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Original article

Outcomes of deep hypothermic circulatory arrest in pediatric cardiac surgery: A single center experience☆

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Abstract

Background: Deep hypothermic circulatory arrest (DHCA) is a technique used in the repair of complex congenital cardiac lesions that require aortic arch or pulmonary vein repair. DHCA has been linked to adverse outcomes and neurologic complications. Selective cerebral perfusion (SCP) may be added to DHCA to prevent neurological complication. Air embolism and hyperperfusion injury may be encountered. The aim of this study was to evaluate the safety and efficacy of simple DHCA and to outline the early outcomes especially the neurological ones.

Methods: Twenty nine patients underwent surgical repair of congenital cardiac lesion with DHCA at a single institution from January 2010 to November 2015. DHCA was conducted with a target esophageal temperature of 18° and placement of an ice pack on the head. No selective perfusion was done. Demographic, operative and postoperative data were reviewed. Mortality, any neurological complications including seizers, coma, and stroke were recorded.

Results: The mean age was 20.6 ± 8.2 months (range: 9 days to 154 months). The majority were males (20, 69%). The mean weight was 5.57 ± 4.2 kg (range: 2.3–17.5 kg). DHCA time was 20.03 min (range 3–52 min). There were three (10.3%) deaths. Two deaths occurred after Norwood operation, and one after interrupted aortic arch repair. None of the deaths were related to neurological injury. None of the patients developed seizers, coma, abnormal movement or neurological deficits.

Conclusions: Simple DHCA without SCP is a safe, expeditious and reliable method for brain protection during repair of complex cardiac lesions, with acceptable outcomes.

Keywords: Deep hypothermic circulatory arrest (DHCA); Selective cerebral perfusion (SCP); Antegrade cerebral perfusion (ACP); Retrograde cerebral perfusion (RCP)

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1. Introduction

DHCA is a technique used in the repair of complex congenital cardiac lesions that require aortic arch or pulmonary vein repair. Since the introduction of DHCA in the early 1960s; it has been increasingly used in centers with expertise in open heart surgery for infants, children, and adults. The use of this technique is based on the premise that there is a safe duration of total circulatory arrest that is inversely related to the body temperature [1]. Circulatory arrest is typically undertaken at 18–20 C and a range of safe periods for DHCA have been reported at this temperature. Most patients tolerate 30 min of DHCA without significant neurological dysfunction. But when this is extended to longer than 40 min, there is a marked increase in the incidence of brain injury especially above 60 min [2]. Clinical studies have identified risk factors for cerebral dysfunction after DHCA, including duration of arrest, duration of cooling and arterial pH, electroencephalographic activity, and somato-sensory evoked potentials during recirculation after arrest [3]. However, SCP may be added to DHCA to prevent neurological complications. Air embolism and hyper perfusion injury may be encountered [4]. Some authors demonstrated that there is no significant difference between the two perfusion techniques with regard to new cerebral lesions as evident on MRI. Antegrade cerebral perfusion (ACP) is no more neuro-protective than DHCA, and may even lead to more focal infarcts in central regions of the brain [5].

The aim of this study was to evaluate the safety and efficacy of simple DHCA without SCP and to outline the early outcomes especially the neurological ones.

2. Methods

Twenty nine patients underwent surgical repair of congenital cardiac lesion with DHCA at a single institution from January 2010 to November 2015. DHCA was conducted with a target esophageal temperature of 18° and placement of an ice pack on the head. No selective perfusion was done. Demographic, operative and postoperative data were reviewed. Mortality, any neurological complications including seizers, coma, and stroke were recorded.

3. Results

With review of 29 patients underwent surgical repair of congenital cardiac lesion with DHCA, we found the mean age was 20.6 ± 8.2 months (range: 9 days to 154 months). The majority were males (20, 69%). The mean weight was 5.57 ± 4.2 kg (range: 2.3–17.5 kg). DHCA time was 20.03 min (range 3–52 min), most of patients underwent interrupted aortic arch (IAA), coarctation (CoA) repair 13 (44.8%), Norwood procedures 5 (17.2%), CoA with VSD 4 (13.7%), and TGA with arch hypoplasia 4 (13.7%). The mean cardiopulmonary bypass (CPB) time was 88.8 ± 32.8 min range from 42 to 186 min, ischemic time was 53.1 ± 31.2 (0–153) minutes, the duration of DHCA was 20.03 ± 10.7 (3–52) minutes, hospital stay was 9.6 ± 13.1 (1–64) days, and ICU stay was 23.1 ± 19.6 (2–75) days. There were three (10.3%) deaths. Two deaths occurred after Norwood operation, and one after IAA repair. None of the deaths were related to neurological injury. None of the patients developed seizers, coma, abnormal movement or neurological deficits (Table 1).

