# Features of the water balance in the acute period of concomitant severe traumatic brain injury

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**Abstract.** The average daily volume for 25 days in group 1 was 48.3 ml/kg/day, in groups 2 and 3 34.6 ml/kg/day and 33.5 ml/kg day. A gradual restriction of parenteral administration was revealed in group 1 at 2 weeks of observation (by 34%), more pronounced in groups 2 and 3 on days 18-25 by 76% and 52%, respectively. The indicators of hourly urine output in groups 2 and 3 were less than in group 1 by 0.5 ml/kg/hour less. In the acute period of CSTBI, compensatory mechanisms for water load, aimed at adaptation to extremely changed life support conditions, were preserved only in traumatized patients under the age of 40.

Keywords: water balance, concomitant severe traumatic brain injury.

**Relevance.** According to numerous studies, more than half of patients who are in a coma within 24 hours after a traumatic brain injury develop disorders of water and electrolyte balance. They are often a consequence of treatment, but metabolic changes in traumatic brain injury are similar to those in injuries of any other location and are important in determining treatment tactics. Water restriction and osmotic drugs cause hyperosmolarity and hypervolemia in most patients, which necessitates monitoring of osmolarity and sodium concentrations. The secretion of aldosterone and antidiuretic hormone (ADH) in response to stress contributes to sodium and free water retention, respectively. The latter usually predominates, leading to minor hypervolemic hyponatremia in untreated patients, which is masked by the simultaneous administration of osmotic drugs. Severe hyponatremia is associated with excessive secretion of ADH, which can occur with increased intracranial pressure (IIP), fractures of the skull base, and after prolonged mechanical ventilation. In traumatic brain injury, potassium is lost due to trauma-induced hypersecretion of aldosterone, drug osmotic diuresis, and corticosteroids. Because potassium is predominantly an intracellular ion, hypokalemia often presents with hypochloremic alkalosis with normal or minimally reduced serum potassium levels. In this case, adequate replacement therapy with the introduction of KCl is required [1-3].

With traumatic brain injury, all types of exchange are affected. But the degree and depth of these shifts (and not only in the brain, but throughout the body) are directly proportional to the severity

of the injury. So with a slight injury, metabolic changes are barely perceptible, but they are distinct with severe brain damage and increase in the absence of adequate treatment.

According to some recommendations, planned infusion therapy requires the management of the patient in a moderate dehydration regimen (up to minus 10 ml/kg per day). The attitude to the use of such osmodiuretics as mannitol, urea, glycerin is ambiguous [4,5]. Taking into account the lack of information on the volume of infusion therapy in the acute period of CSTBI, we made an attempt to analyze and present the traditional picture of prolonged infusion therapy in the acute period of CSTBI in RSCEMA.

**Purpose.** To study the features of water balance in the acute period of concomitant severe traumatic brain injury

**Material and research methods.** The indicators of a comprehensive examination of 30 patients with concomitant severe traumatic brain injury (CSTBI) who were admitted to the ICU of the neurosurgical department of RSCEMA in the first hours after an accident - 28, catatrauma of 2 patients were studied. Continuous daily monitoring of the volumes of injected fluid (intravenous, oral, total), the amount of water loss (volume of urination + stool + from drainage systems), hourly monitoring of the oxygen saturation index (OS), cardiac output (CO), systolic (SBP), diastolic (DBP), pulse (PBP), average (AvBP) blood pressure were performed within 25 days after CSTBI. mechanical respiratory support (MRS) was initiated by artificial lung ventilation (ALV) for a short time followed by transfer to SIMV. ALV was performed in the mode of normoventilation or moderate hyperventilation (pCO2— 30—35 mmHg) with an air-oxygen mixture of 30—50%. The assessment of the severity of the condition was carried out using scoring methods according to the scales for assessing the severity of concomitant injuries - the CRAMS scale, the assessment of the severity of injuries according to the ISS scale. On admission, impaired consciousness in 29 injured patients was assessed on the Glasgow Coma Scale (GS) of 8 points or less. Patients were considered in three age groups: group 1, 19-40 years old (13), group 2 - 41-60 years old (9), 3 - 61-84 years old (8 patients). Infusion therapy is carried out with crystalloid and colloidal solutions and, if indicated, with vasoactive and inotropic drugs (preferably dopamine or norepinephrine). Recent studies have demonstrated the high efficacy of hypertonic sodium chloride solution (NaCl 7.5%), especially in combination with dextrans or HESs. Taking into account the authors' opinion that the infusion of a 7.5% NaCl solution quickly restores BV without causing an increase in IIC, from the first day, according to indications, 100 ml of 0.9% NaCl+100 ml of 10% NaCl was administered 1-2 times a day. In order to compensate for the BV deficiency in patients, crystalloid (Ringer's solution, NaCl

