text{PaO}_2/\text{FiO}_2 < 70$, with $\text{PEEP} > 10\text{cm H}_2\text{O}$, not rising for at least 2 hours, despite optimal respiratory therapy. Depending on the case, ECMO is used in the veno-venous (V-V) or venous-arterial (V-A) configuration. A brief description of both configurations is provided in the table below [1, 6].

Table 1. Comparison of V-V ECMO and V-A ECMO

| Configuration | ECMO | |
|----------------------|--|--|
| | V-A configuration | V-V configuration |
| Location of cannulas | The blood cannula is connected to a large central vein, the cannula donating is connected to the arterial system | Both the cannula that takes blood to the system and the conveying one are connected to the venous system |
| Supported organs | Support for both the lung function and heart function | Support for the lung function |
| Oxygenation of blood | Complete replacement of the cardiac output; ECMO completely determines the perfusion of blood in organs | The amount of blood that will be oxygenated depends on: cardiac output and blood flow on the device |

Source: own elaboration based on literature references [1, 3, 6, 9].

The main indications in adults are primarily: cardiorespiratory failure that does not respond to conventional treatment, severe respiratory failure in the progress of: pneumonia, pulmonary embolism, severe asthmatic

status, sepsis, lung recoil, persistent pulmonary hypertension, influenza (AH1N1), inflammation or myocardial infarction, cardiogenic shock (in the course of myocardial infarction, pulmonary embolism), short-term waiting for a heart / lung transplant, early hemodynamic instability after cardiac surgery, poisoning, multi-organ injuries, heating and support of cardiovascular and respiratory systems in patients with deep hypothermia (body temperature below 28°C), protection of organs for transplantation [1, 3, 5, 7].

During the ECMO therapy it is necessary to use continuous anticoagulation. The most commonly applied for this purpose is heparin, used in such doses that will enable the maintenance of ACT (Active Clotting Time) at 180-220s level. Anticoagulation primarily eliminates blood clotting on artificial surfaces, including in the oxygenator, however, it increases the risk of bleeding not only in the place where the drain is found, but also a very dangerous one, such as intracranial hemorrhage [1, 10, 11].

Nursing a patient treated with ECMO

Care of a patient who uses techniques of in vitro blood oxygenation requires from the nurse wide and specialist knowledge, manual skills as well as high resistance to stressful situations. The main tasks of the nurse, in addition to patient care and monitoring of standard parameters in the intensive care unit, include in this case also the control of the ECMO apparatus or the operation of the ECMO nursing care observation card. Monitored parameters during extracorporeal oxygenation are presented in the table below [4].

Table 2. Monitored patient parameters during ECMO therapy

| Patient parameters monitored during ECMO therapy |
|---|
| Clinical parameters: ECG, pulse oximetry, blood pressure (indirect and direct method), parameters of mechanical ventilation *, body temperature, CVP, diuresis, fluid balance |
| Gasometric parameters: measurement of acid-base balance (at least every 3 hours) |
| Biochemical parameters: (designated on the order of a physician): morphology, APTT, lactate, D-dimers, INR, PTT, fibrinogen concentration, antithrombin concentration, glucose, ACT |
| Additionally: sedation and relaxation levels |

Source: own elaboration based on literature references [4,6,9].

* At this point it needs to be highlighted that, during ECMO therapy, conducting conventional mechanical ventilation is aimed at ensuring protection of the alveoli before collapsing (called ultraprotective ventilation). The gas exchange is provided by the ECMO [1].

During conducting extracorporeal therapy it is necessary to anticipate and prevent many complications and difficulties. They are related to the patient's severe condition, the specificity of ECMO therapy and the work of the device itself. The most common dangers and problems associated with the use of ECMO: hypoxia and lack of hemodynamic stability, bleeding – about 30% of cases; most often due to heparinization, mainly at the site of cannula insertion (including the risk of very dangerous intracranial hemorrhage), air blockage – created as a result of lack of tightness of the system, multi-organ failure, hemolysis - as a result of improper pump operation (damage to blood morphology), neurological disorders - most often as a result of bleeding and congestion within the central nervous system. They appear more often when using ECMO from the veno-arterial system than venous-venous, infection/sepsis, ischemia of the lower limbs, mechanical problems with ECMO circuits – the most dangerous in this case is disconnection of the system and / or falling of the cannula [10, 12].

From the above, the unsealing (disconnection, bending) of the drains or the displacement (advance) of the cannula is a very serious complication to which distraction and haste may lead. Due to the large diameter of cannulas, rapid vascular volume loss, cardiac arrest and consequent death may occur. In this situation, an immediate action of the nurse is necessary, i.e. stopping the apparatus, calling the practitioner and perfusionist, compressing the cannulation (stopping the bleeding), and in the case of V-A ECMO, the immediate initiation of cardiopulmonary resuscitation, as the device completely replaces the work of the heart muscle. Therefore, in order to prevent the described situations, it is necessary to assess the position of cannulas and drains every time, and during the care procedures – especially during transport or changing the body position of the patient, the involvement of as many personnel as possible [4, 13].

As it is clear from the above, ensuring patient safety requires extensive knowledge and high qualifications. In 2015, the Specialist Training Program in the field of Anesthesiology and Intensive Care Nursing was changed – one of the changes in education was to broaden the knowledge, competence and skills of a specialist nurse with issues including specialized techniques of extracorporeal support of vital functions in patients in extreme states of immediate life threat. However, despite these measures, there are still no uniform procedures and nursing standards to be able to fully implement and properly assess the care being used.

