DCD Heart and Lung retrieval with abdominal Normothermic Regional Perfusion Surgical Protocol.

Use in conjunction with DCD Heart Donation Guide to Donor Selection and Assessment Criteria

https://www.odt.nhs.uk/retrieval/policies-and-nors-reports/

Contents

Requirements needed of the NORS teams:

The following are required for the successful removal of the heart and lungs during NRP.

A detailed discussion between cardiothoracic and abdominal teams to agree protocol and steps to be taken.

From the cardiothoracic team

- Senior surgeon who is experienced in DCD lung retrieval
- Assistant surgeon, scrub, and cold perfusion practitioner
- The ex-situ normothermic heart perfusion machine plus practitioner
- The necessary sterile tubing and adapters to connect to the NRP circuit (3/8 and ½ inch tubing) plus Pacifico cannula to drain SVC
- EndoGIA Medtronic vascular with angled tip stapler and AMV tan reloads x10 (45 & 60mm)
- EndoGIA Medtronic vascular stapler AMT purple x2 (60mm)
- EndoGIA Medtronic vascular stapler AXT black x1 (60mm)
- Automatic liga clips (orange and blue)
- Diathermy/Bipolar scissors/Ligasure
- Cell saver
- Sutures

From the abdominal team

- Senior surgeon who is experienced in NRP with DCD Cardiothoracic retrieval
- Assistant surgeon, scrub, cold perfusion, advanced perfusion practitioner
- The NRP disposable circuit
- NRP heater/cooler and pump (e.g. Cardiohelp)
- Experienced NRP perfusion practitioner
- 2 x long vascular clamps (long Debakey) for descending aorta and IVC clamping
- 2 x Roberts clamps for SVC and ascending aorta.
- Consider using an ECMO cannula for venous drainage
- For NRP protocol please see https://www.odt.nhs.uk/retrieval/policies-and-nors-reports/ The protocol must be checked for recent updates

NORS team Mobilisation

- Both NORS team to arrive up to 2 hours before the planned withdrawal of treatment time

Set up

It is recommended that the donor is transfused to Hb of >100g/L.
This is to ensure that oxygenation of the heart is not limited by anaemia during machine perfusion. Timing of the transfusion – once the CT NORS team is mobile.

Where possible the donor should be moved to the anaesthetic room prior to withdrawal of life sustaining treatment.

Height of the donor bed should be the same as the theatre table. This is done by simply marking the height of the donor's bed by tape on the SNOD's trousers and match this with the theatre table height.

The SNOD will prepare units of packed red blood cells (cross matched to donor) to be available.

- 8 units for DCD heart with abdominal NRP

Preparation of NRP Circuit

Full NRP protocol found on the NHSBT ODT Clinical website. It is essential to check that the current version of the NRP protocol is employed. It is updated from time to time and only the updated version is accepted for practice.

The NRP circuit is primed with 1.5 litres of Hartmann's, to which are added 4 units of red cells. The circuit needs to be set up before withdrawal of treatment and warmed to 37°C by circulating through the oxygenator/heat exchanger.

Set up the NRP circuit with an extra venous drainage tubing which will be connected to a Pacifico 90-degree cannula for the SVC.

Diathermy set up of 80/90.

Two long DeBakey vascular clamps will be ready to use by the cardiothoracic team prior to commencing NRP to clamp descending aorta and IVC. Two Roberts clamps will also be ready to clamp SVC and ascending aorta. It has been agreed that clamps will be provided by the abdominal team as they need to stay in place once the CT team has left the operating theatre.

Due to the complexity of the technique cardiothoracic organs will only be perfused and retrieved for transplantation or valve donation purposes.

Preparation of OCS

- Prepare St Thomas cardioplegia - Add the following medication to 500ml bag of Ringers:

  - 2,500iu of Epoetin Alfa
  - 50mgs GTN
  - 3mls Sodium bicarbonate 8.4% (840mgs in 10ml amp)
  - 10mls cardioplegia concentrate
  - Add heparin 300u/kg

  (Solution to be put back into the ice box but easily accessible for use when donor arrives in theatre)

- Prepare St Thomas cardioplegia for back at implant site – Add the following medication to 1L bag of Ringers:

  - 5000iu of Epoetin Alfa
  - 100mgs GTN
  - 6mls Sodium bicarbonate 8.4% (840mgs in 10ml amp)
  - 20mls cardioplegia concentrate