solution 0.9%) and artificial colloidal solutions (hydroxyethyl starches) were traditionally used, as a rule, in a ratio of 3:1.

**Results and its discussion.**

As can be seen from the data presented in tab. 1, in group 1 the average daily volume for 25 days in group 1 was 48.3 ml/kg/day, in groups 2 and 3 at 14 and 15 ml/kg per day (by 28%, 29%) less than in the first ($p < 0.05$, respectively).

Table 1.

Dynamics of water balance parameters in the acute period of CSTBI

| | Daily volume, ml/kg/day | Intravenous, ml/kg/day | Intake, ml/kg/day | Diuresis, ml/kg/hour |
|---|---|---|---|---|
| Group 1 | 48.3±4.4 | 16.4±3.3 | 31.9±4.1 | 1.5±0.2 |
| Group 2 | 34.6±6.4* | 10.8±5.2 | 24.0±3.1 | 1.0±0.2* |
| Group 3 | 33.5±3.5* | 9.9±3.1 | 23.4±2.79 | 1.0±0.1* |

*-reliable relative to the indicator in group 1

Attention was drawn to the tendency towards a decrease in intravenous and oral water load depending on age. At the same time, the indicators of hourly urine output in groups 2 and 3 were less than in group 1 by 0.5 ml/kg/hour ($p < 0.05$, respectively).

