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Volaemic assessment of the elderly hyponatraemic patient: reliability of clinical assessment and validation of bioelectrical impedance analysis

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Summary

Background: Hyponatraemia is the commonest electrolyte disturbance of hospital inpatients. Assessment of volaemic status is an important part of diagnosis and management.
Aim: To determine reliability of clinical assessment of volaemic state by assessing inter-observer variability of clinical measures of volaemic state. To assess validity of bioelectrical impedance analysis as a tool to measure total body water in elderly hyponatraemic patients.
Design: Observational study conducted in a Department of Medicine for the Elderly.
Methods: Hospital inpatients >65 years old ($n = 22$) with serum sodium concentration <130 mmol/l were included. Two assessors determined volaemic state on two occasions 72 h apart. Level of agreement between observers was determined on each occasion. Total body water estimation was undertaken with bioelectrical impedance analysis and measurement of dilution of deuterium oxide. Correlation between these two measures was then analysed.
Results: Cohen's κ for agreement between two observers for overall assessment of volaemic state was 0.59 ($P < 0.01$). Values for agreement between individual clinical markers of volaemic state ranged between 0.16 and 0.45. Pearson correlation coefficient (r) for correlation between estimation of total body water undertaken by bioelectrical impedance analysis and by measurement of dilution of deuterium oxide was 0.69 ($P < 0.001$).
Conclusion: There was moderate inter-observer agreement of overall clinical volaemic assessment of elderly hyponatraemic patients. Total body water estimation by bioelectrical impedance analysis correlates well with estimation by measurement of dilution of deuterium oxide, providing a potentially useful tool to improve the management of the elderly hyponatraemic patient.

Introduction

Hyponatraemia is the commonest electrolyte disturbance of hospital inpatients with a reported incidence of 15%.[1] Frequency is considerably higher among elderly patients due to degenerate physiological regulation, increased prevalence of diseases causing hyponatraemia and polypharmacy.[1–3] Hyponatraemia is associated with increased rates of mortality and morbidity, increased risk of institutionalization and longer length of hospital stay.[2,4]

Hyponatraemia reflects an imbalance between levels of water and sodium in the plasma, and therefore, frequently represents an abnormality of water rather than sodium regulation.[3] Hyponatraemia can occur in hypervolaemic, euvolaemic and

hypovolaemic states and consequently assessment of volaemic state is an important aspect of diagnosing the cause of hyponatraemia.[3] Volaemic assessment of the patient is, therefore, a crucial step in many diagnostic algorithms to determine cause of hyponatraemia.[1,5–8]

Accurate assessment of changing volaemic state is also an important feature in the management of hyponatraemia, which generally requires fluid replacement or restriction in order to attain normonatraemia.[5] However in our experience, and in that of other authors,[9–11] volaemic assessment of elderly patients can frequently be problematic.

Measurement of total body water (TBW) may be of use in helping to determine volaemic status.[12] The gold standard for measurement of TBW is the measurement of dilution of isotopes of water, such as deuterium oxide.[12] Deuterium dilutional analysis (DDA) is, however, expensive and time-consuming, requiring specialized laboratory measurement. It is, therefore, impractical for routine clinical use.

A more recently developed technique is bioelectrical impedance analysis (BIA), which relies on the principle that the reciprocal of the impedance opposed to a weak alternating current applied across the body is proportional to TBW.[13] Low sodium levels affect the conductivity of body fluid, therefore may affect BIA readings.[13] Additionally, hyponatraemia can occur in oedematous, hypervolaemic states, which could again affect and invalidate BIA readings.[13] It is, therefore, necessary to determine validity of BIA measurement of TBW in hyponatraemic patients by comparing with the gold standard DDA.

We sought to determine the inter-observer variability of clinical measures of volaemic status in elderly hyponatraemic patients in order to assess the reliability of clinical assessment in this setting. In addition, we aimed to validate BIA in this patient group to help to determine whether BIA is potentially a useful tool in monitoring treatment and assessing volaemic status in hyponatraemic patients.

Methods

Subjects

The study was undertaken in a department of elderly medicine with no specific age- or diagnosis-related admission criteria, but inpatients are generally elderly and frail, with multiple co-morbidities. Patients >65 years of age with serum sodium concentration of <130 mmol/l were recruited. Patients with permanent pacemaker or implantable cardiac defibrillator and those unable to swallow or co-operate with height and weight measurement were excluded. Subjects gave their informed, written consent when deemed competent to do so by their clinical team under the Adults with Incapacity (Scotland) Act 2000.[14] Adults with incapacity were enrolled with their assent and the written, informed consent of their next of kin or legal guardian.

Ethical approval

Ethical approval was obtained from the Scottish Multi-Centre Research Ethics Committee A, Edinburgh.

