JECT. 2006;38:157–160
The Journal of The American Society of Extra-Corporeal Technology

Case Reports

Modification of a Biventricular Assist Device to Facilitate Preservative Infusion and Organ Recovery in a Nonheart-Beating Donor

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Abstract: A 46-year-old patient supported by a biventricular assist device (BiVAD) was transferred to our institution for evaluation for heart transplant. The patient was found to have a large intracranial hemorrhage with profound deterioration of neurologic status. The poor prognosis prompted the decision to withdraw care and pursue organ donation. Because the patient did not meet brain death criteria, nonheart-beating donor organ donation was pursued. After the termination of care, the BiVAD was modified: the left side to provide organ preservative solution and the right side to allow drainage. Eight liters of cold University of Wisconsin solution were pumped systemically over 10 minutes, the donor was drained, and the liver was harvested. This technique expedited donor perfusion by eliminating the need to cannulate, minimizing ischemic time for the liver. Although the recipient outcome was poor, and retransplantation was eventually necessary, we believe it was most likely not attributable to the quality of organ preservation. This report discusses the technical aspects of this potentially beneficial procedure. **Keywords:** ventricular assist device, nonheart-beating donor, organ preservation, transplant. *JECT. 2006;38:157–160*

The growing disparity between the number of patients awaiting organ transplantation and the number of available donors continues to increase. This has prompted the use of expanded criteria donors, including nonheart-beating donors (NHBDs).

Currently, in the United States, the legal definition of death can be met by two different sets of criteria: cessation of cardiopulmonary function or cessation of whole brain function. Since the mid-1970s, when brain death became legally accepted within the United States, cadaveric organs have been primarily obtained from brain dead donors. In contrast to deceased donors, the NHBD must sustain loss of cardiopulmonary function to be declared dead, after which organ recovery can begin. In the United States, in general, these are individuals with severe irreversible neurological injury who do not meet the criteria of brain death. Next of kin have decided to withdraw care and have also given consent for organ donation. Organ donation may not take place until the patient undergoes cardiopulmonary arrest, and the donor is declared dead. The withdrawal of care is usually a planned event, typically taking place in the intensive care unit (ICU) or operating room, with a surgical team nearby and ready to recover the organs.

There is a further classification made between two types of NHBDs: controlled and uncontrolled. Controlled donors are hemodynamically stable individuals who are ex-

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The senior author has stated that authors have reported no material, financial or other relationship with any healthcare-related business or other entity whose products or services are discussed in this paper.

tubated in the operating room or ICU after a decision by the patient's next of kin to withdraw care and provide consent for organ donation. This is a planned event in which the donor surgical team is present to recover the organs rapidly, therefore limiting warm ischemic time. Uncontrolled donors, as the name implies, are individuals in whom the cessation of cardiopulmonary function is an unplanned event. This group consists of individuals who sustain cessation of cardiopulmonary function before arrival to a hospital, within the emergency department, or as hospital inpatients (1). NHBDs potentially represent an important option for expanding the organ pool. By some accounts, controlled NHBDs may increase the donor pool by as much as 25% (2).

Ventricular assist devices are increasingly being used to support the failing heart until a cardiac transplant becomes available. One such device used commonly is the Abiomed BVS 5000 (Abiomed, Inc., Danvers, MA). Organ recovery from donors with a ventricular assist device has been reported (3), but to our knowledge, the device has not been used as a means of perfusing the donor with preservation solution. We describe the technical aspects of an organ recovery where the donor's biventricular assist device (BiVAD) was used to expedite the in situ flush.

DESCRIPTION

The patient was a 46-year-old man with a history of hypertension, hyperlipidemia, and tobacco abuse who presented to an outside hospital with an acute anterior wall myocardial infarction and cardiogenic shock. The coronary angiogram showed 99% occlusion of the left main coronary artery, 95% occlusion of the left anterior descending, and 80% occlusion of the right coronary artery. The ejection fraction was 19%. The patient was intubated for hemodynamic instability, placed on an intra-aortic balloon pump, and underwent an emergent three-vessel coronary artery bypass graft (CABG). His postoperative course was marked by the need for vasopressors, the development of acute renal failure, and an acute but transient elevation of intrinsic liver enzymes as measured in his serum. Six days after CABG, the patient required the placement of an Abiomed BVS 5000 BiVAD. He was transferred to our institution for emergent heart transplant evaluation.

