

Abdominal Normothermic Regional Perfusion (A-NRP) NORS structure, training and competency

Introduction

The delivery of ANRP as a national program will require expansion in the number of centres currently delivering NRP. It is therefore appropriate to examine the team needed to deliver NRP, the skills needed to provide NRP, how such skills can be acquired by training, and how proficiency is determined.

This document has a strong focus on the lead surgeon; competencies for the scrub and cold perfusion practitioner, as well as the advanced (warm) perfusion practitioner, are well established and available on the ODT website.

1. NORS Structure and ANRP

‘NORS structure and ANRP’ relates to the NORS team and separately to the organisation of NORS as a UK service. These two separate aspects will be considered in basic terms below.

1. NORS Team Structure and ANRP in general

Currently, NORS teams have a minimum configuration which includes a surgeon who is fully registered with NHSBT as a NORS surgeon, a surgical assistant, a scrub practitioner and a cold perfusion practitioner. The competencies for the scrub practitioners are described by NHSBT and are nationally available on the ODT website. The competencies for the lead surgeon are described in the ‘Training and Registration’ document also on the same website.

The relationship with NORS team structure and ANRP team structure is less well described. However, the centres which have established ANRP have a NORS-like team with the addition of an advanced perfusion practitioner. Therefore, an ANRP team comprises a NORS team plus 1, totalling 5 members. A Team which is working towards a fully established service may wish to have additional members for training and support purposes in the early phases.

The roles of the ANRP team members are similar to NORS roles, although the detail is a little different. Clearly, the advanced perfusion practitioner is an entirely new role.

The lead surgeon remains responsible for all activities of the ANRP team. Medical activities, which are defined on the HTA website in the ‘National Operating Procedures’ as developed for NORS teams, remain the direct responsibility of the medical practitioner. This also means that decisions made by more autonomous team members, such as the advanced perfusion practitioners, remain the responsibility of the lead surgeon. This is because these decisions relate to the ‘perfusion and preservation’ of the organs. A medical activity.

Whilst it is not essential for the lead surgeon to be able to demonstrate all the competencies of the advanced perfusion practitioner, it is essential for the lead surgeon to have a detailed knowledge of

the equipment in normal running and troubleshooting situations, and the underlying functions and physiological processes involved in perfusion of the organ donor. In this way, the surgeon can actively manage perfusion parameters, assess organ quality and make key decisions during the perfusion process.

The roles are described in greater detail elsewhere in this document.

2. Delivering an ANRP service and interactions with donation, the Hub and NORS.

UK NORS features 8 whole-time equivalent abdominal retrieval teams who are available 24/7 for organ retrieval. UK NORS currently attends 970 DCD donors per annum, with teams generally attending DCD donors in 50% of all retrievals. Given the substantial improvements in organ quality which ANRP brings, it would be ideal for all DCD donors to be attended by an ANRP team. This would bring increased graft survival and safer transplantation for DCD organ recipients, with substantial financial benefits for the UK health service and considerable clinical benefits for patients.

The delivery of a national ANRP service does bring challenges, however, the established centres have negotiated these challenges and can act as a model to establish a UK service. The following describes the steps for organising an ANRP retrieval, how it might interact with the normal steps of a DCD retrieval, and the repercussions for the national NORS service.

Communication of ANRP utilisation with the Hub/SNOD/recipient teams

ANRP teams have been established on an ad hoc basis consequent on a desire to improve graft quality for a transplant centre's own recipients. Historically, once an organ had been accepted by a centre which was also retrieving that organ, and the centre was able and willing to provide ANRP, a decision was made at the centre to utilise ANRP for that donor.

The centre would then have informed NHSBT/SNOD that ANRP was to be used in the donor. The SNOD needs to know as early as possible, to ensure that blood is crossmatched to the donor (4 units as routine for ANRP). This information, that ANRP may be used, was often delayed for some time whilst the centre established if it could indeed support ANRP. This historical delay arose out of the natural desire to utilise ANRP if possible, as against the reality of numerous team members providing support informally in their own time.

Accordingly, it is better for a new centre to establish a rota so that the retrieval coordinator can be sure there are staff available for a DCD ANRP retrieval. The multiple night-time phone calls to off-duty staff can be demoralising for all, especially the coordinator who is attempting to put a team together.

