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Technique of blood conservation in direct perfusion and procurement of lungs in combination with abdominal normothermic regional perfusion

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Utilization of abdominal-normothermic regional perfusion (A-NRP) for organ procurement in donation after circulatory death is becoming commonplace. Simultaneous procurement of the donor lungs is technically challenging due to blood loss in the chest leading to inadequate circulatory support to the abdominal organs. We describe a priority-based stepwise approach to minimize blood loss in the chest and conserve blood that can be utilized for the A-NRP.
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Background

Abdominal-normothermic regional perfusion (A-NRP) in donation after circulatory death (DCD) offers circulatory support to abdominal organs potentially healing ischemic insult that happened during circulatory death. Its utilization is proven beneficial in liver transplantation with a reduction in early allograft dysfunction, 30-day graft loss, freedom from ischemic cholangiopathy, and fewer anastomotic strictures.[1] Some centers in Spain have reported comparable outcomes in lung transplantation using A-NRP in DCD donors.[2-4] However, globally it has affected the recovery of lungs from these donors mainly due to technically challenging procedures for thoracic surgeons and the reluctance of abdominal surgeons due to bleeding in the chest. Bleeding in the chest not only leads to increased utilization of banked human blood but also causes lower flow and pressure in the A-NRP compromising preservation of the abdominal organs. A thorough preparation and a priority-based approach to lung procurement to facilitate A-NRP can reduce blood loss in the chest.

Technique

Donors after circulatory death are moved to the operation theater after the declaration of circulatory death and 5 minutes of no-touch period. While cannulation for A-NRP is carried out in the abdomen, the chest is opened.

Preparation of donor for normothermic regional perfusion

Two steps in the thorax that are essential for A-NRP commencement are the clamping of the descending thoracic aorta and the introduction of a vent (DLP cannula) in the

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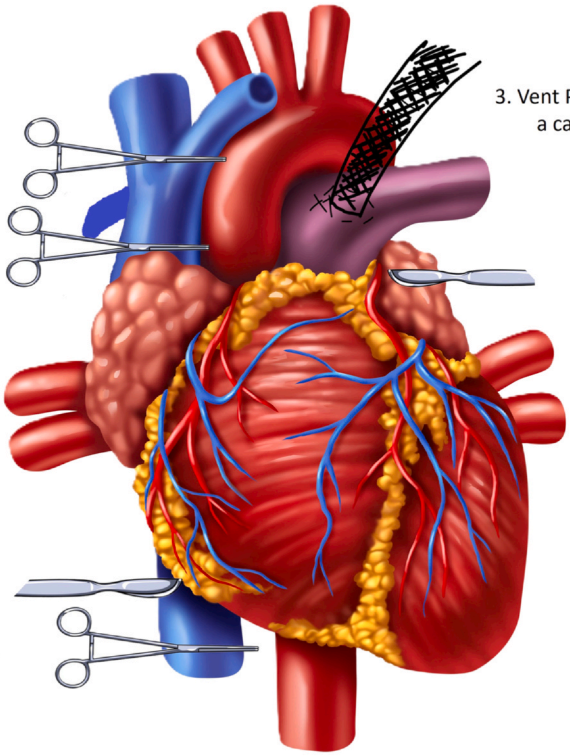

Figure 1 Steps of the procedure. A-NRP, abdominal-normothermic regional perfusion; IVC, inferior vena cava; LA, left atrium; PA, pulmonary artery.

aortic arch. The aortic clamp isolates the A-NRP to the abdomen and prevents perfusion of the brain which is ensured by the absence of blood in the arch DLP.

Control of azygous vein

It is crucial to control azygous vein during A-NRP to avoid blood loss. It is best accessed by opening the right pleura and pushing the right upper lobe down. The azygous vein is ligated or stapled. Suppose the azygous vein cannot be accessed until the A-NRP is ready to commence. In that case, it can be isolated by clamping the superior vena cava (SVC) on either side of it, that is, at SVC- right atrium (RA) junction and at SVC- innominate vein junction (Figure 1).

Clamping of inferior vena cava

Conventionally, the inferior vena cava (IVC) is clamped immediately after the descending thoracic aorta irrespective of commencement of A-NRP. We recommend IVC clamping after starting the A-NRP to allow drainage of the supra-diaphragmatic part of the body and right side of the heart into the normothermic regional perfusion (NRP) reservoir. One can visualize the heart being deflated in 5 to 15 seconds after the NRP is started. This is the ideal time to clamp IVC followed by the SVC clamping. Alternatively, a stapler is used to close and cut IVC which saves time and avoids blood loss in case of inadvertent release IVC clamp.

Drainage of the pulmonary artery, left atrium, and right atrium

The previous step of draining the right heart into the NRP by delayed clamping of the IVC does not drain pulmonary artery (PA) due to intact pulmonary valve. It is facilitated by the suctioning of blood through a cannula put into the PA for delivery of Perfadex. We recommend a wide bore cannula (22 F) and a suction at a medium intensity to avoid collapsing of the PA and blood hemolysis. The cannula is connected to the blood collection reservoir through a sterile suction tubing. Usually, 600 to 800 ml of blood is procured through the PA within 1 to 2 minutes. Once the blood stops coming out of the PA cannula, the cannula is clamped, and the suction tubing detached from the cannula is attached to a wide-bore suction tip. The left atrium (LA) appendage and the RA are opened and 300 to 400 ml of blood vented into the pericardium is sucked into the collection reservoir. Blood gas analysis performed on the reservoir blood offers hematocrit, lactate, potassium, and hemolysis if any. This blood is used in the NRP reservoir as per the requirement.

