Successful extracorporeal membrane oxygenation implantation in a patient with isolated postcardiotomy right ventricle failure: a case report

Udane zastosowanie pozaustrojowej oksygenacji membranowej u pacjenta z izolowaną pokardiotomijną niewydolnością prawej komory – opis przypadku



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Kardiochirurgia i Torakochirurgia Polska 2011; 4: 466–468

Abstract

We present a case of a 63-year-old male who developed isolated right ventricle (RV) failure after routine aortic valve replacement (AVR). One hour after the operation, extracorporeal membrane oxygenation (ECMO) circuit was implanted as a temporary right ventricle assist device (RVAD). A few hours after that when ECMO support was established, inotropic support was significantly reduced and metabolic acidosis was corrected. After 42 hours of support, ECMO was successfully removed. The patient was discharged home after 34 days of hospital stay. Pre-discharge transthoracic echocardiography (TTE) revealed good RV and left ventricle (LV) function and normally functioning tissue AVR. Eight months later the patient underwent a successful hip and knee replacement. Three years after his cardiac surgery, the patient remains in New York Heart Association heart failure classification (NYHA) class I.

Key words: right ventricular dysfunction, extracorporeal membrane oxygenation, right ventricle assist device.

Introduction

ECMO is an established and widely reported method in pediatric patients but its use in adults is relatively uncommon and variable results were reported. Acute RV failure is fortunately a rare complication after cardiac surgery [1].

Streszczenie

W artykule przedstawiono przypadek 63-letniego mężczyzny, który przebył elektywny zabieg wymiany zastawki aortalnej z powodu stenozy, po którym rozwinęła się izolowana niewydolność prawej komory. Po godzinie pobytu na oddziale intensywnej terapii u chorego zastosowano pozaustrojowe utlenowanie krwi (ang. extracorporeal membrane oxygenation – ECMO) w celu tymczasowego wspomagania prawej komory serca. Po kilku godzinach od zastosowania ECMO stan kliniczny chorego istotnie się poprawił, umożliwiając znaczną redukcję amin katecholowych i korektę kwasicy metabolicznej. Po 42 godz. wspomagania urządzenie ECMO zostało usunięte. Pacjent po 34 dniach hospitalizacji został wypisany do domu. Wykonana przed wypisem echokardiografia przezklatkowa pokazała dobrą funkcję zarówno prawej, jak i lewej komory serca oraz prawidłowo funkcjonującą biologiczną protezę zastawki aortalnej. Po 8 mies. pacjent przeszedł udaną operację wymiany stawu biodrowego i kolanowego. Obecnie pacjent jest ponad 3 lata po operacji serca i jest w bardzo dobrej kondycji ogólnej, pozostając w klasie I wg Nowojorskiego Towarzystwa Chorób Serca (ang. New York Heart Association – NYHA). Słowa kluczowe: niewydolność prawej komory serca, ECMO, mechaniczne wspomaganie prawej komory serca.

However, once it occurs the mortality rates are very high (65-85%) even if some form of a temporary assist device is employed [1, 2]. ECMO physiologically offloads the RV but potentially does not offload the LV by increasing afterload as a result of the arterial inflow from ECMO circuit [3]. Therefore, ECMO theoretically appears to be an acceptable

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method of a temporary assist device for isolated postcardiotomy RV insufficiency in patients who are resistant to optimized medical treatment.

Case presentation

We present a case of a 63-year-old male who was referred to our department with a diagnosis of severe aortic stenosis (AS) for routine aortic valve replacement. AS was discovered during work up for his knee and hip replacement due to the chronic osteoarthritis. At the time of admission, the patient presented with NYHA class II symptoms, complaining of shortness of breath on moderate exertion for the last two years. He had a history of chronic obstructive pulmonary disease (COPD), chronic osteoarthritis with significantly affected mobility - the patient was using crutches and waiting for orthopedic surgery. Transthoracic echocardiography (TTE) revealed good LV function with ejection fraction (EF) of 55% and moderate concentric LV hypertrophy, calcified aortic tricuspid valve with a maximum gradient across the valve of 65 mm Hg, mean gradient of 40 mm Hg and aortic valve area (AVA) estimated at 1 cm² with mild aortic insufficiency. Coronary angiography revealed normal coronaries with a dominant right coronary system. After detailed discussion with the patient and taking into consideration his future major orthopedic operations, a biological tissue valve implantation was planned.