If a rota is in place, even if ANRP cover is not 100%, the coordination will be much more efficient and potential delays will be avoided. The reputation of ANRP is always a consideration, and ANRP should not detract from the efficient organisation of a retrieval. Of course, the benefits are considerable, and SNODs, intensivists and families may fully support modest delay if the organs will be better quality or more transplants can be done.

As combined ANRP retrieval with the CT team is a major step up from abdominal-only ANRP, which is itself a major step up from standard DCD, it is recommended that developing ANRP teams avoid combined retrievals until a degree of fluency has been acquired with ANRP.

For the reasons above, the abdominal retrieval coordinator should establish as early as possible whether the CT organs will be retrieved from the DCD donor. If so, ANRP should be avoided unless there is a senior surgical mentor present from an established centre, currently Cambridge or Edinburgh.

Coordination

The coordination of an ANRP team in terms of mustering and preparation requires a little more time at the NORS base than would be the case for a standard DCD retrieval. This relates to the increased volume of equipment and the completion of checklists required to ensure that no specialist items are left behind (ANRP consumables are not available in donor hospitals). There is also a small increase in time required for the Retrieval Coordinator to arrange for all staff members to travel to the retrieval centre prior to departure; routine DCD retrieval will involve 4 staff whereas ANRP will need 5 for established teams.

Individual teams will therefore need to consider mustering times. In general, an additional 30 minutes will be required at base to prepare for departure of an ANRP team.

If there are to be unintended delays because of ANRP utilisation, it is wise to communicate with the SNOD as early as possible. In certain donation situations, there may be little scope for additional time.

Arrival time should be set, in keeping with national ANRP guidelines, 2 hours prior to withdrawal of life-sustaining treatment (WLST). All novel technology retrievals, whether cardiothoracic or abdominal, are required to attend 2 hours in advance of WLST to ensure there is adequate set-up time and no delays for the ITU team.

Transport

The standard NORS team of 4 staff plus equipment and boxes can be easily accommodated by current transport providers in all cases. For ANRP, the additional staff member, plus the additional equipment, poses challenges for transport in single vehicles. Centres in development may also wish to bring additional team members for training and support, again placing a premium on space.

IMT, the current national transport provider, will happily perform load test for teams considering ANRP retrievals. With careful and systematic loading, it is feasible for all equipment and staff to be accommodated in one vehicle in most cases. Of course, additional staff (for training purposes) may exceed capacity.

In general terms, it is most unusual for an ANRP team and equipment to be accommodated by air travel in a single plane.

Set up

The ANRP team will arrive 2 hours prior to WLST, and should have enough time to prepare all equipment, including the circuit, blood tubes and all fluids, according to the national protocol.

There will need to be discussion with the SNOD for information and reassurance. If point of care testing devices are being used by the team, these require to be quality assured by the NORS centre biochemistry service. If these have not been through the QA process, the ANRP team will need to have bloods and gases sent to the donor hospital lab which will be fully compliant with national QA processes (CPC accreditation). This is to ensure that all clinical decisions, with all their consequences, are made on the basis of quality-assured blood results.

If bloods are going to the donor hospital lab, a local staff member will need to be identified to take them, as there won't be enough staff to allow ANRP team members to leave the operating theatre. ANRP staff will not have appropriate clearance and access to do so at any rate.

Blood cross matched to the donor should be available in theatre (4 units for standard ANRP). This blood may be required immediately at the start of ANRP. Therefore, it should be to hand (in theatre) or within 10 metres of the ANRP practitioner.

If the retrieval involves cardiothoracic retrieval as well as ANRP, such retrievals are recognised to be substantially more complex than standard DCD retrievals. This relates to the very high risk of major bleeding in the chest during lung retrieval. Although there is now a hiatus agreed such that the CT team will cold perfuse the lungs, then stand back for 30 minutes before commencing lung retrieval, lungs bring significant additional complexity.

If the CT team is present, teams should discuss jointly and in great detail the precise operative steps required, and joint review of the national protocol is recommended, prior to WLST.

