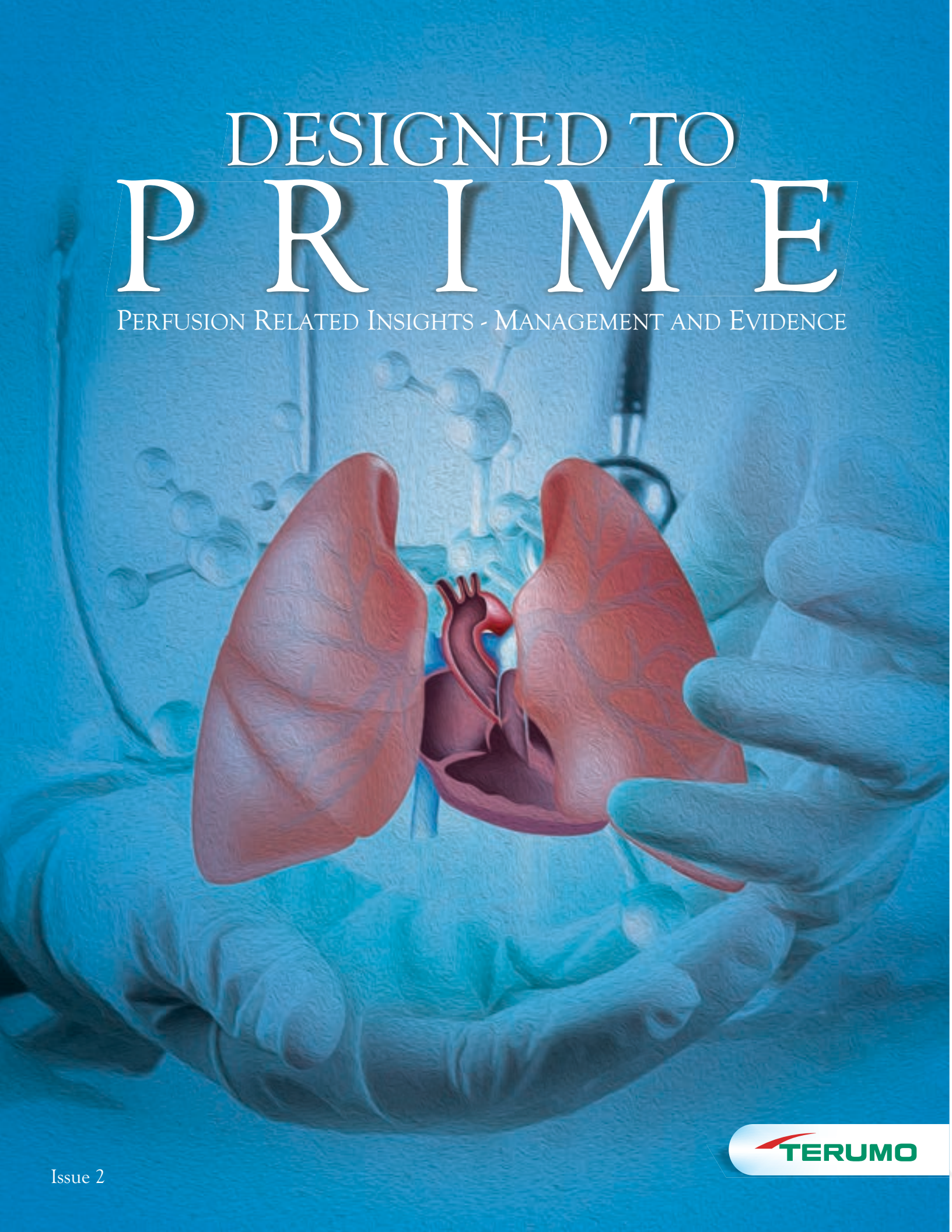
DESIGNED TO PRIME

Perfusion Related Insights - Management and Evidence



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Issue 2

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Editorial Letter

Dear Readers,

PRIME – '**P**erfusion **R**elated **I**nsights - **M**anagement and **E**vidence' – is a scientific newsletter published every quarter with the help of our editorial board members and includes latest reviews, guidelines, and expert experiences in relation to perfusion strategies.

We are happy to present the 2nd issue of PRIME to you.

