CASE REPORT

USE OF TWO PARALLEL OXYGENATORS IN A VERY LARGE PATIENT (2.76 m^2) FOR AN ACUTE "A" DISSECTING AORTIC ANEURYSM REPAIR

Vladimír Lonský, Jiří Manďák, Jaroslav Kubíček, Martin Volt, Egon Procházka, Jan Dominik

Charles University in Prague, Faculty of Medicine in Hradec Králové and University Hospital Hradec Králové, Czech Republic: Department of Cardiac Surgery

Summary: The very large patient (weight 142 kg, height 197 cm, body surface 2.76 m^2) was referred to acute operation with dissecting type A ascending aortic aneurysm. The calculated blood flow was 6.63 l/min. To anticipate potential difficulties with perfusion and oxygenation two oxygenators connected in parallel were incorporated into the circuit. Bentall procedure with ACB to the RCA was performed. The perfusion was uneventful. Bypass time was 259 minutes, cross – clamp time 141 minutes, circulatory arrest 7 minutes. The highest oxygenators gas flow was 2.6 l/min with maximum FiO_2 0.42. The use of two in parallel connected oxygenators is a very effective, easy and safe method in such extreme perfusions, offering to the perfusionist a great reserve of oxygenator output.

Key words: *Cardiopulmonary bypass; Extra large patient; Two oxygenators*

Introduction

There have been only few reports describing the perfusion of very large patients (2,3,4,5). Despite of relatively very large patients with ischaemic heart disease operated at our department during several last years on (the mean BSA of our patients was 1.92 ± 0.18 m^2) we did not meet such a large patient – body surface 2.76 m^2 – during our practice (more than 25 years). There were several questions to answer before preparing our circuit according body surface and required flow calculation (6.65 l/min).The first concern was the capability of the oxygenator to adequately oxygenate such a large patient, the second was the transmembrane pressure gradient and the third was the oxygenator heat-exchanger output in such high calculated perfusion flow-rates. We have found only one literature case report concerning large patients pefusions, printed in 1994 in The Journal of Extra-Corporeal Technology published by Carole Hamilton from St. Michaels Hospital, Toronto, Ontario, Canada, in our database at the time of this case (3). Author describes a little bit larger patient (BSA 2.88 m^2) perfused successfully in normothermia with two Cobe CML oxygenators in parallel.

On the basis of this article anticipating potential difficulties with perfusion and oxygenation we have decided to use two membrane oxygenators connected in parallel for perfusion in this particular case.

Case History

The patient, 43 year old male, was admitted to our department with a primary diagnosis of acute myocardial infarction, for which he was treated with thrombolytic therapy in one regional hospital. After six hours of ineffective treatment the echocardiography was made and the diagnosis of acute type A dissection of ascending aortic aneurysm was made. He was transferred to our department. Because of his enormous weight and size it was absolutely impossible to place him into the CT scanner. After coagulation correction (1000 ml of fresh frozen plasma and 4 g of fibrinogen) he was transferred to the operating room.

Tab. 1: Patients data.

Age (years)	43 years
Height (cm)	197
Weight (kg)	142
Body surface (m^2)	2.76
Calculated flow (l/min)	6.63

The calculated flow using a cardiac index 2.4 l/min/m^2 was 6.63 l/min. All other patients data are summed in Tab 1. The patient was anaesthetized and surgery started first with incision in the right groin and after heparinization (ACT > 500 s) *(Hemochron, ITC, Edison, N.J.USA),* 22 F arterial cannula (*BARD, Central Avenue Murray Hill, New Jersey, USA)* was introduced into femoral artery (because of a small diameter of the artery). Than sternotomy and a 36/52 F two stage venous cannula, *(DLP-Medtronic, Parkway Minneapolis, MN, USA),* and pulmonary vent *(DLP-Medtronic Parkway Minneapolis, MN, USA),* were inserted. The CPB using Biomedicus centrifugal pump was started, aneurysm resection and Bentall procedure with aorto-coro-

nary bypass to the right coronary artery were performed without any accident.

His postoperative course was characterized by the development of temporary low cardiac output syndrome, ARDS requiring longterm ventilation and renal insufficiency (without the necessity of CVVHD). The patient recover consciousness and for further prolonged ventilation was transferred to the department of anaesthesiology and resuscitation of our hospital on the 6th postoperative day.

Perfusion equipment and perfusion data

The four pump heads Polystan *(Vaerlose, Denmark)* heart – lung console and separate *Biomedicus (Medronic, Minneapolis, MN, USA)* centrifugal pump (not routinely used for all cases at our department) were used for this case. Closed system (routinely used) with two in parallel connected oxygenators Oxim II 34 – Ultra *(Edwards Lifesciences, One Edwards Way Irvine, CA,USA),* one 800 ml venous reservoir, one 4000 ml cardiotomy reservoir *(Edwards Lifesciences,One Edwards Way, Irvine, CA, USA),* and two extra volume storage bags (volume 1000 ml) connected to the venous line were used for perfusion circuit. The 4 : 1 ratio cold blood cardioplegia was used for myocardial protection and cell saver *(Hemonetics, Braintree, USA)* for postoperative blood loss collection.

