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Current opinion in clinical nutrition and metabolic care

DOI:
10.1097/MCO.0000000000000320

Published: 01/11/2016

Peer reviewed version

Diagnosing dehydration? Blend evidence with clinical observations

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Diagnostic Considerations for Dehydration

ABSTRACT

Purpose of Review

The purpose of the review is to provide recommendations to improve clinical decision making based on the strengths and weaknesses of commonly-used hydration biomarkers and clinical assessment methods.

Recent findings

There is widespread consensus regarding treatment, but not the diagnosis of dehydration. Even though it is generally accepted that a proper clinical diagnosis of dehydration can only be made biochemically rather than relying upon clinical signs and symptoms, no gold standard biochemical hydration index exists. Other than clinical biomarkers in blood (i.e. osmolality, BUN/creatinine) and in urine (i.e. osmolality, specific gravity), blood pressure assessment and clinical symptoms in the eye (i.e. tear production, palpitating pressure) and the mouth (i.e. thirst, mucous wetness) can provide important information for diagnosing dehydration.

Summary

It is recommended that clinical observations based on a combination of history, physical examination, laboratory values, and clinician experience remain the best approach to the diagnosis of dehydration.

Keywords

hydration assessment, hypovolemia, fluid balance, body water, hydration status

INTRODUCTION

Adults and children continuously lose and replace body water, and often develop mild, but not clinically significant dehydration several times each week. Although very mild dehydration of 1.5 – 2 % body mass loss alters mood and results in reduced cognitive (1, 2) and physical (3) performance, it is easily corrected. When left chronically untreated, moderate-to-severe dehydration increases the risk of urinary tract infection, chronic kidney disease (4-6), and also increases medical costs, morbidity, and mortality (7). Unfortunately, despite numerous investigations (8), the methods of dehydration assessment have not been refined to the point that a single reference standard has been identified for clinical decision making (9); this magnifies the difficulty of diagnosing dehydration in clinical practice (9-12). This article provides recommendations to improve clinical decision making based on the strengths and weaknesses of commonly-used hydration biomarkers and clinical assessment methods.

Scientific evidence that informs clinical observations

We approached this problem from three perspectives: (a) rating the scientific and clinical value of hydration assessment techniques; (b) rating the time, monetary cost, and technical expertise required; and (c) incorporating the conclusions of previously published review papers. Table 1 provides a synthesis of the findings of previous publications (9, 13-16) and consensus of the present authors.

[Table 1]

There is widespread consensus regarding treatment, but not the diagnosis of dehydration. Although it is generally accepted that a proper clinical diagnosis of dehydration can only be made biochemically (e.g. using clinical laboratory tests), rather than relying upon clinical signs and symptoms (Table 1) (16), no gold standard biochemical hydration index exists (13, 16). The techniques presented in Table 1 include signs and symptoms that are frequently used in

clinical practice for screening purposes because of their relative simplicity, speed of measurement and low cost. Unfortunately, the teaching and choice of signs and symptoms are largely based on clinical experience and medical tradition (11, 16); very often, the underpinning scientific evidence supporting their use is weak (e.g., lack of comparison to a recognized criterion or reference standard). The holy grail of identifying a single gold standard hydration index is unrealistic given that the clinician evaluates different types of dehydration (e.g. hypertonic and isotonic), different severities of dehydration, and often observes a patient only once (i.e., static assessment in an emergency department), as opposed to monitoring hydration relative to a euhydrated baseline (i.e., dynamic assessment in a nursing facility). Further, the clinician accounts for the potentially confounding effects of illness and medications, and considers the desired precision, accuracy, cost, analytical time and expertise required to perform the measurement (Table 1).

Blood osmolality has been proposed as a suitable index of dehydration (typically defined as > 300 $mOsm \cdot kg^{-1}$) (9, 12); however, this is not universally accepted (13, 17). Evidence supporting blood osmolality as a hydration index typically comes from studies that incorporate a sweat-loss model of hypertonic hypovolemia in young, fit, and healthy individuals. As such, blood osmolality is unsuitable to detect isotonic hypovolemia that often results from illness and medications (e.g., diuretics) in a clinical setting. This situation is compounded by a lack of standardization in blood osmolality measurements (calculated values versus direct measurements via osmometer, Table 1) and other clinical laboratory indices of hydration.

