

Case report

Right-left atrium by-pass as salvage treatment for graft failure after heart transplantation

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Abstract

Chronic functional pulmonary hypertension (FPH) secondary to end-stage cardiomyopathy constitutes a risk factor for graft right ventricular failure (RVF) after orthotopic heart transplantation (HTx). A novel form of mechanical assist circuit, the extracorporeal right to left atrium bypass (ECRLAB), has been proposed. Since 1998, at our institution, a total of six patients with FPH who experienced graft RVF after HTx, as ischemic end-stage cardiomyopathy, during the effort to wean from cardiopulmonary bypass, underwent ECRLAB support. There were five men and one woman with a mean age of 55 ± 3.5 years (49–59 years). The Jostra Rota Flow pump was used in five patients and the Bio-Medicus in one. Mean duration of support was 94.3 ± 17.5 h (75–126 h). All (100%) patients were successfully weaned from ECRLAB support. Hemodynamic parameters improved in all patients. Two patients died from cerebral haemorrhage. Four (66.6%) patients were successfully discharged home. ECRLAB could be proposed during HTx in patients with increased preoperative transpulmonary gradient to promote the functional adaptation of the graft and avoid graft RVF, until the decline of pulmonary resistances.

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1. Introduction

Chronic functional pulmonary hypertension (FPH) due to end-stage cardiomyopathy constitutes a risk factor for graft right ventricular failure (RVF) after heart transplantation (HTx). Actually the results of implanting a right ventricular assist device (RVAD) are not encouraging [3–8]. We proposed, as previously reported [1], a novel form of circuit, the extracorporeal right to left atrium bypass (ECRLAB), with the purpose of a central setting of an extracorporeal membrane oxygenator (ECMO).

2. Material and methods

2.1. Implanting criteria

ECRLAB was achieved in case of graft isolated RVF, unresponsive to long reperfusion time and maximal drug therapy (isoproterenol during reperfusion, prostaglandin I₂ and, since 2000, inhaled nitric oxide before weaning from cardiopulmonary bypass, milrinone and other inotropic drugs

in case of little impact of initial therapy). Graft RVF was defined as dilatation and hypocontractility of right ventricle as well as dilatation of right atrium observed in the surgical field and by echocardiography. RVF was characterized by an increased central venous pressure (>20 mmHg), a decreased mean arterial pressure (<50 mmHg), and a decreased cardiac index ($IC < 2 \text{ l min}^{-1} \text{ m}^{-2}$).

2.2. Mechanical support

A centrifugal device, Jostra Rota Flow pump (Maquet Cardiopulmonary AG, Hirrlingen, Germany) and an oxygenator, Quadrox Jostra D (Maquet Cardiopulmonary AG, Hirrlingen, Germany) were used. Only initially a Bio-Medicus pump (Medtronic Inc, Eden Prairie, MN) and an Avecor I-4500-2A membrane oxygenator (Avecor Cardiovascular Inc, Plymouth, MN) were adopted.

The blood circuit tubing was a 3/8 in polyvinyl chloride circuit with a total length of 2.5 m. The cannulation was performed centrally, using the right atrium for venous drainage and the left atrium, between the right pulmonary veins, for arterial return. The employed cannulae were two 28 Fr. wire-reinforced angled venoatrial cannula (Jostra Venous Catheter OD, Maquet Cardiopulmonary AG, Hirrlingen, Germany) for both atria. All the circuit was heparin-coated (Bioline Coating®, Jostra AG, Hirrlingen, Germany).

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The cannulae exited inferior to the medial third of right and left costal margins, thus allowing the sternal closure.

2.3. Management and weaning procedures

Anticoagulation management was based on the protocol proposed by Szefer (activated clotting time within 200 s) [2]. Mechanical ventilation was adjusted at the lowest Fio2 and minute volume possible to minimize barotrauma.

