EXPERIMENTAL BRAIN INJURY DURING HYPOTHERMIA*

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(Received for publication October 28, 1957)

MORBIDITY and mortality following acute trauma to the brain are often the result of fulminating, severe cerebral edema. Any procedure that could reduce the magnitude of edema would facilitate the management of such injuries. Hypothermia is known to decrease the volume of normal brain and to protect against infarction following permanent interruption of major vascular channels.11–13 This study was undertaken to determine the effect of hypothermia upon the pathogenesis of experimental brain injury and, in particular, the effect of reduction of temperature upon the size of a pathologically swollen brain.

METHODS

Forty mongrel dogs, weighing between 11.0 and 23.4 kg., and unselected as to age and sex, were used in this investigation. Acute and chronic experiments were done. In the acute group, brain injuries were inflicted in pairs of animals. One dog of each pair was normothermic at the time of injury, and the other was hypothermic, 25°C. or less, at the time of injury. Each pair was sacrificed at given intervals following the injury and the data to be described below were obtained.

In the chronic experiments, a control group of animals was subjected to brain injury at normal body temperature. A second group was injured during hypothermia; their temperature was maintained at 25°C. or less for 18 hours, and then they were rewarmed. Both groups were observed for life expectancy and survival.

At the start of each experiment, each animal received long-acting Benza-thine penicillin G, 600,000 units, intramuscularly. Diphenylhydantoin sodium, 0.4 gm. daily, was given to suppress convulsions; this was continued through the 5th post-traumatic day in surviving animals.

Anesthesia was achieved with intravenous Pentobarbital Sodium, 30 mg./kg., and the dogs were intubated with a cuffed No. 38 Fr. endotracheal catheter. The catheter was attached to an automatic positive-negative pressure closed-system respirator which delivered 100 per cent oxygen at a rate of 24 respirations per minute. The positive pressure was adjusted between 7 and 11 mm. Hg and the negative pressure was set between 1 and 4 mm. Hg in order to maintain a tidal exchange of

This investigation was supported in part by research grant B-1372 from the National Institute of Neurological Diseases and Blindness, Public Health Service.
The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.
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200–400 ml. A thermistor was inserted 200 mm. into the esophagus for the recording of body temperature. The animals that were to receive brain injuries at normal body temperature were maintained in the 35–39°C. range, with the aid of a heating pad when necessary. In the hypothermic group, reduction of temperature was effected by immersion to the shoulders in ice water. The injury was inflicted when the body temperature reached 25°C.

Standardized brain injuries were produced by a modification of the method of Clasen and his co-workers. The animals were placed in the right lateral recumbent position. The left hemiceranium was exposed by reflecting the overlying scalp and musculature, using aseptic technique (Fig. 1). An imaginary line was projected along the prominence of the convexity between the apices of the frontal and parietal bosses. A burr hole, \( \frac{3}{8} \) inch in diameter, was made two-thirds of the way from the frontal boss along this line. An insulating plastic bushing was inserted into the burr hole. The tip of a brass cylinder was placed through the bushing at such a depth as to make intimate contact with the intact dura mater beneath. The diameter of the tip of the cylinder was 1 cm. With the instrument fastened in place, liquid air, at a temperature of \(-196°C\), was poured into the cylinder. The cylinder was left in situ exactly 8 minutes. The instrument and bushing were removed and the bony defect was filled with bone wax and was covered with steel screening. The muscle and scalp were closed in layers. Thus, a brain injury was created which, for practical purposes, could be called a closed head injury.

The animals were sacrificed at appropriate intervals with an overdose of Pentobarbital Sodium. At the time of sacrifice or death, the brain was removed immediately and was treated as follows. The brain stem was sectioned at the caudal end of the 4th ventricle and through the midbrain at the level of the tentorium. The supratentorial portion of the brain was cut in the mid-sagittal plane. Each of the three segments was weighed to the nearest 0.1 gm. They were then displaced volumetrically to determine their total volume. The density of the brain was calculated and the percentage increase in size of the injured side of the brain as compared to the