STUDIES IN EXPERIMENTAL BRAIN SWELLING
AND BRAIN COMPRESSION*

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The studies reported herein offer a correlation between water-induced
"brain swelling," intracranial pressure and volume, and water and
electrolyte content of the brain, and offer observations on experimental
cerebral compression.

Brain swelling has been defined variously and often used synonymously
with brain edema. While the latter process may or may not be the cause of
the swelling, it implies that convincing evidence is available of excessive
fluid, primarily interstitial, within the tissues. In the present studies, the
criteria for brain swelling are 1) an apparent increase in bulk of the brain
and 2) a corresponding rise in cerebrospinal fluid pressure in the absence of
obstructive hydrocephalus, tumefaction, or vascular obstruction.

In 1919 Weed and McKibben demonstrated the ability that intra-
venously administered distilled water has in producing brain swelling in the
cat. This work stands as a reference point. The occurrence of associated his-
tologic alterations as seen in the rabbit was noteworthy. Fishman reported
rises of cerebrospinal fluid pressure in dogs when 5 per cent dextrose in
water was given both with and without the presence of an extradural mass
which raised the base-line pressure above normal. Systemic administration of
water and techniques of local compression of the brain have been utilized in
these studies.

WATER ADMINISTRATION

Adult mongrel cats of either sex were utilized. Under intravenous pentobarbital
sodium anesthesia, the animals were placed in a head-fixation apparatus. The
cisterna magna was exposed and cannulated, and the calvarium was uncovered. The
animals were then heparinized. Continuous records were made of both the femoral
arterial pressure and the cisternal cerebrospinal fluid pressure via a Statham trans-
ducer on a Sanborn apparatus. In 20 animals, distilled water at 37°C. was ad-
ministered intravenously in a dosage of 40 ml. per kg. at a rate of 60 drops per min.

Ten cats were sacrificed at the completion of the intravenous drip, and 10 were
observed for 60 minutes following the conclusion of the water drip.

Pressure Measurements. When water was administered to these 20 ani-
mals, the cisternal pressure rose from a mean pre-injection pressure of 83

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mm. H₂O to 293 mm. H₂O. These pressure relationships are summarized in Table 1, from which it can be seen that intravenously administered distilled water produced elevations in the cerebrospinal fluid pressure above those recorded in the control animals, as well as above those in animals receiving physiologic salt solution in the same dosage.

When animals treated with water in a similar fashion were observed with the calvarium removed, the brain appeared to swell into the cranial defect, thus fulfilling our criteria of cerebral swelling.

**Volume Measurements.** A second series of 10 animals received distilled water intravenously in identical fashion. At the completion of the infusion, the calvarium was removed with a dental saw. The brain was sectioned at the bony tentorium, removed, and weighed. Its volumetric displacement of water was then measured. The calvarium cap was resealed in place, and a small opening into the cap was made to fill the cranium with fluid and measure its capacity. In 9 control animals to which no distilled water had been administered, brain volume was 19.1 ± 2.0 ml. and intracranial volume was 21.0 ± 1.3 ml. In the 10 animals to which water was administered, brain volume averaged 18.7 ± 1.2 ml. and intracranial volume 19.8 ± 1.8 ml.

Percentages of intracranial volumes occupied by the brains in this group of animals to which distilled water had been administered were compared with similar data from the control animals. It was found that among the latter the mean occupancy by the brain of the intracranial space was 90.0 ± 6.8 per cent, and among the former animals the figure was 94.8 ± 4.5 per cent. P > .05. Increase in bulk of the brain would therefore appear more apparent than real.

**Artificial Respiration: Venous Pressure and Blood Content.** Obstruction to the venous system of the calvarium might raise the cisternal pressure and increase brain bulk, and CO₂ retention caused by inadequate pulmonary ventilation (barbiturate anesthesia) might be another pitfall in the search for the correct explanation of the phenomenon under study.17,21,22

### Table 1

**Pressure relationships**

<table>
<thead>
<tr>
<th>No. of Animals</th>
<th>Cisternal Base Pressure (mm. H₂O)</th>
<th>Maximum Pressure Observation (mm. H₂O)</th>
<th>Pressure at End of Drip (mm. H₂O)</th>
<th>Final Pressure (mm. H₂O)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls</td>
<td>10</td>
<td>106 ± 39</td>
<td>133 ± 65</td>
<td>116 ± 72</td>
</tr>
<tr>
<td>I.V. distilled water 40 ml./kg. at 60 drops/min.</td>
<td>10</td>
<td>68 ± 23</td>
<td>248 ± 85</td>
<td>248 ± 85</td>
</tr>
<tr>
<td>I.V. physiological salt solution. Same dose</td>
<td>10</td>
<td>68 ± 33</td>
<td>134 ± 43</td>
<td>124 ± 39</td>
</tr>
<tr>
<td>I.V. distilled water plus post-I.V. observation</td>
<td>10</td>
<td>99 ± 52</td>
<td>338 ± 114</td>
<td>318 ± 85</td>
</tr>
</tbody>
</table>

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