  (Solution to be put back into the ice box for use when heart is at implant site)

DCD HEART Functional Warm ischaemia and Stand Down Criteria

- After withdrawal of treatment, regular contact will be maintained with the SNOD regarding blood pressure and arterial saturations on the donor.
    - Functional warm ischaemia begins when systolic blood pressure falls below 50mmHg.
    - 30 minutes from beginning of functional warm ischaemia until cold cardioplegia is delivered will be tolerated before standing down.
    - Essential for the team diagnosing death to be familiar with the Academy of Medical Royal Colleges Code of Practice for the Diagnosis and Confirmation of Death. View the Code of Practice.
    - If cardiac arrest does not occur within 120 minutes from withdrawal of treatment, consider standing down DCD heart retrieval at this stage, unless death is likely to be imminent.
    - We recommend having a discussion between retrieval and recipient centres after 60 min from withdrawal.

Transfer to operating theatre.

Following verification of death 5 minutes after circulatory arrest, the patient is transferred to the operating table, the SNOD shows the patient's name band to confirm donor identity. This is cross-checked with the donor authorisation/consent form. It is best practice if the physician who has pronounced death attends with the donor to confirm the pronouncement of death in person.

Surgical protocol:

The thoracic and abdominal surgeons will prepare the skin with an alcohol-based skin preparation solution and apply 4 drapes.

If the patient has been extubated as part of treatment withdrawal, the airway should be reintubated with a cuffed endotracheal tube as soon as possible after death has been confirmed to prevent contamination of the airways with gastric contents (the likelihood of which increases considerably during the retrieval laparotomy).

a. At a point no earlier than 10 minutes after the onset of irreversible asystole, the lungs are re-inflated with a single vital capacity breath of oxygen-enriched air.
b. Cyclical ventilation, either with an anaesthetic machine or by hand-bagging, should start during lung perfusion to aid distribution of perfusate. Cyclical ventilation of the lungs is not allowed until the retrieval team has started to flush the lungs and vented the left atrium. As per the National Standards for Organ Retrieval.

For all heart retrievals:

Initially perform the heart assessment for:

- **coronary disease**
- **visible anomalies**
- **trauma**
- **left ventricular hypertrophy**
- **congenital disease**
- **other causes preventing transplantation**

If none of the above give clear instruction to open and prime the OCS.

The heart assessment can take place while draining blood to prime the OCS.

Abdominal procedure

1 The circulating pump is stopped, and the sash is clamped and divided; the arterial cannula may be attached and primed at this point.

2 Once the donor is in theatre, the abdomen team will cannulate the right femoral artery and right femoral vein (or iliac vein or IVC) and connected to the venous limb of the sash, with care to exclude air. Care should be taken not to insert too much length of cannula to prevent it going into the right atrium.

3 The abdominal team will wait for the cardiothoracic team to clamp the descending thoracic aorta and vent the aortic arch with a 24 French cannula prior to starting the pump. Cross clamping the descending thoracic aorta, and venting the aortic arch, will be announced for all to hear. Only then can NRP commence.

4 Abdominal surgeons will then support the cardiothoracic team.

Cardiothoracic procedure

1 The chest is opened in the midline and sternum split. Meticulous haemostasis with wax and energy device.

2. Pericardiotomy

3. The left pleural space is opened, and DESCENDING THORACIC AORTA IS CLAMPED. The act of clamping the descending aorta should be announced loud enough for all to hear and the time will be recorded on the DCD Heart Passport.

4. Placement of a 24 French cannula in the aortic arch, at least 5 cm from the aortic valve, to demonstrate absence of brain perfusion. (a 24 Fr cannula fits precisely in the incision made by an 11 blade inserted to its hilt).

5. Dissect the azygos. Either tie off or if unable to visualise clearly place a clamp above and below the azygos.

6. Now you are ready to start the NRP.

Once the aortic vent cannula is in place and open to air, and the azygos is dealt with, the cardiothoracic surgeon announces that the aortic arch is vented and the abdominal NRP can start. The time will be recorded on the NRP Passport. If there is copious arterial bleeding from the aortic vent cannula, the NRP pump must stop and the clamp on the descending aorta must be re-positioned to ensure it completely occludes the aorta. Only then can the NRP pump re-start.

7. Bronchoscopy should be performed as soon as practicable and include thorough bronchial toilet if an additional surgeon is available, or later after pneumoplegia completion.