Study design

This was an observational study with assessments performed on Days 1 and 4 after recruitment. Each assessment comprised clinical assessment of volaemic status, measurement of TBW by DDA and measurement of TBW by BIA. Serum sodium was also measured on each occasion.

Successive assessments were performed after 72 h in order to determine whether changes in TBW and serum sodium over this time could be used to extrapolate a definitive assessment of volaemic state. For example, if TBW fell, with subsequent normalization of sodium levels, this would imply a hypervolaemic cause for the hyponatraemic state, and vice versa.

Clinical assessment

Two experienced assessors independently appraised indicators of volaemic status including skin turgor, peripheral oedema, axillary moistness, tongue moistness, mouth and nose moistness, capillary refill time and jugular venous pressure (JVP). These individual indicators were selected as previous work looking at clinical assessment of volaemic state has suggested that they have clinical utility.[9,15] The assessors also gave an evaluation of overall volaemic status (hypovolaemic, euvolaemic or hypervolaemic). Weight, postural changes in blood pressure and heart rate were measured on each occasion.

TBW measurement by deuterium oxide dilutional analysis

A pre-test blood sample was taken and subsequently a weighed amount of deuterium oxide (~5 g) was administered orally. A period of 3 h was allowed for the ingested deuterium oxide to equilibrate with the TBW pool, before a further blood sample was taken. Deuterium concentration in the aqueous

phase of the blood samples was determined by infra-red spectro-photometery using essentially the method of Lukaski and Johnson.[16] The TBW volume of each patient was calculated from the deuterium enrichment of the second blood sample produced by the known amount of ingested deuterium oxide using the formula of Schoeller.[17]

TBW measurement by BIA

BIA measurements were performed with a Quantum/S analyzer (Akern/RJL systems, Pontassieve, Italy). Four electrodes were attached to the patient's foot and hand in predetermined positions on one side of the body (distal ends of the third metacarpal and of the second metatarsal bone, between the styloid process of the radius and ulna and between the two maleoli of the ankle). Impedance was measured at 50 kHz. TBW was calculated using impedance, height and weight using the RJL Systems formula.[18]

Statistical analysis

Cohen's κ was used to measure level of agreement between the two observer's clinical assessments. Correlation between TBW levels calculated by DDA and BIA methods was assessed using Spearman's correlation coefficient (r) and the intra-class correlation coefficient of agreement. Statistical significance was assumed where $P < 0.05$. Statistical analyses were performed using SPSS v15 (Chicago, IL, USA).

Results

Clinical assessment

Twenty-two patients were identified, 68% female, mean age 83 years (SD = 6). Subjects were assessed on two occasions giving 44 sets of paired observations.

Mean sodium on Day 1 was 126 mmol/l (SD = 5, range: 116–133).

On Day 1, there was full agreement between the two assessors for the overall volaemic status of 17 subjects (eight hypovolaemic, three euvolaemic and six hypervolaemic) and of the remaining five subjects, in all cases one assessor felt the subjects were hypovolaemic and one assessor felt the subjects were euvolaemic.

Table 1 gives levels of agreement (κ) between the two observers for overall assessment of volaemic status and for each individual clinical marker, combining assessments on Days 1 and 4.

Table 1 Levels of agreement (κ) between two observers for overall assessment and individual markers of volaemic status

	κ	95% CI	*P-value*
Overall assessment	0.59	0.38 to 0.79	<0.01
Tongue moistness	0.30	0.02 to 0.58	0.04
Mouth and nose moistness	0.16	−0.10 to 0.43	0.25
JVP	0.18	−0.04 to 0.40	0.06
Peripheral oedema	0.45	0.24 to 0.65	<0.01
Axillary moistness	0.21	−0.04 to 0.46	0.11
Capillary refill time	0.27	0.02 to 0.51	0.02
Skin turgor	0.42	0.17 to 0.66	<0.01

Measurement of TBW

Two of the 22 subjects were unable to complete the TBW measurements by BIA and DDA satisfactorily due to one patient being too unwell to comply with ingestion of deuterium oxide and one patient being bedbound and unable to comply with weight measurements.

Twenty patients were, therefore, included; 75% female, mean age 83 years (SD = 6). Subjects were assessed on two occasions, giving 40 sets of TBW measurements by BIA and by DDA.

Mean sodium on Day 1 was 126 mmol/l (SD = 5, range: 116–133).

Mean TBW measured by DDA was 35.65 l (SD = 8.69), mean TBW measured by BIA was 32.75 l (SD = 7.53) [Pearson correlation coefficient (r) = 0.69 ($P < 0.001$), intra-class correlation coefficient of agreement = 0.65 (95% CI 0.40–0.80)].