At the level of the arterial inflow, a Y connector was introduced into the circuit and connected with the oxygenators. The outflow of the oxygenators was joined just beyond the outflow parts (Figs. 1,2). One 40 microns arterial line filter was used. The gas line from the blender was connected with Y connector to both oxygenators.

With the use of two oxygenators we got 4.4 m^2 area of fibres, 2x 0.18 m^2 of heat exchanger surface and approx. 3.4 l/min of blood flow through one oxygenator (Tab. 2).

The system was primed with 1000 ml H1/1, 1500 ml 10% mannitol, 500 ml Rheomacrodex, 350 ml 4.2% $NaHCO_3$, 5000 IU heparin, 1000 mg metylprednisolon,

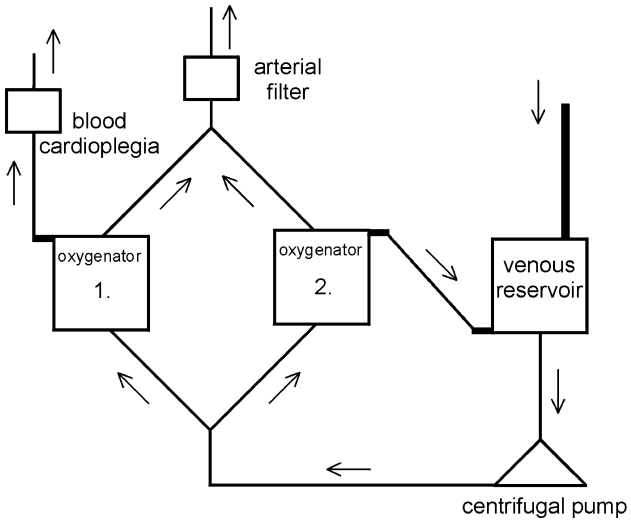

Fig. 1: Drawing of circuit with oxygenators.

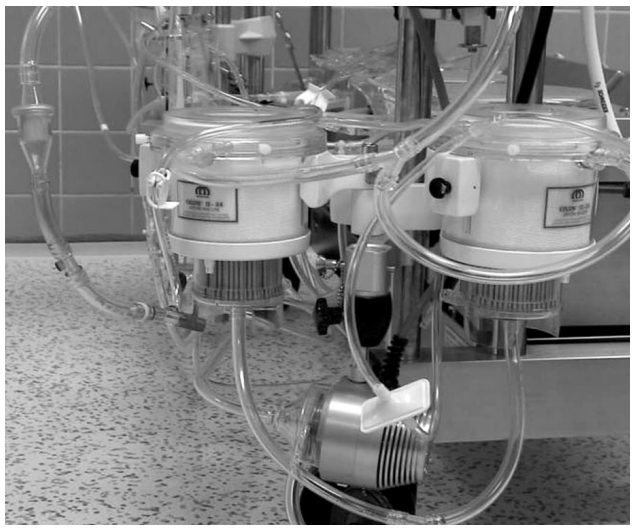

Fig. 2: Picture viewing the position of two oxygenators on HL console prior operation.

Tab. 2: Oxygenator characteristics – OXIM II – 34 Ultra.

Manufacturer	Edwards Lifesciences – (The former Macchi, Engenharia Biomédica LTDA, Av. Santa Catarina, Sao Paulo, Brasil)
Hollow fibres material	Microporous polypropylen
Total surface area (m^2)	2.20
Oxygenator priming volume (ml)	470
Maximum recommended blood flow (l/min)	6
Heat exchanger material	Anodised aluminium
Priming volume of heat exchanger (ml)	80
Surface area of heat exchanger (m^2)	0.18
Maximum O_2 transfer (ml/min)	392
Maximum CO_2 transfer (ml/min)	441
Maximum pressure inlet to outlet drop (mmHg)	120

Tab. 3: Perfusion and laboratory data.