8. The SVC and azygos vein are dissected to ensure enough length.

9. The IVC is dissected around. 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. Check to ensure the venous cannula does not encroach into the right atrium.

10. 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. The SVC is transected caudal to clamp, placed below azygos vein.

11. The ascending aorta is clamped, in addition to the descending thoracic aortic clamp.

12. IVC is opened just cranial to the clamp for venting and left atrium is opened at level of pulmonary veins for pulmonary return.

13. Cardioplegia supplemented with 25000 IU heparin, EPO, and 50 mg of GTN is administered via a large bore needle PROXIMAL to the cross clamp. The previously placed aortic vent cannula, distal to the cross clamp, at the level of the arch will remain in situ and open to air.

14. **Once cardioplegia is finished, the large bore cannula is removed.**

15. The heart is then excised leaving all previously placed clamps in situ to minimize blood loss.

16. Cannulate the PA using a purse string and large (>22Fr) cannula and directly attach to suction cannister (0.5-0.8L) to drain the heart, lungs, and upper limbs.

17. Once it stops sucking attach the ante and retrograde plegia.

18. Clamp the proximal PA across the full circumference.

19. Antegrade pneumoplegia cannula is placed in the PA. Prior to administer pneumoplegia, the cannula is linked to the NRP circuit aiming to drain blood from the pulmonary artery circuit.

20. Cut the LA appendage.

21. SVC, IVC dissection is performed, proximal to the respective clamps/ties. The IVC is opened just proximal to the clamp for venting and the left atrial appendage is vented widely.

22. Ensure the NRP venous cannula is pulled below the clamp. Cardiectomy performed leaving**.** Ascending aorta and SVC are both cut proximal to clamp/ties which stay in place to avoid bleeding.

23. Azygos vein – extra care should be exercise while securing and dividing the azygos vein. Use staples, ties, or clips to secure the distal end which remains in the mediastinum.

Dissection of the Left atrium. If cell saver available – be ready to use it at this stage.

Cut the aorta proximal to the cross clamp. Ensure long aorta attached to the heart in order to secure to the OCS.

24. The pericardium is now empty. If the lungs are suitable and accepted for

transplantation the rest of dissection will be completed while abdominal NRP continues, being careful to avoid bleeding.

25. Antegrade pneumoplegia is delivered as per UK guidelines through 2 Foley catheters prepared in advance with a Y connector. 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.
26. Deliver retrograde pneumoplegia through the pulmonary veins.

27. CT WILL WAIT after delivering antegrade and retrograde pneumoplegia to complete 30min ANRP prior to continuing with any further dissection. CT NORS might choose to use this time to repeat bronchoscopy or assess in more detail the lungs.

28. THIS WILL ALLOW ESTABLISHMENT OF ANRP flows for at least 30min, a period crucial to liver recovery. Risk of bleeding is minimal at this stage.

29. The abdomen may be opened at a suitable point as per lead abdo surgeon decision.

The care and detail required to retrieve lungs whilst NRP is running is the same as would be required in a living patient. The abdominal organs may be lost if the lung retrieval is performed in haste. If we are to build a future with novel technologies, both teams need to support maximal organ retrieval and utilization.

30. Cut the right side of the pericardium, in the right cardio phrenic angle and cut the phrenic nerve and go down until you meet the anterior wall of the oesophagus and stop there. To do so, you will cut and dissect the inferior pulmonary ligament.

31. Do the same on the left side cardiophrenic angle and cut the phrenic nerve and go down until you reach the anterior wall of the descending aorta. To do so, you will cut and dissect the inferior pulmonary ligament.

32. Now cut across the pericardium to join between anterior wall of oesophagus to anterior wall of aorta.

33. Ensure the sternotomy is as widely open as possible.

34. Take the right lung out of the chest, put in on the left side and you have a good view of the posterior wall of the right hilum and posterior mediastinum. Using energy device, dissect along the anterior wall of the oesophagus from low to high and stop at the arch of the azygos/membranous part of the trachea. (To ensure no membranous perforation of the trachea). This ensures no bleeding from small arteries beneath the anterior wall of the oesophagus. Stay very close to oesophagus. Usually, one bronchial artery which can be divided with energy.

35. For safety, staple the azygos again (45 mm tan) and return the right lung into the chest.

36. Place the right lung back in the chest, take the left lung out of the chest and put on the right side. Develop the plane between anterior wall of aorta and lung block/pericardium from inferior to superior. Dissect along the anterior wall of the descending aorta with energy device (may use clips also if required) until you reach the aortic arch. Staple the aortic arch just below the left subclavian artery (60 mm tan).