For an ANRP team in development, it is recommended to avoid CT retrievals until there is a level of competence attained with ANRP. Team members should not hesitate to contact suitable colleagues at other centres for help and support in this regard.

Withdrawal and ANRP

Once WLST goes ahead, the remainder of the retrieval should proceed as usual. In general terms, abdominal cannulation is recommended to begin with. Groin cannulation may also be considered, using alternative venous cannulas once competence in abdominal cannulation becomes routine.

Management of acid-base status, blood gases and organ quality assessment will be required and is described elsewhere. It is expected and recommended that an ANRP team early in development will discuss perfusion management with a surgical mentor from an established centre during the perfusion phase, if there is not a surgical mentor present at the retrieval. Mentorship is a key part of ANRP development and programs may not proceed until mentorship arrangements have been agreed with a suitable representative from NHSBT (Abdominal co-chair of NTIG).

Organ dispatch

The use of ANRP must be recorded on the A form(s). All relevant A forms now contain the appropriate opportunities to record the details of ANRP. It is also essential that the organ passport document which contains all blood results from the ANRP circuit also goes with the organ – a photocopy or an emailed scan will suffice.

In addition, direct telephone communication with the liver recipient centre is very strongly recommended to discuss organ assessment and the interpretation of the ANRP blood results in terms of organ quality and safety.

2. ANRP Team; Roles and Responsibilities

The following team structure is envisaged as a minimum. During the learning curve, it will be advantageous if additional staff attend ANRP retrievals, partly to learn, partly to assist and partly to mitigate unexpected events. It is essential, in the early part of the journey towards expertise, that the most senior surgeons lead NRP retrievals.

Notwithstanding the roles described below, the NRP team has to work as a team; surgeons should be prepared to help with tube labelling, running bloods or any other tasks as appropriate. It simply generates ill feeling when one set of team members heads off for coffee whilst the others are working at top speed during set up. It also takes longer.

When the 5-yearly HTA audit takes place, ANRP retrieval will be audited in the same way as the routine service. It is therefore essential that this highly effective yet more demanding approach is well supported with training and documentation of competence for staff.

2.1 Surgical Team; Roles.

Lead Surgeon (NRP Surgeon).

This surgeon is required to be a Consultant Surgeon who is proficient in retrieval and fully registered with NHSBT as a NORS surgeon. This surgeon is clinically responsible for the conduct of the retrieval surgery and for all aspects thereof, including management of the perfusion pump and supporting staff. Once a centre is established, non-consultant staff may be trained for this role.

Assistant Surgeon

This surgeon is strongly recommended to be a second consultant surgeon who is fully registered with NHSBT as a NORS surgeon. In the early part of a new NRP program, the shared decision making between two consultant colleagues will make the conduct of NRP considerably more straight forward. It is notable that the long-established centres set out with 2 consultants operating together.

Additional Surgical Staff.

It is considerably easier to secure caval cannulation when there is a second surgical assistant. This may not be practical. However, the benefits, especially early in the development phase, are substantial. This addition will be most easily achieved during retrievals in the NORS base hospital.

Scrub Practitioner.

The scrub practitioner will have achieved all general and scrub competencies which are provided by NHSBT to indicate independent practice in abdominal organ retrieval. It may be beneficial for the scrub nurse to have completed the competencies required of the organ preservation practitioner, although this is not mandatory. The scrub practitioner will have extensive experience in DCD retrieval.

Organ Preservation Practitioner

The organ preservation practitioner will have achieved all general and preservation competencies which are provided by NHSBT for independent practice in abdominal organ retrieval. The practitioner will have extensive experience in DCD retrieval.

Advanced Perfusion and Preservation Practitioner

The Advanced Practitioner will have completed all general and preservation competencies which are provided by NHSBT to indicate readiness for independent practice in abdominal organ retrieval, as well as the Advanced Preservation Practitioner Competencies for ANRP. It is ideal if this practitioner has also completed scrub competencies. This individual will be Band 6 or above, and will have leadership roles during the retrieval to support the other practitioners, as well as educational and mentorship roles. This practitioner will be very experienced in all aspects of retrieval practice.

