

# Paraplegia Associated with Hyperthermia during Repair of Coarctation of the Aorta

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(Key words: anesthesia, heart, aortic coarctation, paraplegia)

The occasional complication of repair of coarctation of the aorta is spinal cord damage which may lead to partial or complete paraplegia<sup>1,2</sup>. The mechanism for this injury is not well understood, but may possibly be due to interruption of the blood supply to the lower spinal cord during aortic cross-clamp<sup>3</sup>. However, we encountered two patients who had a significant paraplegia after the repair of coarctation of the aorta and in whom common factors were hyperthermia during the time of aortic cross-clamp. Hyperthermia may contribute to the development of paraplegia and thus an attempt should be made to avoid hyperthermia during repair of coarctation of the aorta.

## Case Report

### Case 1

A 11-month-old girl was admitted due to inadequate weight. She weighed

920 grams at the time of birth at 37 weeks gestation. On admission, she was 56 cm high and weighed 3,563 grams. Cardiac catheterization showed a discrete preductal coarctation, ventricular septal defect (VSD) and patent ductus arteriosus (PDA). Physical examination revealed the possibility of Silver-Russel syndrome, since the right leg was 3 cm longer than the left and both little fingers were bent. There were signs of congestive heart failure and digitalis and diuretics were administered orally.

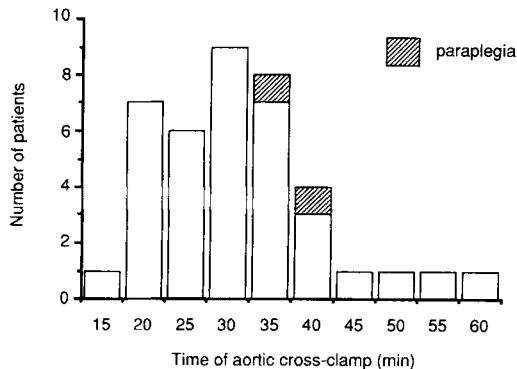
On the day of scheduled surgery for repair of coarctation of the aorta, trichloryl 400 mg was given orally and 2 hours later anesthesia was induced with nitrous oxide and halothane in oxygen, via a face mask. Two 22-gauge i.v. cannulae were inserted, then pancuronium bromide 0.5 mg was used to facilitate the insertion of a 3 mm endotracheal tube. Anesthesia was maintained with fentanyl 100 µg and nitrous oxide 3 liters/oxygen 1.5 liters with a non-rebreathing circuit. The patient was then placed in the right lateral decubitus position and left thoracotomy was conducted. PDA was first ligated and the coarctation was repaired by subclavian flap angioplasty. The aortic cross-clamp time was 39 min. Before the opera-

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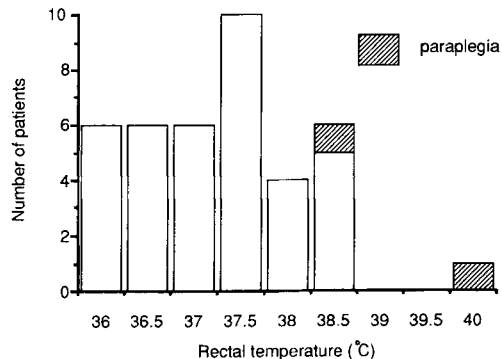
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**Fig. 1.** Time of aortic cross-clamp in 39 patients who underwent repair of coarctation of the aorta from 1981 to June 1986.



**Fig. 2.** Rectal temperature during aortic cross-clamp in 39 patients who underwent repair of coarctation of the aorta from 1981 to June 1986.

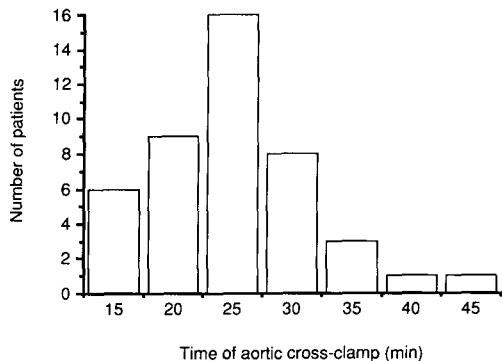
tion dopamine  $5 \mu\text{g}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$  was given intravenously to maintain the systolic blood pressure above 70 mmHg, and during the operation same dose of dopamine was administered. At the start of the operation, rectal temperature was  $37.6^\circ\text{C}$  and it gradually increased. Despite efforts to cool the body, rectal temperature remained at about  $38.0\text{--}38.5^\circ\text{C}$  during the period of aortic cross-clamp. Arterial blood gases during this period were pH 7.413,  $\text{P}\text{O}_2$  198 mmHg,  $\text{P}\text{C}\text{O}_2$  51.9 mmHg at an  $\text{F}\text{I}\text{O}_2$  of 0.5, and hematocrit was 35%. In the intensive care unit about six hours postoperatively, lack of movement in the lower extremities was noted and the patient was diagnosed as complete flaccid type paraplegia with neurogenic bladder. She died on the fiftieth day after the operation due to pulmonary infection and congestive heart failure.

