Utilization of Blood Volume Analysis for Distinguishing Cerebral Salt Wasting from SIADH

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Introduction
• Neurocritical care patients frequently develop hyponatremia secondary to cerebral salt wasting (CSW) or the syndrome of inappropriate antidiuretic hormone secretion (SIADH).
• CSW results in a decreased circulating plasma volume whereas SIADH leads to a normal or increased plasma volume.
• Neurocritical care patients are at risk for fatal vasospasm, especially when dehydrated.
• SIADH is usually treated by restricting fluids, but fluid restricting patients with CSW can precipitate vasospasm.
• Physical examination and central venous pressure have been proven unreliable for assessing circulating blood and plasma volume.
• Recent improvements in isotopic blood volume analysis (BVA) have decreased its complexity allowing this procedure to be performed with a single tracer at the bedside in the ICU.

Methods
• All charts of patients admitted to the surgical service between August 2006 and June 2012 who underwent a BVA were reviewed.
• Patients with neurologic illness were identified and categorized according to their BVA results and serum sodium levels.
• The following data was collected: Age, Height, Weight, Sex, Na+, K+, BUN, Cr, Hct, Urine SG, Urine Na+, Urine Osmolarity. Days with a normal serum Na+ level. Days with an abnormal serum Na+ level, fluid and sodium balance, BVA results, and neurological outcome.
• BVA results were correlated with the patient’s fluid and sodium balance. Treatment methods between groups were compared based on fluid and sodium balance, assessed volume status, and clinical response.
• Means were expressed as mean ± SD, categorical variables were compared using X², and continuous variables were compared with either a t-test or ANOVA.

Purpose
• The objective of this study was to evaluate the use of bedside BVA to distinguish SIADH from CSW in neurocritical care patients with hyponatremia.

Table 1. Comparison of BVA results and selected physiologic parameters in 37 patients with hyponatremia.

<table>
<thead>
<tr>
<th>Parameter*</th>
<th>Low Plasma Volume (n=22)</th>
<th>Normal Plasma Volume (n=15)</th>
<th>High Plasma Volume (n=20)</th>
<th>Total (n=37)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na+ (mEq/L)</td>
<td>130 (≤ 1)</td>
<td>128 (≤ 4)</td>
<td>128 (≥ 5)</td>
<td>128 (≤ 5)</td>
</tr>
<tr>
<td>K+ (mEq/L)</td>
<td>4.4 (≤ 0.5)</td>
<td>4.0 (≤ 0.5)</td>
<td>4.0 (≤ 0.6)</td>
<td>4.0 (≤ 0.5)</td>
</tr>
<tr>
<td>Cr (mg/dL)</td>
<td>0.5 (≤ 0.5)</td>
<td>0.7 (≤ 0.7)</td>
<td>0.8 (≤ 0.8)</td>
<td>0.7 (≤ 0.7)</td>
</tr>
<tr>
<td>BUN/Cr Ratio</td>
<td>33.0 (≤ 14)</td>
<td>26.4 (≤ 12.6)</td>
<td>22.6 (≤ 8.5)</td>
<td>24.7 (≤ 10.4)</td>
</tr>
<tr>
<td>Urine SG</td>
<td>1.018 (≤ 0.707)</td>
<td>1.011 (≤ 0.773)</td>
<td>1.013 (≤ 0.104)</td>
<td>1.013 (≤ 0.450)</td>
</tr>
<tr>
<td>Urine Na+ (mmol/L)</td>
<td>114.0 (≤ 83.9)</td>
<td>129.6 (≤ 61.9)</td>
<td>124.4 (≤ 67.3)</td>
<td></td>
</tr>
<tr>
<td>Urine Osmo</td>
<td>N/A</td>
<td>508.8 (≤ 376)</td>
<td>476.6 (≤ 278)</td>
<td>492.7 (≤ 278)</td>
</tr>
<tr>
<td>Water Ratio</td>
<td>1.2 (≤ 0.9)</td>
<td>1.8 (≤ 1.3)</td>
<td>1.7 (≤ 0.7)</td>
<td>1.7 (≤ 1.6)</td>
</tr>
<tr>
<td>Na+ (mEq/L/day)</td>
<td>184.0 (≤ 25.0)</td>
<td>291.1 (≤ 112.2)</td>
<td>273.8 (≤ 135.2)</td>
<td>274.8 (≤ 119.6)</td>
</tr>
<tr>
<td>Peripheral Hot</td>
<td>30.1 (≤ 0.7)</td>
<td>30.5 (≤ 4.7)</td>
<td>29.1 (≤ 4.9)</td>
<td>29.7 (≤ 4.7)</td>
</tr>
<tr>
<td>Corrected Na+ Deficit (mEq/L)</td>
<td>364.3 (≤ 69.7)</td>
<td>451.0 (≤ 177.4)</td>
<td>544.2 (≤ 257.9)</td>
<td>496.7 (≤ 224.9)</td>
</tr>
</tbody>
</table>

*Means are expressed as mean ± SD, categorical variables were compared using X², and continuous variables were compared with either a t-test or ANOVA.

Results
• There is a significant difference in the number of patients with a decreased plasma volume versus total blood volume (p < 0.01)
• Using plasma volume accurately diagnoses cerebral salt wasting in 5.4% of the patients.
• Any method which uses total blood volume to assess the patient’s volume status will incorrectly diagnose CSW up to 40.6% of the time.
• There were no statistical differences between groups for any parameter (ANOVA).

Conclusions
• Using plasma volume as a standard, CSW was present in only 5.4% of hyponatremic patients.
• Traditional markers of volume status are not useful in these patients. Measurement of total blood volume may incorrectly identify CSW in 40.6% of hyponatremic patients.
• Management of hyponatremia can be improved with BVA data and contraindicated interventions avoided.
• A prospective evaluation of blood volume analysis in these hyponatremic patients is warranted.

Acknowledgments
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