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HEALTHY AGING RESEARCH

Salt in the desert: A comparison of clinical versus serum-calculated osmolality determination of dehydration

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Abstract

Background: Clinicians frequently use their own judgement to assess patient's hydration status although there is limited evidence for the diagnostic utility of any individual clinical symptom. Hence, the aim of this study was to compare the diagnostic accuracy of clinically assessed dehydration in older hospital patients (using multiple symptoms), versus dehydration measured using serum-calculated osmolality (CO) as the reference standard.

Method: Participants were 44 hospital patients aged ≥ 60 years. Dehydration was assessed clinically and pathologically (CO) within 24 hours of admission and at study exit. Indicators of diagnostic accuracy were calculated.

Results: Clinicians identified 27% of patients as dehydrated at admission, and 19% at exit, compared to 19% and 16% using CO. Agreement between the measures was fair at admission and poor at exit. Clinical assessment showed poor sensitivity for predicting dehydration with reasonable specificity.

Conclusions: Compared to the use of CO, clinical assessment of dehydration in older patients was poor. Given that failure to identify dehydration in this population may have serious consequences, we recommend that clinicians do not rely upon their own assessments without also using the reference standard.

Citation: McCrow J, Morton M, Travers C, Harvey K, Eeles E (2016) Salt in the desert: A comparison of clinical versus serum-calculated osmolality determination of dehydration. Healthy Aging Research 5:4. doi: 10.1097 /01.HXR.0000511868.72087.78

Received: November 17, 2015; **Accepted:** January 17, 2016; **Published:** April 20, 2016

Competing interests: The authors have declared that no competing interests exist.

Sources of funding: Funding to undertake this study was kindly provided by the DCRC. Ongoing support was generously provided by Professor Beattie (DCRC-CC).

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Introduction

Dehydration is common in older people and particularly frequent among those admitted to hospital; prevalence rates of between 21 and 44% have been reported [1–2]. Dehydration is associated with a range of serious adverse events in this population including falls, fractures, confusion, delirium, urinary and respiratory tract infections, longer lengths of hospital stay, and increased mortality [3–5]. Hence, it is important for dehydration to be accurately diagnosed and treated.

No 'gold standard' exists for defining dehydration, although serum-calculated osmolality (CO) appears to be the most appropriate and frequently used reference standard for water-loss dehydration in older people [6]. In several settings, however, including small, rural and remote hospitals and primary care settings, ready access to pathology services may be limited,

and it may take several hours to obtain pathology results. Nevertheless, clinicians must make diagnostic decisions and implement treatment and management plans, and frequently rely upon their own clinical assessment to diagnose dehydration [2, 6–8].

A systematic review published in 2015 [6] highlights results that further cloud this issue. Evaluating the diagnostic accuracy of clinical assessments of water-loss dehydration in older people, it concluded that there was limited evidence that any individual clinical symptom, sign or test, or combination of tests, was useful for identifying dehydration in older people, and therefore should not be used for this purpose. While these results are an important reminder that no stand-alone clinical symptom or sign should be relied upon to diagnose dehydration, clinicians do not generally rely upon one single symptom or sign [2, 8] but rather use multiple indicators to inform their diagnosis.

Hence, it is important for clinicians to know the accuracy and reliability of the clinical assessment of dehydration using multiple measures. The aim of this study, therefore, was to compare the accuracy of clinically diagnosed dehydration in older medically ill hospital patients versus dehydration measured using serum-calculated osmolality, the most commonly used reference standard [3, 6], especially in older people [8].

Methods

Design

The study was a prospective study of patients aged ≥ 60 years admitted to the medical unit of a major hospital in Brisbane, Australia. The study took place between 2013 and 2014.

Ethics

Ethical approval was obtained from the Ethics Committees of the University of Queensland and The Prince Charles Hospital, Queensland, Australia, prior to commencement of the study. Informed written consent to participate in the study was obtained from each patient (or their legal guardian) prior to the study.

Participants

A convenience sample of patients aged ≥ 60 years was recruited for the study. Patients eligible for the study were aged ≥ 60 years and English speaking; research staff must also have been available to collect baseline data from included participants within the first 24 hours of their admission. Patients meeting any of the following criteria were excluded from the study: unstable congestive heart failure; stage 5 chronic kidney disease; classified as nil-by-mouth on admission; an expected length of stay of < 24 hours. Baseline data were collected within the first 24 hours of admission and follow-up data regarding the patient's hydration status were collected on day 4 of the admission or at discharge (exit data), whichever occurred first. Trained research assistants collected baseline demographic information from participants or their proxy including age, gender, and co-morbidities.

