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Masters of Cardiothoracic Surgery

# Normothermic regional perfusion and donation after circulatory death heart-lung procurement

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## Clinical vignette

In April 2023, the first Italian protocol for heart transplantation (HT) following donation after circulatory death (DCD) was implemented, which includes a mandatory stand-off period of 20 minutes for the confirmation of circulatory death (1). This currently represents one of the longest stand-off periods worldwide (2), however, promising early results of DCD HT have been reported using grafts with such a prolonged warm ischemic time (WIT) to further expand the donor pool (1,3,4).

A 22-year-old male with unremarkable medical history was involved in an accidental trauma, including multiple cranial fractures. Despite a decompressive craniotomy, the brain injury was severe, without meaningful recovery. Since criteria for brain death were not met, after family consent, the patient was considered a potential donor for DCD multi-organ procurement. We describe the technique for DCD heart and lung procurement using normothermic regional perfusion (NRP).

## Surgical techniques

### Preparation

Transthoracic echocardiography is used to confirm normal biventricular function and dimensions, absence of wall motion anomalies, valve dysfunction or ventricular hypertrophy and, coronary angiography is performed to rule out clinically significant coronary lesion (if the donor is ≥45 years old or has risk factors for coronary artery disease). A clear chest radiograph, no signs of lung trauma, aspiration, or infection, no purulent secretions at bronchoscopy, and a partial oxygen pressure >300 mmHg at 100% inspired fraction of oxygen are major criteria for lung eligibility for donation. The donor is brought to the operating room; analgesia and sedation are given using propofol, sufentanil and sevoflurane. One 7fr femoral venous and two femoral arterial (7fr and 12fr) vascular sheaths are inserted, to allow for rapid initiation of peripheral cardiopulmonary bypass (CPB) and for positioning aortic endo-clamp in the descending aorta, after declaration of circulatory death.

### Exposition

Immediately before withdrawal of life support (WLS), heparin (300 IU/kg), N-acetyl-L-cysteine (150 mg/kg), and methylprednisolone (15 mg/kg) are administered. Subsequently, WLS is performed and once systolic blood pressure is <50 mmHg, the WIT is counted. After 20 minutes of asystole circulatory death is declared. Subsequently, the femoral venous and arterial vascular sheaths are used to percutaneously insert a femoral vein cannula and a femoral arterial cannula. At the same time, the second femoral arterial vascular sheath (12fr) is used to advance an aortic endo-clamp in the descending aorta below the origin of the left subclavian artery under transesophageal echocardiographic guidance. The endo-clamp is inflated and peripheral CPB is initiated, establishing an abdominal

NRP. The CPB circuit is primed with two units of red blood cells, mannitol, bicarbonate, and albumin; a CytoSorb filter is included in the circuit. While peripheral CPB is prepared, rapid sternotomy is performed, the pericardium opened, and the heart and the epi-aortic vessels are exposed.

### Operation

A vent is inserted in the left atrial appendage, an antegrade cardioplegia cannula is inserted in the ascending aorta, the aorta is cross-clamped, and type C Buckberg cardioplegia is administered in the aortic root followed by a 3-minute blood reperfusion. The epiaortic vessels are clamped, and, after the return of cardiac activity, the aortic cross-clamp and the endo-clamp are removed. The heart is allowed to reperfuse on full CPB for at least 60 minutes. During this period, the lungs are visually inspected and manual recruitment during gentle hyperinflation performed. Gradual weaning from CPB is achieved and cardiac function reassessed using transesophageal echocardiography. The graft is considered eligible for donation if in sinus rhythm, with a mean arterial pressure >60 mmHg, ejection fraction >50%, tricuspid annular plane excursion (TAPSE) >20 mm, and without regional wall abnormalities or valve dysfunction. Arterial blood gas analysis is performed to assess lung function off CPB [with ventilator $FiO_2$ set to100% and positive end-expiratory pressure (PEEP) of 5–7 $cmH_2O$]. Subsequently, heart and lung harvesting is conduced according to the standard beating heart procurement technique. A cannula is inserted in the main pulmonary artery (PA) 1.5 cm below the bifurcation. The ascending aorta is cross-clamped and antegrade Celsior cardioplegia in the aortic root and lung preservation solution into the PA are administered. The superior vena cava is then ligated, the inferior vena cava is transected partially to vent the right heart, and the left heart is vented using the previously inserted vent. Cardiectomy is completed by full transection of the inferior vena cava, the left atrium is opened and an adequate cuff around the pulmonary veins is excised, the main PA, the aorta and the superior vena cava are transected. Subsequently, retrograde perfusion through each of the pulmonary vein orifices is performed using a Foley catheter until the perfusate refluxing from the PA is clear. Then, each lung is dissected off the mediastinum, the lungs are insufflated and then the donor is extubated, to partially deflate the lungs. The trachea is stapled twice and divided and the lung block is removed from the thoracic cavity.

### Completion

The harvested heart is preserved in sterile plastic transport bag filled with cold Celsior cardioplegia and stored in an insulated rigid container. Similarly, the lungs are stored in a transport bag filled with cold preservation solution positioned in an insulated rigid container.

## Comments

### Results

Our experience with controlled DCD heart and lung procurement confirms efficacy and safety of DCD. In the presented case, harvested organs were successfully implanted in different recipients, who displayed an excellent clinical recovery without primary graft dysfunction.

### Advantages

The presented procurement technique was designed to preserve abdominal organs by an early peripheral CPB perfusion and to avoid pulmonary congestion by placing an aortic endo-clamp in the descending aorta (in addition to preventing brain perfusion by supra-aortic vessels). Moreover, our technique aims to resuscitate heart function by controlled coronary reperfusion and biventricular unloading (by femoral venous cannula and left ventricular vent). After heart reperfusion, the donor is weaned from CPB, and the whole circulatory system is reconditioned by antegrade physiologic perfusion. This allows the transition from a non-beating heart donor to a conventional beating heart donor.

### Caveats

Given the mandatory 20-minute stand-off period required by the Italian law, DCD heart procurement requires a controlled setting and the utilization of NRP.

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## Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

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