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CASE REPORT / ПРИКАЗ БОЛЕСНИКА

Acute respiratory distress syndrome following coronary artery bypass grafting successfully treated with venovenous extracorporeal membrane oxygenation

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SUMMARY
Introduction Acute respiratory distress syndrome (ARDS) is one of the most serious complications during the postoperative period in cardiac surgery. Venovenous extracorporeal membrane oxygenation (VV-ECMO) has proven to be a valuable therapy in ARDS when standard therapy is insufficient. Our aim is to present a case of severe ARDS which was succesfully treated by VV-ECMO.
Case outline A 54-year-old male patient was urgently admitted to our hospital due to anterior wall myocardal infarction. Urgent coronarography was performed, which found severe three-vessel coronary disease. Triple coronary artery bypass grafting (CABG) was performed. After surgery, due to prolonged respiratory insufficiency, the patient was diagnosed with ARDS and VV-ECMO was placed. Nine days later, normal values of gase exchange were achieved and the patient was succesfully weaned from VV-ECMO.
Conclusion We showed that when conventional therapy for ARDS is not effective, use of ECMO should be considered.
Keywords: cardiac surgery; ARDS; VV-ECMO

INTRODUCTION

Acute respiratory distress syndrome (ARDS) is one of the most serious complications in the postoperative period of cardiac surgery patients and it has an extremely high mortality rate. Factors contributing to the development of ARDS are prolonged mechanical ventilation, systemic hypothermia, catecholamine administration, and transient postoperative heart failure [1, 2]. In these patients, the use of extracorporeal circulation (ECC) is also a predisposing factor. ECC leads to a systemic inflammatory response and increased cytokine release, due to the interaction of blood elements with the surface of the ECC machine. Prophylactic measures for ARDS include the use of mechanical ventilatory support (MVS), which will have the least adverse effect on the lungs, adequate fluid intake and early use of neuromuscular blockade [1, 3]. If, in addition to all these measures, ARDS develops, mortality is high because even the MVS cannot provide satisfactory respiratory function [4]. The diagnosis of ARDS is given when the Berlin criteria for ARDS (2012) are met [5].

If a rapid progression of ARDS with life-threatening hypoxemia occurs, a prompt response is required, which includes the use of extracorporeal membrane oxygenation (ECMO) [1]. ECMO provides significant respiratory and circulatory support in patients with advanced acute respiratory and heart failure that are refractory to standard MVS [4]. There are two types of ECMO: venoarterial (VA) and venovenous (VV). VV-ECMO is used in hemodynamically stable patients, when the problem is only in the respiratory function, while VA-ECMO provides both respiratory and hemodynamic support [6]. Therefore, VV-ECMO has proven to be a valuable therapy in ARDS when standard therapy cannot help [1].

CASE REPORT

We present a 54-year-old male patient who was urgently admitted to the hospital due to the anterior wall ST-segment elevation myocardial infarction. The patient complained of feeling pain in the chest and both forearms that started an hour before the admission. Among the risk factors for ischemic heart disease, the patient had unregulated arterial hypertension, obesity (body mass index – BMI of 35.19 kg/m^2), long-term smoking experience as well as positive family history for coronary heart disease. Also he had non-allergic bronchial asthma and cerebrovascular stroke.

On admission, the ST-segment elevation in the anterior leads up to + 3 mm (V1–V4) was registered electrocardiographically, as well as

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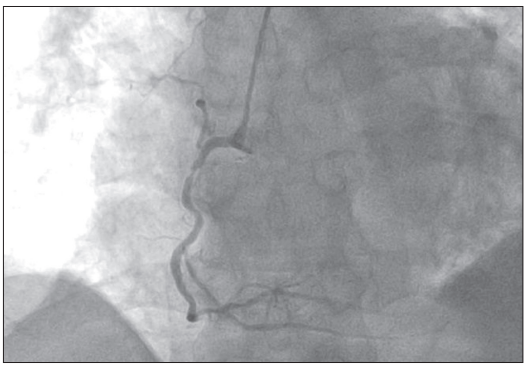