The pump output was decided on keeping the right ventricular (RV) preload to a mean right atrial pressure of 7–8 mmHg, and if higher, a blood withdrawal was preferred to an increase of the blood output. Consequently the pulmonary blood output (PBO) could be physiologically self-regulated. An improvement of RV contractility or a reduction of pulmonary resistance could lead to an increase in PBO. In this case the weaning of the ECRLAB was carried out by reducing the pump output by 10–25% every 1–3 h with concomitant increase of the PBO and decrease of transpulmonary gradient as well. The ECRLAB was stopped and the atrial cannulae were removed by re sternotomy.

Table 1

Demographic data, pre-transplantation cardiac catheterization results, donor characteristics, outcome of mechanical support, and post-support 30-days cardiac catheterization results

	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6
Recipient age (years)	49	56	58	54	54	59
Recipient gender (male)	Yes	Yes	No	Yes	Yes	Yes
ICMP	Yes	Yes	Yes	Yes	Yes	Yes
Previous CABG	Yes	Yes	Yes	Yes	Yes	Yes
TPG (mmHg)	12	13	11	13	12	15
PVR (wood units)	6	7.1	5.3	7	6.4	7.1
Donor age (years)	39	43	46	43	42	40
Donor gender (male)	Yes	Yes	Yes	Yes	Yes	Yes
D/R size match	0.9	1.03	1.01	1.03	1.01	1.04
Total ischemic time (min)	124	181	162	175	178	146
Reperfusion time (min)	170	234	194	220	210	188
Duration of support (h)	82	97	126	92	94	75
Weaned from support	Yes	Yes	Yes	Yes	Yes	Yes
Deceased on support	No	No	No	No	No	No
ReHtx on support	No	No	No	No	No	No
Deceased after support	No	No	No	Yes	Yes	No
Patient discharge from hospital	Yes	Yes	Yes	No	No	Yes
30-Days TPG (mmHg)	11	12	11	—	—	12
30-Days PVR (Woods units)	2.1	3.1	2.4	—	—	3.3

ICMP: ischemic dilative cardiomyopathy; CABG: coronary artery bypass grafting; TPG: transpulmonary gradient; PVR: pulmonary vascular resistance; D/R size match: donor/recipient size match expressed as body height ratio; Htx: heart transplantation.

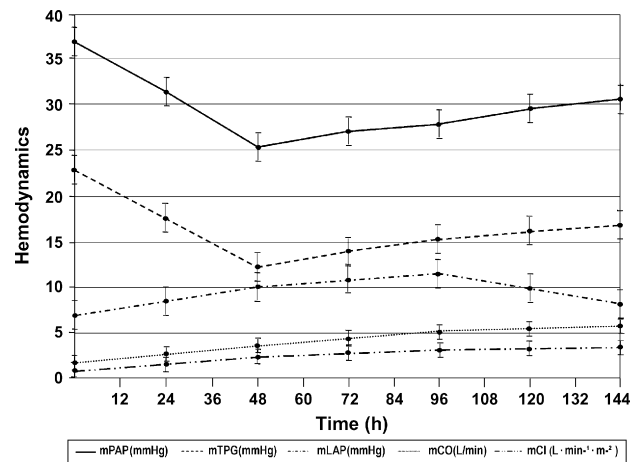


Fig. 1. Hemodynamic trends just before (0 h), during and off (24 h) mechanical support (mean \pm error of the mean). mLAP: mean left atrial pressure; mPAP: mean pulmonary arterial pressure; mTPG: mean transpulmonary gradient; mCO: mean cardiac output; mCI: mean cardiac index.

3. Results

Between January 1998 and December 2006, 312 patients underwent Htx at our institution. Six of them (Table 1), 5 men and 1 woman with a mean age of 55 ± 3.5 years (49–59 years), and preoperative FPH secondary to ischemic end-stage cardiomyopathy, received ECRLAB.

The Jostra Rota Flow pump was used in five patients and the Bio-Medicus in 1. Mean duration of support (Table 1) was 94.3 ± 17.5 h (75–126 h). All patients were successfully weaned from ECRLAB support. Hemodynamic parameters improved in all cases (Fig. 1). Thirty-days cardiac catheterizations reconfirmed the hemodynamic results. No rejections on biopsies were encountered. Patients 4 and 5 died from cerebral haemorrhage. Four (66.6%) patients were successfully discharged home.

