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The physiological effects of hyperosmolar resuscitation: 5% vs 3% hypertonic saline

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Abstract

BACKGROUND: Use of 5% normal saline (NS) is gaining renewed interest. The primary aim of our study was to compare the physiological effects after the administration of different concentrations of hypertonic saline (3% vs 5%NS) in the initial resuscitation of trauma.

METHODS: We performed a retrospective analysis of a prospectively collected database of all trauma patients who received hypertonic saline during initial resuscitation. Medical records were reviewed for serum electrolytes and serum osmolarity, coagulation parameters, complications, and mortality.

RESULTS: A total of 212 patients were included in the study, of which 170 patients received 5%NS and 42 patients received 3%NS. Both groups were similar in age (41.16 ± 19 vs 44.17 + 23.6; $P = .45$) and ISS score (26 [17 to 29] vs 25 [16 to 27]; $P = .6$). Mean serum osmolarity (316 ± 20.3 vs 294 ± 22.5; $P = .02$) and serum sodium levels (143 ± 8.6 vs 137 ± 10.9; $P < .001$) remained higher in the 5%NS group within 72 hours of admission. The pH was lower in the 5%NS group compared with the 3%NS group at 24 hours (7.29 ± .12 vs 7.33 ± .12; $P = .01$); however, at 48 and 72 hours (7.40 ± .07 vs 7.41 ± .07; $P = .7$), no difference was found. There was no difference in blood products requirement (1,734 vs 2,253 mL; $P = .11$) between the 2 groups.

CONCLUSIONS: The 5%NS has sustained higher serum osmolarity and serum sodium concentration within the first 72 hours without any increase in adverse effects in comparison with 3%NS.

Determining the ideal initial resuscitative fluid after trauma remains an area of active research. Hypertonic saline provides for an ideal resuscitative fluid as it allows an increase in mean arterial pressure by selectively increasing both the intravascular volume and the cardiac output.[1] Compared with conventional isotonic crystalloids, use of hypertonic saline in trauma patients has been associated with hemodynamic, immune-modulating, and anti-inflammatory benefits.[1,2]

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Several recent prospective trails have evaluated the role of prehospital 7.5% hypertonic saline in trauma patients.[3–5] However, most of the recorded clinical experience with hypertonic saline is with 3% normal saline (NS).[6] The availability of clinical data using 5%NS is virtually nonexistent.[1,2] A recently published study has shown the beneficial effects of 5%NS in traumatic brain injury patients compared with NS.[6] However, the efficacy and safety of 5%NS compared with 3%NS in trauma patients are not well defined.[1,2,7] The primary aim of our study was to compare the physiological effects after the administration of different concentrations of hypertonic saline (3% vs 5%NS) in the initial resuscitation of trauma.

Methods

After the approval of the institutional review board at the University of Arizona, we performed a retrospective analysis of all trauma patients who received either 3% or 5%NS during the initial resuscitation period from January 2008 to December 2011. The initial resuscitation period was defined as the administration of 3% or 5%NS within the first 6 hours of presentation. Hypertonic saline (3% and 5%NS) was administered in a single 250-mL intravenous bolus for 15 minutes through peripheral line. Patients transferred from other institutions and patients with missing data were excluded from the study.

Medical records were reviewed for demographics, grade of injury, serum electrolyte levels and serum osmolarity, coagulation parameters, and complications, such as seizures, infections, coagulopathy, organ failure, and mortality. These physiological parameters were measured at 24, 48, and 72 hours of admission.

The normal laboratory reference range for sodium was between 135 and 145 mEq/L. The first laboratory draw was at the time of infusion of the 3% or 5%NS. The subsequent laboratories were drawn at 8, 24, and 48 hours after the initial admission laboratory draws.

Complications were defined as seizures, peripheral venous thrombophlebitis, and infectious complications (wound infection, sepsis, pneumonia, and urinary tract infections); hematologic complications (disseminated intravascular coagulopathy, deep venous thrombosis, and hemorrhage); and organ failure (acute renal failure, brain herniation, cardiac arrest, and pulmonary insufficiency). Complications were recorded based on the documentation in the patients' medical records. Organ failure was defined based on the documentation of acute renal failure, cardiac arrest, brain herniation, or pulmonary insufficiency obtained through the patients' charts. The use of hypertonic saline was at the discretion of the attending physician.

Data are presented as mean ± standard deviation. SPSS, version 20.0 software (IBM, Chicago, IL), was used for statistical analysis. Data analysis was performed using Student *t* test for continuous variables and chi-square test or Fisher exact test for categorical variables. *P* value of .05 or less was considered statistically significant.

Results

A total of 13,472 trauma patients were reviewed, of which 212 patients were included in the study (170 patients received 5%NS and 42 received 3%NS). There was no difference in age (44.17 ± 23.6 vs 41.16 ± 19 years; $P = .45$) and ISS score (26 [17 to 29] vs 25 [16 to 27]; $P = .6$) between the 2 groups. The median dose of hypertonic saline used was 500 mL (500 to 500) in the 5% NS group and 500 mL (250 to 500) in 3%NS group. However, patients in the 5%NS group were more likely to have a lower Glasgow Coma Scale (GCS) score (3[3–11] vs 12 [3 to 14]; $P = .001$), need intubation (35.6% vs 17.1%; $P = .04$), and have a higher international normalized ratio (1.4 ± .7 vs 1.15 ± .3; $P = .001$) on admission (Table 1).

Serum osmolarity was higher in the 5% NS group at 24 hours (310 vs 280; $P = .001$), 48 hours (309 vs 285; $P = .02$), and 72 hours (316 vs 294; $P = .02$) of admission. At 24 hours, 4 patients had a serum sodium level of 160 mg/dL or more. Three patients had received 5%NS, whereas 1 patient had received 3%NS. At 48 hours, 6 patients had serum sodium level of 160 mg/dL or more, all of whom received 5%NS. At 72 hours, 8 patients had sustained hypernatremia, all of whom had received 5%NS (Table 2).

The use of 5%NS was associated with sustained hypernatremia. Serum sodium levels were higher in the 5%NS group than in the 3%NS group at 8 hours after administration (144 vs 138 mg/dL, $P < .001$) and remained significantly higher for 3 days. Similarly, serum chloride levels were higher in the 5%NS group at 24 hours after administration (109 vs 104 mg/dL; $P < .001$) and remained significantly higher for 3 days. Although the pH was lower in the 5%NS group at 24 hours (7.29 ± .12 vs 7.33 ± .12; $P < .001$) of admission, no significant difference remained at 48 or at 72 hours (Table 3).

On subanalysis of patients with isolated TBI, the use of 5%NS was associated with sustained hypernatremia. Serum sodium levels were higher in the 5%NS group than in the 3%NS group at 8 hours after administration ($P < .001$) and remained significantly higher for 3 days (Table 4).

There was no difference between the 2 groups in terms of volume of crystalloids (1,630 ± 1,294 mL vs 1,328 ± 949; $P = .2$) and blood products (539 ± 1,293.6 mL vs 371 ± 735.8; $P = .4$) administered in the emergency department or in the intensive care unit (ICU; 1,734 ± 2,935.1 mL vs 2,253 ± 7,619.5; $P = .11$).

There was no difference in seizures (5% vs 4.5%; $P = .9$) and peripheral venous thrombophlebitis (7.3% vs 4.7; $P = .4$) between the 2 groups (Table 5).

The group receiving 5%NS did have a longer mean ICU stay (13.2 vs 9.9 days; $P = .045$); however, there was no