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First Case of Deep Hypothermic Circulatory Arrest in Senegal (West Africa): Congenital Heart Disease Management

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Abstract: Background: Deep hypothermic circulatory arrest (DHCA) is an extracorporeal circulation (EC) technique used to correct complex congenital cardiac lesions. This technique ensures excellent operating conditions while reducing consequences of organ ischaemia, particularly of the brain. Griepp was the first to demonstrate in 1975, that the technique offered a practical and safe approach for aortic arch surgery. Case Report: Authors aim at reporting the practical conduct of DHCA's first case performed in Dakar (Senegal) on a 30- month-old patient diagnosed with supracardiac total anomalous pulmonary venous connection (TAPVC). The cooling had started 8 minutes after CPB was initiated and continued while the surgeon dissected the pulmonary veins, the collector, and the innominate vein. After the establishment and the starting up of the cardiopulmonary bypass, circulatory arrest was performed at 18°C with 32 minutes of arrest time. The anastomosis between collector and posterior of the left atrium was achieved during a circulatory arrest. In the immediate postoperative period, patient showed episodes of hypothermia and biological bleeding. During her hospitalization, the patient developed a lung infection and PAH crisis, kept under control with antibiotic, diuretics, oxygen and sildenafil. Neurological, kidney, metabolic or ionic complications have not been observed. The patient stayed at the hospital for 32 days. Conclusion: DHCA technique is a common practice in developed countries. However, it can also be carried out in West Africa as evidenced by this clinical case. This prowess testifies a strengthening of our skills in EC technique; and also, the possibility of correcting complex congenital cardiac lesions.

Keywords: Deep Hypothermic, Circulatory Arrest, Congenital Cardiac Lesions

1. Introduction

Deep hypothermic circulatory arrest (DHCA) is a technique used to repair complex congenital cardiac lesions that requires aortic arch or pulmonary vein repair. This technique ensures excellent operating conditions while reducing consequences of organ ischaemia, particularly of the brain. Since the introduction of DHCA in early 1960s, Griepp was the first to demonstrate in 1975, that the technique offered a practical and safe approach for aortic arch surgery. Since then, this technique has been increasingly used in centers with expertise on open heart surgery for infants, children, and adults. Most patients tolerate 30 minutes of circulatory arrest at 18°C without significant neurological damage. Above 40 to 60 minutes, brain lesions frequency increases significantly. DHCA is an unusual cardiopulmonary bypass (CPB) technique in West Africa where cardiac surgery is virtually non-existent in most countries. This report aims at describing a practical conduct of the first case of DHCA that has been performed for surgical correction of TAPVC at the Pediatric Cardiac Surgery Center of the University Hospital of Fann in Senegal. [1-4]

2. Case Report

MD was a 30-month-old female patient diagnosed with supracardiac TAPVC. Her previous medical history revealed no abnormality. The physical examination of the patient identified failure to thrive (weight = 10 kg, height = 82 cm, BSA = 0.47, BMI = 14.8), pulmonary systolic murmur and accentuated second heart sound. The electrocardiogram was in regular sinus rhythm with right ventricular hypertrophy. The chest x-ray identified cardiomegaly (cardiothoracic ratio = 0.7) and indirect signs of pulmonary arterial hypertension (PAH). The echocardiography identified:

1. supra cardiac TAPVC with a partially stenosed collector (mean gradient = 9 mmHg) draining into the innominate vein; an atrial septal defect (ASD), ostium secundum type measuring 6 mm and shunting from left to right;
2. Right cavities dilatation, good biventricular function: LVEF = 73%
3. PAH with SPAP (systolic pulmonary arterial pressure) = 110 mmHg

