

**Protocol:
Direct procurement of the heart and *in situ* normothermic regional perfusion of the abdominal organs**

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1. Preparation

1.1 Circuit

The NRP circuit needs to have a Y attachment on the venous return limb just above the reservoir. This needs to be connected to the receptacle into which the donor blood will be recovered, but clamped initially.

1.2 Prime solution

-4 units packed red cells (approx. 1200mls)

-1 litre Hartmann's solution

-1 litre Gelofusin

-50000 units heparin

-1gm Methyl prednisolone

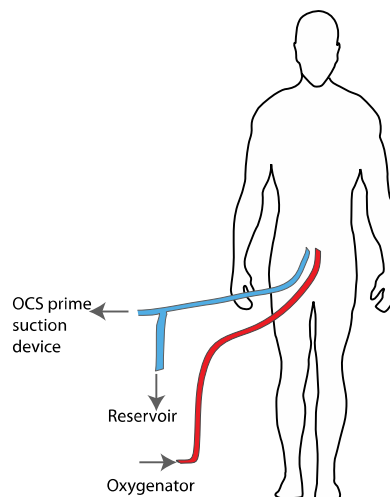
-500mg Meropenem

-200mg Fluconazole

-1ml/kg 8.4% sodium bicarbonate (=1mmol/kg)

1.3 The NRP circuit is primed with a litre of gelofusine and a litre of Hartmann's, to which are added 4 units of red cells.

1.4 The circuit needs to be set up before withdrawal of treatment, and warmed to 35°C by circulating through the oxygenator/heat exchanger.



2. Operative procedure

2.1 Following verification of death 5 minutes after circulatory arrest, the patient is transferred to the operating table.

2.2 Abdominal procedure:

-The abdomen is opened through a midline incision

-The circulating pump is stopped, and the sash is clamped and divided

-The venous cannula is placed in the right common iliac vein (or IVC) and connected to the venous limb of the sash, with care to exclude air. Care should be taken not to place too much cannula in the IVC to prevent it going into the right atrium

-Clamps are removed and 1.5L venous blood drained out and diverted into the collecting receptacle for the OCS (such as the cell saver system used by Harefield)

-The Y-connector is clamped and venous blood now diverted to drain back into the reservoir (see figure)

-The arterial cannula is connected to the arterial limb of the sash and placed in the right common iliac artery or aorta

-Once the cardiac team have clamped the descending thoracic aorta, SVC and IVC, and the 1.5L venous OCS prime has drained, the NRP pump is started aiming for flows over 2.5L/min

2.3 Once the heart is removed it is important to check the security of the supra-hepatic IVC clamp – this may need to be sutured in place to avoid inadvertent unclamping or slipping from the IVC.

2.4 The cut ends of the pulmonary vessels may be oversewn with 3/0 Prolene at this stage also.

2.5 While the cardiac surgeons should ensure haemostasis in the chest, in reality it is the abdominal surgeons who are usually free at this stage and can stop large vessel bleeding.

2.6 There should be no major bleeding.

2.7 Cardiac procedure:

-The chest is opened in the midline and sternum split

2.8 Heart retrieval only

-The left pleural space is opened and descending thoracic aorta is clamped above diaphragm to isolate abdominal NRP and ensure absence of brain reperfusion via NRP system.

2.9 Pericardiotomy

-The SVC and azygous vein are dissected

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-The IVC is dissected around and checked to ensure the venous cannula does not encroach into the right atrium

-If the tip of the cannula is inside the right atrium, the abdominal team should be asked to pull the cannula back below diaphragm to allow for IVC clamping at a later stage

-The ascending aorta is clamped to avoid cerebral blood flow and minimise blood loss

-The heart is assessed for any visible anomalies, palpable coronary artery disease, left ventricular hypertrophy, trauma, congenital disease etc.

-Once 1.3-1.5L of donor blood has been received into the receptacle / cell saver for the OCS prime, clamps are placed across the IVC above the diaphragm, and the SVC caudal to the Azygos

-Once absence of heart anomalies has been assured and enough donor blood has been drained, the OCS module is opened and primed in preparation for graft ex-situ perfusion.

-IVC is opened just proximal to the clamp for venting and left atrium is opened at level of pulmonary veins for pulmonary return

-Cardioplegia supplemented with 20000 UI heparin, EPO and GTN is administered and the heart is then excised leaving all previously placed clamps in situ to minimize blood loss.

-The heart graft is prepared at the back table and re-perfused with ex-situ normothermic perfusion technology in the usual manner

2.10 Heart and Lung retrieval

-Once the donor is transferred to the operating table, an endotracheal tube size above 8 is inserted

-The lungs are inflated with a single recruitment manoeuvre and kept inflated with 100% oxygen

-Bronchoscopy performed usually at this point if an additional surgeon is available, or later after pneumoplegia completion

-Once ascending and descending aorta are clamped, lung ventilation is commenced. SVC, IVC dissection and donor blood drainage, as per heart retrieval only technique is performed

-Clamps are placed across the IVC above the diaphragm, and the SVC caudal to the Azygos

-IVC is opened just proximal to the clamp for venting and left atrial appendage is vented widely

-Once cardioplegia delivery starts, an additional cannula is inserted in the main pulmonary artery. 1-2 L of antegrade pneumoplegia supplemented with heparin as per UK National guidelines, are administered during cardiectomy

-After cardiectomy, antegrade pneumoplegia is completed. Simultaneously, the pleurae are opened widely and lungs inspected and palpated, ensuring adequate delivery of flush and topical cooling with copious volumes of 4°C saline

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-If the lungs are suitable and accepted for transplantation a competent lung retrieval surgeon will complete rest of dissection while abdominal NRP continues, being careful to avoid bleeding

-The azygous vein must be ligated twice and cut in between. This can be done easily in the right pleural space

-The rest of the lung dissection can be completed with diathermy and by using surgical Liga-clips aiming to minimize blood loss

-The trachea is stapled and cut leaving a clamp or staple line on the top end. Retrograde pulmonary venous flush of the lungs is performed on the back-table at the donor site and Lungs are packed as per National protocol

2.11 The cardio-thoracic surgeon should ensure haemostasis in the chest during and at the end of retrieval, before leaving the donor hospital.

3. Requirements to undertake DPP and NRP

3.1 The following are required for the successful removal of the heart during NRP

Cardiac team:

-Senior surgeon who is experienced in DPP

-A cell saver, to enable blood to be washed plus disposables

-The ex situ heart perfusion machine, e.g. Transmedics OCS

-Technician to man the ex situ perfusion machine and the cell saver

-The necessary sterile tubing and adapters to connect to the NRP circuit (3/8 and 1/2 inch tubing)

-An appropriately staffed and equipped lung retrieval team if the lungs are also being retrieved

Abdominal team:

-Senior surgeon who is experienced in NRP

-The NRP disposable circuit

-NRP heater and in situ pump

-Experienced NRP perfusion practitioner

Donor Hospital:

-7 units of bank blood, 4 to be added to prime

This protocol has been written after one successful experience of direct procurement of the DCD heart and in situ normothermic regional perfusion of the abdominal organs.

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The protocol will be updated accordingly depending on future activity.