Hydration status

Study participants were categorized as either euhydrated (having normal body water content)[9] or dehydrated, defined as the loss or removal of fluid from the body that occurs when fluid intake fails to fully replace fluid losses [10]. Two measures of dehydration were used: clinically assessed dehydration (described below), and dehydration as defined by serum-calculated osmolality (CO). Patients were considered dehydrated if they had a CO reading ≥ 295 mmol/L. Hence, this definition included both impending water loss dehydration (CO: 295–300 mmol/L) and current dehydration (CO: > 300mmol\L) [3].

Clinical assessments

Patients were clinically assessed for hydration status within 24 hours of admission and at study exit by experienced consultant geriatricians involved in the study. Clinical judgement was informed by: lying and standing blood pressure (BP); pulse rate; weight; visual assessment of jugular venous pressure; tissue turgor; self-reported thirst; inspection of oral mucous membranes for dryness; inspection of tongue for dryness and longitudinal furrows; and urinary specific

gravity. These measures constitute the standard dehydration assessment at the study hospital and have been previously validated as practical and useful indicators of dehydration in older hospital patients [8].

Pathology samples were collected at baseline and at study exit to measure CO and urinary-specific gravity.

Data analysis

Measures of sensitivity, specificity, positive (PPV) and negative predictive values (NPV), and receiver operating curves (ROC) were calculated to evaluate the accuracy of clinically assessed dehydration in predicting dehydration diagnosed by CO, at admission and study exit. Levels of inter-rater agreement (poor agreement: $\kappa < 0.2$; fair agreement: $\kappa = 0.20 – 0.40$; , as defined by Altman were used to rate strength of agreement [11]. Data analyses were performed using SPSS for Windows v21.

Results

Of the 68 patients admitted to hospital with the study period who met all eligibility criteria, 44 agreed to participate in the study. The majority of participants were female (n = 25, 57%), and the population had an average age of 81 years (SD = 8.5). Characteristics of the study population are reported in Table 1.

On the basis of clinical assessment 11 patients (27%) were considered dehydrated at admission, and six (19%) at study exit. By comparison, eight patients (19%) were dehydrated at admission, as measured by CO, and five (16%) at exit. Of the participants assessed for dehydration at admission, nine (22%) were discharged prior to them being re-assessed clinically, and 10 (24%) were unavailable to have their serum osmolality levels re-calculated at study exit.

The sensitivity and specificity of clinically assessed dehydration in predicting CO defined dehydration at admission was 0.50 and 0.77, respectively (see Table 2). Agreement between the measures was fair (κ= 0.24) [11], and the area under the ROC curve was 0.64 (95%CI: 0.41-0.87), reflecting poor accuracy.

Table 1. Baseline characteristics of study participants, and dehydration status at baseline and study exit

Characteristic		Number (%)
Gender	Female	24 (54.5%)
	Male	20 (45.5%)
Age (years)	Average (SD)	81.1 (SD = 8.5)
Number of comorbid medical conditions	Average number (SD)	2 (1.2)
	Range	0–6
Weight at admission in kilograms (kg)	Average (SD)	71.4 (16.9)
	Range	45.8–114.5
Body Mass Index (BMI)	<21[±]	8 (18.2)
	22–27	19 (43.2)
	>27[±]	17 (38.6)
Clinical assessment of hydration status at admission	No dehydration	30 (73.1%)
	Potential dehydration	11 (26.8%)
		(n = 41)
Serum calculated osmolality at admission	Normal (< 295 mmol/L)	30 (73.1%)
	Impending and potential dehydration (≥ 295 mmol/L)	8 (19.5%)
		(n = 41)
Clinical assessment of hydration status at study exit	No dehydration	26 (81.3%)
	Potential dehydration	6 (18.8%)
		(n = 32)[#]
Serum osmolality at exit	Normal (< 295 mmol/L)	26 (83.9%)
	Impending and potential dehydration (≥ 295 mmol/L)	5 (16.1%)
		(n = 31)[#]

[±]BMI < 21 or > 27 confers an increased risk for dehydration.
[#]Research staff missed some patients at discharge, hence some data were missing at study exit

Table 2. The diagnostic accuracy of clinician-assessed dehydration in predicting dehydration defined by serum osmolality