2.2 Surgical Team; Responsibilities.

The Lead Surgeon will lead the operative procedure and is responsible for all aspects, including confirmation of donor identity and certification of death, and perfusion of the abdominal organs, both warm and cold. The Lead will perform arterial and venous cannulation, will ensure that an appropriate occlusion is in place prior to pump start, that the aorta is vented, and will give the direction to start warm perfusion. The lead will be responsible for ensuring a large bore cannula (10 French or larger) is placed in the aortic arch (venting) to confirm absence of cerebral circulation. The Lead will be responsible for decisions regarding fluids, drugs and blood provided to the circuit, and will have signed off on the drugs and fluids added to the prime as prepared by the APP. The Lead will refer to blood results and recommend any changes in pump management during NRP. The Lead will decide when the pump should stop and cold perfusion should commence.

The Assistant surgeon will assist the lead surgeon in all aspects of donor management, including surgical assistance, but also including collegiate discussion of donor and perfusion management. Although the Lead surgeon retains overall responsibility, the Assistant Surgeon will provide a high level of support to the Lead. It is envisaged early in an NRP program that individuals will act as Lead and Assistant on an alternating basis, so as to maximise experience and exposure within an NRP team.

A second surgical assistant, if present, will perform the tasks assigned to them by the Lead and Assistant Surgeons. Such tasks will likely be operative tasks, but may include supporting the Advanced Preservation Practitioner in any manner required in the preparation required to run the NRP.

The Scrub Practitioner and the Organ Preservation Practitioner will be responsible for performing the operative and preservation tasks they would normally perform during retrieval surgery.

The Advanced Preservation Practitioner is responsible, working under the direction of the Lead Surgeon, for the setting up and management of the perfusion device throughout the retrieval process, as well as coordinating blood tests, ensuring blood, fluids and suitable drugs are available should they be required. This practitioner will often acquire a high degree of autonomy, however, the Lead Surgeon retains overall responsibility.

3. Knowledge Base - Lead Surgeon

All retrieval staff will have met current standards for independent retrieval practice in their role prior to starting NRP training. Established perioperative competencies for core skills, scrub and preservation are appended to this text, as are the competencies for the Advanced Preservation Practitioner. NRP places additional requirements on surgical and perioperative staff, and these requirements can only be met with a combination of theoretical and practical training.

Training goals are set to support Lead Surgeons in demonstrating competencies described in sections 3 and 4. The Knowledge Base set out here represents the theoretical basis for NRP management. The Lead Surgeon must acquire a thorough knowledge of the following and be able to demonstrate this. It is essential that the surgeon is acquainted in detail with published work describing NRP technique and outcomes.

3.1 Knowledge Base; Physiology of NRP

This subject is best learned on a theoretical basis in the first instance. The central issue is the understanding of blood gases and the relationship with perfusion, oxygen delivery, acid/base status and carbon dioxide elimination.

There are numerous texts which describe the basics of arterial blood gases. The BMJ 'ABC' series includes a straightforward guide to begin with via the following free text link [British Medical Journal \(nih.gov\)](http://www.bmj.com/abc).

Having understood blood gases and basic interpretation, NRP staff are directed to more detailed ITU texts for an understanding of oxygen delivery and carbon dioxide elimination (Watson and Hinds; Intensive Care (Saunders) for example).

The lead surgeon will need practical knowledge and awareness of the following topics at a level which allows immediate and reflex management of the donor on the pump.

1. Adequacy of oxygen delivery to tissues

paO₂, SaO₂, SvO₂, Hb/oxygen binding and mass oxygen carriage in blood, arterio-venous oxygen gradient, oxygen consumption across a vascular bed, mixed venous oxygen saturation and interpretation, effects of pH on oxygen carriage and binding by haemoglobin.

2. Elimination of CO₂ from tissues and relationship with acid-base status

pCO₂, HCO₃⁻, Standard Bicarbonate, CO₂ carriage in blood, anion gap

Relationship of pCO₂/HCO₃⁻ with acid base status; H⁺/pH; Base Excess, role of Bicarbonate treatment in managing extreme acidosis (pH<7.0).

3. Metabolic Assessment

Aerobic and anaerobic metabolism as it relates to adequacy of oxygen delivery and effects on lactate generation/consumption and acid generation by intermediate metabolism in the liver.