Shortly after the patient was transferred, it was noted that he was not moving his extremities. A computed tomography scan of the head was obtained, which showed a large intracranial hemorrhage. The patient's neurologic examination deteriorated with the development of decorticate posturing. Given the poor prognosis, next of kin chose to withdraw care and pursue organ donation. Because the patient did not meet formal brain death criteria, next of kin chose to pursue NHBD organ donation.

NHBD organ donation took place according to our institutional and local organ procurement organizational protocols. These followed the guidelines outlined by Institute of Medicine and Society of Critical Care Medicine (4). The donor had been on systemic anticoagulation for BiVAD support. Before the removal of BiVAD support from the patient, two separate circuits were constructed. The first circuit, the "perfusate" circuit, consisted of a cardiotomy reservoir connected to 3/8" tubing. This served as the holding reservoir for the University of Wisconsin (UW) solution. Assembly and priming was performed using aseptic technique. The outflow from the left atrium to the left ventricular assist device (LVAD) was interrupted. The second, or "drainage" circuit, consisted of dividing the right atrial return to the right ventricular assist device (RVAD) and using the right atrial cannula to drain the blood and perfusate from the donor.

When care was withdrawn, concurrent with extubation, the BiVAD was turned off. The right and left sides of the VAD were clamped, and a cut was made between the left atrial inflow cannula and the inflow to the pump. Using sterile technique, an air-free connection was made between the "perfusate" circuit and the inflow to the LVAD. The RVAD was cut between the right atrial (RA; inflow) cannula and the pump. Using sterile technique, the RA cannula side was attached to the "drainage" circuit (Figure 1). Both of these connections required a total of approximately 2 minutes to make.

After the patient was pronounced dead, a 5-minute waiting period was observed before initiating the organ recovery. This follows the recommendations of the Institute of Medicine to ensure there is no return of spontaneous cardiopulmonary activity. During this period, the

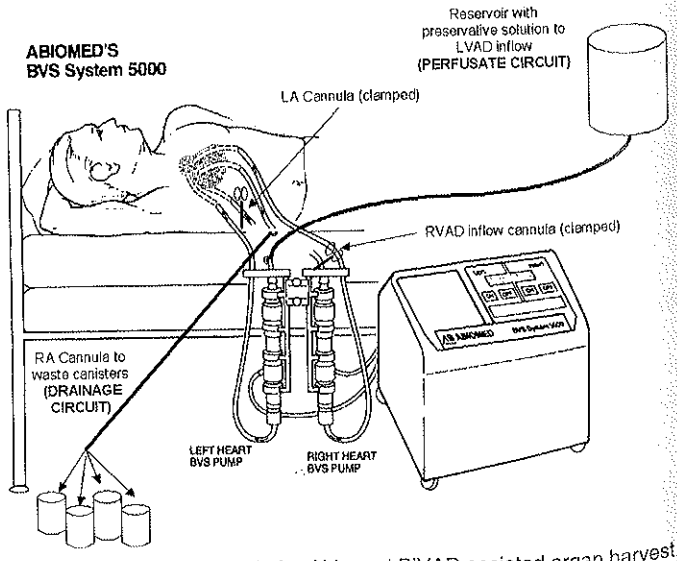

Figure 1. Circuit schematic for Abiomed BiVAD assisted organ harvest (reprinted with permission). LA, left atrial; LVAD, left ventricular assist device; RA, right atrial; RVAD, right ventricular assist device.

reservoir in the perfusate circuit was filled with cold UW solution (3–10°C). Once 5 minutes had elapsed, the clamps were removed from both perfusate circuits, and UW solution was allowed to flow through the pump by gravity. The clamp was removed from the drainage circuit, and controlled exsanguination (into waste canisters) began. The surgical team made a midline abdominal incision after the mandatory 5-minute waiting period was completed. The distal aorta was cross-clamped to prevent perfusion of the lower extremities and unnecessary dilution of the perfusate solution. The inferior mesenteric vein was cannulated for portal perfusion. The LVAD side of the Abiomed console was turned on in wean mode, and pumping began at the minimum allowed (2 L/min). This was determined to be too fast, and a partial occluding clamp was placed on the outflow of the pump to slow the flow down to approximately 1 L/min. Topical cooling of the donor organ was performed simultaneously with the perfusion. A total of 8 L of UW solution were pumped through the patient in approximately 10 minutes. This was deemed adequate, and the pumped was stopped. After allowing the patient to completely exsanguinate, the circuit was removed. After the systemic flush through the BiVAD cannulas and the portal flush were completed, recovery of the liver took place. The liver appeared to have a good color and texture.