This issue of PRIME gives an insight on the use of del Nido cardioplegia in adult cardiac surgery. It focuses on the significance of maintaining normothermia during pediatric cardiac surgery. Using blood warmer cartridge in modified ultrafiltration (MUF) circuit is quite a meaningful management procedure while performing complex congenital cardiac case surgeries. The issue also consists of cases managed with cardiopulmonary bypass (CPB) and total circulatory arrest (TCA). A recent update on the development of minimally invasive extracorporeal circulation (MiECC) is done with an attempt to incorporate all advances in CPB technology in one closed circuit, which shows improved biocompatibility and reduces the systemic detrimental effects of CPB. Additionally, it also mentions about the American Society of ExtraCorporeal Technology Standards and Guidelines for Perfusion Practice. They are evidence based; thereby implementation helps in better patient outcomes. This issue gives valuable clinical knowledge for perfusionists.

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Use of del Nido cardioplegia for adult cardiac surgery at the Cleveland Clinic

Introduction

For decades, del Nido cardioplegia has been used in pediatric surgical centers; however, its usage in adult surgical centers is a relatively new phenomenon. There is no prospective data on the use of del Nido cardioplegia in adults; however, retrospective data have been available on the same. Thus, the current article aims to provide information on the use of del Nido cardioplegia in adult cardiac surgery at the Cleveland Clinic.

del Nido cardioplegia for adults at the Cleveland Clinic

A single dose of del Nido cardioplegia containing 26 mEq/L of potassium chloride, 13 mL of 1% lidocaine, 3.2 g/L of 20% mannitol, 2 g of 50% magnesium sulfate, 13 mEq/L of sodium bicarbonate, and 1000 mL of Plasma-Lyte A is given 1:4 with oxygenated patient's blood to crystalloid. It can be delivered antegrade if the duration of the operation is limited and if there is no significant coronary artery disease or aortic insufficiency to limit the distribution of cardioplegia. Generally, it is used in a single-dose fashion and has been in use for nearly two decades at Children's Hospital Boston for both adult and pediatric surgeries.

Dual cardioplegia circuit and delivery methods

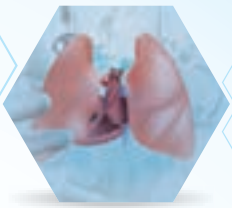
Currently, a custom disposable dual circuit is being used for del Nido cardioplegia delivery, which was designed with a set of Robert clamps on the blood inlet to the cardioplegia heat exchanger and a set of Robert clamps on the crystalloid cardioplegia inlet, based upon the required cardioplegia to be used in the case. One set of Robert clamps is open, while the other set is closed to deliver either 4:1 or 1:4 blood: crystalloid ratio.

As per the Cleveland Clinic del Nido protocol, adult patients are administered 20 mL/kg with a maximum dose of 1000 mL for patients >50 kg. If the aortic cross-clamp time is expected to be <30 minutes, then a half dose can be used to arrest the heart. But, even in a small-sized patient with a hypertrophic ventricle, a full dose of cardioplegia (20 mL/kg) is recommended to provide satisfactory delivery of cardioplegia to ensure sufficient myocardial protection of the hypertrophic muscle mass. Moreover, del Nido cardioplegia is given at a temperature of 4°C. Once the cross-clamp is placed on the ascending aorta, antegrade del Nido cardioplegia is delivered as a single dose over a duration of 1-4 minutes at a rate of 250-450 mL/min. In cases of aortic insufficiency where aortotomy will be performed, the aortotomy may provide exposure and access to the coronary ostia for direct administration of cardioplegia. Accordingly, handheld ostia cannulas are used with flows and pressures adjusted. The surgeon decides how much more del Nido cardioplegia needs to be administered after 90 minutes of aortic clamp time. Though retrograde coronary sinus delivery is not used routinely, there is no contraindication for its use in this manner, and administration in such a way may be a useful adjunct in case of aortic insufficiency.

CONCLUSION

The use of del Nido cardioplegia allows to customize myocardial protection for adult cardiac procedures. Like with any myocardial protection strategy, it is critical to maintain adequate and uniform distribution of cardioplegia solution to the myocardium, which is especially important in "one-shot" cardioplegia such as del Nido cardioplegia.

Source: Kim K, Ball C, Grady P, Mick S. Use of del Nido cardioplegia for adult cardiac surgery at the Cleveland Clinic: Perfusion implications. *JECT*. 2014;46:317-23.



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Case 1: Management of a heparin-induced thrombocytopenia patient on cardiopulmonary bypass

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The management of a heparin-induced thrombocytopenia (HIT) patient on cardiopulmonary bypass (CPB) is a very difficult task.