The angioscanner or cardiac magnetic resonance imaging was not performed and the patient had no preoperative biological abnormality. She did not benefit from any sedative premedication or administration of corticosteroids prior to surgery. The monitoring was performed by an invasive measurement of the radial arterial pressure and the central venous pressure (internal jugular). The central temperature was measured at the rectal and nasopharyngeal sites. A transœsophageal echocardiography was set up as such: no cerebral monitors and no pulmonary arterial catheter. In addition, sevoflurane, propofol, norcuron and fentanyl were used as anesthetic. The anticoagulation was performed with heparin at 3500 IU parenterally and 2000 IU in the priming. The ACT (Activated clotting time) before CPB was 700 seconds (sec). The anti-fibrinolytic agent used was tranexamic acid: a bolus of 300 mg then 600 mg in continuous perfusion. A 50-mg of hydrocortisone was administered prior to CPB initiation. The cell-saver was installed systematically. The CPB was carried out with S5 SORIN equipped with a roller pump. The related elements that were connected to the CPB circuit are: conventional ultrafiltration, an inline infusion bag. The size of the cardiotomy reservoir was 1200 ml; and heparin-coated circuits were used. The priming was composed of 300 ml of homologous blood, 250 ml of FFP (fresh frozen plasma). During CPB, 500 ml of ringer, 250 ml of FFP, 25 ml of Mannitol (20%) were perfused. (Figure 1)

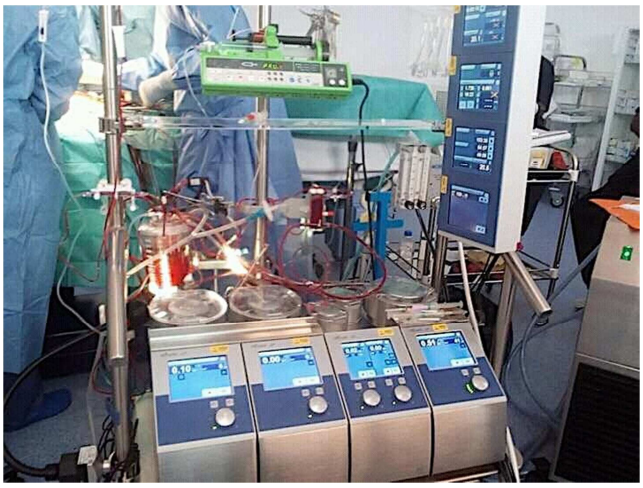

Figure 1. *Assembly of CPB circuit for the DHCA.*

The CPB was established between an aortic cannula of 12 French (F) and two vena cava cannulas of 16 F each; connected to heparin-coated arterial and venous lines of 1⁄4 inch each. A left discharge cannula (12 F) at the infundibulum. The cooling had started 8 minutes after CPB was initiated and continued while the surgeon dissected the pulmonary veins, the collector, and the innominate vein. Additional cerebral cooling was achieved by coating ice packed around the head. At the nasopharyngeal temperature of 28°C, aortic cross clamping was followed by cold blood cardioplegia. Circulatory arrest was performed at 18°C followed by exsanguination. The anastomosis between collector and posterior of left atrium was achieved during a circulatory arrest. ASD was partially closed during rewarming.

Circulatory arrest time was 32 minutes (min) and hypothermic perfusion time prior to rewarming initiation was 10 min. The amount of blood stored in the inline infusion bag during the circulatory arrest was 400 ml; this blood was transfused during rewarming. The CPB flow during mild to moderate hypothermia varied between 1.08 – 1.38 L/min/ m^2 and varied between 0.73 – 0.77 L/min/m^2 in deep hypothermia. The mean arterial pressure varied between 30 and 60 mmHg. The resumption of cardiac activity was in sinus bradycardia regularized by external electrical stimulation. CPB time was 197 min and that of clamping 66 min; CPB assistance lasted 31 min while rewarming changed temperature up to 36.5°C. The amount of hemofilter blood was 240 ml. The biological data during CPB were: ACT = 762 –999 sec; hematocrit =

21%– 25%; pH = 7.46 –7.57; PaO_2 = 304 – 368 mmHg; $PaCO_2$ = 29-30 mmHg, SaO2 = 100%, SvO2 = 78 mmHg; diuresis = 220 ml. The biological data at the exit of CPB were: pH = 7.58; $PaCO_2$ = 25 mmHg; PaO_2 = 269 mmHg; hematocrit = 26%. There were no ionic and metabolic disorders during or after CPB. Protamine was administered at a dose of 7000 IU. An amount of 150 ml of blood was collected in the cell-saver; and transfused to the patient.