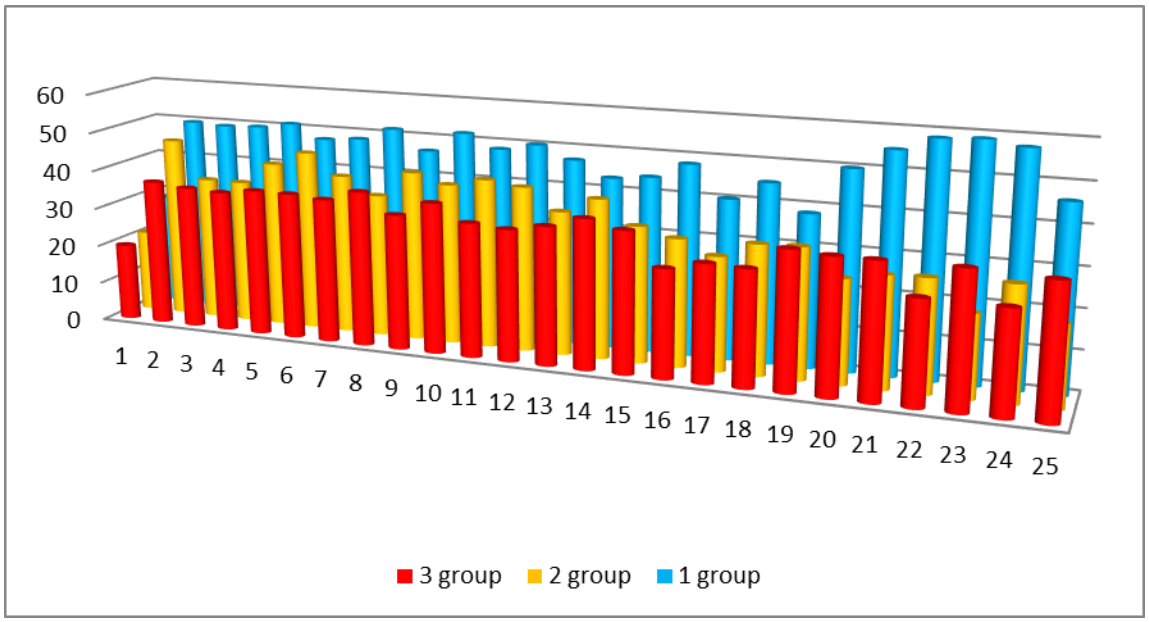


Fig. 1 Dynamics of the total water load in the acute period of CSTBI, ml/kg/day

Changes in the volume of infusion therapy occurred in waves, in group 1 on days 20-25 with a slight increase, in groups 2 and 3 a slight tendency towards a decrease in the daily volume of water load (fig. 1). Throughout the observation, the indicators in group 1 remained higher than in groups 2 and 3.

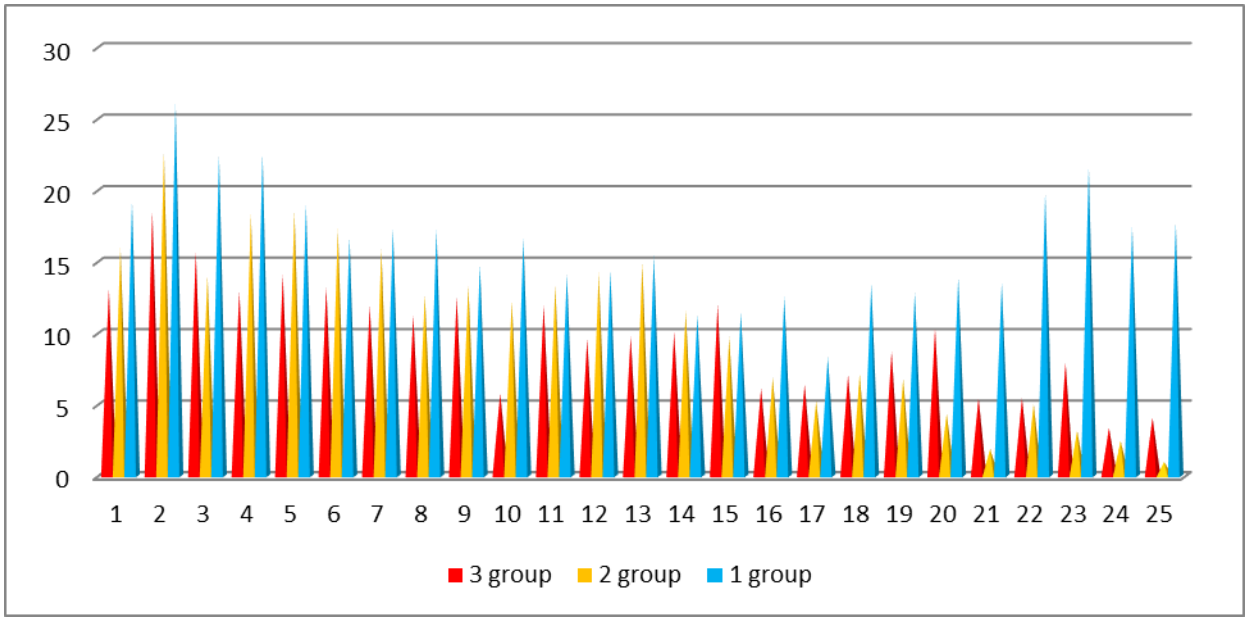


Fig. 2. Dynamics of parenteral administration in ml/kg/day

Fluctuations in the volume of intravenous infusion therapy in group 1 occurred from 19 ml/kg/day on day 1 after injury to 25 ml/kg/day on day 2, gradually decreasing to 10 ml/kg/day on day 14 with a gradual re-increase to 21 ml/kg/day on the 23rd day of treatment (fig. 2). In group 2, 15 ml/kg/day was administered intravenously on day 1, increasing by day 2 to 22 ml/kg/day and gradually decreasing to 5 ml/kg/day on day 17, and on day 25 to 2 ml/kg/day. In group 3 of patients, 12 ml/kg/day were administered intravenously on day 1, 18 ml/kg/day on day 2 and gradually decreased to 3 ml/kg day on day 25.