37. Place the left lung back into the chest.

38. Go upwards and staple and divide the innominate vein (45mm tan).

39. Once the innominate vein is cut; on right we have SVC, left side innominate vein and ascending aorta. (On ascending aorta we have great vessels; BC trunk, Left CC, and Left SC artery). Dissect between SVC on right and ascending aorta on other side, will arrive to just in front of the carina.

40. Staple the BC trunk (45 mm tan), now dissect the trachea upwards until you reach the neck on the anterior wall of the trachea, ascending aorta on the left

with arch vessels and superior vena cava with venous confluent on the right side.

41. Dissect on right side of trachea to reach the posterior dissection plane previously performed. Use a 60mm tan stapler.

42. On left side of trachea, will reach the left posterior plane previously performed, at the origin of the left subclavian artery. Again, 60 mm tan stapler.

43. As high as you can, separate the trachea from oesophagus (using blunt dissection). Then inflate the lungs after withdrawing (accordingly) the ETT. Use 60 mm purple re-load to staple the trachea, or black stapler in cases of severe calcification. Now complete the plane between the trachea and the oesophagus – under vision.

44. Remove the lungs.

45. 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.

The cardio-thoracic surgeon should ensure haemostasis in the chest during and at the end of retrieval, before leaving the donor hospital. Excess bleeding may result in an unusable liver, pancreas, and kidneys.

Preparation of the DRP-DCD heart prior to Ex-Situ perfusion

- The heart is immediately placed into a basin of ice cold sterile saline solution.

- Dissection made to free the aorta from the pulmonary artery placing and securing the appropriately sized perfusion connector for the Organ Care System (OCS) with the supplied cable tie. Teflon pledgeted aortic stitches are used to further secure the aorta to the OCS so reducing the risk of disconnection during travel to the recipient hospital.
- The heart is placed and de-aired onto the primed OCS.

- Insert and secure LV vent through the left atrium into organ chamber.

Place ventricular pacing wires in case pacing is required at a later stage.

PA cannula (Protocol difference)

Harefield retrieval – PA cannula secured and connected. (SVC and IVC - sutured) and connect blue flow probe – follow Transmedics protocol.
Glasgow/Papworth retrieval – PA cannula NOT connected, allowing free drainage.

OCS perfusion parameters during transport:

Commence OCS perfusion of donor heart aiming for:

- Mean AOP 55-70 mmHg
- Aortic flow of 900-1100 mL/min-
- Coronary flow 650-750 ml/min
- Heart rate 70-90 BPM with V-pacing
- Once heart rhythm and perfusion are stable consider synchronising perfusion depending on discussion with implanting team

Acquire simultaneous AV blood samples. Perfusate targets are:

- Hct >15%
- Calcium 1.0-1.3 mmol/l
- Bicarbonate 22-29 mmol/l
- pH – 7.3-7.45

Video clip to be transferred to implanting centre at 30min reperfusion on the rig. In order to reduce OCS perfusion time, a direct communication between lead retrieval and lead implanting surgeon should be established en route. Both parties must agree on good organ function, before the recipient preparation begins.

Transport

Ensure to travel with a safety ice box and roadside bag which will include:

- Ice, cardioplegia, giving set + pressure bag, 8 litres of cold saline

Roadside bag – sterile instruments, sterile gloves different size, sterile gowns, 3 packing bags for heart.

Cardioplegia at recipient site (agreed telecom 2.9.20)

Once implanting team are happy to receive the heart,

- The retrieval team have set up to administer cardioplegia.
- All 3 teams will administer St. Thomas at retrieval and implant site when retrieving for any 6/7 UK centres.
- Harefield will carry both Custodiol and St. Thomas and will have a choice of Custodiol or St. Thomas when retrieving for Harefield.

(Refer to St. Thomas preparation on page 7)

Trouble shooting.

- Check placement heart on the rig (twist, impaired drainage)
- Syringe drives
- Flow probes and sensors
- Module position within the rig
- Redo medication preparation

Set up of Transmedics OCS and use of Cell Saver

Papworth have developed an OCS training manual for DCD hearts and an OCS blood collection with cell saver manual. These are available for reference on the NHSBT ODT microsite: Policies and NORS reports - ODT Clinical - NHS Blood and Transplant

OCS perfusion parameters during transport:

In general, it is recommended to maintain the OCS in manual rather than automatic mode.