Guidelines for the treatment of dehydration are widely accepted, as published by the U.S. Centers for Disease Control and Prevention, the World Health Organization, the American

Academy of Pediatrics, and the National Institute for Health and Clinical Excellence of the United Kingdom. Guidelines for the diagnosis of dehydration are not universally accepted.

The decision algorithm

From the clinical perspective, volume depletion (loss of sodium from the extracellular space) and dehydration (loss of water from the intracellular space) must be distinguished because this influences the type and rate of fluid and electrolyte replacement. At this time, the evaluation for both remains largely a clinically based process incorporating the patient history, physical examination, and available laboratory values. The history and presenting circumstances often drive the decision algorithm. Confounding factors influence the decision to treat for dehydration, including intravascular volume depletion in the face of obvious total body water increase with peripheral edema on physical exam.

[Figure 1]

Clinical observations such as skin turgor, mucous membrane moisture, sunken eyes, and tear production can be helpful in children when multiple findings are present, but are not as reliable in the elderly (16). Physical examination measurements such as orthostatic blood pressure and heart rate responses support the clinical observation of dehydration. However, orthostatic changes can be difficult to obtain in a compromised patient and may reflect dilated lower extremity vasculature in an athlete post competition. Body weight can vary from day to day and is useful in the acute clinical setting when there is a reasonable baseline weight to compare to the current weight; however, variations in scales make this assessment less reliable. The admission body weight measurement provides a useful baseline to assess body fluid changes, especially when measured within a 24-h period on the same scale.

Clinical laboratory values are helpful in the context of the history and physical exam. BUN/creatinine ratio, hematocrit/hemoglobin ratio, serum sodium concentration, serum osmolality, and urine specific gravity are commonly measured in clinics, emergency departments and on the wards, but have not been validated as a reference standard. In particular, urine specific gravity reportedly is unreliable in diagnosing dehydration in children with gastroenteritis (18). Medications, especially from the diuretic classes, can confuse the biochemical picture by varying the renal clearance of water and electrolytes. Invasive procedures with central intravascular lines help establish the volume status and fluid balance of critically ill patients, but are not used in non-critical dehydration patients. Chronic kidney disease, heart failure, and other maladies that affect renal blood flow also confound the clinical picture and complicate diagnostic efforts. Recent evidence further complicates the assessment of hydration status, in that different hydration indices may validly identify dehydration in one circumstance but not another (19).

CONCLUSION

Clearly, a pressing need exists for well-controlled studies of clinically relevant dehydration models (i.e., both hypertonic and isotonic hypovolemia) in appropriate patient populations (i.e., other than athletes and military personnel) that identify hydration indices with scientific and clinical validity and precision. Only then can normal and clinically significant population ranges be determined. At present, clinical observations based on a combination of history, physical examination, laboratory values, and clinician experience remain the best approach to the diagnosis of dehydration. Figure 1 and Table 1 provide guidance to that end.

KEY POINTS

- Clinical observations based on a combination of history, physical examination, laboratory values, and clinician experience is the best approach to the diagnosis of dehydration.
- There is widespread consensus regarding treatment, but not the diagnosis of dehydration.
- There is a pressing need for well-controlled studies of clinically relevant dehydration models in appropriate patient populations (i.e., other than athletes and soldiers) that identify hydration indices with scientific and clinical validity and precision.

Acknowledgements

None

Financial support and sponsorship

None

Conflicts of interest

LEA is currently a consultant for Drinking Water Research Foundation, Alexandria VA and Danone Research, France; has received grants from Danone Research, France; is on the speaker's bureau for Drinking Water Research Foundation, Alexandria VA and Danone Research, France. **SAK** is currently a consultant for Quest Diagnostics, Secaucus, NJ and Danone Research, France; has active grants with Danone Research, France; is on the speaker's bureau for Danone Research, France. **NPW** has received a grant with HydraDX. **WOR** None.