Case

A 50-year-old female patient was diagnosed with chronic pulmonary thromboembolism, severe pulmonary artery hypertension, severe right ventricular dysfunction, right lower limb deep vein thrombosis, and anti-phospholipid antibody syndrome. In pre-operative days, she was administered low molecular weight heparin for thrombolysis due to which she had developed HIT. The patient was referred for an emergency pulmonary thromboendarterectomy (PTE).

Management

Bivalirudin was used as an alternative anticoagulant. Further, 1.5 mg/kg body weight of bivalirudin was given. Cooling titrated the bivalirudin infusion rate; at 36 to 32°C kept at an infusion rate of 2.5 mg/kg/hr, at 32 to 28°C at an infusion rate of 2 mg/kg/hr, and below 25°C at a rate of 1 mg/kg/hr. The activated coagulation time (ACT) was checked every half an hour. While cooling, the patient was fibrillated at 24°C, and administered cold blood cardioplegia at 20 mL/kg. When the temperature of 18°C was achieved, the ACT was kept 2.5 times more than the normal ACT. The cerebral protective drug (thiopentone sodium 10 mg/kg body weight) was administered. The patient got hyperventilated and went on TCA because the pulmonary clots were very deep. The clots were removed from the right and left lung. The ACT was checked every 30 minutes and brought down to the range of 500 to 600 seconds. The bivalirudin infusion rate was titrated, a good urine output was maintained and hemofiltration was started, as these can eliminate free bivalirudin molecules. Modified ultrafiltration (MUF) for 15 minutes helped to reduce the pulmonary artery pressure. The patient was discharged on the 8th day.

Discussion

Pulmonary thromboendarterectomy surgery is complex, requiring careful assessment and visualization. Bivalirudin as a heparin alternative was used because of its short half-life period.

In order to avoid stagnation, the blood cardioplegia device (BCD) and delivery line should be flushed out with normal saline and the aortic root cardioplegia delivery needle should be decannulated and snugged and kept.

CONCLUSION

While using bivalirudin, low flow technique can be used to avoid stagnation. The usage of crystalloid cardioplegia also helps to avoid stagnancy and complexity of perfusion management.

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Case 2: Using a blood warmer cartridge in the modified ultrafiltration circuit to prevent a temperature drop

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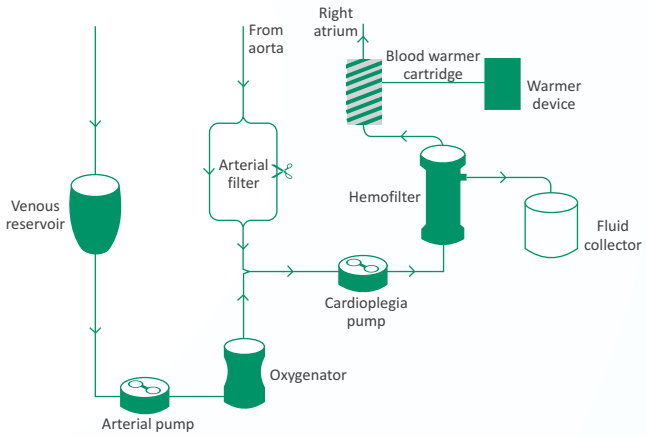
Normally, the operating room temperature is maintained at around 20°C. When pediatric cardiac surgeries are performed on small babies, the patients' temperature tends to come all the way down. One of the important reasons for this is that the chest is kept exposed to the room temperature.

Maintaining normothermia is a necessity

It is estimated that 50-90% of the patients around the world suffer from hypothermia. One of the contributing factors to accidental hypothermia is cold fluid/blood delivery. A further analysis in 2010 also concluded that infusion of warm blood/fluid is effective in keeping patients nearly normothermic and prevents postoperative shivering. Disadvantages of hypothermia include arrhythmias, coagulopathies, shift of O_2 dissociation curve to the left, peripheral vasoconstriction leading to increased afterload, decreased renal output, and prolonged stay at the intensive care unit.

Using a blood warmer cartridge in MUF circuit (Figure 1) is quite a meaningful management procedure for complex congenital case procedures like bidirectional Glenn (BDG), Fontan procedure and any other cases where the surgeon doesn't require CP but HEMOFILTER and MUF are mandatory. Blood warmer cartridge in MUF circuit with Bair Hugger device is more effective to hold the temperature.

