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LETTER FROM THE FRONTLINE

One Donor, Two Types of Preservation: First Description of a Donation After Circulatory Death Donor With Normothermic Abdominal Perfusion and Simultaneous Cold Perfusion of Lungs

Received March 17, 2014; accepted April 17, 2014.

TO THE EDITORS:

Despite the success of liver transplantation using organs retrieved from donation after circulatory death (DCD) donors, increased perioperative morbidity and mortality rates remain an issue. The inferior outcomes of DCD grafts are attributable solely to the variable donor warm ischemia beginning at the time of treatment withdrawal.[1] Data have confirmed that the super-rapid technique described for DCD organ procurement is not able to counteract the negative effects of warm ischemia; hence, there is a need for novel strategies for procuring DCD organs.[2,3]

Normothermic regional perfusion (NRP) using autologous blood is an exciting option for the uncontrolled DCD setting, where it has been successful in maintaining the viability of intra-abdominal organs.[4] NRP allows the recovery of abdominal organs damaged by donor warm ischemia, the study of organ dysfunction, further pharmacological interventions, and research with the eventual objective of increasing the safety and utility of organs from DCD donors. Promising results of transplantation using machine-resuscitated DCD liver grafts have been published,[5,6] and this undoubtedly will provide an additional source of grafts. Similar techniques have been tested in controlled DCD donors (Maastricht category III) by a limited number of centers, but the techniques in all these cases have involved precannulation (before treatment and, ultimately, death) for the input and output sources of the extracorporeal oxygenation device. Precannulation requires legal and ethical clearance not entertained by many countries and, therefore, limits the applicability of NRP. The alternative is to perform rapid cannulation after the certification of death; this maintains some features of the super-rapid technique, namely, the rapid thoracolaparotomy and the prompt access to the aorta and vena cava for cannulation.

Recent evidence suggests the functional superiority of DCD lungs over lungs obtained from donation after brain death donors. However, the applicability of NRP to combined thoracic and abdominal multiorgan retrieval may be complicated, and it may require the coordination of complex surgical steps. Therefore, the procurement of lungs from DCD donors while in situ NRP of abdominal organs is being performed appears to be a valid option for retrieving all suitable organs. Here we present a technical note for a case in which the lungs were procured after cold perfusion while NRP of the abdominal organs was being performed. This allowed optimization of the quality of the DCD liver graft, and similar outcomes would also be expected for kidney grafts. This complex surgical scenario has not been described in the surgical literature before.

TECHNICAL ASPECTS OF ORGAN PROCUREMENT

The withdrawal of treatment from the potential donor was performed in the anesthesia room according to previously published guidelines. From the time of the withdrawal, 16 minutes elapsed before cardiac death was declared and the patient was transferred onto the table.

Laparotomy and Intra-Abdominal Vascular Access

After midline thoracoabdominal incision, the peritoneal cavity was accessed. The steps for isolation of the aorta

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The normothermic regional perfusion (NRP) was approved by the Novel Therapeutics Committee of the Queen Elizabeth Hospital Birmingham.

