The Analysis of Body Water Compartments in Postoperative Craniotomy Patients

Part 1: The Effects of Major Brain Surgery Alone
Part 2: The Effects of Mannitol Administered Preoperatively

HENRY A. SHENKIN, M.D., WILLIAM F. BOUZARTH, M.D., AND TETSUO TATSUMI, M.D.
Department of Neurosurgery, Episcopal Hospital, Philadelphia, Pennsylvania

The metabolic response to surgery has been extensively studied by Moore\textsuperscript{12,13} in recent years. It has become well known that increased antidiuretic activity and aldosterone secretion are major responses to surgical stress. This has been demonstrated also in the neurosurgical patient.\textsuperscript{10,21} These metabolic responses are believed to be regulated through the central nervous system.

Verney\textsuperscript{18} has introduced the term “osmoreceptor,” thought to be located in the suprachiasmatic nucleus and adjacent anterior hypothalamus, controlling secretion of the antidiuretic hormone. Bartter, \textit{et al.},\textsuperscript{4} emphasized the term “volume receptor” and suggested that it is stimulated by reduction of the extracellular volume, causing an increased aldosterone secretion. Farrell\textsuperscript{14} localized the volume receptor rostral to the corpora quadrigemina. Gilbert\textsuperscript{4} recently emphasized the subcommissural organ as a primary site for control of water consumption and urinary electrolytes. Previous investigators\textsuperscript{10,21} have found that intracranial lesions can disturb these control systems. However, studies to determine the effect of brain surgery itself on the activity of these presumed centers and resulting changes in the body fluid spaces have never been done.

\textbf{Method}

Ten patients operated on for intracranial mass lesions served as the basis for this study. The age, sex, weight, type of intracranial lesion, and location in each patient is given in Table I. None of the patients was in acute distress preoperatively except patient 7, who had been unconscious for 21 days after a spontaneous subarachnoid hemorrhage and a massive intracerebral hematoma. This patient's neurological status had stabilized for 14 days with normal vital signs, although she was hyponatremic.

Each patient was anesthetized with intravenous sodium pentothal and succinyl choline, intubated, and maintained with fluothane oxygen mixture. All patients did well postoperatively without any apparent complications. Determinations of the body water compartments, plasma and urinary electrolyte contents and osmolality, and plasma cortisol levels were made in the immediate preoperative period. These studies were repeated twice in each patient, once during the early postoperative period (at 1 or 2 days postoperatively) and again in the late postoperative period (5 to 8 days postoperatively).

The laboratory methods employed were isotopic dilution techniques described by Moore\textsuperscript{12} for total body water (TBW), Walser, \textit{et al.},\textsuperscript{20} for extracellular water (ECW), and Silver\textsuperscript{17} for plasma volume (PV). Electrolytes were determined with a Coleman flame photometer, osmolality was determined with a Fiske osmometer (freezing point depression), and plasma cortisol by a fluorometric method described by Rudd, \textit{et al.}\textsuperscript{15}

The study was carried out in the following manner. With the patient in a fasting state, 20 ml of blood were withdrawn, usually between 8 and 9 a.m., for a radioactivity blank and determination of the plasma electrolytes, osmolality, and plasma cortisol levels. Then approximately 50 ml of tritiated water containing 20 mc/ml were injected intravenously with a Harvard infusion-withdrawal pump, which was set at an injection speed of 7.64 ml per minute. The exact volume injected was determined by multiplying 7.64 by the duration of the injection.