Gluconeogenesis as a stress response and the endocrine drive to gluconeogenesis in the ANRP donor.

Acid/base derangement after profound ischaemia and implications of resolution or non-resolution on pump.

4. Cellular Injury and Organ Assessment

Origin of ALT/AST during NRP; trends and limits for safe NRP.

Lactate trends and implications.

3.2 Knowledge Base; Equipment for NRP

By personal study and team training, the surgeon will need to be very familiar with the appearance, function, connections and set up of the components below. The surgeon should be able to assemble the circuit if asked to do so and prime the reservoir correctly and safely.

Oxygenator

Oxygenator structure and function; effects of changing FiO_2 /changing gas flow rate on SaO_2 and total oxygen carriage bound to Hb and in solution, effects of changing FiO_2 /changing gas flow rate on CO_2 elimination (and therefore $paCO_2$, pH).

Centrifugal Pump

Mechanism of function, responses of flow rates to changing resistance and pump speed.

Heater

Function, maintenance and minimising infection risk.

Circuit

Circuit layout and in-line components, side branches and connections.

Monitoring Devices as appropriate to the device.

SvO_2 , bubble detector, flow detector, Hct.

Pump Controller

Control inputs, alarms, emergency modes and re-setting.

Point of Care Testing devices

The surgeon may provide support for team members aside from directing interventions 'on-pump'. Use of point-of-care (POC) testing devices may require certification from the employing hospital's Quality Assurance team. Please do not expose recipients to risk by failing to complete such requirements; up-to date certification and training is required for all staff who might use POC devices.

Checklists

The surgeon needs to be familiar with all checklists which are being used to deliver the ANRP service, as the surgeon will be responsible when ANRP cannot go ahead, as a now-marginal, standard DCD liver is declined instead of being transplanted post ANRP. Inadequate check lists will translate to failed NRP.

3.3 Lead Surgeon; Training

Training in NRP prior to clinical practice can be obtained in several ways which are complementary and vital to safe practice.

Training from the Device Manufacturer

Teams using the 'Macquet Cardiohelp' will be able to secure the assistance of technical specialists from Macquet who are expert in the routine running and troubleshooting of the device. Teams using other devices should seek direct personal training from the UK agents of the device manufacturer.

Any surgeon who proposes to lead an ANRP team must have participated in a manufacturer's training program to gain basic competence in the use of the device. A certificate of attendance/completion is retained by the surgeon should it be required for later reference.

Such courses may be repeated. Any such opportunity to do so should be seized.

Training in an Established NRP centre (Edinburgh or Cambridge)

Both established NRP centres in the UK offer training courses to support the development of NRP teams. Although these are currently organised on an ad-hoc basis, these courses give theoretical and practical instruction in the use of NRP, as well as practice with cannulation in mannequins and troubleshooting.

Any surgeon who is training to lead an ANRP team must attend one of these established centres with his or her own team members to participate in advanced ANRP training as a team. It is considered mandatory for safe practice that such a course is completed. Appropriate

documentation should be retained for later reference. Such courses may be repeated, especially if time has passed before implementation. This is regarded as best practice.

Whilst the training described above is the minimum, there is clearly much more to learn in order to establish safe NRP practice. Surgeons in particular, and NRP staff in general, should reflect on weaknesses in their knowledge base and seek to deal with these by active pursuit of training, formally or informally, with expert colleagues (ITU staff, Anaesthetists, Clinical Perfusionists and NRP staff in established centres).

Management on the Pump

A surgeon may wish to obtain informal training with an ANRP surgeon from an established centre to reinforce detailed knowledge around the management of Oxygen and air mixture management (AIRWAY) with reference to arterial gases, Gas flow rate and pCO₂ control (BREATHING) and pump flow rate management and relationship with blood gas and other parameters (CIRCULATION). Acid base management will also be important, as will the complex assessment of the liver on pump.

3.4 Lead Surgeon; Assessment

When an ANRP team feel ready for external assessment, contact should be made with NHSBT who will arrange this on a virtual basis using staff from established centres.