FIGURE 1 Blood warmer cartridge used in MUF circuit



HOW TO USE MODIFIED ULTRAFILTRATION CIRCUIT

STEP-1: Blood warmer cartridge has to be incorporated into the outlet of the hemofilter which goes to the right atrium (RA) line and primed while re-warming or 5 or 10 minutes before coming off CPB.

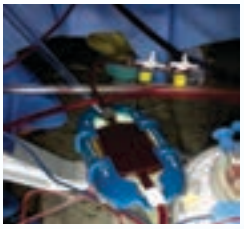
STEP-2: Cartridge has to be mounted on the blood warmer bracket.

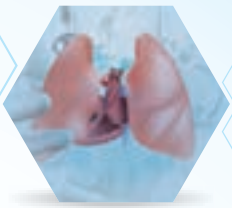
STEP-3: Keep the warming device on and wait for the green indicator to glow. It has a preset temperature of 40°C. Come off CPB with the normal temperature of 36.5°C and start MUF. While filtering, concetrated blood goes through the blood warmer cartridge to RA. Keep the warmer on throughout MUF.

Blood/fluid warmer device

Warmer cartridge mounting bracket

Cartridge connected to the mounting bracket





GUIDELINES

SECTION 3

American Society of ExtraCorporeal Technology Standards and Guidelines for Perfusion Practice (2013)

Standard and guideline for safety of devices

Pressure monitoring of the arterial line, cardioplegia delivery systems and venous reservoir should be employed during cardiopulmonary bypass (CPB) procedures. A bubble detector, level sensor, temperature monitoring of the arterial outflow from the oxygenator, arterial-line filter, and a one-way valve in the vent line should also be employed. Additionally, a method for retrograde flow avoidance while using a centrifugal pump and an anesthetic gas scavenge line (when inhalation agents are introduced into the circuit) should be employed. Hand cranks, back-up gas supply and a back-up battery supply for the CPB machine should be available during the CPB procedures. The guideline states that a ventilating gas oxygen analyzer and level sensor should be employed during CPB procedures utilizing a soft shell reservoir.

Standard and guideline for monitoring

Arterial blood pressure, arterial line pressure, arterial blood flow, cardioplegia dose, delivery method, line pressure (antegrade), coronary sinus pressure (retrograde) and ischemic intervals, and patient and device temperatures should be monitored continually during CPB. Additionally, blood gas analyses, hematocrit (or hemoglobin), oxygen fraction and gas flow rates, % of venous line occlusion of the venous occlude, and venous oxygen saturation should be monitored continually. The guideline states that carbon dioxide removal, arterial oxygen saturation, central venous pressure and/or pulmonary artery blood pressure, and continuous in-line blood gas should be monitored at regular intervals during CPB. It is recommended to use cerebral oximetry during CPB. Additionally, arterial blood flow should be monitored regularly at a point in the CPB circuit where it precisely shows the flow delivered to the patient during CPB.

Source: Baker RA, Bronson SL, Dickinson TA, Fitzgerald DC, Likosky DS, Mellas NB, *et al*. Report from AmSECT's International Consortium for evidence-based perfusion: American Society of Extracorporeal Technology Standards and Guidelines for Perfusion Practice: 2013. *J Extra Corpor Technol*. 2013;45(3):156-66.

LATEST NEWS

SECTION 4

Modular minimally invasive extracorporeal circulation systems

The development of minimally invasive extracorporeal circulation (MiECC) is done with an attempt to incorporate all advances in CPB technology in one closed circuit, which shows improved biocompatibility and reduces the systemic detrimental effects of CPB. The utilization of MiECC technology into clinical practice is hindered due to concerns pointed out by perfusionists and surgeons about air handling together with blood and volume management during CPB. Thus, a modular MiECC circuit was designed which consisted of an accessory circuit for immediate transition to an open system, that can be used in every adult cardiac surgical procedure, giving more safety features. The study results exhibited that the modular AHEPA circuit design gives a 100% technical success rate in a random cohort of high-risk patients who underwent complex procedures, including reoperation and valve and aortic surgery, together with emergency cases.

Source: Anastasiadis K, Antonitsis P, Argiriadou H, Deliopoulos A, Grosomanidis V, Tossios P. Modular minimally invasive extracorporeal circulation systems; can they become the standard practice for performing cardiac surgery? *Perfusion*. 2015;30(3):195-200.

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Control No.: TIPL-014-00-PRI Date of Preparation: April 2015 For the use of a registered medical practitioner or a hospital or a laboratory only

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