Numbers were too small to perform meaningful subgroup analysis dependent on overall volaemic state (as determined by clinical assessment on Day 1).

Figure 1 shows a graphical representation of the correlation of estimation of TBW by DDA and BIA.

Comment

Our results indicate only moderate inter-observer agreement (κ 0.59) for clinical assessment of overall volaemic status in elderly hyponatraemic patients. This calls into question the clinical utility of the great majority of diagnostic algorithms for determining the cause of hyponatraemia, which have an assessment of volaemic status at their core. This also has potentially serious clinical consequences, as therapy for hyponatraemia is aimed at correction of fluid status to achieve normonatremia. Misdiagnosis of volaemic state and subsequent

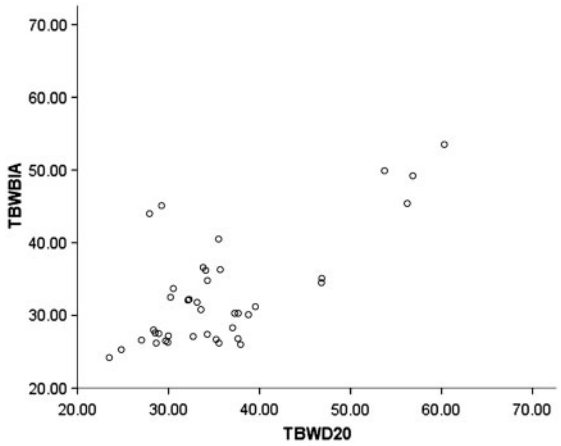

Figure 1. Correlation of estimation of TBW (litres) by DDA (TBWD2O) and by bioelectrical impedance analysis (TBWBIA).

inappropriate management (e.g. fluid restriction in a hypovolaemic state) may worsen hyponatraemia and associated morbidity.

There is poor inter-observer agreement between individual measures of volaemic status, despite many of these measures having been shown to be of use in younger patients in different settings.[9,15] The greater agreement in overall assessment of volaemic state than in individual markers of volaemic state suggests that some further factor is being taken into consideration to determine overall volaemic state (perhaps clinical history or knowledge of drug therapy). This emphasizes the difficulty of clinical assessment of the elderly patient in the context of degenerate physiology and multiple co-morbidities, and highlights the importance of comprehensive assessment of the patient rather than reliance on one or two clinical indicators of volaemic state.

Our research suggests, therefore, that clinicians should be cautious of basing their approach to the elderly hyponatraemic patient solely on clinical assessment of volaemic state. Invasive measures of volaemic state (such as measurement of central venous pressure) may add to clinical information, but it is highly questionable whether the discomfort and risks of invasive techniques justify routine clinical use, especially given the high frequency with which hyponatraemia is encountered. Non-invasive measurements of TBW to monitor changes in volaemic status, such as performed by BIA, could therefore be of great use in this setting.

We have shown that measurement of TBW by BIA correlates well with measurement by dilution of deuterium oxide. This suggests that BIA can be used to estimate TBW reliably in elderly hyponatraemic patients. Estimates of TBW cannot, however, give a direct measurement of volaemic status, as there is wide inter-subject variability of TBW in elderly patients (i.e. a wide normal range of TBW). However, serial measurements of TBW by BIA could be of direct practical use in monitoring therapy to normalize sodium levels, as this generally involves altering volaemic status by fluid replacement or restriction.

Serial estimates of TBW with comparison to changes in plasma sodium could also allow retrospective determination of volaemic status aiding clarification of diagnosis (for example, if TBW fell, with subsequent normalization of sodium levels, this would imply a hypervolaemic cause for the hyponatraemic state, and vice versa). Unfortunately, we were unable to validate this methodology in this patient cohort, perhaps because the interval between serial measurements was too short resulting in only small, or no, change of both TBW and serum sodium levels.

The main limitation of this study is its small size. Confirmation of the results in larger studies would be useful. We did not measure the relative influence of the patient history in our patient population, but this was not the purpose of the study, and it is well recognized that older patients can present atypically or be unable to give a history due to cognitive impairment. It is therefore likely that the clinical examination remained important and relevant. It was not possible to derive definitive diagnoses of the cause of hyponatraemia with any certainty, but this limitation reflects the clinical reality and emphasizes the importance of improving diagnostic methods in the older patient with hyponatraemia.

Conclusion

There was moderate inter-observer agreement of overall clinical volaemic assessment; however, there was poor inter-observer agreement between individual indicators of volaemic status. This calls into question the reliability of clinical assessment to determine volaemic status in elderly hyponatraemic patients.

In this group, TBW measured by BIA correlates well with the gold standard DDA. The speed and reliability of BIA measurement of TBW may provide a useful adjunct to clinical and laboratory measures to improve the management of the elderly hyponatraemic patient.

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