Profound Hypotension with Differential Cooling of the Brain in Dogs

Tomio Ohta, M.D., Javier Sagharminaga, M.D.,* and Maitland Baldwin, M.D.

Branch of Surgical Neurology, National Institute of Neurological Diseases and Blindness, National Institutes of Health, Public Health Service, Department of Health, Education and Welfare, Bethesda, Maryland

Effective hemostasis is usually attained by routine and standardized procedures. However, since the operative treatment of highly vascularized lesions often requires additional hemostatic measures, unique adjuncts such as controlled hypotension or hypothermic techniques have been employed. Indeed, hypotensive agents have also been used in combination with body-surface cooling, while the nervous system has been cooled topically, selectively, or indirectly. Moreover, various levels of hypothermia (or more precisely, brain temperatures), ranging from 35°C to 10°C, have been used. In the lower ranges (or profound hypothermia), extracorporeal circulation has been applied either as a cardiac bypass, or for selective cooling.

Since the hypothermic brain is relatively hypotensive, and indeed, at very low temperatures even appears bloodless, the cooling techniques have been exploited with the hope that their further development might make possible operative dissection with little bleeding, while the surrounding brain was protected by lowered metabolic requirements. Woodhall et al., Uihlein et al., and Patterson and Ray have proposed extracorporeal systems and applied them to clinical neurosurgery. Kristiansen et al. have applied a selective brain cooling system, while Ommaya and Baldwin have reported a technique for direct or topical cooling of the brain. The complexities of extracorporeal techniques and the undesirable side effects of the necessary anticoagulants have proven obstacles to their general use, despite many successful applications in selective centers. Moreover, the profound hypothermic states which can provide an ideal field for dissection may also set the stage for abnormal cerebral permeability and consequent cerebral edema, while the cardiac effects of such low temperatures on the heart may also be undesirable.

This investigation was aimed at the development of a method which would obviate the danger of cardiac arrest and ventricular fibrillation, yet provide controlled profound hypotension with differential cooling of the brain without dissection of the neck vessels.

Method

Seventy mongrel dogs (12–26 kg.) were used in these experiments. Anesthesia was induced with pentothal (25 mg./kg.), the trachea intubated, and thereafter anesthesia was maintained with halothane-oxygen using intermittent positive pressure respiration by means of a Bird respirator. Each animal was heparinized (2 mg./kg.). A venous catheter (#18) was placed in the thoracic part of the inferior vena cava through the left femoral vein. An arterial catheter (#14) was also passed through the left femoral artery to a point at the arch of the aorta close to the branching of the brachiocephalic and left subclavian arteries (Fig. 1). The position of the tip of the arterial catheter was confirmed by thoracotomy.

The venous and arterial catheters were connected to an extracorporeal circuit containing a roller-type pump, a Harrison-Brown heat exchanger with a bubble trap and a bubble-type oxygenator (100 per cent oxygen). The latter included a special reservoir made from 2 plastic graduated cylinders. This reservoir was used to measure in-flow volume. The extracorporeal parts were filled with 1,000 ml. of fluid: 700 ml. of fresh blood containing 40 mg. of heparin, and 300 ml. of 5 per cent dextrose in water.

Drainage of blood into the oxygenator was by gravity, and the direction of flow in the shunt of the extracorporeal circulation was veno-arterial. The inflow blood was cooled to 20°C. The average rate of flow was estimated at 25 ml./kg./min., although it was much more than the average rate at the beginning, and progressively decreased to the end.

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* Department of Anesthesiology, Georgetown University School of Medicine, Washington, D. C.
For roentgenographic examination of hemodynamics during this procedure, a tube containing 15 ml of 50 per cent Hypaque was attached just proximal to the arterial catheter and parallel to the connection coming from the bubble trap. It was ordinarily clamped off from the remainder of the circuit. However, at any time in the cooling phase, this side tube could be opened so as to let the radiopaque medium flow into the artery at the velocity and force of pumping. A serial exposure apparatus (Sanchez-Perez) was used and 12 films were taken at the rate of 2 films per second.

**Temperature Gradients**

With constant arterial catheter bore size, a fixed temperature of blood inflow and a fixed placement of the catheter tip, the cooling rate of the brain depended upon the arterial pressure (Figs. 2 and 3). Below 70 mm. Hg of mean arterial pressure, the cooling rate of the brain was 0.74°C./min., and above 70 mm. Hg it was 0.34°C./min. (Table 1). However, in these conditions, the cooling rates of the rectum were 0.32 and 0.36°C./min., respectively. Thus the rectal temperature (which never fell below 28°C.) seemed irrelevant to the level of blood pressure. During the period of low blood pressure at

![Figure 1. Schematic representation of the circuit used in the "technique of profound hypotension with differential cooling of the brain."]