Lung procurement

Antegrade pulmonary perfusion with Perfadex Plus™ Solution (Perfadex Plus™, XVIVO Perfusion, Gothenburg, Sweden) is commenced through the PA cannula already in place. The cardiectomy is performed and the retrograde pulmonary perfusion via pulmonary veins is followed. The right lung is dissected from the esophagus and the left lung is dissected from the descending thoracic aorta. Paratracheal soft tissue is cut using diathermy with ligation or clipping of visible blood vessels. The trachea is stapled and cut before the lungs are delivered out of the thorax. Meticulous hemostasis is performed in the chest after lung procurement with special attention to the intercostal arteries.

Discussion

Previously we have described the world's first direct procurement of donor heart along with A-NRP.[5] However, lung procurement with A-NRP is still under development. A recent meta-analysis focusing on outcomes of NRP used in DCD donors reported 24 lung transplants with 1- and 2-year survival of 84% to 100% and 90%.[6] The early and mid-term survival and primary graft failure in lung transplant utilizing A-NRP in DCD donors are found comparable in contemporary studies.[2,7] To improve these encouraging outcomes further, it is essential to perform this procedure with minimal bleeding and maximal blood conservation. Our technique involves isolation of the azygous vein with a priority followed by delayed clamping of the IVC to drain blood from the supra-diaphragmatic body into the NRP circulation and collection of blood from the heart and lungs by venting PA, LA, and the RA that can be returned into the NRP reservoir.

The azygous vein is an Achilles's heel in the A-NRP. The A-NRP flow in the abdominal aorta floods collaterals across the diaphragm returning blood into the Azygous vein that drains into the SVC. Azygous vein left unclamped causes blood loss via 2 channels: (i) RA, right ventricle, PA, lungs, pulmonary veins to LA and (ii) internal jugular vein, brain, carotid arteries to the aortic arch flooding the DLP placed in it. There is a theoretical possibility of retrograde perfusion of the donor brain if the azygous vein is not ligated and the SVC is not clamped cephalad to the azygous opening. The dark blood coming out of the DLP cannula in the aortic arch confirms inadequate isolation of the azygous vein. It could be challenging to identify, dissect, and ligate the azygous vein by the time NRP is ready to commence. Our technique of isolating the azygous vein in an emergency by clamping the SVC at 2 places: (i) near its junction to RA and (ii) as cephalad as possible near its junction with the innominate vein comes in handy. With these clamps in place, the NRP can be started, and the azygous vein can be dissected and ligated at ease.

Following circulatory death, the venous tone is lost and most of the blood in circulation is stored in the venous compartment. The heart is stopped and is distended with a significant amount of volume in its chambers. This enormous volume of blood if returned to the NRP circulation significantly improves the NRP reservoir level and hematocrit potentially avoiding blood transfusion. Delayed clamping of the supra-diaphragmatic IVC suggested in this technique offers the A-NRP return cannula access to the blood in the upper part of the body as well as to the blood in the RA and right ventricle. We believe this is potentially more than a liter of blood returned to the NRP circulation.

Venting of different parts of the heart enables the collection of blood that can be returned to the NRP reservoir. A wide bore cannula is used to drain blood from the PA which in turn is used to deliver antegrade pulmonary perfusion. Additionally, blood is vented by opening the left atrial appendage and RA into the pericardium. Blood drained in this way from right-sided chambers of the heart, and postcapillary and precapillary vessels of the lungs not only help minimize blood loss but also offer a bloodless field during perfusion and procurement of the thoracic organs.

Disclosure statement

None of the authors have any conflicts of interest.

References

1. Watson CJE, Hunt F, Messer S, et al. In situ normothermic perfusion of livers in controlled circulatory death donation may prevent ischemic cholangiopathy and improve graft survival. Am J Transplant 2019;19:1745-58.
2. Mora V, Ballesteros MA, Naranjo S, et al. Lung transplantation from controlled donation after circulatory death using simultaneous abdominal normothermic regional perfusion: a single center experience. Am J Transplant 2022;22:1852-60.
3. Tanaka S, Luis Campo-Cañaveral de la Cruz J, Crowley Carrasco S, et al. Effect on the donor lungs of using abdominal normothermic regional perfusion in controlled donation after circulatory death. Eur J Cardiothorac Surg 2020:ezaa398.
4. Campo-Cañaveral de la Cruz JL, Miñambres E, Coll E, et al. Outcomes of lung and liver transplantation after simultaneous recovery using abdominal normothermic regional perfusion in donors after the circulatory determination of death versus donors after brain death. Am J Transplant 2023;23:996-1008.
5. Mohite PN, García Sáez D, Butler AJ, et al. Direct procurement of donor heart with normothermic regional perfusion of abdominal organs. Ann Thorac Surg 2019;108:597-600.
6. De Beule J, Vandendriessche K, Pengel LHM, et al. A systematic review and meta-analyses of regional perfusion in donation after circulatory death solid organ transplantation. Transpl Int 2021;34:2046-60.
7. Miñambres E, Ruiz P, Ballesteros MA, et al. Combined lung and liver procurement in controlled donation after circulatory death using normothermic abdominal perfusion. Initial experience in two Spanish centers. Am J Transplant 2020;20:231.