4. Discussion

DHCA is a technique used in the repair of complex congenital cardiac lesions that require aortic arch or pulmonary vein repair. SCP may be added to DHCA to prevent neurological complications. SCP has its complications including embolization, hyperperfusion with increase intracranial tension, and adds complexity to operation by inserting more cannulae [2]. Accordingly, all our patients underwent repair of complex cardiac lesions, using DHCA without SCP. We observed absence of neurological complications after operation regarding coma, abnormal movements, stroke, and seizures. Sarah C et al. reported that circulatory arrest is typically undertaken at 18–20 C and a range of safe periods for DHCA have been reported at this temperature [2]. Abdelkhalik M and El-Sawy H demonstrated that neurological complications which frightened many surgeons to adopt this DHCA technique is not very common & it seemed that arresting the circulation up to 60 min is safe & does not affect the recovery of babies provided that we go down with temperature to 15° [10]. So in our study, DHCA was conducted with a target esophageal temperature of 18° and placement of an ice pack on the head. The mean duration of DHCA in our patients was 20.03 ± 10.7 (3–52) minutes, in Zheng G et al. study it was 30.64 ± 15.81 (7–63) minutes [1] and in Tassani P et al. it was 40 ± 4 min [9]. Some

Table 1
Results details.

Demographic	
Age	42.2 ± 8.2 months (9 day to 91.9 months)
Gender	
Male	20 (69%)
Female	9 (31%)
Weight (kg)	5.57 ± 4.2 (2.3–17.5)
Diagnosis	
Interrupted aortic arch (IAA) or coarctation of aorta with transverse arch hypoplasia (CoA)	13 (44.8%)
Hypoplastic left heart syndrome (HLHS)	5 (17.2%)
CoA with VSD single/multiple	4 (13.7%)
Transposition with arch hypoplasia	4 (13.7%)
Truncus Areteriosus with IAA	1 (3.4%)
TAPVC	1 (3.4%)
Aortic Aterisa, VSD, PAPVC	1 (3.4%)
Surgical data	
CPB duration (minutes)	88.8 ± 32.8 (42–186)
Myocardial ischemia duration (minutes)	53.1 ± 31.2 (0–153)
Duration of DHCA (minuets)	20.03 ± 10.7 (3–52)
Postoperative	
Mortality	3 (10.3%)
Norwood operation	2
IAA	1
Neurological complication	0 (0%)
Length of stay on ICU/days	9.6 ± 13.1 (1–64)
Length of hospital stay/days	23.1 ± 19.6 (2–75)

Continuous data: Mean ± Standard Deviation (Range), Categorical data: frequency (%), TAPVC: total anomalous pulmonary venous connection, PAPVC: partial anomalous pulmonary venous connection, IAA: interrupted aortic arch.

studies demonstrated that there is no difference in neurological outcome between DHCA alone and with retrograde cerebral perfusion (RCP) [5,6]. Goldberg et al. [7] demonstrated that development in children with hypoplastic left heart syndrome (HLHS) and other related single ventricle malformations is overall delayed, RCP was not associated with improved neuro-developmental outcomes when compared with DHCA. Algra et al. [8] reported that increasing duration of DHCA, but not ACP, during neonatal aortic arch reconstruction prolongs short-term postoperative recovery. This suggested that all efforts should be made to reduce the duration of DHCA to the shortest period possible, which may be achieved by exclusive use of ACP or a combination of the 2 perfusion techniques.

We concluded that, in spite of the introduction of the techniques of SCP, simple DHCA without SCP is still a safe, expeditious and reliable method for brain protection during repair of complex cardiac lesions, with acceptable outcomes especially neurological one.

Conflict of interest

No conflict of interest.

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