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The crystalloid cardioplegia : advantages with a word of caution

La cardioplégie cristalloïde
Avantages et précautions d'emploi

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Abstract

Technical success and absence of iatrogenic injury from inadequate myocardial protection are the foremost targets of every cardiac surgical procedure. The current trends of pediatric cardiac surgery are aimed to achieve definitive repair of complex cardiac defects at birth as to avoid the risks related with palliative surgery and to reduce the long term impact of the untreated defect on the cardiac function. Thus, even newborn patients are exposed to a prolonged time of myocardial ischemia. The aim of this paper is to describe the impact of crystalloid HKT Custodiol cardioplegia infusion on myocardial protection in the early and late outcome of newborn patients who underwent arterial switch operation (ASO) for transposition of the great arteries (TGA).

Keywords: Cardioplegia; Neonates; TGA

Résumé

La réussite technique et l'absence de lésion iatrogène due à une protection du myocarde insuffisante sont les premières cibles de tout geste chirurgical en cardiologie. Les tendances actuelles en chirurgie cardiaque pédiatrique ont comme objectif la réparation définitive de déformations congénitales complexes afin d'éviter les risques liés à la chirurgie palliative et de réduire l'impact à long terme sur la fonction cardiaque d'une déformation non traitée. Ainsi, même les nouveau-nés subissent une exposition prolongée à l'ischémie du myocarde. L'objectif de cet article est de décrire l'impact de l'infusion de la solution cardioplégique cristalloïde Custodiol HTK sur la protection du myocarde dans le résultat précoce et tardif chez les nouveau-nés bénéficiant d'un switch artériel pour la transposition de gros vaisseaux (TGV).

Mots-clés : Cardioplégie ; Nouveau-nés ; TGV

1. Introduction

The protection of the heart during cardiac surgery, especially of the immature myocardium of newborn patients, has a great importance to avoid those intraoperative insults that can lead to both early and late cardiac dysfunction.

Cardioplegia is one of the most significant tools used to increase myocardial protection. Due to the availability of several and well tested cardioplegia infusions, quality and outcome assessment in humans is a difficult task [1]. The reported data in the literature led us to speculate that the "optimal" cardioplegia is still to come and that a careful selection of the appropriate cardioplegic infusion should be tailored considering the type of the cardiac defect being treated as well as the duration of cardiac ischemia.

Cardioplegic solutions may be either crystalloid or blood. Among the group of crystalloid cardioplegia, the HKT Custodiol [2] is the one which often arouses the curiosity of surgeons and anesthesiologists, still being a matter of debate and sometimes criticism. This is a

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solution based on intracellular level of electrolytes, initially proposed by Bretschnider in the 70s, modified to allow prolonged organ protection during transplantation [3]. The addition of histidine, ketoglutarate and mannitol act as buffer, improving high energy production, stabilizing cell membres and maintaining osmotic regulation of the cell membrane, with a safe time of cardioplegic arrest of 180 minutes with a single dose.

2. Materials and Methods

We retrospectively analyzed a group of 30 patients with diagnosis of TGA who underwent ASO in our hospital between February 2008 and December 2009. Simple transposition was diagnosed in 20 patients, while 7 patients had associated VSD and 3 patients had TGA with VSD and aortic coarctation. Coronary artery pattern was type A in the 67.5 % of patients. The mean age at operation was 10.9±7.4 days, mean weight was 3.05 kg (range 1.9- 3.9 kg).

The ASO was performed by the same surgeon, with standard aortic and bicaval venous cannulation, and moderate hypothermic cardiopulmonary bypass (CPB), range of temperature between 28 °C and 32 °C. Selective cerebral perfusion was required in 3 patients during aortic arch reconstruction.

Cardiopulmonary bypass (CPB) was performed using a neonatal hollow fibre membrane oxygenator Dideco Kids D100 (Sorin, Mirandola, Italy).

A single dose of 50 ml/kg of crystalloid cardioplegia was delivered in the aortic root during 7 minutes, with infusion pressure steadily below 50 mmHg.

During the cardioplegic infusion, the right atrium was opened and the solution was almost completely removed. Continuous ultrafiltration was performed beginning with the onset of cardioplegic infusion. Continuous monitoring of the electrolytes, especially of Calcium was necessary during CPB time.