In the immediate postoperative period, patient showed episodes of hypothermia and biological bleeding >3 ml/kg/hour; which required an administration of 200 ml of FFP and tranexamic acid. Postoperative PAH (sPAP = 77 mmhg) was managed by the administration of sildenafil (90 mg/day). The patient was extubated at 21st postoperative hour. She had marked an anemia of 9 g/dl and thrombocytopenia at 120,000/mm^3, but did not present any neurological, kidney, metabolic or ionic complications. The patient was kept on intensive care observation for 7 days. However, during her stay at the hospital, she developed a lung infection and PAH crisis, kept under control with antibiotic, diuretics, oxygen and sildenafil. The length of her stay in the hospital was 32 days.

3. Discussion

Dillard et al. performed corrections of TAPVC using DHCA in 1967. This technique is commonly used in American, European and Asian cardiac surgery centers. However, this technique was implemented for the first time in our cardiac surgery center, indicating a strengthening of EC technical skills. There is no literature on the use of DHCA in the correction of congenital cardiac lesions reported by cardiac surgery centers in west Africa. [1, 5]

We did not use any specific premedication. Although the use of corticosteroids (6–8 h before surgery) may decrease the release of inflammatory cytokines and preventing lysosomal breakdown during hypothermia. Despite a limited evidence of outcome benefit, neurological monitoring is routinely used in many centers. Our Center doesn't dispose of a cerebral monitoring device as well as a centrifugal pump, the latter must be preferentially used to reduce haemolysis, maintains the leucocyte count, and preserves platelet function. [3]

Theoretically, avoiding volatile agents, which uncouple cerebral blood flow from cerebral metabolism, may confer some benefit. In a recent survey, 83% of anesthetists used agents as pharmacological neuroprotection during DHCA: thiopental (59%), propofol (29%) and others in 48% of cases, most commonly corticosteroids However, thiopental is commonly used for children. The optimal strategy for protecting the brain remains controversial [6-9].

In our case, despite haemodilution, the minimum hematocrit was 21%. Haemodilution, typically to a haematocrit of 20%, improves flow in the microcirculation during hypothermia. Excessive haemodilution significantly reduces oxygen carrying capacity and causes tissue ischaemia. Priming to blood as in our patient, limits excessive haemodilution and improves brain recovery after circulatory arrest. [3, 10-11]

Circulatory arrest time was 32 minutes (min). Indeed, the literature reports a mean time of 32 min (range, 28 to 37 min) especially towards the correction of TAPVC. However, it is on average 20 min (range, 3 to 52) in the correction of various complex congenital cardiac lesions. Circulatory arrest is typically undertaken at 18–20°C and a range of safe periods for DHCA have been reported at this temperature. Hypothermic perfusion should be maintained for 10–20 min before initiation of rewarming. This would reduce the risk of increasing intracranial pressure. The temperature variation after rewarming from DHCA is associated with survival and neurologic outcome. [3, 4, 10, 12, 13]

The incidence of acute neurological complications after DHCA is on the order of 1– 25%. The main complication of our patient was a postoperative bleeding. Coagulopathic haemorrhage remains a significant cause of morbidity and early death after DHCA. In most centers, thromboelastography during surgery and laboratory tests of coagulation are used to guide early, aggressive correction of thrombocytopenia and clotting factor deficiency. This strategy appears to reduce the amount of blood derivatives administered. [3, 14-16]

4. Conclusions

DHCA technique is a common practice in developed countries. However, it can also be carried out in West African country as evidenced by this clinical case. This prowess testifies a strengthening of our skills in EC technique; and also, the possibility of correcting complex congenital cardiac lesions.

Conflict of Interest

All the authors hereby disclose that they do not have any potential conflicts of interest to be mentioned. Funding: This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

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