The assessment will mimic an ANRP retrieval from call-out onwards. Although the lead surgeon will be one focus of this process, the assessment will also look at the preparedness of the whole team and the completeness of the documentation.

The team will be questioned on a range of matters, all on a practical basis, relating to the routine events which occur whilst preparing equipment, loading the van, setting up and then taking down the equipment. The team will be presented with several donor datasets by group of tutors, who will represent all the competencies of the ANRP team (surgical, perioperative, perfusion). The team will be asked to comment in detail, as well as in general. The surgeon and the team will need to demonstrate competencies consistent with safe ANRP practice. These will cover the aspects experienced in the training material, as well as managing incomplete data, risk management and communication.

Once the assessment has been completed, a brief report will be compiled by the assessors to summarise the strengths of the team which emerged during the assessment, as well as any deficiencies and whether or not these are significant in the journey towards performing NRP. In general terms, new teams which have performed well will be recommended to commence NRP with direct mentorship. This will involve a trained surgeon from an established centre attending with the new team for NRP retrievals.

In reality, the assessors' recommendations will be highly bespoke, and could involve repeat team attendance at an NRP course prior to re-assessment, specific training for surgeons or perfusion specialists, or revision of documentation, for example. It is essential to appreciate that the safety and good name of NRP are more important than the determination of teams to perform NRP as soon as possible.

4. NRP Competencies for the Lead Surgeon

The lead surgeon will be competent in a wide variety of surgical, technical and non-technical aspects, including a strong grounding in NRP donor physiology, pump technology, and the ability to manage and troubleshoot perfusion in real time at the donor, including surgical and non-surgical aspects.

Core, Scrub and Preservation Competencies for Perioperative Staff have already been defined by NHSBT. These are appended to this document.

Donor Physiology.

The surgeon must understand and be able to demonstrate competence in the following aspects;

1. Mechanisms of Oxygen delivery to tissues and the effects of blood flow, saturation, pH, and haemoglobin concentration on bulk oxygen delivery, plus the relative contributions of dissolved oxygen and oxygen bound to Haemoglobin, and the effect of partial pressure. This knowledge and competence will include thorough knowledge of the normal values in humans.
2. Oxidative and anaerobic metabolism in general terms, specifically considering the effects of hypoxia on metabolic function and the assessment thereof. A knowledge of lactate metabolism and the relationship with aerobic and anaerobic metabolism is required.
3. The characteristics and complications of acidosis, the causes of acidosis in the donor, and the management thereof using drugs and/or pump interventions.

Donor Anatomy as it relates to NRP

The arterial and venous anatomy from the groins to the neck, specifically focussing on the anastomoses which could bring arterial blood to the brain by conventional and other routes, and those pathways which lead to excessive venous bleeding.

Donor Blood Sampling; limitations and caveats.

1. The surgeon must know which blood tests are required during NRP, how often these should be obtained, and be able to discuss the implications of trends and absolute values in the results obtained. The surgeon must be able to demonstrate competent interpretation in terms of circuit management when presented with incomplete results.
2. The surgeon should demonstrate knowledge of liver functional assessment using bloods obtained during warm perfusion. It is expected that early in an NRP program, external support for interpretation of bloods in terms of liver viability would be obtained on a routine basis from an established centre.

Perfusion Pump; Basics

1. Must be able to demonstrate/indicate the devices and component parts which make up the perfusion system.
2. Must be able to describe the structure and function of the heat exchanger, oxygenator, and pump controls in detail.
3. Must be able to explain the external manifestations when components of the system fail, and what should be done to rescue the situation or when to go cold.

4. Must be able to describe how blood makes its way from the cava to the reservoir, and how the pump head propels blood through the arterial limb of the circuit, and what can happen if syphoning effects occur in the venous circuit.

Perfusion Pump; Setup

1. The surgeon must be able to demonstrate preparation and labelling of all fluids and drugs prior to priming.
2. Must be able to demonstrate the correct attachment of the reservoir and circuit to the perfusion pump, ensuring all sensor wires and connections are correctly placed.
3. The surgeon must be able to demonstrate safe priming of the reservoir, and be aware of drug reactions in the reservoir and how to deal with these.
4. Must be able to demonstrate pump start up to purge air from the circuit and to ensure the circuit contains warm perfusate at all times.
5. Must be able to describe and demonstrate the safe position and securing of the 'sash' to prevent accidental displacement of the sterile tubing onto the floor.
6. Must be able to demonstrate the attachment of cold perfusate to an appropriate point on the circuit in preparation for emergency cold perfusion.