Figure 1. Image from percutaneous coronary intervention

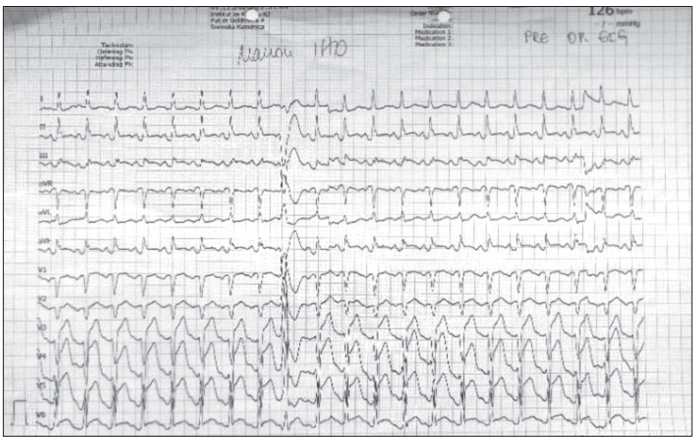

Figure 2. ECG before revascularization

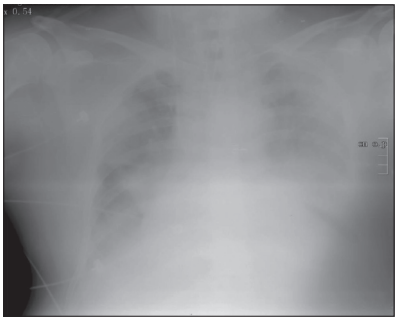

Figure 3. Chest X-ray on the day of venovenous extracorporeal membrane oxygenation placement: decreased transparency of the lung parenchyma completely, primarily of congestive or inflammatory etiology, as well as pleural effusions on both sides

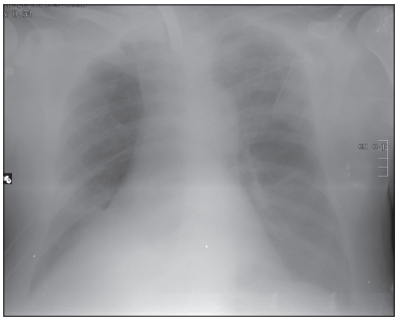

Figure 4. Chest X-ray immediately before weaning from venovenous extracorporeal membrane oxygenation: there is still reduced transparency of pulmonary fields, but improved when compared to the previous image, and there are smaller pleural effusions in the costophrenic angles

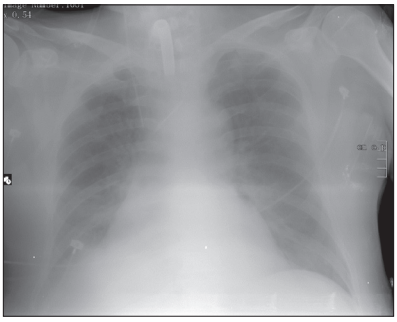

Figure 5. Chest X-ray one week after weaning from venovenous extracorporeal membrane oxygenation: pulmonary parenchyma with significantly better transparency compared to the previous images, a smaller pleural effusion is recorded on the right

biphasic T waves in the lateral leads, while echocardiography registered global left ventricular hypokinesia with decreased left ventricular ejection fraction (40%). Urgent coronarography was performed (Figure 1), which found severe three-vessel coronary disease with the occlusion of the distal segment of the left anterior descending (LAD) artery. Since adequate percutaneous coronary intervention could not be performed, urgent coronary artery bypass grafting (CABG) was indicated. Immediately before the surgical intervention, the progression of electrocardiographic changes in the zone of the septum and lateral wall in the sense consistent acute myocardial ischemia were observed (Figure 2).

