Rescue mechanical circulatory support for failing transplanted hearts

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Keywords: Heart transplantation • Graft failure • Extracorporeal membrane oxygenation • Ventricular assist devices

It is indeed a rewarding experience for transplant surgeons when the donor heart, after being weaned from the cardiopulmonary bypass, beats in sinus rhythm, with satisfactory haemodynamics, and has excellent biventricular function as assessed by transoesophageal echocardiography, the chest is closed and the patient returns to the intensive care unit for postoperative monitoring and recovery.

Conversely, it becomes a humbling and indeed terrifying experience when, while waiting expectantly, we find that the transplanted heart does not contract, but we observe an echocardiogram showing arrhythmias, which herald impending cardiac failure [1]. When this happens, we may have a recipient who cannot be weaned from cardiopulmonary bypass despite maximal medical management, or the donor heart may begin to fail on the intensive care unit, which may end in graft failure during his/her hospital stay.

Why does the transplanted heart fail? It is believed to be largely due to the mechanism of ischaemia-reperfusion injury. Graft failure may result from long ischaemic times, inadequate myocardial preservation at the time of procurement, hyperacute rejection, which is extremely rare, or poor adaptation of the graft to the recipient's haemodynamic environment. It may also be caused by donor heart hypertrophy, coronary artery disease, air embolism and the neural influence of the donor's brain death. In children, it may be due to increased pulmonary vascular resistance either as a consequence of left ventricular (LV) failure or as a result of single ventricle physiology, resulting in the risk of right ventricular failure after transplantation [2].

Primary graft failure is a severe cardiac dysfunction of the cardiac allograft without obvious anatomical or immunological causes [2], characterized by hypotension, high filling pressures, and refractory low-cardiac output, and mostly right ventricular failure after coming off the cardiopulmonary bypass.

Measures aimed at decreasing pulmonary vascular resistance after transplantation include the use of inhaled nitric oxide as well as medications with pulmonary vasodilator effects such as prostacyclin and milrinone. Graft ventricular function is also supported postoperatively with inotropes. However, despite these interventions, ventricular failure may persist, and mechanical circulatory support (MCS) then becomes necessary.

Prior to the introduction of MCS, primary graft failure was fatal except in isolated cases where emergency salvage retransplantation, sometimes after prolonged periods of extracorporeal circulation, was attempted, but the outcomes of this strategy were poor [3], and it has, therefore, been seldom applied.

With the advent of MCS devices, hopes of rescuing failing transplanted hearts have been resurfacing. Presently, we offer support either with extracorporeal membrane oxygenation (ECMO) or with ventricular assist devices (VADs), depending on whether recovery can be expected or retransplantation is anticipated.

It is very important to implement early MCS to avoid potentially irreversible graft injury if medical therapy does not result in cardiac improvement. Among univentricular devices, the intra-aortic balloon pump and right and left VADs have been used with different outcomes. ECMO is indicated when graft failure is due to a biventricular dysfunction. It provides a means of supporting the function of organ systems and allows the freshly transplanted heart to work under less stressful conditions.

ECMO, the logical protégé of extended extracorporeal circulation, and a well-established technique in the treatment of post-cardiectomy shock, has therefore become an established therapeutic modality for early graft failure as a bridge to graft recovery after transplantation. Improved ECMO technology has made it the 'short-term' mechanical assist device of choice in this setting. With ease of insertion and versatility, ECMO allows circulatory support and improved gas exchange, has the advantage of providing both right and LV support and can be implanted promptly in the operating room and in the intensive care unit. It is commonly applied in patients who cannot be weaned from cardiopulmonary bypass and in those who suffer cardiac arrest after transplantation, due to either pulmonary graft failure or later in the course of severe acute rejection. It provides decompression of the failing transplanted heart until antirejection medications take effect. ECMO allows full haemodynamic support until ventricular recovery occurs in all patients, whether it is a question of primary graft failure or of resolving donor ventricular dysfunction. Patients who receive a heart from an extended criteria donor (marginal donor) who may have had preceding impaired LV function or prolonged ischaemic time, and from older donors, have been reported to benefit from planned ECMO after the transplant [4]. The utmost consideration to use MCS rather than ECMO in this group is the severity of cardiac failure and secondary organ function.

Other short-term VADs are now available that have the advantages of LV decompression, lower anticoagulation requirements and the opportunity to proceed with extubation.

If clinical recovery seems unlikely and/or the patient is a good candidate for retransplantation, consideration of converting to VAD support is reasonable if longer duration of support is anticipated.
Given the challenges of donor shortage and the increased risk of transplantation after mechanical assistance, the decision to list for retransplantation should be reserved for those patients who are deemed to be good candidates for this option. Given our own personal experience, we believe that, particularly for patients in whom the LV function is preserved but there is a right ventricular issue with borderline pulmonary artery pressures and pulmonary vascular resistance, the use of ECMO is a valuable bridge to recovery strategy in those who have had heart transplant with graft failure-related low-cardiac output. Its use for >5 days can still result in a successful outcome.

The paper by Perri et al. [5] on the outcome of extracorporeal life support after paediatric heart transplantation describes a very interesting experience of early (time of transplant to 30 days post-transplant) and late graft failure (>30 days to 14 months post-transplant) and one that should be of great interest to all centres performing heart transplantations in children. This series reminds us that the total ischaemic time continues to be important and that hyperacute rejection is rarely a cause of primary graft failure in an immediate post-transplant period. The 66% survival rate in an extraordinarily complex group of patients is quite good, but there remains room for improvement. In particular, the fact that 46% (7/15) of children were successfully weaned from ECMO with recovery of graft function and 85% (6/7) of them were discharged alive is very encouraging. However, it would be very interesting to know how many remain alive over a certain period of time. That the authors’ use of extracorporeal support was able to bridge 28% to retransplantation is also remarkable. It would have been fascinating to know the time duration of support before this happened.

As mechanical support technology improves and progresses over time, one would anticipate that the results of postoperative ECMO support to rescue failing transplanted hearts would continue to improve. The other support systems that have evolved to become equally important in the rescue of failing allografts are the VADs, which continue to be miniaturized and improved and hence have been added to our post-transplant armamentarium.

**Conflict of interest:** none declared.

**REFERENCES**