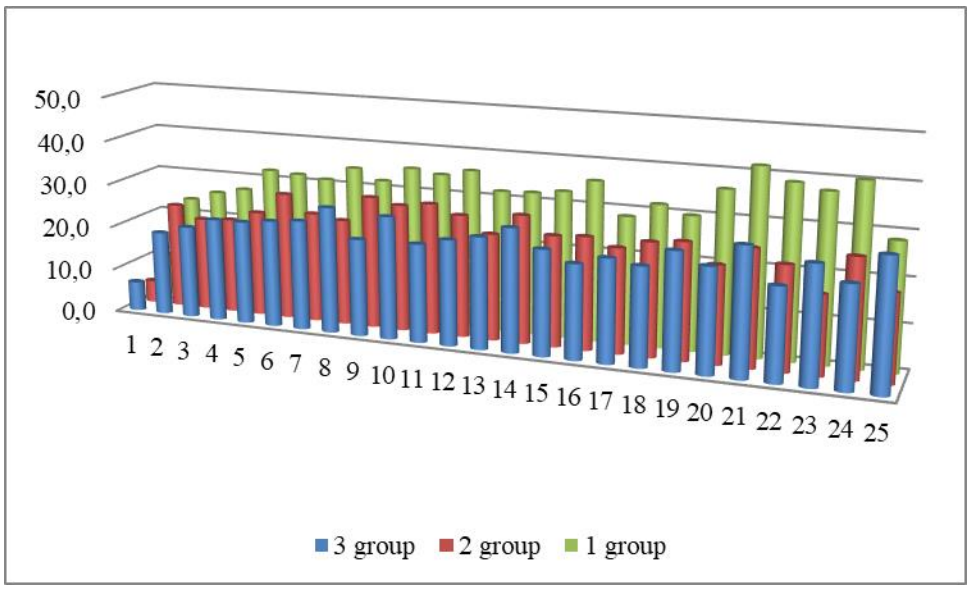


Fig.3. Enteral volume in ml/kg/day

The minimum enterally administered volume of water per day was 9 ml/kg/day in group 1, 5 ml/kg/day in group 2, and 6 ml/kg/day in group 3. Feeding volume gradually increased, reaching the highest value in group 1 on day 21 (42 ml/kg/day), in group 2 - 29 ml/kg/day (on day 9), in group 3 - 27 ml/kg/day on day 8 (fig. 3).