The patient underwent surgery on the same day under general endotracheal anesthesia. Revascularization was performed with triple CABG (right coronary artery – posterior descendning artery, ramus intermedius, and LAD). During the operation, the patient was in mild hypothermia, aortic closs-clamp lasted 77 minutes, and the patient was on the ECC for 86 minutes. Upon leaving the operating room, the patient was hemodynamically and rhythmically unstable with frequent single ventricular extrasystoles and on inotropic and vasopressor support with adrenaline and noradrenaline. Gas analyses of the arterial blood at MVS in VC-MMV mode on FiO_2 100% registered respiratory acidosis and type 2 respiratory failure: $PaCO_2$ 58 mmHg, PaO_2 70 mmHg, SaO_2 90%, while pH was 7.27. During the further postoperative course, SaO_2 dropped to 84%. Empiric correction of antibiotics was performed since radiographic finding showed suspected inflammatory process in the lungs. During that period, there was a high rate of SARS-CoV-2 patients, so a possible infection with that virus was suspected. The patient was tested on several occasions, but tracheal aspirate and nasopharyngeal swabs for PCR test were negative. On the second postoperative day the patient developed hypotension and further gas exchange deterioration. SaO_2 decreased to 72% and $PaCO_2$ increased to 67 mmHg with a tendency to worsen. The patient was in severe respiratory acidosis (pH 6.86), and PaO_2 dropped to 40 mmHg. In addition to inadequate pulmonary parameters, an increase in inflammatory markers (leukocytes 24×10^9/l, procalcitonin 1.33 ng/ml) was registered. An increase in urea of 11.6 mmol/l and in creatinine of 228 umol/l with anuria indicated the development of acute kidney injury.

On the third postoperative day, due to prolonged type 2 respiratory failure and worsened radiographic findings of the lungs (Figure 3), high pleateau pressure was observed despite ventilator optimization, which corresponded to the clinical picture of ARDS, and VV-ECMO was placed. VV-ECMO cannulas were placed in the left and right femoral veins. After that, there was a gradual improvement in

the patient's gas exchange, but respiratory failure was still observed ($PaCO_2$ 55 mmHg, PaO_2 42 mmHg, SaO_2 92%, pH 7.5). At the same time, acute kidney injury developed, requiring renal replacement therapy. Continuous veno-venous hemodiafiltration (CVVHDF) was applied via ECMO system.

Due to the prolonged MVS, on the seventh postoperative day, a percutaneous tracheostomy was placed to prevent complications caused by the prolonged endotracheal intubation. On the same day, bronchoscopy was performed for aspiration of airway secretions. The conditions were met for gradual liberation from VV-ECMO. At the same time, the radiographic pulmonary infiltrates improved (Figure 4). Nine days after the placement of VV-ECMO, the patient was assessed as ready for weaning from ECMO.

After the deoxy and CO_2 challenge test, the patient was successfully weaned from ECMO. Subsequently, transient deterioration of respiratory function was observed, which still required high values of FiO_2 on the ventilator (90–100%). Impaired gas exchange with the values of $PaCO_2$ 51 mmHg, PaO_2 52 mmHg, SaO_2 80%, and pH 7.26 can be explained by the abolition of hypoxic vasoconstriction during the ECMO support. After the stabilization of respiratory function, the conditions for re-reduction of FiO_2 were met. On the 14th postoperative day, a high fever appeared, followed by an increase in markers of inflammation (leukocytes 26.41 × 10^9/l, procalcitonin 0.42 ng/ml), due to which antibiotic therapy was corrected and the bronchoscopy was performed again. The normal flora of the upper respiratory tract was obtained.

After the gas exchange stabilization and improvement of the patient's general condition, as well as radiographic findings (Figure 5), the conditions to separate the patient from the MVS were obtained, so the decannulation of tracheostomy was performed. In the meantime, CVVHDF was performed on two more occasions, after which the renal function recovered.