Troponin-I level was monitored preoperatively, 30 minutes after aortic clamp removal, and after 6, 12,18 24 hours following the end of the operation.

3. Results

There was no hospital mortality. Mean CPB time and cardioplegic cardiac arrest were 148±29minutes (range, 113 to 229 minutes) and 98±14 minutes (range, 71 to 131 minutes).

Cardioplegia was delivered in a single shot and didn't require any further infusion.

At cross clamp removal the heart started beating spontaneously on sinus rhythm in the 100% of cases.

During the CPB a continuous ultrafiltration was performed, with a mean value of 116.02 ml/Kg. The hematocrit level was stable at 35%.

The median stay in intensive care unit was 2.1 days (range 0.8 to 12 days) and mean duration of ventilatory support was 20 hours (range, 17 to 92 hours).

Inotropic support was used in all patients with the association of dopamine, dobutamine and adrenaline.

Troponin-I level increased in the early hours after aortic cross clamp removal and subsequently decreased within the first 24 hours (Fig. 1).

Postoperative echocardiographic assessments showed a normal systolic function of the left and right ventricles without areas of abnormal motion.

There were no late deaths. All patients were followed at 3 and 6 months with electrocardiographic and echocardiographic monitoring.

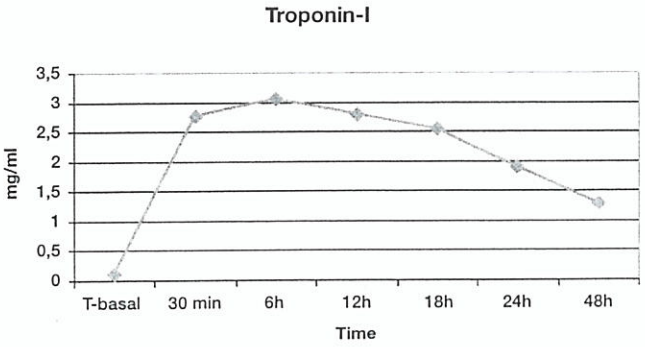

Fig. 1. Levels of troponin-I level in the early hours after aortic cross clamp removal.

4. Discussion

Many factors are involved in neonatal myocardial protection and the cardioplegia is only one of the actors in this play. Indeed, the complexity of surgical repair, the prolonged ischemic time, the severe hemodilution during CPB, and the amount of blood transfusions are still important issues that need to be considered. All these variables may have a deep effect on the early and late outcome of our patients. Unfortunately, Troponin-I is the only parameter which is actually recognized as being able to assess the efficacy of myocardial protection [1]. At present, several cardiac surgeons prefer blood warm cardioplegia, that normally needs to be repeated every 10-15 minutes, thus avoiding crystalloid cardioplegia. In our experience, the HTK solution appears to be allow a prolonged and safe time of ischemic arrest with a single shot infusion, avoiding the risk of a selective cannulation of the coronary ostia for repeat cardioplegic infusion during complex cardiac interventions. Moreover, the absence of blood is of great comfort to surgeons, fine balancing of potassium levels is important and the impact of a huge quantity of water can be partially solved by a correct conduction of CPB and continuous ultrafiltration. We focused our attention on the impact of moderate hypothermic CPB and crystalloid HKT Custodiol cardioplegia infusion in the myocardial protection on the newborn patients who had ASO for TGA. This operation is actually a very standardized surgery, performed in neonatal period with a low early and late mortality and morbidity. Even in the hands of very quick

surgeons this operation requires repeated administrations of the routinely used blood cardioplegia, selectively into the coronary ostia. The risk of intimal lesions during this procedure is an interesting point of discussion and led us to use this solution.

Data concerning biochemical markers, time at extubation, inotropic support, intensive care unit (ICU) stay, systolic function at echocardiography and late postoperative have been collected in order to evaluate the efficacy of this type of cardioplegia, confirming the favorable impact of this on the overall results.

Nevertheless we believe that other types of cardioplegia might be more useful in case of short cross clamp times, as described in several experience, with encouraging results.

Conflict of interests

The author has declared no conflict of interest with this article.

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