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* of special interest

** of outstanding interest

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Figure 1 Legend

Physical examination and laboratory measurements aid diagnosis when multiple findings exist

Table 1 Title

Comparison of research and clinical techniques to diagnose dehydration during a single examination.

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Table 1. Comparison of Research and Clinical Techniques to Diagnose Dehydration, Using a Single Measurement.

Hydration Assessment Techniques	Patient Self-Evaluation	Cost Efficiency	Time Efficiency	Simplicity of Test	Scientific Value [c]
Signs & Symptoms					
Dry mucous membrane		●●●●●	●●●●●	●●●○○	●○○○○
Skin turgor		●●●●●	●●●●●	●●○○○	●○○○○
Nail bed refill time (sec)		●●●●●	●●●●●	●●●○○	●○○○○
Thirst sensation (thirst scale rating)	✓	●●●●●	●●●●●	●●●●●	●●●○○
Respiratory pattern		●●●●●	●●●●●	●●●●○	●○○○○
Dry axilla		●●●●●	●●●●●	●●●●●	●○○○○
Seated systolic blood pressure (mmHg)		●●●●●	●●●●○	●●●●○	●●●●○
Blood pressure change supine/upright [a] (mmHg)	✓	●●●●●	●●●●○	●●●●○	●●●●○
Heart rate change supine/upright (beats·min^{-1})	✓	●●●●●	●●●●●	●●●●●	●●○○○
Absence of tears		●●●●●	●●●●●	●●●●●	●○○○○
Sunken eyes		●●●●●	●●●●●	●●●●●	●○○○○
Palpated intraocular pressure		●●●●●	●●●●●	●●●●●	●○○○○
Dark urine color (color chart rating)	✓	●●●●●	●●●●●	●●●●●	●●●○○
Body mass (kg)	✓	●●●●●	●●●●●	●●●●●	●○○○○
Clinical Diagnostic Laboratory Tests					
BUN/creatinine ratio		●●●○○	●●●○○	●●●○○	●●●●○
Serum sodium concentration (mEq·L^{-1} or mmol·L^{-1})		●●●○○	●●●○○	●●○○○	●●●○○
Blood osmolality, calculated (mOsm·kg^{-1} or mmol·kg^{-1})		●●●○○	●●●○○	●●○○○	●●●●○
Hematocrit/hemoglobin ratio		●●●○○	●●●○○	●●●○○	●●●○○
Mean corpuscular volume (fL)		●●●○○	●●●○○	●●●○○	●●●○○
Urine specific gravity		●●●●●	●●●●○	●●●●○	●●●●○
Research Measurements					
Isotope dilution, total body water (L)		●○○○○	●○○○○	●○○○○	●●●○○
Neutron activation analysis, fluid volumes and ionic content		●○○○○	●○○○○	●○○○○	●●●○○
Bioelectrical impedance analysis, total body water (L)		●●●●○	●●●●○	●●●●○	●●●○○
Body mass (kg)	✓	●●●●●	●●●●●	●●●●●	●○○○○
Blood osmolality, measured [b] (mOsm·kg^{-1} or mmol·kg^{-1})		●●●○○	●●●○○	●●●○○	●●●●○
Urine osmolality (mOsm·kg^{-1} or mmol·kg^{-1})		●●●●○	●●●●○	●●●●○	●●●●○
Salivary osmolality (mOsm·kg^{-1} or mmol·kg^{-1})		●●●●○	●●●●○	●●●●○	●●●●○
Tear osmolarity (mOsm·L^{-1} or mmol·L^{-1})		●●●●○	●●●●○	●●●○○	●●●○○
Intraocular pressure (mmHg)		●●●●○	●●●○○	●●●○○	●●○○○

[a] lying to sitting, sitting to standing, lying to standing
[b] measured via freezing point depression osmometry
[c] considering measurement resolution, reliability and accuracy