Changes to flow and pacing have an immediate effect whereas changing the infusions of epinephrine or maintenance fluid may take minutes to take effect.

Commence OCS perfusion of donor heart aiming for:

- AOP: 55-70 mmHg
- Aortic flow: 800-1100 mL/min
- Heart rate: 70-90 BPM with V-pacing

Aim CF: 650-750 ml/min

- Once heart rhythm and perfusion are stable consider synchronising perfusion depending on discussion with implanting team.

Acquire simultaneous AV blood samples. Perfusate targets are:

- Hct: >15%
- Calcium: 1.0-1.3 mmol/l
- Bicarbonate: 22-29 mmol/l
- pH: 7.30-7.45

Parameters to consider prior to final decision.

- AOP 55-75 mmHg with Maintenance fluid <30 ml/Hr
- Aortic flow 800-1100 ml/min
- HR
- Total lactate trend decreasing over time
- Lactate consumption profile i.e. $Lac_{Art} > Lac_{Ven}$
- Contractility
- Prescence of superficial petechia and/or oedema
- FWIT < 30min i.e. Time from SBP<50mmHg to start of *in situ* cold perfusion
- OCS perfusion time + all the above + predicted preparation of implant (for example, if OCS > 4hours and redo surgery with predicted additional 2-2.30 hours OCS perfusion) need to assess all the above real time
- If in doubt, call on-call retrieval consultant surgeon at Royal Papworth Hospital for advice

Recipient Centre Guidance

- Recipient team should assemble at the hospital once asystole has occurred
- It takes at least one hour on the OCS to have an initial assessment of the heart
- The DCD Team should leave the donor hospital with the OCS machine to travel to the recipient centre within 60 minutes of the heart being placed on the OCS machine

Appendix 1: Safety Checklist for Direct Retrieval of the Heart

SAFETY CHECKLIST FOR DIRECT RETRIEVAL OF THE HEART/ HEART AND LUNGS AND *IN SITU* NORMOTHERMIC REGIONAL PERFUSION OF THE ABDOMINAL ORGANS

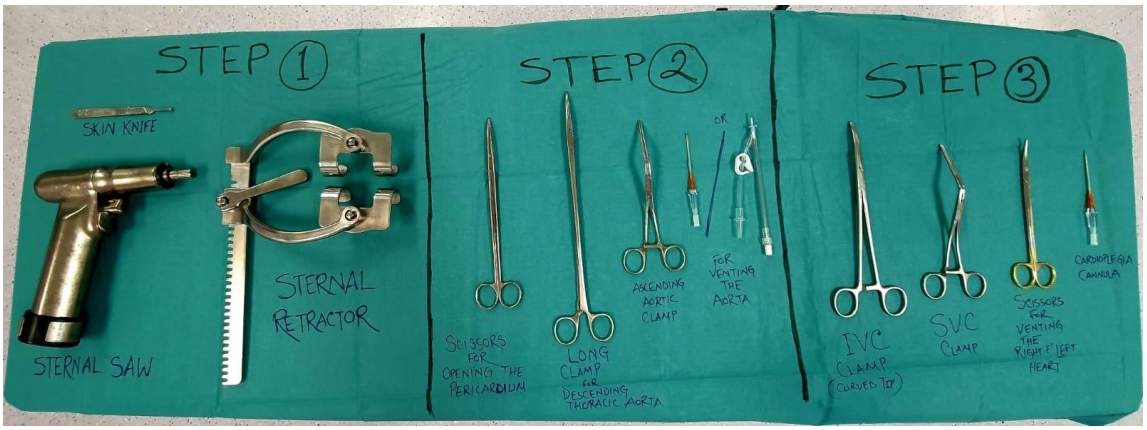
TO BE COMPLETED AT HANDOVER	***CTH SURGEON***	***ABDO SURGEON***
1 Protocol reviewed prior to WLST	☐	☐
2 Debrief completed prior to WLST	☐	☐
3 CTh team equipment ready (Cell saver, Clamps, OCS, Fluids for perfusion)	☐	
4 Abdominal team equipment ready		☐
Leading surgeon; Full name and signature		

TO BE COMPLETED PRIOR TO START ABDOMINAL NRP
(Time to be noted and signed by Abdominal team Perfusionist)

1 Descending Aorta x clamp time

Appendix 2: Scrub trolley set up.

