VENOVENOUS SHUNT FOR RAPID HYPOTHERMIA*

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General body hypothermia produced by physical methods is being used more and more frequently in neurosurgery to achieve protection of the brain from ischemia secondary to operative occlusion of cerebral vessels during intracranial operations.\(^5,6,8,26,33,41\) It has been shown to be useful in brain tumor operations,\(^8,38\) in cerebral trauma,\(^23\) in cerebrovascular occlusive disease,\(^1\) in hyperthermia,\(^24\) and even in shock from burns.\(^12\) In 1940, Fay\(^17-19\) pointed out advantages in the use of this technique in clinical neurosurgery, but hypothermia has gained impetus in neurosurgery only recently. In the interim, cardiac surgeons have used and studied hypothermia extensively as an aid to open heart surgery. Little emphasis has been given to protection of the brain from ischemia during these studies, however. Through these studies it has become clear that fibrillation is the major complication in hypothermia. Even now, the actual cause of this has not been clearly defined. This emphasis on the danger of fibrillation has undoubtedly delayed the use of hypothermia in neurosurgery. Now, however, protection of the brain against ischemia by hypothermia has been clearly delineated,\(^3,22,26,27,31,33\) and the use of hypothermia in neurosurgery is steadily broadening.

External and internal methods of body cooling have been used. External methods include the use of a hypothermia blanket, immersion in ice water in a bathtub, exposure to cooled air, and application of an ice bag to the body.\(^5,6,28,41\) All have the disadvantages of: 1) lack of precise control of the degree of temperature decline; 2) excessive time involved with often cumbersome equipment to achieve the desired level of hypothermia (2 to 3 hours average); and 3) minor danger of trauma of the skin from excessive local cooling.

Internal cooling methods using extracorporeal shunts of circulation have been devised which can produce rapid hypothermia, apparently without increased cardiac complications. An arteriovenous type of shunt has been used mainly, involving a heat exchanger for cooling the blood prior to its return to the body circulation.\(^7,9\) Arterial damage, danger of emboli and expense have prevented wide usage. The advantage of using the arterial pressure to drive blood through the heat exchanger has possibly simplified these systems, but the dangers of producing an arteriovenous shunt of large volume in such people has been stressed.\(^34\)

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618
Venovenous shunts were first used extensively by Ross\textsuperscript{34,35} and Brock,\textsuperscript{8} using a simple device to cool the venous blood in the shunt in which a hand-operated pump was inserted to provide adequate flow of blood. This method required thoracotomy and cardiotomy, however, since the afferent catheter was introduced through the right atrium into the inferior vena cava, and the efferent through the same site but into the superior vena cava. The report of these experiences was limited, but the simplicity of the apparatus and the rapidity of apparently safe cooling were striking. Others have used this method in experimental animals.\textsuperscript{15,20}

A simple, low-cost, venovenous cooling shunt was therefore devised from commercially available units and tested in the laboratory. This shunt demonstrated convenience, safety, and precise control of temperature in over 50 dogs when utilized to produce hypothermia of moderate degree (26°C–29°C). Spontaneous ventricular fibrillation, the major complication of hypothermia, occurred in 19 of the 30 dogs in this series reported.\textsuperscript{43} The mean temperature at which this appeared was 22.8°C. (±0.5°C. standard error), a level somewhat higher than the series reported by Hegnauer.\textsuperscript{21} This critical temperature is therefore much lower than that utilized for clinical purposes.\textsuperscript{5,6,33} The only modification used to adapt this method for clinical needs was to lengthen the cooling coil by 2 feet. The proposed advantages of such a method of rapid hypothermia for clinical use were substantial. Subsequent to the initial experiences with this shunt, the advantages appear to be sufficient to warrant a description in detail.

DESCRIPTION OF VENOVENOUS SHUNT

Fig. 1 demonstrates the shunt. It consists of a Sigmmotor pump unit (Model T\textsuperscript{6S})\textsuperscript{*} with an electric motor-power supply (E), and a torque converter (F) for con-

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* Sigmmotor Corp., Middleport, N.Y.