The recipient of this liver was a 64-year-old woman with end-stage liver disease secondary to hepatitis C cirrhosis. The hepatectomy portion of the recipient operation was uneventful. The cold ischemic time was 8 hours, 52 minutes, and the anastomotic time was 38 minutes. However, on portal reperfusion, the liver became swollen and congested, which was suspicious for hepatic venous outflow obstruction. The portal vein and inferior vena cava were reclamped, and the suprahepatic anastomosis was opened. No outflow obstruction was noted. This took only a few minutes, and on removal of the clamps, the liver improved, but was still firm and edematous. The recipient hepatic artery was evaluated and found to be only 2–3 mm in diameter, and the pulse in the native celiac artery was poor. In addition, the donor iliac vasculature was too atherosclerotic to be used for a graft. The donor celiac artery with aortic cuff was therefore anastomosed to the supraceliac aorta. The liver failed to function, and the patient was relisted and eventually retransplanted.

DISCUSSION

The growth of liver transplantation activity has been affected by the shortage of organ donor supply and has resulted in an expansion in the number of patients on the waiting list. This disparity between supply and demand has led to the search for new donor sources such as split-liver transplantation, live donation, and expanded-criteria donors to help alleviate the organ shortage. The use of expanded criteria organs has become the norm in many transplant centers. By some estimates, controlled NHBDs may increase the donor pool by 25%, with an even greater potential if one considers the use of uncontrolled donors.

Several authors have reported the use of organs from NHBDs including kidney (5), liver (1,6), and pancreas (7). Recent data showed that kidneys allografts from NHBDs have graft survival rates comparable with brain dead donors (4). Among recipients of a hepatic allograft, the data are not as mature, with the results in some single center studies comparable with those with organs recovered from brain dead donors (8). Other centers, however, have reported inferior results (5). United Network of Organ Sharing (UNOS) data suggest that the rate of primary nonfunction is around 8%, and graft failure is significantly linked to ischemic time.

Another potential problem in the use of NHBDs is the effect of inadequate in situ perfusion. Typically, our institution uses a rapid, in situ cannulation technique [the "superrapid" technique previously described in the literature (9)] for harvest in a NHBD. Theoretically, potential problems with this procedure include prolongation of ischemic time (because of cannulation) and complications arising from the technique itself. It has been described in the literature (10) that inadequate/ineffective in situ perfusion results in a high rate of primary nonfunction. The technique used in this report reduces the period of ischemic time (by eliminating the time required for cannulation) and the potential for complications arising from cannulation.

To our knowledge, there has been one reported case of an organ recovery from a donor on a LVAD (2). Unlike the case reported here, the LVAD was not used to pump the perfusate. Our report describes the technical feasibility of using the assist device as a means of expediting donor perfusion by eliminating the need to cannulate, thus minimizing warm ischemic time. While we have shown the technical aspects of this procedure, given the poor outcome with this graft, caution may be in order. Although possible, we doubt that the infusion pressure of the preservation solution, achieved by the LVAD, had a negative impact on the donor organ. Intrahepatic pressure monitoring is not typically performed during the organ flush. Additionally, we felt that the temperature of the perfusate solution was adequately cold, and with the rapid rate of delivery, the efficacy of the preservation would not have been compromised by warming caused by the donor's body temperature. We surmise that the poor graft function was related to a combination of factors that include 1) physiologic events that occurred in the donor before withdrawal of care (the donor had a significant ischemic insult as reflected by his anuric state and elevated intrinsic liver enzymes), 2) reclamping of the liver after reperfusion, and 3) delay in completion of the arterial anastomosis.

While the case reported here represents a unique clinical situation in which an organ donor also happens to have a BiVAD, it is not unreasonable to believe that this clinical scenario may occur with greater frequency. The number of patients receiving VADs as a treatment modality for either bridge to transplant, bridge to recovery, or bridge to bridge continues to increase every year. One of the many complications associated with these VADs is intracranial hemorrhage (11). Many times, these patients have salvageable organs. These controlled NHBDs could make a small contribution toward alleviating the disparity between the number of patients listed for organ transplant and the number receiving them.

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