Duration of Cooling During Pediatric Cardiac Surgery Influences Cerebral Metabolism in Infant

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Introduction: Recent clinical studies during pediatric cardiac surgery have demonstrated that rapid cooling negatively influences neuropsychologic outcome. (1, 2) In these studies, failure of hypothermia to adequately suppress cerebral metabolism (CMR02) prior to deep hypothermia circulatory arrest (DHCA) was speculated to be the mechanism for injury. Other experimental studies have suggested that the brain cools unevenly during cardiopulmonary bypass (CPB). (3) We therefore, hypothesized that a longer duration of cooling would enhance more homogeneous brain cooling and promote suppression of CMR02 prior to DHCA, and improve recovery of CMR02 after CPB.

Methods: After Institutional Review Board approval and informed consent, 60 neonates and infants undergoing cardiac surgery with CPB and deep hypothermic circulatory arrest (DHCA) were randomized to one of two groups. Group A (n=30) were exposed to prolonged CPB cooling of 20 min prior to DHCA, and compared to a cohort group (B) of another 30 patients undergoing standardized cooling to a nasopharyngeal temperature of 18°C and then arrested, where a shorter duration of cooling is customary. Anesthetic management consisted of midazolam (75 mcg/kg load; and 0.75 mcg/kg/min infusion), fentanyl (25 mcg/kg; and 1 mcg/kg/hr infusion) and pancuronium as required for neuromuscular blockade. Nonpulsatile CPB pump flow with a membrane oxygenator was maintained at the rate of 150 ml/kg/min during cooling and rewarming, and alpha-stat blood gas management was used. Cerebral blood flow (CBF), CMR02, and cerebral oxygen extraction (A-V02) were measured before, during and after CPB. Intragroup data were analyzed using ANOVA for repeated measurements and intergroup data were analyzed using unpaired T-tests, with significance assumed at the $P<0.05$ level.

Results: There was no intergroup difference with respect to age, congenital heart lesion, surgical procedure, or starting hematocrit. Duration of cooling was significantly longer in Group A vs Group B (20.2±1.9 vs 11.6±2.0 min. respectively; $p<0.01$). CMR02 and A-V02 difference were significantly lower in Group A compared to B after cooling (Table). Despite greater CMR02 suppression in A, the recovery of CMRO2 after DHCA was not significantly different from Group B (Table).

Discussion: We conclude that increasing the duration of CPB cooling to 20 minutes prior to DHCA in infants optimizes cerebral metabolic suppression. We speculate that increasing the duration of cooling promotes more homogeneous cooling of the brain and recommend its application during cardiac surgery. However, despite the enhanced metabolic suppression due to prolonged cooling, the recovery of CMR02 after DHCA is still abnormal, suggesting that hypothermic protection with enhanced cooling may still be insufficient as a sole protective measure when DHCA is used.

TABLE I

CMRO2	I	II	III
A	1.2±0.40	0.08±0.04*	0.52±0.25#
B	1.2±0.33	0.19±0.10	0.65±0.34#
A-V 02			
A	6.0±1.4	0.8±0.30*	4.4±1.4#
B	5.7±1.3	1.7±0.50	5.0±2.0
02Ext			
A	40%±21	11%±5*	37%±15
B	45%±13	19%±6	39%±18

A=Prolonged cooling group; B=Control group; I=Baseline, warm; II=Cold, CPB; III=Rewarmed, Post-CPB; CMR02=Cerebral metabolic rate, oxygen (ml/100gm/min); A-V 02=Cerebral AV 02 difference; 02 Ext=Cerebral oxygen extraction ratio (%). Mean values ±S.D.; *$p<0.05$, grp A vs B; #$p<0.05$, stage III vs I.

Refs:

1. Bellinger D. et al., Pediatrics 1989
2. Greeley W.J. et al., J Thorac Cardiovsc Surg, 1991
3. Hindman, B.J. et al., Anesthesiology, 1992