The patient was discharged on the 39th postoperative day, in good general condition, hemodynamically and rhythmically stable. At a regular check-up after three months, the patient appeared in an improved clinical condition with the presence of sternum instability, due to which the sternal resuture was indicated.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research comimittee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

DISSCUSION

Coronary artery surgery is a high-risk procedure and is associated with 30-day morbidity of up to 14% and a mortality rate of up to 2% (in the USA) [7]. Many complications can occur during the intervention, especially when it comes to an emergency procedure. The most common are bleeding, operative site infections, cardiac arrhythmias, myocardial infarction, acute kidney injury, cerebrovascular stroke, as well as respiratory complications, primarily pneumonia and ARDS [7].

Perioperatively, chest trauma and postoperative pain limit the expansion of the operated patient's chest, impede normal lung function and expectoration, and carry an increased risk of respiratory complications [7]. In addition, the reduction of lung function can be related to respiratory muscle dysfunction, because the synthesis of proteins needed for skeletal chest muscles is reduced immediately after surgery leading to muscle weakness and atrophy in the first weeks after surgery. It should be emphasized that during the first week after the operation, there is a reduction of vital capacity by 30–60%, which remains reduced by 12% even one year after the surgery [8]. Since our patient had bronchial asthma as an associated disease, as well as long-lasting history of smoking, his lung function was certainly impaired, which also contributed to the appearance of ARDS. Obesity can lead to disorders of the mechanics of the respiratory organs, obstruction of the airways, and disruption of normal gas exchange, and therefore is also classified as a risk factor for the development of ARDS. Since our patient had a BMI of 35.19 kg/m^2, this certainly had an impact on the lung function impairment and contributed to the development of ARDS [9].

ARDS is characterized by acute, diffuse, inflammatory lung damage that leads to increased permeability of alveolar-capillary membranes and loss of functional lung tissue. It is clinically manifested by hypoxemia with bilateral radiographic consolidation of the lung parenchyma, functionally reduced compliance, and increased dead space in the lungs [10]. The onset of ARDS is abrupt and usually occurs in the first few hours after surgery [11]. The treatment of ARDS still mostly remains only on the application of the supportive measures with the MVS. In the past two years, high mortality from this syndrome has been registered in hospitalized patients – around 40%. Those who survive may suffer consequences in the form of permanent psychological and neurological morbidity that affect the quality of life of these patients, even up to five years after recovery [12, 10]. In this case report, the diagnosis of ARDS was made on the third postoperative day after a radical worsening of the patient's clinical condition, persistent hypoxemia and severe hypercapnia with respiratory acidosis, and a characteristic radiographic finding showing reduced parenchymal transparency with pleural effusion on both sides.

According to the recommendations of the Extracorpreal Life Support Organization, the indications for the use of VV-ECMO are as follows:

1. It should be considered in hypoxic respiratory failure due to any cause when a predicted risk of death is > 50% and is indicated when the risk of mortality is > 80%;
2. CO_2 retention at MVS regardless of high Pplat (> 30 cm H_2O);
3. Severe air leak syndromes;
4. Need for intubation in a patient on lung transplant list;
5. Immediate respiratory collapse [13].

We applied the femoro-femoral VV-ECMO to our patient. High blood flow (4–8 l/minute) and diffusion of gases between the blood and the sweep gas passing through the membranes supply the blood with oxygen and remove carbon dioxide directly from the blood, which allows the use of more protective MVS and thus reduce the frequency of ventilation-induced lung injury [12]. One of the more important roles of ECMO is that, by improving tissue oxygenation, it reduces damage to other organs, primarily reduces respiratory acidosis, and reduces neurocognitive sequelae [12].

