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.

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.

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 Osmolality, 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 ± SD, categorical variables were compared using X^2, and continuous variables were compared with either a t-test or ANOVA.

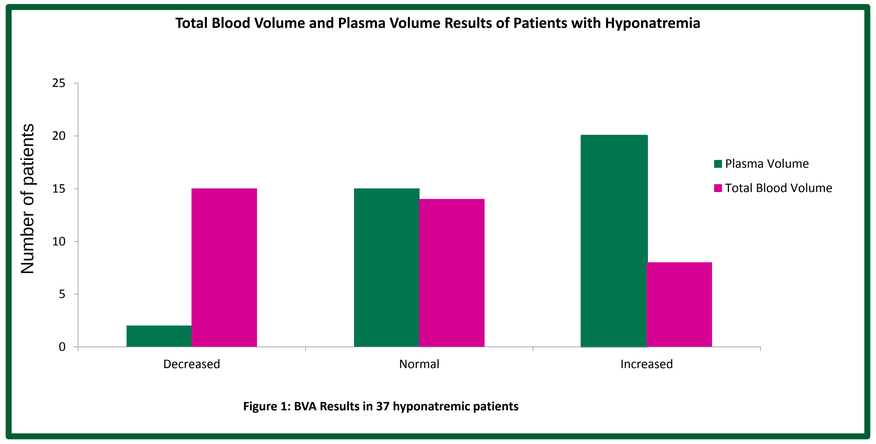

Figure 1: BVA Results in 37 hyponatremic patients

- 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.

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

Parameter*	Low Plasma Volume (n=2)	Normal Plasma Volume (n=15)	High Plasma Volume (n=20)	Total (n=37)
Na^+ (mEq/L)	130 (± 1)	128 (± 4)	128 (± 5)	128 (± 5)
K^+ (mEq/L)	4.4 (± 0.5)	4.0 (± 0.5)	4.0 (± 0.6)	4.0 (± 0.5)
Cr (mg/dL)	0.5 (± 0.5)	0.7 (± 0.7)	0.8 (± 0.8)	0.7 (± 0.7)
BUN/Cr Ratio	33.0 (± 1.4)	26.4 (± 12.6)	22.6 (± 8.5)	24.7 (± 10.4)
Urine SG	1.018 (± 0.707)	1.011 (± 3.773)	1.013 (± 5.104)	1.013 (± 4.450)
Urine Na^+ (mmol/L)	N/A	114.0 (± 83.9)	129.6 (± 61.9)	124.4 (± 67.3)
Urine Osmo	N/A	508.8 (± 376)	476.6 (±177)	492.7 (± 278)
Water Ratio	1.2 (± 0.0)	1.8 (± 1.3)	1.7 (± 0.7)	1.7 (± 1.0)
Na^+ (mEq/Day)	184.0 (± 25.0)	291.1 (± 111.2)	273.8 (± 135.2)	274.8 (± 119.6)
Peripheral Hct	30.1 (± 0.7)	30.5 (± 4.7)	29.1 (± 4.9)	29.7 (± 4.7)
Calculated Na^+ Deficit (mEq/day)	364.3 (± 69.7)	451.0 (± 177.4)	544.2 (± 257.9)	496.7 (± 224.9)

Values are mean ± SD

*There were no statistical differences between groups for any parameter (ANOVA).

Results

- BVA was performed on 293 patients; 72 of these had a neurologic disorder and were included in this study.
- The group consisted of 38 (52.8%) females and 34 (47.2%) males. The mean age was 60.62 ± 18.1 years.
- Overall mortality was 15.3% (11/72).
- In this group, 51.4% (37/72) were hyponatremic (Serum Na^+ <136 mEq/L), 36.1% (26/72) were normal, and 12.5% (9/72) were hypernatremic (Serum Na^+ >146 mEq/L).
- In the hyponatremic patients: (Figure 1)
  - 5.4% (2/37) had decreased PV, 40.5% (15/37) had normal PV, and 54.1% (20/37) had increased PV.
  - All hyponatremic patients had normal or low red cell volume. In the hyponatremic group, TBV was decreased in 40.6% (15/37), normal in 37.8% (14/37), and increased in 21.6% (8/37).
- Physiologic parameters were not predictive of plasma or blood volume status. (Table 1).
- Treatment for hyponatremia (fluid restriction, saline bolus, or 3% saline administration) was similar for all volume statuses.
- Hyponatremic patient mortality was 20.0%.
- Mortality trended higher in patients who failed to recover from hyponatremia 28.6% (2/7) compared to those who normalized their sodium 17.9% (5/28).

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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