Conclusion

Throughout the world, also in our country, the extracorporeal oxygenation of blood is an increasingly used

method. Since the first application in Poland in 1959 by Leon Manteuffel, the extracorporeal circulation (heart-lung machine) medicine has made a significant progress. Treatments, including cardiosurgical operations, are becoming less and less invasive for the patient, on the other hand they are more and more advanced in terms of technology. Nevertheless, the described therapy still has limitations, especially financial ones. The cost of the equipment is high, and the patient's treatment with ECMO is around 5000–6000 PLN per day. It should be emphasized that it is used in patients with 'poor prognosis', whose treatment often fails.

The use of extracorporeal oxygenation of blood in patients in severe condition, where conventional methods of treatment are not sufficient to ensure recovery, it requires high qualifications among medical personnel, including nurses. It is the nurse who constantly carries out patient care while on duty. Care for patients in the intensive care units is also characterized by building relationships and some kind of connection with their family. The specificity of the ward, the often changed appearance of the patient and the use of a large number of medical equipment arouses many negative emotions among family: fear, anxiety, uncertainty. A nurse who also has educational functions, thanks to the knowledge of the principles of proper interpersonal communication, gives the possibility of lowering the level of negative emotions.

References

1. Arendarczyk A, Wilimski R, Michniewicz M, Czub P, Hendzel P. Zasady kwalifikacji do ECMO u osób dorosłych. *Folia Cardiol.* 2017; 12(1):113–117.
2. Napp ChL, Kühn Ch, Hoepfer M, Vogel-Claussen, Haverich A, Schäfer A, *et al.* Cannulation strategies for percutaneous extracorporeal membrane oxygenation in adults. *Clin Res Cardiol.* 2016; 105:283–296.
3. Mroczkowska R, Serzysko B. Wsparcie hemodynamiczne i krążenie pozaustrojowe. W: Mroczkowska R, Serzysko B, Szkutnik M, red.. *Standardy opieki pielęgniarskiej w kardiologii inwazyjnej.* Warszawa: Wydawnictwo Lekarskie PZWL; 2016;45–52.
4. Gruszka-Wojnar K, Segal A, Adamus M, Nowak-Kózka I, Kózka M. Postępowanie i opieka na miejscu zdarzenia nad pacjentem w przypadkowej hipotermii głębokiej, zakwalifikowanym do leczenia metodą ECMO. *Pielęg anestezjologii intensywnej opieki.* 2017; 3(4):187–192.
5. ELSO Guidelines for Cardiopulmonary Extracorporeal Life Support, Extracorporeal Life Support Organization, Version 1.1, April 2009.
6. Lango R, Szkulmowski Z, Maciejewski D, Sosnowski A, Kusza K. Zaktualizowany protokół postępowania u chorych wymagających zastosowania pozaustrojowej oksigenacji krwi (ECMO) w leczeniu ostrej niewydolności oddechowej dorosłych. Zalecenia i wytyczne Zespołu ds. Terapii ECMO żylny-żylnym, powołanego przez konsultanta krajowego w dziedzinie anestezjologii i intensywnej terapii. *Anestezjologia i Intensywna Terapija.* 2017; 49(2):92–104.

7. Grzybowski A, Urbańska E, Przybylski R, Skalski JH. Pozaustrojowe utlenowanie krwi (ECMO). W: Skalski JH, Religa Z, red. nauk. Kardiologia dziecięca. Wrocław, Wydawnictwo Naukowe „Śląsk”; 2013, s. 226–243.
8. Urbańska E, Grzybowski A, Przybylski R, Szary T, Włoczka G, Skalski J, et al. Zastosowanie pozaustrojowego utlenowania krwi (ECMO) u noworodków. *Anestezjol Inten Terap.* 2001; 2:101–106.
9. Rybicki Z. Aspekty kliniczne i praktyczne monitorowania w intensywnej terapii. W: Rybicki Z (red). *Intensywna terapia dorosłych*. Lublin: Wydawnictwo Makmed; 2014.
10. Daves S M. Pozaustrojowe utlenowanie krwi (ECMO). W: Fleisher L A, Michael F. *Anestezjologia w praktycznej klinice. Procedury i farmakoterapia od A do Z*. Wrocław: Elsevier Urban & Partner; 2014.
11. Mossadegh Ch, Combes A. *Nursing care and ECMO*. wyd. Springer; 2017.
12. Jarosz A, Kosiński S, Darocha T, Sanak T, Podsiadło P, Drwiła R, et al. Wczesne powikłania ogrzewania pozaustrojowego. *Wiad. Lek.* 2017; 70(2)cz.II:415–420.
13. Ogino M, Chuo J, Short B. ECMO. Administrative and Training Issues and Sustaining Quality. W: Annich G, Lynch W,

MacLaren G, Wilson J, Bartlett R. ECMO. Extracorporeal Cardiopulmonary Support in Critical Care. Michigan: Extracorporeal Life Support Organization; 2012.

The manuscript accepted for editing: 01.09.2018.

The manuscript accepted for publication: 13.03.2019.

Funding Sources: This study was not supported.

Conflict of interest: The authors have no conflict of interest to declare.

Address for correspondence:

Aleksandra Jaworska-Czerwińska

Department of Clinical Anaesthesiology and Intensive Care, 10th

Military Research Hospital and Polyclinic, Bydgoszcz

Powstańców Warszawy 5

85-681 Bydgoszcz

phone: +48 261 416 144

e-mail: ola_jaworskaczerwinska@o2.pl