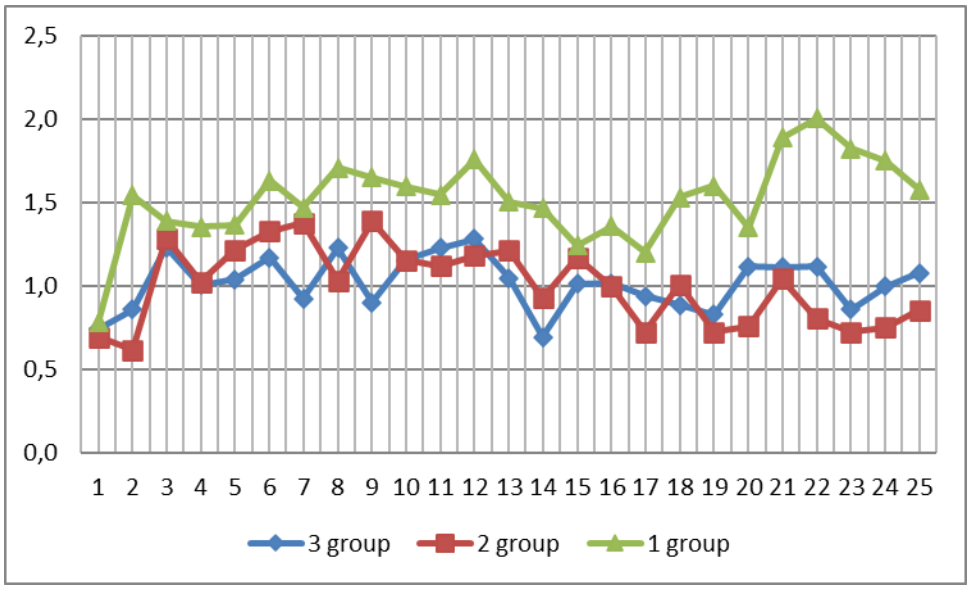


Fig. 4. Hourly urine output in ml/kg/hour.

Hourly urine output fluctuated within the acceptable values typical for normal renal excretory activity. However, the indicator of hourly urine output in group 1 fluctuated at a slightly higher level than in the injured in older age groups. Most likely, this was due to a relatively higher water load than in groups 2 and 3 (tab. 1).

Table 2.

Comparative assessment of weekly average water balance

| Days | Group 1 | | | | Group 2 | | | | Group 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total volume, ml/kg/day | I.v, ml/kg/day | Intake, ml/kg/day | Diuresis, ml/kg/hour | Total volume, ml/kg/day | I.v, ml/kg/day | Intake, ml/kg/day | Diuresis, ml/kg/hour | Total volume, ml/kg/day | I.v, ml/kg/day | Intake, ml/kg/day | Diuresis, ml/kg/hour |
| 1 - 8 | 47.1± 4.6 | 20.1± 2.7 | 27.0± 5.5 | 1.4± 0.2 | 38.4± 5.6 | 16.9± 2.3 | 21.6± 4.3 | 1.1± 0.2 | 35.2± 3.8 | 13.9± 1.7 | 21.3± 4.4 | 1.0± 0.1 |
| 9-17 | 46.8± 2.7 | 13.2± 2.1 | 33.2± 1.9 | 1.5± 0.1 | 37.8± 4.4 | 11.3± 2.7* | 26.8± 2.2 | 1.1± 0.1 | 33.9± 2.6 | 9.4± 2.2* | 24.0± 1.8 | 1.0± 0.1 |
| 18-25 | 51.3± 6.3 | 16.3± 2.9 | 35.6± 4.2 | 1.7± 0.2 | 27.2± 3.6* | 4.0± 1.9* | 23.2± 2.7 | 0.8± 0.1 | 31.4± 3.2 | 6.6± 2.0* | 24.8± 2.6 | 1.0± 0.1 |

*- reliably relative to the indicator for 1-8 days

As shown in tab. 2, a significantly significant decrease in the total daily fluid intake was found in group 2 on days 18-25 (by 28%, $p < 0.05$). The volume of intravenous infusion therapy in group 1 on days 9-17 was limited by 34% (by 7 ml/kg/day, $p < 0.05$) with a tendency to increase in the next 18-25 days by 3 ml/kg/day. Attention is drawn to the significant limitation of intravenous administration in group 2 on days 9-17 by 33% (by 5 ml/kg/day, $p < 0.05$), and on the next 18-25 days by 76% (by 12.9 ml/kg/day, $p < 0.05$). In group 3, on the second week of treatment, the limitation of intravenous infusion therapy was 32% (4.5 ml/kg/day, $p < 0.05$), in the next 18-25 days, the gradual limitation of intravenous infusion continued and amounted to 52% (by 7, 3 ml/kg/day, $p < 0.05$).

Thus, a gradually increasing restriction of parenteral administration was revealed in group 1 at week 2 of observation, and more pronounced in groups 2 and 3 at days 18-25 by 76% and 52%, respectively. In group 1, the daily volume of enteral administration showed a tendency to increase by 8 ml/kg/day. In group 2, oral administration in the second week showed a tendency to increase by 5 ml/kg/day, in the next 18-25 days, a decrease by 3 ml/kg/day.