Time of CPB (min)	Gas flow-both oxygen. (l/min)	FiO_2	Temper. oes. (°C)	PH	pO_2 (mmHg)	pCO_2 (mmHg)	pvO_2 (mmHg)	Htc	Perfusion Flowrate (l/min)
05	2.1	0.1	36.1	7.40	200	45	45	0.22	6.8
17	2.0	0.05	29	7.34	219	51	54	0.22	6.8
43	2.2	0.05	26.1	7.34	204	46	48	0.23	6.14
80	2.6	0.18	25.8	7.31	222	45	48	0.22	5.9
115	2.4	0.09	26.7	7.30	188	45	49	0.23	6.7
165	1.7	0.41	33.8	7.27	182	51	36	0.24	6.2

(*SoluMedrol, Pharmacia, Puurs, Belgium),* 1 mil IU trasylol *(Gordox, Gedeon Richter, Hungary).*

We started the perfusion with two oxygenators and did not wait for the first blood gas analysis (4). Complete perfusion data were summarized in the table 3. The perfusion was unpertubed during the entire operation. The pressure in the arterial line did not exceed 350 mmHg during the highest flow rates. There were no problems with the venous return and cooling/rewarming the patient. The bypass time was 259 minutes, the cross-clamp time was 141 minutes with the 7 minutes period of circulatory arrest. The highest oxygenators gas flow was 2.6 l/min with maximum FiO_2 42% (Table 3).

Discussion

The ability to adequately oxygenate a patient on cardiopulmonary bypass (CPB) depends on various factors – haemoglobin concentration, the percentage of haemoglobin saturated with oxygen in arterial blood (SaO_2), cardiac output (CO), oxygen consumption (vO_2), and the affinity of haemoglobin for oxygen. One of the most important factors is also the physical characteristics of the perfusion equipment.

Membrane oxygenators have a fixed oxygen transfer rate and will transfer a specific amount of oxygen to the blood on each pass through the oxygenator, regardless of the venous saturation. The gas transfer rates are determined by the oxygenator manufacturer and listed on the insert with oxygenator. This rates are determined at a rated blood flow. Nowadays the performance of new modern ogygenators allows an oxygen transfer of about 350–450 ml/min. Other information in the pamphlet with the oxygenator are the pressure drop across the membrane, related blood flow, prime volume, surface area and heat exchanger efficiency. On the basis of the formulas measuring O_2 blood values (1) we can determine if a particular oxygenator has the ability to oxygenate a particular patient or to determine if it is functioning up to standard.

In extremely obese patients an oxygen debt may appear at any time during perfusion, particularly after starting bypass, during initial cooling, and during rewarming. The problems can also be expected in case of complete normothermic perfusion. Using perfusion rates above 6 l/min it is necessary to consider also the size of arterial cannula, sufficient venous return, probable high arterial line pressure and the heat exchanger output.

The oxygen demand of this extreme patient should be routinely calculated assuming an average O_2 consumption of 130 ml/min/m^2. The oxygen demand may be decreased with anesthesia or hypothermia (4).

It is also recommend to assess membrane oxygen transfer capacities which are calculated on the basis of arterial – venous oxygen differencies using the following formula (4):

$$O_2 \text{ transfer} = (SaO_2 - SvO_2) \,.\, (1.34 \,.\, Hb) \,.\, (10) \,.\, (\text{blood flow rate l/min})$$

This formula may be used to state the flow rates necessary to deliver adequate oxygen to the tissues if the patient's oxygen consumption has been known or to calculate the capacity of an oxygenator to transfer the oxygen. Arterial blood gases reveal information about gas transfer capabilities of the oxygenator whereas the venous blood gases reveal information about the oxygen extraction of the patient.

According to our experience it is also necessary to implement oxygenators used in normal daily routine to know exact practical limitations of these devices. In these extreme situations we cannot conduct perfusion on the basis of literature data only.

Performing the next case with two oxygenators in future we should change our circuit using **two arterial line filters** and joining the arterial lines beyond the filters.

Conclusion

The use of two in parallel connected oxygenators is a very effective, easy and safe method in such extreme perfusions, offering perfusionist a great reserve of oxygenators output.

Supported by research project MZO 00179906.

References

1. Brodie JE, Johnson RB. The manual of clinical perfusion. 2nd ed. Atlanta, GA: Glendale Medical Corporation, 1997:45–54.

2. Cleland A, Mac Donald J, Mayer R. Normothermic cardiopulmonary bypass in the larger patient. J Extra Corpor Technol 1989;21(1):21–3.
3. Gydax E, Schüpbach P, Carrel TP. Thoracoabdominal Aortic Repair in a 190-kg Patient: Optimized Perfusion With Two Oxygenators. Ann Thorac Surg 2001;71:347–9.
4. Hamilton C. Case study: Use of Two Parallel Oxygenators in a 159 Kilogram Patient During Normothermic Cardiopulmonary Bypass. J Extra Corpor Technol 1993;25(3): 101–4.
5. Hill AG, Lefrak EA. Cardiopulomonary bypass in the massive patient. Proc Amer Acad Cardiovasc Perf 1984;(5):173–6.

Submitted January 2005.
Accepted March 2005.

Doc. MUDr. Vladimír Lonský, Ph.D., FETCS,
University Hospital Hradec Králové,
Department of Cardiac Surgery,
500 05 Hradec Králové,
Czech Republic.
e-mail: vlonsky@seznam.cz