Perfusion Pump; Running the Circuit

1. The surgeon must be able to demonstrate initiating perfusion by operating the controls of the pump.
2. The surgeon must be able to demonstrate knowledge of the usual parameters to which the pump is adjusted as part of a normal NRP. This would include oxygen fraction and gas flow rate, blood flow rate and SvO₂.
3. Must be able to indicate acceptable parameters below which action would be required.

Perfusion Pump; course correction on pump

1. The surgeon must be able to explain the effects of gas flow into the oxygenator in terms of oxygenation and CO₂ elimination
2. Must be able to explain the effects of low and high blood flow rate, and low and high gas flow rate into the oxygenator, on blood results from the circuit, specifically acid base status, CO₂ and bicarbonate, and oxygen parameters.
3. Must be able to explain, using blood results, the adequacy of perfusion in terms of oxygen delivery, CO₂ removal, acid-base status.

Perfusion Pump; troubleshooting

1. The surgeon must be able to discuss the manifestations and management of common problems which occur during perfusion. These include air in the circuit whilst on pump (and causes); massive bleeding; sudden loss of volume in the reservoir in the absence of bleeding (cavitation) and how it can be avoided.

2. Must be able to demonstrate an understanding that persisting with NRP in the face of overwhelming difficulty must be avoided, and going to emergency cold perfusion is the better option, and when such an option becomes the correct choice.

5. Surgical Competencies for the Lead Surgeon

5.1 Donor Surgery

1. The surgeon must be able to discuss and demonstrate exposure of the abdominal aorta and vena cava, as well as groin vessels.
2. Must discuss and demonstrate efficient cannulation of the vessels exposed, having chosen suitable cannulas and the appropriate site (abdomen or groin) based on age of donor and the potential for CT team involvement.
3. Must demonstrate connection of cannulas to the sash, having divided the sash appropriately and ensuring there are no air bubbles introduced.
4. Must demonstrate correct placement of aortic occlusion, and the correct placement of the aortic arch vent cannula.
5. The surgeon must be able to demonstrate occlusion of the intrapericardial IVC and SVC with clamps to prevent cardiac filling.
6. The surgeon must be able to discuss actions required if there is high pressure blood emerging from the arch cannula.
7. The surgeon must discuss and demonstrate appropriate actions if there should be large volume blood loss at the initiation of NRP, acting with the APP in managing the perfusion system.
8. The surgeon should demonstrate an understanding of trigger points to go to cold perfusion on an emergency basis.
9. The surgeon should demonstrate the normal progression to cold perfusion at the end of 120 minutes NRP.

5.2 Documentation and Communication

1. The surgeon must be able to complete the NRP passport and ensure that a copy goes with each abdominal organ. The surgeon should demonstrate an appropriate communication with the recipient centre in terms of organ quality and organ assessment on NRP.
2. The surgeon is required to demonstrate a willingness to discuss organ quality assessment by telephone with a fully trained NRP surgeon, and to engage in a collegiate discussion to determine organ quality.

6. Summary

This document represents the current requirements for a team looking to develop an ANRP program. Early contact with Edinburgh or Cambridge centres, or with the chairs of the Novel Technology Implementation Group (NTIG), will allow optimal development of new ANRP programs within the current NSHBT governance framework.

Caveat

New teams should be mindful that the temptation to publicise successful NRP retrievals in various media has a very high risk of identifying the donor; if the family can work out that it was their loved one being described (hospital, date) then the donor is no longer anonymous. This is a breach of medico-legal conventions and an unnecessary risk to a program. There is also a question over the tastefulness of such media communications, given the invariably celebratory tone.

Social media communications about individual retrievals have resulted in complex investigations of individuals historically. Teams are strongly advised not to present retrievals of any kind on social media. Publicity of any kind could have serious adverse effects for organ donation.