In group 3, as well as in group 2, a tendency to increase enteral administration on days 8-17 only by 3 ml/kg per day was revealed, remaining unchanged until the end of intensive therapy. Thus, the restriction of parenteral administration does not always correspond to the favorable dynamics of the condition; it may turn out to be a forced measure aimed at reducing the load on the heart function; an increase in the enteral administration of fluid is not an indicator of an improvement in the general condition. The study and development of optimal methods for correcting the water balance need further improvement, taking into account the severity of the injury, the individual characteristics of the response to water, drug loads, including age-related anatomophysiological

differences, the influence of concomitant aggravating factors, chronic diseases, and the state of the cardiovascular system at the time of severe injury.

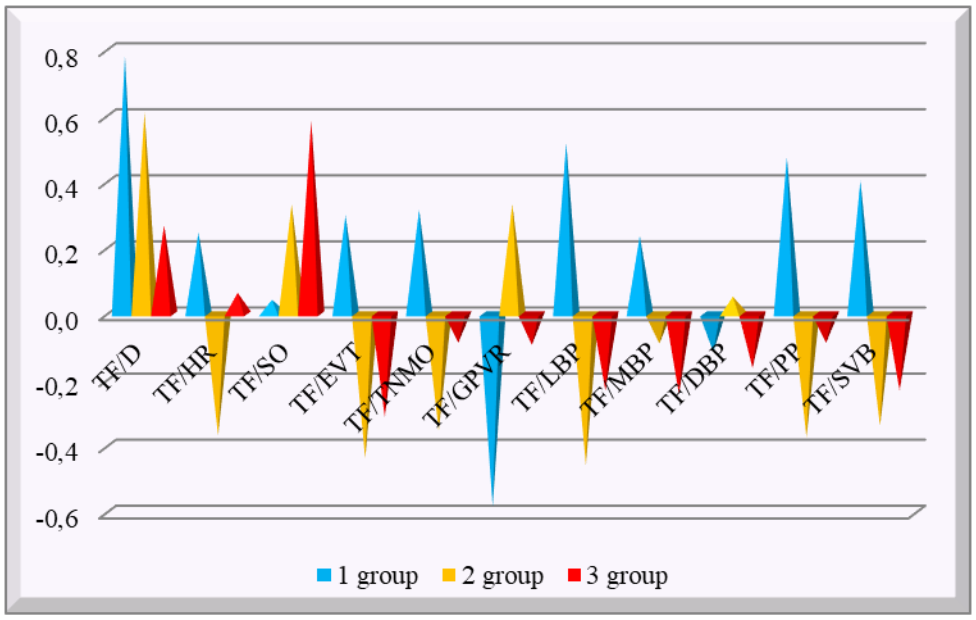


Fig.5. Correlations between daily water load and hemodynamic parameters.

As shown in fig. 5, only group 1 showed a direct correlation between daily water load and urinary volume (0.78), less pronounced with CO (0.48), PBP (0.41) and SV (0.38 ) and inverse with GPVR (-0.6). In groups 2 and 3, the correlations were significantly less significant. That is, in the acute period of CSTBI, compensatory mechanisms for water load, aimed at adaptation to extremely changed life support conditions, were preserved only in traumatized patients under the age of 40.

**Conclusion.** The average daily volume for 25 days in group 1 was 48.3 ml/kg/day, in groups 2 and 3 34.6 ml/kg/day and 33.5 ml/kg/day. A gradually increasing restriction of parenteral administration was revealed in group 1 at 2 weeks of observation (by 34%), more pronounced in groups 2 and 3 on days 18-25 by 76% and 52%, respectively. The indicators of hourly urine output in groups 2 and 3 were less than in group 1 by 0.5 ml/kg/hour. In the acute period of CSTBI, compensatory mechanisms for water load, aimed at adaptation to extremely changed life support conditions, were active only in traumatized patients under the age of 40.

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