On 18 August 2008, the patient underwent a routine aortic valve replacement (AVR) and Sorin Soprano size 22 biological valve was implanted using interrupted pledgeted Ticron 2.0 sutures. Routine arterial and venous cannulation was employed to establish cardiopulmonary bypass (CPB). The body was cooled to 32 degrees Celsius (°C), cross clamp time 91 min, CPB time 128 min. Blood cold cardioplegia (4 : 1 at 5°C) delivered. The first dose delivered antegrade and retrograde, then repeated every 20 min retrograde. Satisfactory cardioplegia backflow from both coronary ostia was observed. During CPB weaning, transesophageal echocar-



Fig. 1. Extracorporeal membrane oxygenation (ECMO). (Stockert SCPC System; Sechrist Air-Oxygen gas blender series; 3500 Maquet Jostra heater cooler unit HCU 30)

diography (TEE) showed dilated RV with poor contractility, especially the area of RV free anterior wall was affected. We were able to terminate CPB on high doses of noradrenaline, adrenaline and milrinone with arterial blood pressure (ABP) of 90/58 mm Hg. The patient reasonably tolerated sternum closure and was transferred to the intensive care unit (ICU). Swan-Ganz catheter was inserted at the end of the case in the operating theatre.

In the ICU, the patient continued to deteriorate. Vasopressors and inotropes requirements were increasing, reaching noradrenaline up to 0.23 μ g/kg/min, adrenaline of 0.25 μ g/kg/min and vasopressin of 2.4 units/h. Cardiac index (CI) was measured at 1.8 l/m²/min with ABP 85/55 mm Hg and the patient was in profound metabolic acidosis (ph 7.12). TEE confirmed very poor RV contractility and good contracting LV with no regional wall abnormality and well functioning tissue AVR. After 1-hour stay in the ICU, a decision was made to implant ECMO using peripheral groin cannulation.

Medtronic Biomedicus 21Fr arterial and long 2-stage Medos 26Fr venous cannulae were used for percutaneous right groin cannulation. The right common femoral artery and vein were cannulated. ECMO (Stockert SCPC System; Sechrist Air-Oxygen gas blender series; 3500 Maguet Jostra heater cooler unit HCU 30) (Fig. 1) was established achieving flow of 3.2 l/min with 2100 revolutions per minute (RPM). Activated clotting time (ACT) maintained at 189-224 seconds with heparin infusion. ECMO was closely monitored and maintained by a perfusionist team during the whole time of support. Flow varied from 2.4 to 4.0 l/min. ECMO implantation allowed to significantly reduce inotropic support and to correct metabolic acidosis over several hours. Next morning TEE showed noticeable improvement in RV contractility with good LV function and normally functioning implanted aortic tissue valve. ECMO continued and the patient was gradually improving hemodynamically. 40 hours after ECMO implantation the patient was reassessed with TEE discovering near normal RV contractility and good tolerance of RV loading by reducing ECMO flow to 0.5 l/min. These findings allowed us to take a decision to prepare for weaning ECMO support. After 42 hours of support, ECMO was removed successfully in the ICU setting.

After ECMO removal, CI was measured at 2.5 l/m²/min with ABP of 120/55 mm Hg on 0.02 μ g/kg/min of adrenaline and 0.05 µg/kg/min of noradrenaline infusion. Continuous veno-venous hemofiltration (CVVH) was introduced and used for the next 4 days. The only problem encountered in the ICU besides ECMO was a large hematoma developing in the left brachial fossa after removal of a non-functioning brachial arterial cannula while the patient was heparinized on ECMO. This required left arm fasciotomy followed later by delayed skin grafting. During ICU stay the patient did not require resternotomy. Fifteen units of concentrated red blood cells (RBC), 7 units of fresh frozen plasma (FFP) and 5 pools of platelets were transfused during postoperative course. The patient stayed in the ICU for twelve days and was discharged from the hospital after 34 days. Pre-discharge ECHO showed normal LV and RV function, well seated tissue AVR with a mean gradient of 15 mm Hg. 8 months later the patient underwent a successful knee and hip replacement. Three years later the patient remains in a very good condition, back to his normal daily activities. Annually repeated ECHO showed normally functioning aortic valve with good RV function and LV contractility.

Discussion

Fortunately, pure postcardiotomy RV dysfunction develops rarely [1] but it may occur if retrograde cardioplegia is used and fails to protect RV. Despite numerous advantages of retrograde cardioplegia in the AVR procedure such as reduced risk of coronary embolization and possibility to deliver cardioplegia without interrupting the surgical procedure, it can result in poor distribution of cardioplegic solution in the RV [4]. This can be due to variable venous anatomy of the heart where the anterior wall veins of RV are not drained to coronary sinus but directly to the RV chamber [5]. In these situations, RV protection can be insufficient and the patient may require a temporary assist device to support RV function. RV insufficiency may also occur in patients after pulmonary thromboendararterectomy or large RV infarction.