At a convenient time after injection of the tritiated water, 2 ml (containing 50 mc/ml) of radioactive sulfate (S\textsuperscript{35} labeled Na\textsubscript{2}SO\textsubscript{4}) were

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TABLE 1

Age and sex of patients, nature of intracranial lesion, and change in postoperative weight in 10 craniotomy patients

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age, Sex</th>
<th>Nature of Lesion</th>
<th>Preop. Weight (kg)</th>
<th>Postoperative Weight (% of Preop.) (day after operation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21 M</td>
<td>mixed glioma, right temporoparietal</td>
<td>72.7</td>
<td>66.4</td>
</tr>
<tr>
<td>2</td>
<td>65 M</td>
<td>glioblastoma, right temporal</td>
<td>78.3</td>
<td>96</td>
</tr>
<tr>
<td>3</td>
<td>36 M</td>
<td>astrocytoma, right temporal</td>
<td>59.3</td>
<td>95</td>
</tr>
<tr>
<td>4</td>
<td>23 M</td>
<td>arteriovenous malformation, left temporoparietal</td>
<td>60.0</td>
<td>98</td>
</tr>
<tr>
<td>5</td>
<td>37 M</td>
<td>metastatic carcinoma, left cerebellum</td>
<td>62.6</td>
<td>97</td>
</tr>
<tr>
<td>6</td>
<td>47 F</td>
<td>meningioma, right temporo-occipital</td>
<td>66.9</td>
<td>101</td>
</tr>
<tr>
<td>7</td>
<td>66 F</td>
<td>anterior commissural aneurysm</td>
<td>57.0</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>37 M</td>
<td>mid cerebral aneurysm</td>
<td>56.0</td>
<td>104</td>
</tr>
<tr>
<td>9</td>
<td>58 F</td>
<td>glioblastoma, right temporal</td>
<td>55.0</td>
<td>95</td>
</tr>
<tr>
<td>10</td>
<td>54 M</td>
<td>glioblastoma, right frontal</td>
<td>76.5</td>
<td>96</td>
</tr>
</tbody>
</table>

Average: 44.4

injected intravenously; exactly 3 minutes thereafter, 2 ml (5 mc/ml) of RISA-I^{131} were injected intravenously through the same needle. Exactly 18 minutes after the injection of radiosulfate, 20 ml of blood were withdrawn for determination of the extracellular water (sulfate space) and plasma volume. Two hours after the injection of the tritiated water, another 20 ml of blood were withdrawn for determination of the total body water.

The withdrawals of the blood samples were made from the arm opposite the one injected. Plasma was separated from the blood samples immediately and kept frozen until analyses were made. Radioactivity was counted with a scintillation well counter for RISA-I^{131} and a Tricarb liquid scintillation counter for tritiated water and sulfate.

The volume of each body water compartment was calculated by the following equations:

\[ TBW = \frac{A_1 - E}{A_2} \]

where \( TBW \) is the total body water; \( A_1 \) is the injected activity (counts/min/ml×1000×volume of tritiated water injected); \( A_2 \) is the counts/min/ml of plasma; and \( E \) is 0.4% of the injected activity.

\[ ECW = \frac{(A_1 - 0.4 \times A_1 \times 10,000 \times V \times 0.93)}{A_2} \]

where \( ECW \) is the extracellular water; \( A_1 \) is the counts/min/ml of standard S^{35}; \( A_2 \) is the counts/min/ml of plasma; \( V \) is the volume of S^{35} injected; and 10,000 is the dilution factor of standard.

\[ PV = A_1 \times 1000 \times V \]

\[ \frac{A_2}{A} \]

where \( PV \) is the plasma volume; \( A_1 \) is the counts/min/ml of standard I^{131}; \( A_2 \) is the counts/min/ml of plasma; \( V \) is the volume of I^{131} injected; and 1000 is the dilution factor of standard.

Each patient was weighed by an in-bed scale (0.1 kg accuracy). The fluid intakes and urinary outputs were recorded, and samples of the 24-hour urine collections were used for determination of electrolyte excretions and osmolality.

We did not measure the electrolytes ingested, but these patients were maintained preoperatively on the routine hospital diet with fluids generally restricted. On the day of surgery the estimated blood loss was replaced; the total fluid given intravenously averaged 2 liters, the difference consisting of 5% glucose in water. On the first postoperative day the cooperative patients received 1000 ml of 5% glucose in water and 500 to 1000 ml of the routine hospital liquid diet. On the second postoperative day the patients were placed on a full liquid diet and then a soft to regular diet.