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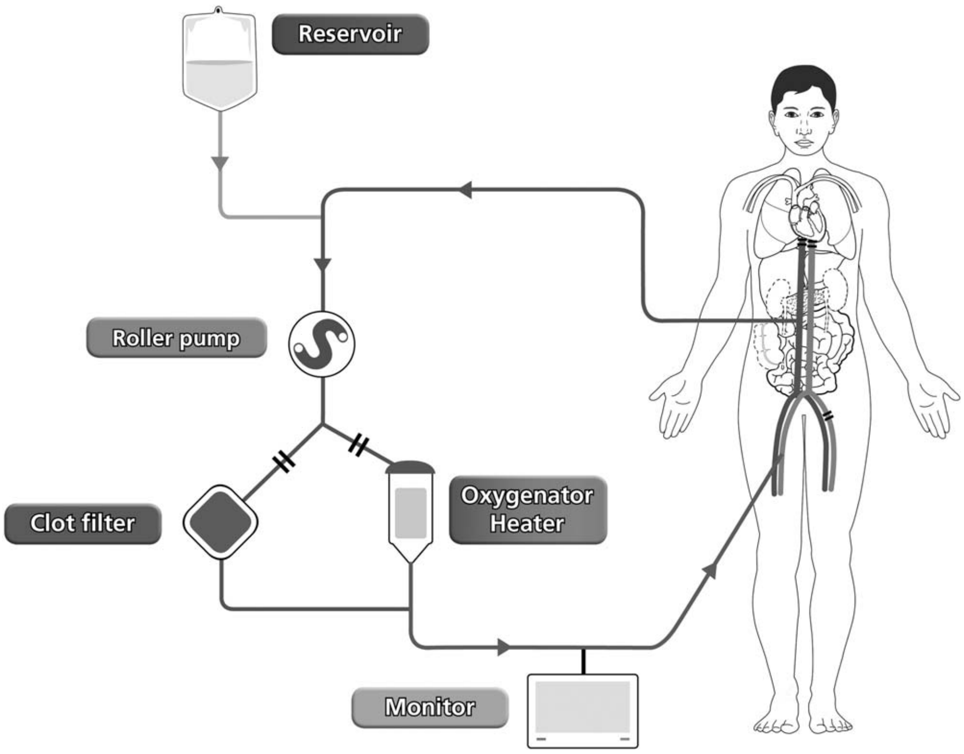

Figure. 1. Birmingham circuit used for NRP. Grey lines indicate oxygenated blood, black solid lines indicate venous blood returning to the circuit, and short parallel bars indicate places where cross-clamps are applied to isolate the circulation. The blood bypasses the oxygenator during the first 2 cycles and is routed via the clot filter to trap blood clots.

and cannulation were similar to those for standard organ procurement from DCD donors; however, the dissection was performed with electrocautery to minimize blood loss. The aortic cannula was then connected to the output source of the extracorporeal membrane oxygenation (ECMO) device, which delivered oxygenated blood to the isolated intra-abdominal compartment (Fig. 1). A larger diameter (20-gauge or greater) provided a flow sufficient for organ perfusion. The inferior vena cava was then identified immediately to the right of the aorta, and a purse string was placed before the introduction of the venous cannula. The venous cannula providing the inflow to the device should also have a wider caliber to prevent low-flow NRP problems. The importance of these 2 vital steps is manifold, and technical failures may lead to unsuccessful and failed ECMO circuits. Preventing leaks around both cannulae prevents circuit failure. In this case, both aortic and vena cava cannulation was completed within 10 minutes of the declaration of death, and this included the transfer and preparation time.

Thoracotomy and Aortic Control

Early cross-clamping of the supradiaphragmatic aorta prevented perfusion of the heart and brain with oxygenated blood in accordance with British Transplantation Society DCD guidelines. This step had to be performed before the circulation was recommenced with NRP, and it was performed in the left hemithorax in a fashion similar to the traditional super-rapid technique. Total exclusion of the abdominal vascular compartment was ensured by the placement of a cross-clamp across the intrapericardial inferior vena cava. The cardiothoracic team began dissection of the lungs with mobilization and evisceration of the heart, which was intended for valve/tissue donation in this case, without the use of electrocautery. This was followed by the procurement of lungs for transplantation.

Beginning of NRP Circulation

The NRP circulation was started once the thoracic aorta cross-clamp was in place. The overall warm ischemia time was 29 minutes before the commencement of NRP. The initial 2 cycles of NRP circulation needed to be run through the filter (rather than the membrane oxygenator itself) to trap blood clots. In this particular case, the temperature was set at 36.1°C with an oxygen concentration of 40%. The target flow through the ECMO device was 2.5 L/minute.

