### CLINICAL CIRCULATION IV

**Title:** CARDIOPULMONARY BYPASS AND TOTAL CIRCULATORY ARREST ALTERS CEREBRAL METABOLISM IN INFANTS, CHILDREN

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**Introduction:** Cardiopulmonary bypass (CPB) management in infants and children involves extensive alterations in temperature (18-37°C) and perfusion pressure, with occasional periods of circulatory arrest. Despite the use of these biological extremes of temperature and perfusion, their effects on cerebral metabolic rate (CMRO₂) are unknown. This study was designed to examine the effect of hypothermic CPB in children with and without periods of total circulatory arrest on CMRO₂ and to determine the temperature coefficient (Q₁₀), which defines the relationship of temperature to CMRO₂.

**Methods:** After Institutional Review Board approval and informed parental consent, CBF and CMRO₂ were measured in 46 infants and children, ages 1 day to 9 years, undergoing CPB. Patients were grouped based on CPB conditions: 1) moderate hypothermic CPB (MHC-PBP) at 28°C with continuous flow, 2) deep hypothermic CPB (DHC-PBP) at 18-20°C with continuous flow, and 3) deep hypothermic CPB at 18-20°C with total circulatory arrest (DHCRA). CBF was measured using xenon clearance methodology. Using a jugular venous bulb catheter, cerebral venous oxygen content was directly measured, and CMRO₂ and oxygen extraction (CaO₂ - CvO₂) were determined. Measurements were made before CPB (stage A); during stable hypothermic CPB (stages B + C) or at stable hypothermic CPB immediately before and after DHCRA (B + C); and after CPB (stage E). To examine the relationship of temperature to CMRO₂, the temperature coefficient (Q₁₀), defined as the ratio of metabolic rates at two temperatures separated by 10°C, was determined from data from the stages A (baseline at 36°C) and B (CPB, cold) for each group. Data was analyzed using paired t-tests and linear regression techniques.

**Results:** See Table. All groups showed a significant decrease in CBF and CMRO₂ during hypothermic bypass conditions at stage B compared to pre-bypass levels (A; p < 0.001). In the MHC-PBP and DHC-PBP groups, CBF, CMRO₂ and CaO₂ - CvO₂ returned to near baseline levels in the rewarming phase of bypass (D) and after bypass (E). In DHCRA patients, CBF, CMRO₂ and CaO₂ - CvO₂ remained reduced during rewarming after circulatory arrest at stage D and persisted after being warmed from bypass at stage E. The Q₁₀ for the MHC-PBP, DHC-PBP and DHCRA groups were 3.2, 4.1 and 5.1 respectively.

**Discussion:** These data demonstrate several new findings: 1) CBF and CMRO₂ are significantly reduced during hypothermic CPB in children, principally related to temperature reduction. Q₁₀ quantifies this relationship and shows a considerably greater Q₁₀ for the deep hypothermic groups (DHC-PBP, DHCRA). The striking increase in Q₁₀ going to 18-20°C proves that the known protective effect of deep hypothermia for circulatory arrest up to periods exceeding 1 hour can be explained on a metabolic basis alone. 2) After rewarming from DHCRA, CBF and CMRO₂ remain reduced, suggesting post-ischemic hyperperfusion and a metabolic disturbance in oxygen utilization. In the presence of slow flow after DHCRA, these patients are unable to increase oxygen extraction to meet tissue demands during rewarming and after CPB.

### TABLE

<table>
<thead>
<tr>
<th>Group</th>
<th>CBF (ml/min/kg)</th>
<th>CMRO₂ (ml/min/kg)</th>
<th>CaO₂ - CvO₂ (ml/min/kg)</th>
<th>TEMP (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MHC-PBP</td>
<td>20.55 ± 0.05</td>
<td>0.02 ± 0.02</td>
<td>0.02 ± 0.02</td>
<td>37.05 ± 0.15</td>
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<tr>
<td>DHC-PBP</td>
<td>7.00 ± 0.05</td>
<td>0.02 ± 0.02</td>
<td>0.02 ± 0.02</td>
<td>37.05 ± 0.15</td>
</tr>
<tr>
<td>DHCRA</td>
<td>7.00 ± 0.05</td>
<td>0.02 ± 0.02</td>
<td>0.02 ± 0.02</td>
<td>37.05 ± 0.15</td>
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</tbody>
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### References

1. Anaesthesia 43: 935-938, 1988