ECMO was developed and established in 1970-80 mainly in treatment of acute respiratory failure in infants [6]. The development of ECMO as a temporary assist device in postcardiotomy cardiac failure patients was reported in the 1990s. Typical ECMO circuit consists of hollow-fiber oxygenator with an integrated heat exchange system, centrifugal pump and biocompatible heparin bonded bypass circuit. Variable survival rates (20-65%) were published with ECMO support in postcardiotomy heart failure patients [3, 9, 10].

There are a few advantages that may favor ECMO usage in isolated RV failure such as:

- 1. Possibility of a relatively quick and easy ECMO implantation through peripheral cannulation without the need to transfer the patient to the operating theatre and avoid unnecessary delay to introduce the mechanical support. Also ECMO removal can be performed in the ICU setting.
- 2. Unloading RV allowing for restoring its function while the patient's vital functions are safely supported. ECMO reduces LV preload but increases afterload by arterial inflow and may increase LV wall tension; therefore, a good LV function is essential, otherwise IABP should be inserted [11].

- 3. Bleeding and need for re-exploration is still the major problem when the patient is on ECMO. Peripheral cannulation may reduce the need for re-exploration and blood product usage during ECMO support [7, 12].
- Possibility of oxygenation and ventilation control by manipulating CO² and O² exchange in the ECMO circuit. In our opinion, these key features make ECMO a very

attractive method of choice as a temporary RVAD in isolated postcardiotomy RV failure. A multidisciplinary approach with a very good cooperation between the surgeon, perfusionist and anesthesiologist teams are crucial to achieve satisfactory results.

References

- Moazami N, Pasque MK, Moon MR, Herren RL, Bailey MS, Lawton JS, Damiano RJ Jr. Mechanical support for isolated right ventricular failure in patients after cardiotomy. J Heart Lung Transplant 2004; 23: 1371-1375.
- 2. Kitamura M, Aomi S, Hachida M, Nishida H, Endo M, Koyanagi H. Current strategy of temporary circulatory support for severe cardiac failure after operation. Ann Thorac Surg 1999; 68: 662-665.
- Magovern GJ Jr, Magovern JA, Benckart DH, Lazzara RR, Sakert T, Maher TD Jr, Clark RE. Extracorporeal membrane oxygenation: preliminary results in patients with postcardiotomy cardiogenic shock. Ann Thorac Surg 1994; 57: 1462-1468.
- Villanueva FS, Spotnitz WD, Glasheen WP, Watson DD, Jayaweera AR, Kaul S. New insights into the physiology of retrograde cardioplegia delivery. Am J Physiol 1995; 268: H1555-1566.
- Ruengsakulrach P, Buxton BF. Anatomic and hemodynamic considerations influencing the efficiency of retrograde cardioplegia. Ann Thorac Surg 2001; 71: 1389-1395.
- Bartlett RH, Roloff DW, Custer JR, Younger JG, Hirschl RB. Extracorporeal life support: the University of Michigan experience. JAMA 2000; 283: 904-908.
- Pagani FD, Lynch W, Swaniker F, Dyke DB, Bartlett R, Koelling T, Moscucci M, Deeb GM, Bolling S, Monaghan H, Aaronson KD. Extracorporeal life support to left ventricular assist device bridge to heart transplant: A strategy to optimize survival and resource utilization. Circulation 1999; 100 (19 Suppl): II206-210.
- Magovern GJ Jr, Simpson KA. Extracorporeal membrane oxygenation for adult cardiac support: the Allegheny experience. Ann Thorac Surg 1999; 68: 655-661.
- 9. Muehrcke DD, McCarthy PM, Stewart RW, Foster RC, Ogella DA, Borsh JA, Cosgrove DM 3rd. Extracorporeal membrane oxygenation for postcardiotomy cardiogenic shock. Ann Thorac Surg 1996; 61: 684-691.
- Wang SS, Chen YS, Ko WJ, Chu SH. Extracorporeal membrane oxygenation support for postcardiotomy cardiogenic shock. Artif Organs 1996; 20: 1287-1291.
- 11. Kolobow T, Rossi F, Borelli M, Foti G. Long-term closed chest partial and total cardiopulmonary bypass by peripheral cannulation for severe right and/or left ventricular failure, including ventricular fibrillation. The use of a percutaneous spring in the pulmonary artery position to decompress the left heart. ASAIO Trans 1988; 34: 485-489.
- 12. Aranki SF, Adams DH, Rizzo RJ, Couper GS, DeCamp MM, Fitzgerald DJ, Cohn LH. Femoral veno-arterial extracorporeal life support with minimal or no heparin. Ann Thorac Surg 1993; 56: 149-155.