Scrub trolley set up:

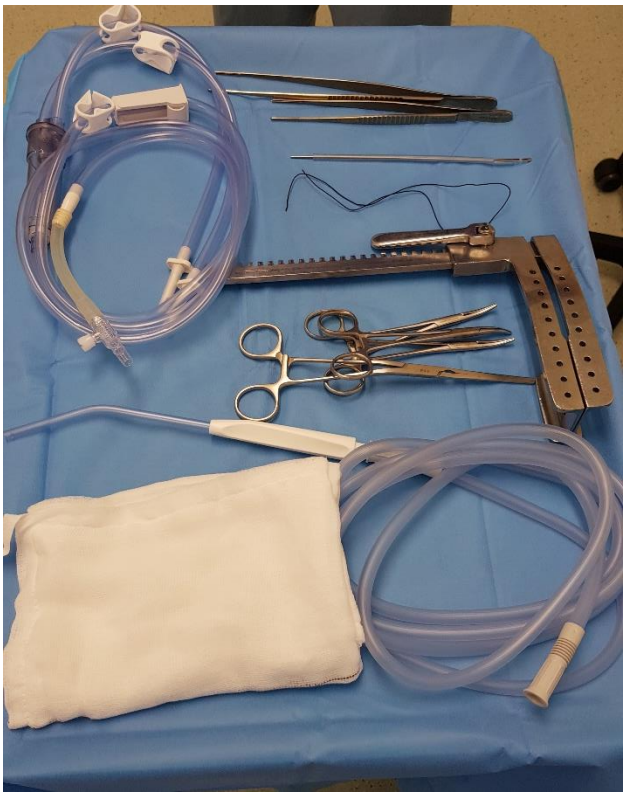


The above figure demonstrates the scrub trolley discipline, which correlates with the surgical steps, and this can be very helpful in the DCD with A-NRP retrieval specially at the very beginning of the process till the start of the antegrade cardio and pneumoplegia. This is not only helpful but also comfortable for the surgeons and the scrub to work in harmony and to prevent unwanted events as well as to maintain sterility in a hasty procedure.

Some teams would prefer a second trolley is prepared for the assistant and will be on the left of the donor.

The trolley contains: SEE PHOTO

- Two suckers (Cell saver and wall sucker (Cell saver marked by a black tie to distinguish from wall sucker and not be used once cardioplegia started)
- Clamp for the SVC
- Two Dunhill clips.
- One Abdo pack
- Heparin syringe
- Two forceps
- Chest retractor
- Cardioplegia and pneumoplegia lines.



In the setting of DCD heart and lungs retrieval cardioplegia delivery finishes before pneumoplegia. But, if one has to wait for the pneumoplegia to finish before starting procurement of the heart, several precious minutes will be lost. To avoid that as soon as cardioplegia delivery finishes, antegrade pneumoplegia delivery can be paused for procurement of the heart. After that through the cut end of main pulmonary artery the selective antegrade pneumoplegia delivery cannula (shown in the figure) can be used to complete the rest of the pneumoplegia.

Appendix 3: Cardiothoracic Synchrony between surgeons

Cardiothoracic Synchrony between the Surgeons

SURGEON 1	**SURGEON 2**
• Skin Incision • Sternotomy	Handle the suckers and the plegia lines
	• Placing the Sternal retractor Not fully opened in order not to stretch the pericardium
• Opening of the pericardium • Opening of the Left pleura • Retracting the Left lung to expose the descending thoracic aorta	
• Inject heparin in right atrium	Inject heparin in PA
	• Clamping the Descending Thoracic Aorta with a long clamp
• Incising right atrial appendage and collection blood for OCS	
• Ascending Aortic clamp • Insertion of venting needle distal to the clamp	
	• Securing the venting needle/cannula
• Rule out CAD	
• Venting the Right (Clamping the IVC in the pericardium and Flush cutting) and Left Heart (through LAA or LSPV) • Inserting with wide bore cannula (medicut) **and holding it in place** proximal to the ascending aortic	• SVC clamp caudal to Azygos away from SA node

clamp to deliver antegrade cardioplegia	
	• Connecting the cardioplegia line to the cannula • Surface cooling with cold saline
• At the completion of the cardioplegia, careful procurement of the heart (after securing the Azygos and ensuring adequate SVC length)	• Helping the Surgeon 1
• Heart out and preparing it for OCS in the back table	
	• Securing bleeding points and ensuring haemostasis for a smooth A-NRP run