In a study conducted by Song et al. [1], 13 out of 2234 patients underwent VV-ECMO after cardiac surgery procedure. The mean time of VV-ECMO placement was about 7.5 days after surgery, which coincides with the time of placement in our patient. In their study, separation from ECMO was successful in nine of 13 patients (69%) and the duration of VV-ECMO averaged 7.2 days, while in our patient, the removal was done on the ninth day of placement, and the patient was on the ECMO treatment for seven days. When the patient is weaned from ECMO, transient hypoxemia may occur. This happened with our patient, and it can be elucidated by the abolition of hypoxic vasoconstriction during ECMO support [14]. In patients who undergo the ECMO procedure, an extended stay in the intensive care unit (ICU) and longer hospital treatment are observed, which is confirmed in our patient, who was hospitalized for 39 days. Although the long-term prognosis after the ECMO administration in ARDS has not yet been sufficiently studied, the patients who underwent ECMO in the Conventional Ventilation or ECMO for Severe Adult Respiratory Failure (CESAR) study had almost the same or better quality of life than those who had ARDS and were treated with conventional therapy. However, in 84 patients who survived the first six months after ECMO, long-term psychological and emotional problems were observed [12].

In March 2020, the World Health Organization declared a pandemic of SARS-CoV-2, which resulted in a globally devastating effect, with over 180 million people being affected and about six million deaths [15]. It is necessary to mention that at the time of the patient's admission to the hospital, there was a large number of patients with the SARS-CoV-2 in our country. Since one of the possible manifestations of this viral infection is the sudden appearance of ARDS, it was suspected that it was a SARS-CoV-2 infection. Therefore, the PCR testing was repeated twice, and the results were negative. Also, it should be emphasized that ARDS caused by infection with this virus has some unique features, but much of the experience with severe respiratory failure in SARS-CoV-2 patients is not different from other forms of ARDS, and it is one of the indications for the VV-ECMO use [16]. Recent studies have shown that in patients infected with the SARS-CoV-2 and treated with ECMO the mortality in the first 60 days was about 31%, and a very similar result was obtained in the ECMO to Rescue Lung Injury in Severe ARDS (EOLIA) study (35% in 60 days) [12]. Although the patient has been PCR- and antigen-tested on several occasions, the SARS-CoV-2 etiology of ARDS could not be ruled out with certainty to date.

In cardiac surgery patients in whom conventional therapy is not effective in ARDS, the use of ECMO should be considered. Although still insufficiently studied, VV-ECMO shows great potential and provides a chance of survival to patients who have a severe form of ARDS, regardless of the etiology.

Conflict of interest: None declared.

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Успешно лечење синдрома акутног респираторног дистреса после хируршке реваскуларизације миокарда применом веновенске екстракорпоралне мембранске оксигенације

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САЖЕТАК

Увод Синдром акутног респираторног дистреса (САРД) једна је од најозбиљнијих компликација у постоперативном периоду кардиохируршких болесника. Веновенска екстракорпорална мембранска оксигенација (ВВ-ЕКМО) показала се као драгоцена терапија код САРД-а када стандардна терапија не може да помогне.

Наш циљ је да прикажемо случај тешког облика САРД-а који је успешно лечен применом ВВ-ЕКМО.

Приказ болесника Болесник стар 54 године хитно је примљен у болницу због инфаркта миокарда антериорне регије. Ургентном коронарографијом нађена је тешка тросудовна коронарна болест, те је начињена хируршка реваскуларизација миокарда троструким аортокоронарним бајпасом. Постоперативно се уочава продужена глобална респираторна инсуфицијенција, те је болеснику постављена дијагноза САРД-а, због чега је пласиран ВВ-ЕКМО. Девет дана после пласирања постигнута је адекватна гасна размена, те је болесник успешно одвојен од ВВ-ЕКМО.

Закључак Код кардиохируршких болесника код којих конвенционална терапија није делотворна за САРД, неопходно је размотрити примену ВВ-ЕКМО.

Кључне речи: кардиохирургија; синдром акутног респираторног дистреса; веновенска екстракорпорална мембранска оксигенација