●●●●● = high, ●●●○○ = medium & ●○○○○ = low

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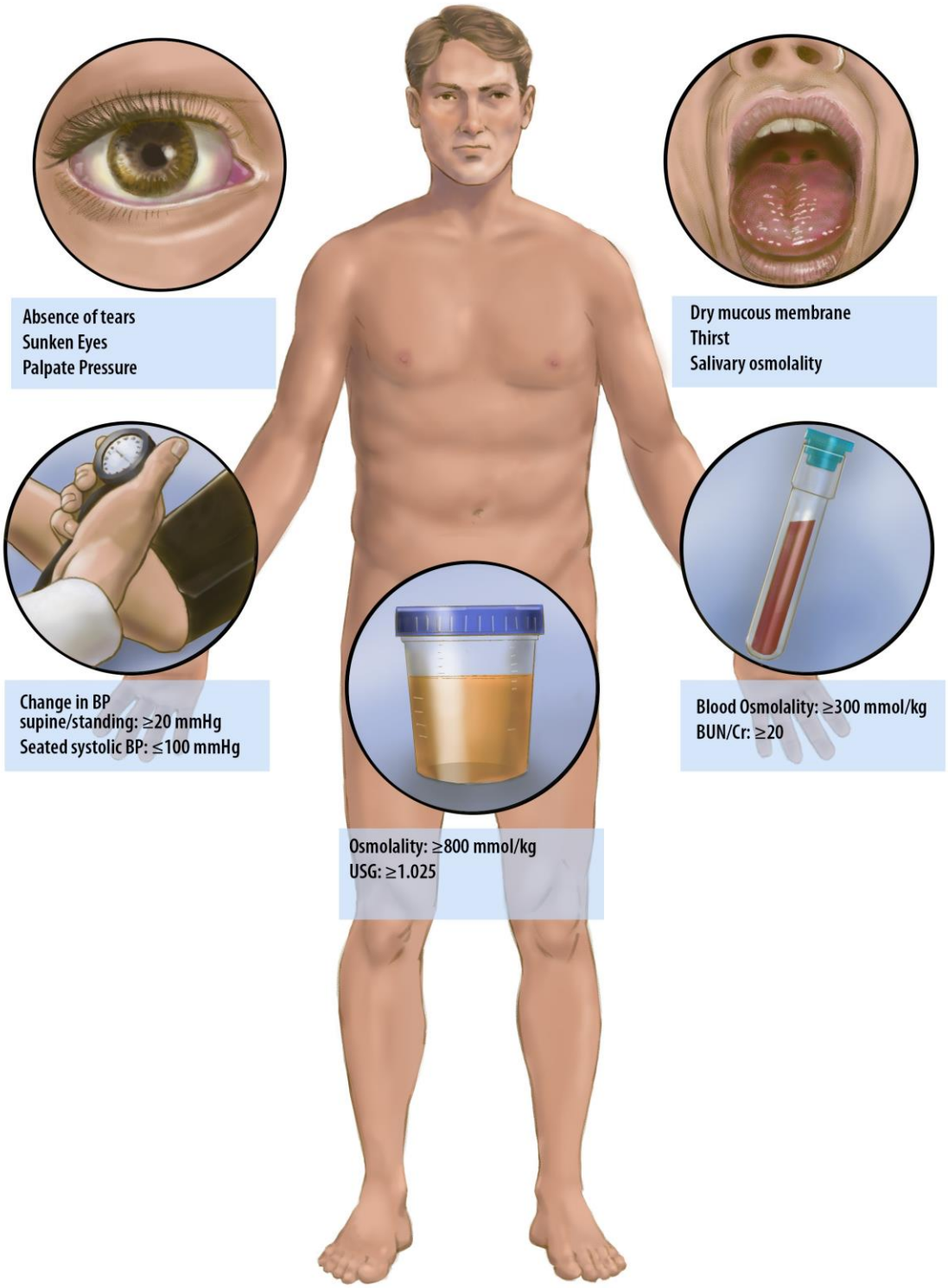
240 Figure 1



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