Volume Loss and Poor Flow to the ECMO Device

One of the technical aspects identified for this combined organ procurement was the volume loss through bleeding into the chest. This occurred despite the isolation of the supradiaphragmatic vena cava and the descending aorta in the chest, and continuous oozing from the divided intrathoracic blood vessels was thought to be the reason. As a result, an initial infusion of volume with cross-matched, group-specific blood and volume expanders was required. Significant volume loss occurred through the cut azygous vein, and this required the application of clamps and hemostatic control. Further blood loss in the chest through numerous blood vessels required the application of several clamps to all major and minor bleeders. This was not anticipated in the original planning; however, flow problems in the circuit were addressed without delay in order to maintain successful perfusion pressure for the abdominal organs.

Flow and Perfusion Pressure Monitoring

A peripheral arterial cannula was introduced into the abdominal aorta to monitor abdominal perfusion pressures. We expected a target perfusion pressure of 100 mm Hg before this procedure; however, this was not achieved immediately because of the loss of perfusion volume.

Organ Function During NRP

Successful perfusion of the organs could be witnessed during the NRP procedure through the color of the organs. The peristalsis of the small intestine was visible throughout the procedure. Urine production was also noted. The standard duration of 90 to 120 minutes was believed to be satisfactory for the revival of the abdominal organs from the warm ischemia damage. For the monitoring of liver function, the aspartate aminotransferase, alanine aminotransferase, and glucose concentrations were sequentially monitored along with the blood gas analysis performed at half-hour intervals. The lactate clearance and acid-base status of the deoxygenated blood returning to the ECMO circuit were helpful in determining the suitability of the liver for transplantation.

Abdominal Organ Procurement

The abdominal organ procurement was conventional and was performed in the super-rapid fashion at the end of NRP. Division of the bile duct, bile flushing, and procurement of the liver followed by the bilateral kidneys were performed in that order.

Graft Outcomes

The bilateral lung, liver, and bilateral kidney grafts were successfully procured and transplanted into 4 recipients; a detailed account of the outcomes of these grafts is beyond the scope of this letter explaining the technical aspects of organ procurement. All NRP-revived abdominal grafts, the liver graft, and the 2 kidney grafts demonstrated primary function.

DISCUSSION

Although ECMO-assisted organ procurement and transplantation have been reported in the literature[7] and have predominantly involved Maastricht category II donors, the advantages of applying this technique to controlled DCD donation from category III donors are manifold. Category II DCD organ transplantation has limited applicability, with only a handful of centers using this technique. Meanwhile, liver and kidney transplantation and even pancreatic transplantation are well established with category III donors. To determine the potential of this in situ NRP procedure to revive organs from donor warm ischemia and to facilitate decisions regarding transplantability, data need to be accumulated through the wider application of this procedure. We believe that the future of DCD organ transplantation will be centered on measures beyond conventional super-rapid organ procurement, and they may encompass NRP, ex situ perfusion, pharmacological modulation, and even a combination of new strategies. Equally, the transplant community requires the rapid dissemination of knowledge on technical advances or breakthroughs for the progression of the field. The technical aspects described here are meant to provide guidance for the development of NRP at other centers. The technique described in this letter is probably the single surgical technique that allows the procurement of both thoracic and abdominal organs while abdominal organs are being supported by NRP.

The experience from this case will also help to determine further refinements to the NRP technique. The use of electrocautery throughout the procedure may be helpful in preventing blood loss. Isolated single-limb perfusion can probably be performed more quickly than the placement of purse-string sutures over the aorta and inferior vena cava. The right common iliac artery, because of its superficial course in comparison with the left artery, may be suitable for introducing the aortic cannula. The right common iliac vein has a deeper course, so its isolation may be more challenging; however, it provides alternative access. We believe that the feasibility and success of simultaneous thoracic and abdominal organ procurement with normothermic in situ perfusion further expand the horizon of solid organ transplantation with organs from DCD donors; furthermore, organ resuscitation through this procedure may allow the relaxation of warm ischemia time limits set for the acceptance of DCD liver grafts.

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