4. Conclusions

Reports regarding mechanical support, as treatment of graft RVF after Htx, have generated conflicting results and some authors advocated the use of ECMO to provide a better outcome [3–8].

The conventional circuits, with the inflow cannula in the right atrium and the outflow cannula in the pulmonary artery, could not completely decompress the right heart in case of high pulmonary arterial pressures, presumably because no blood entering the chamber could be ejected across the pulmonary valve.

ECRLAB improved the right-sided pressures, showing that the component of the right ventricular afterload is 'reversible'. ECRLAB appeared as well, by increasing both cardiac output and return to the left atrium and ventricle, to improve end organ function avoiding any eventual multiple organ failure syndrome (MOF). The support provided all of them with a short recovery time.

In summary, the choice of ECRLAB, always employed at our institution as unique mechanical support for isolated RVF, could be advantageous for several reasons. (1) Right

ventricular afterload and right ventricular workload are reduced owing to the assist device working in parallel. ECRLAB makes the systemic and pulmonary circulations independent and provides a good peripheral organs perfusion and a prolonged reduced lung perfusion, thus achieving low pulmonary resistances and a low right ventricle afterload. (2) The mechanical support is easily managed as defining the sufficient minimal flow and establishing a physiological preload of the left ventricle (8–10 mmHg): the pump output can be unchanged until the weaning. (3) The presence of an oxygenator reduces barotrauma during ventilation and eventually offers the possibility to extubate the patients early, as in patients 2, 3 and 6.

In conclusion, after further investigations due to our limited experience, ECRLAB could be proposed during HTx in patients with FPH to promote the adaptation of the graft and avoid RVF, until the decline of pulmonary resistances.

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References

- [1] Arpesella G, Lombardi P, Albanese SB, Mikus PM, Marinelli G, Pierangeli A. Extracorporeal right to left atrial bypass to treat right ventricular failure. *Ann Thorac Surg* 1999;67:246–8.
- [2] Szefer J, Cabrol C. Control and treatment of hemostasis in patients with a total artificial heart: the experience of La Pitié. In: Roque Pi, editor. *Anticoagulation, Hemostasis, and Blood Preservation in Cardiovascular Surgery*. Philadelphia: Hanley and Belfus Inc.; 1993. p. 237.
- [3] Minev PA, El-Banayosy A, Minami K, Koertke H, Kizner L, Koerfer R. Differential indication for mechanical circulatory support following heart transplantation. *Intensive Care Med* 2001;27:1321–7.
- [4] Kavarana MN, Sinha P, Naka Y, Oz MC, Edwards NM. Mechanical support for the failing cardiac allograft: a single center experience. *J Heart Lung Transplant* 2003;22:542–7.
- [5] Moazami N, Pasque MK, Moon MR, Herren RL, Bailey MS, Lawton JS, Damiano RJ. Mechanical support for isolated right ventricular failure in patients after cardiomy. *J Heart Lung Transplant* 2004;23:1371–5.
- [6] Taghavi S, Zuckermann A, Ankersmit J, Wieselthaler G, Rajek A, Laufer G, Wolner E, Grimm M. Extracorporeal membrane oxygenation is superior to right ventricular assist device for acute right ventricular failure after heart transplantation. *Ann Thorac Surg* 2004;78:1644–9.
- [7] Chou NK, Chi NH, Ko WJ, Yu HY, Huang SC, Wang SS, Lin FY, Chu SH, Chen YS. Extracorporeal membrane oxygenation for perioperative cardiac allograft failure. *ASAIO J* 2006;52:100–3.
- [8] Leprince P, Aubert S, Bonnet N, Rama A, Leger Ph, Bors V, Levasseur JP, Szefer J, Vaissier E, Pavie A, Gandjbakhch I. Peripheral extracorporeal membrane oxygenation (ECMO) in patients with posttransplant cardiac graft failure. *Transplant Proc* 2005;37:2879–80.