#### Case 2

A 13-month-old girl was admitted for repair of coarctation of the aorta. She was 68 cm high and weighed 6,670 grams. She had previously undergone VSD closure and PDA ligation at 8 months of age. Subsequently, a second degree atrio-ventricular block occurred and pacemaker implantation was con-

ducted. Heart failure ensued and cardiac catheterization revealed postoperative coarctation of the aorta due to ligated PDA. After premedication with trichloryl 700 mg orally, anesthesia was induced with nitrous oxide and halothane via a face mask in a semi-closed circuit. Pancuronium bromide 0.8 mg was administered and a 4.5 mm endotracheal tube was inserted. Anesthesia was maintained with fentanyl  $400 \mu\text{g}$  and nitrous oxide. Subclavian flap angioplasty was attempted but adhesion around the coarctation was severe. Consequently the Blalock-Park operation was performed (the left subclavian artery was anastomosed end to the side to the distal aorta). The aortic cross-clamp period was 42 min. At the start of the operation, rectal temperature was  $38^\circ\text{C}$ . Despite externally applied cooling, the temperature remained at  $40.2^\circ\text{C}$  during aortic cross-clamp. At this point, arterial blood gases were pH 7.389,  $\text{P}\text{O}_2$  185 mmHg,  $\text{P}\text{C}\text{O}_2$  42.6 mmHg at an  $\text{F}\text{I}\text{O}_2$  of 0.5 and hematocrit was 33%. Flaccid paraplegia of the lower extremities was indicated postoperatively.

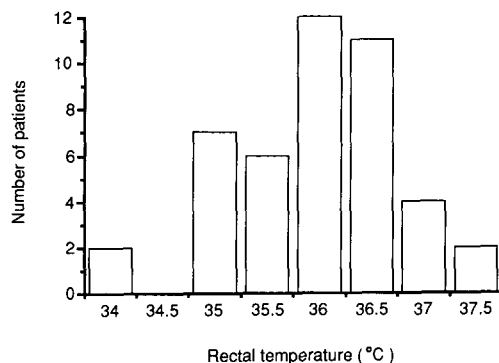
From 1981 through June 1986, 39 children with coarctation of the aorta



**Fig. 3.** Time of aortic cross-clamp in 44 patients who underwent repair of coarctation of the aorta from June 1986 to May 1990.

had been treated at the Fukuoka Children's Hospital Medical Center. Figure 1 shows the distribution of aortic cross-clamp time. This period ranged from 18-62 min with a mean of 35 min. The aortic cross-clamp time of two cases with paraplegia were 39 and 42 min. Figure 2 shows rectal temperature during the time of aortic cross-clamp to have ranged from 36.0-40.2°C with a mean of 37.5°C. In both cases, rectal temperature was high. Other parameters, such as the blood pressure, total blood loss or arterial blood gas analysis were also checked and found essentially the same for patients with and without paraplegia. Hyperthermia would thus appear to be a contributing factor to paraplegia following repair of coarctation of the aorta. Since June 1986, attempts have thus been made to prevent hyperthermia during aortic cross-clamp by keeping the operating room cool and placing a cooling blanket over and under the patient.

Figure 3 shows the distribution of aortic cross-clamp time for 44 children with coarctation of the aorta, who underwent operation between June 1986 and May 1990. The mean cross-clamp time was 27 min and the range was 15-48 min. Figure 4 shows rectal temperature during the time of aortic



**Fig. 4.** Rectal temperature during aortic cross-clamp in 44 patients who underwent repair of coarctation of the aorta from June 1986 to May 1990.

cross-clamp when efforts were made to prevent hyperthermia. This was successfully done and the mean rectal temperature was 36.1°C ranging from 34.0-37.8°C. No paraplegia was noted among these 44 children.

### Discussion

Paraplegia is an occasional complication in repairing coarctation of the aorta, with the incidence being 0.41% or 1.5%<sup>1,4</sup>. The main cause of this complication may be hypoxia of the spinal cord during aortic cross-clamp, but the factors which modify the development of paraplegia have not been definitely established.

From the view of blood supply to the spinal cord during aortic cross-clamp, attention should be paid to the anatomy of the anterior spinal artery and the development of collateral circulation between the proximal and distal segments of the aorta. Spinal cord is supplied from one anterior spinal artery and two posterior spinal arteries, the former being dominant. The anterior spinal artery arises from the vertebral arteries before they fuse to form the basilar artery, and radicular branches of intercostal arteries further supply this artery. Therefore,

ischemic damage could occur if the continuity of the anterior spinal artery is not good and/or if the collateral circulation is inadequate. In addition to these anatomical factors, there are other contributing factors such as long aortic cross-clamp time, decreased systemic blood pressure and interruption of intercostal arteries<sup>3,4</sup>.

From the view of oxygen demand of the spinal cord during aortic cross-clamp, the body temperature is the most important factor. So, increased metabolism of the spinal cord due to hyperthermia could also be a cause of paraplegia.

Crawford and Sade<sup>5</sup> reported three infants with significant paraplegia following repair of coarctation and having hyperthermia in common during the period of the aortic cross-clamp. The two cases of paraplegia presented here were also hyperthermic. Hyperthermia may contribute even more significantly than other factors such as aortic cross-clamp time to bringing about paraplegia. For reducing the metabolism of spinal cord and prevent paraplegia, hypothermia induced deliberately may be the best way. However, the incidence of ventricular fibrillation may be higher under hypothermia than under normothermia<sup>6</sup>. We therefore attempted only to prevent hyperthermia. As a result of preventing hyperthermia, rectal temperature was maintained between 34.0-37.8°C during the

aortic cross-clamp, and no paraplegia was encountered.

Although factors contributing to the development of paraplegia could not be determined clearly, avoiding hyperthermia during aortic cross-clamp may be essential for the prevention of paraplegia.

(Received Nov. 18, 1991, accepted for publication Dec. 19, 1991)

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