	Clinician Diagnosis		Serum osmolality		Sensitivity (range)	Specificity (range)	PPV[a] (95% CI)	NPV[b] (95% CI)	Agreement *k* (95% CI)
	Number of participants positive for dehydration	Number of participants negative for dehydration	Number of participants Positive for dehydration	Number of participants Negative for dehydration					
Admission	11	30	8	33	0.50 (0.16–0.84)	0.77 (0.59–0.90)	0.36 (0.11–0.69)	0.86 (0.67–0.96)	0.24 (-0.09–0.57) Fair agreement
Study exit	6	26	5	26	0.00 (0.00–0.52)	0.78 (0.56–0.92)	0.00 (0.00–0.52)	0.78 (0.56–0.92)	-0.22 (-0.35–0.09) Poor agreement

[a]PPV = Positive Predictive Value, [b]NPV = Negative Predictive Value

By comparison, the sensitivity and specificity of clinically assessed dehydration in predicting CO defined dehydration at exit was 0.00 and 0.78, respectively. Agreement between the two measures at exit was poor (κ=-0.22) [11], and the area under the ROC curve was 0.39 (95%CI: 0.18-0.64), indicating the clinical assessment was not useful in predicting CO defined dehydration These results as well as PPVs and NPVs are presented in Table 2.

Discussion

On the basis of clinician assessment alone, 27% (n = 11) of the older hospitalized patients in the sample were dehydrated at admission and 19% at study exit (n = 6). Using the measure of serum-calculated osmolality, 19% (n = 8) were dehydrated on admission to hospital, and 16% (n = 5) on exit. Results showed fair agreement between the two measures at admission (κ= 0.24) and very poor agreement at exit (κ=-0.22). On both occasions, sensitivity was very poor (admission: 0.50), particularly at exit (0.00), in which case there was no agreement between the clinical assessment and CO results. This lack of agreement is likely to be partly attributable to the small sample size and missing data at exit. Otherwise, specificity was moderate at both admission (0.77) and at study exit (0.78), indicating that the clinical assessment was reasonably accurate in identifying euhydration.

While few studies have reported on the accuracy of clinical assessments in predicting dehydration, our findings are consistent with those of two previously reported studies [2, 6]. Fortes and colleagues [2] found that 21% of their sample of older patients (aged ≥ 60 years) admitted to hospital were dehydrated on the basis of CO; a rate similar to our result. They also reported poor sensitivity (0–44%) of each of the physical signs (tachycardia, low systolic BP, dry mucous membrane, dry axilla, poor skin turgor, sunken eyes and long capillary refill time) used by their hospital clinicians to predict CO-defined dehydration. Like us, they also reported that each measure had reasonable-to-good specificity (60–99%) in identifying euhydration.

In this study, clinical dehydration was established following assessment of multiple physical features. More extensive research is required to determine whether individual elements of clinical dehydration assessments are more predictive of dehydration than others. However, until a specific measure is developed or identified, our results serve as a useful reminder

that clinicians should not rely solely upon clinical dehydration assessments for older patients, but that they should confirm their suspicions through pathology results. By comparison, it seems that experienced clinicians may have a degree of confidence in their assessments when concluding that a patient is euhydrated. This finding is encouraging for clinicians working in rural and remote areas, or in other settings (e.g. primary care) where ready access to pathology services may be limited. It should be borne in mind, however, that the clinicians who performed clinical assessments in this study were experienced geriatricians, and their findings might not be extrapolated to less experienced clinicians.

Strengths of this study include the rigorous assessment of dehydration by experienced clinicians within 24 hours of patients' admission to hospital, as well as the collection of blood samples. Study limitations include its small sample size and the fact that some data were missing, owing to research staff missing patients at discharge. While this reflects the reality of conducting research in the busy hospital setting, it also limits the conclusions we were able to make.

Conclusions

In this small sample of older hospitalized patients, clinical assessment sometimes failed to diagnose dehydration, which was otherwise accurately diagnosed using the reference standard (serum osmolality). However, clinicians' own assessments seemed reasonably accurate in identifying euhydrated patients. Clinicians should not rely upon their own clinical assessments to detect dehydration in older hospital patients without supporting empirical evidence from pathology tests, but may be reasonably confident using this method to identify those who are euhydrated.

Acknowledgements

We would like to acknowledge the contribution of Dr Elaine Fielding, Senior Research Fellow at the Dementia Collaborative Research Centres (DCRC), who provided valuable statistical advice for this manuscript.

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