Dehydration in Infants and Young Children

EBEM Commentator Contact

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RATIONAL CLINICAL EXAMINATION REVIEW SOURCE

This is a rational clinical examination abstract, a regular feature of the *Annals*' Evidence-Based Emergency Medicine (EBEM) series. Each features an abstract of a rational clinical examination review from the *Journal of the American Medical Association* and a commentary by an emergency physician knowledgeable in the subject area.

The source for this rational clinical examination review abstract is: M Steiner, D DeWalt, J Byerly. The rational clinical examination: is this child dehydrated? *JAMA*. 2004;291:2746-2754. The *Annals*' EBEM editors assisted in the preparation of the abstract of this rational clinical examination review, as well as selection of the Evidence-Based Medicine Teaching Points.

OBJECTIVE

To systematically review the precision and accuracy of symptoms, signs, and basic laboratory tests for evaluating dehydration in infants and children (aged 1 month to 5 years).

DATA SOURCES

The authors performed direct searches for potential sources of primary data or reviews with potential background information on the MEDLINE database through the PubMed search engine. They supplemented these searches with the standardized search technique used in the "Rational Clinical Examination" series to yield 1,561 potential articles. Searches of bibliographies of retrieved articles, the Cochrane Library, textbooks, and private collections of experts in the field yielded an additional 42 articles.

STUDY SELECTION

All authors reviewed the titles and available abstracts of the 1,603 potential articles to identify studies for further review. Of 110 retained articles, 26 contained original data on the precision or accuracy of a symptom, sign, or laboratory value for the diagnosis of dehydration in young children. These underwent full quality assessment with a standardized methodologic filter, with group consensus on level of evidence. The difference between the rehydration weight and the acute weight divided by the rehydration weight was chosen as the best available criterion standard of percentage of volume lost. Thirteen studies were assigned level 4 quality or higher and were included in the meta-analysis.

DATA EXTRACTION AND ANALYSIS

Two of the 3 authors independently reviewed and abstracted data into 2×2 tables for each test to calculate sensitivity, specificity, and likelihood ratios, with corresponding 95% confidence intervals (CIs). When 2 studies evaluated an individual diagnostic test, a range of values was provided. If more than 2 studies evaluated a test, a random-effects model was used. Significant heterogeneity (a common finding with this model) was demonstrated for most signs.

MAIN RESULTS

The authors found few high-quality studies with accurate criterion standards and minimal systematic bias. Tests of dehydration were imprecise, generally showing only fair to moderate agreement among examiners (key signs of dehydration are listed in the Figure; precision of signs on examination is listed in Table 1). Historical points had moderate sensitivity in screening for dehydration, but parental reports of dehydration symptoms were so nonspecific that they had limited clinical utility. Prolonged capillary refill time, abnormal skin turgor, and abnormal respiratory pattern were the best 3 signs of dehydration (Table 2), and groups of signs or the use of clinical

Table 1. Precision of signs for dehydration.

Finding	Total No. of Participants	Range of κ Values
Prolonged capillary refill	216	0.01-0.65
Abnormal skin turgor	184	0.36-0.55
Abnormal respiratory pattern	184	0.04-0.40
Extremity perfusion	100	0.23-0.66
Absent tears	184	0.12-0.75
Sunken fontanelle	100	0.10-0.27
Sunken eyes	184	0.06-0.59
Dry mucous membranes	184	0.28-0.59
Weak pulse	184	0.15-0.50
Poor overall appearance	184	0.18-0.61

Table 2. Summary test characteristics for clinical findings to detect 5% dehydration.

Finding	Total No. Participants	LR Summary Value (95% CI) or Range	
		Present	Absent
Prolonged capillary refill	478	4.1 (1.7-9.8)	0.57 (0.39-0.82)
Abnormal skin turgor	602	2.5 (1.5-4.2)	0.66 (0.57-0.75)
Abnormal respiratory pattern	581	2.0 (1.5-2.7)	0.76 (0.62-0.88)
Sunken eyes	533	1.7 (1.1-2.5)	0.49 (0.38-0.63)
Dry mucous membranes	533	1.7 (1.1-2.6)	0.41 (0.21-0.79)
Cool extremity	206	1.5-18.8	0.89-0.97
Weak pulse	360	3.1-7.2	0.66-0.96
Absent tears	398	2.3 (0.9-5.8)	0.54 (0.26-1.13)

LR, Likelihood ratio.

Table 3. Summary test characteristics for selected laboratory tests assessing dehydration

Laboratory Value	Total No. of Participants	LR Summary, Value (95% CI) or Range	
		Present	Absent
BUN, mg/dL			
>8		2.1-2.4	0.41-0.76
>45	168	46.1 (2.9-733)	0.58 (0.49-0.68)
BUN/Cr ratio >40	40	2.1 (0.5-8.9)	0.87 (0.62-1.20)
Bicarbonate, mEq/L			
<17	97	3.5 (2.1-5.8)	0.22 (0.12-0.43)

BUN, Blood urea nitrogen; *Cr,* creatinine.

scales improved accuracy. Laboratory tests generally were helpful only when results were markedly abnormal, but none were considered definitive for dehydration with the authors' reference standard (Table 3).

CONCLUSIONS

The authors advocate the approach recommended by the World Health Organization (WHO) and other groups: use the physical examination to classify dehydration as *none*, *some*, or *severe*, and then use this general assessment to guide clinical management. Table 4 summarizes this classification scheme.

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COMMENTARY: CLINICAL IMPLICATIONS

Each year in the United States, acute gastroenteritis results in 5% of pediatric outpatient visits and is frequently complicated by some degree of dehydration. Volume depletion accounts for 5% of pediatric hospital admissions and more than 300 deaths each year. In the United States, gastroenteritis accounts for more than 1.5 million pediatric outpatient visits and 200,000 hospitalizations annually.[1]

The goals of treatment of the child with gastroenteritis are prevention of dehydration, rehydration efforts when necessary, rapid refeeding, and pharmacologic treatment whenever appropriate (eg, antinauseants and antimotility agents). Throughout the last decade, randomized controlled trials in both developed and developing countries have confirmed the success rates (90%) of oral rehydration solutions in achieving these treatment goals, as well as their lower complication rates, shorter treatment times, and lower cost compared with intravenous therapy.[2,3]

Unfortunately, oral rehydration solution therapy remains underused, particularly in developed countries.[4] Historically, clinicians who provide care in emergency departments have been more likely to choose intravenous over oral rehydration when vomiting is a major symptom.[5] In one survey, 36% of pediatricians reported that vomiting was a contraindication to oral rehydration[5]; however, a recent large trial demonstrating safety and efficiency of oral-dissolvable ondansetron in controlling nausea and vomiting in gastroenteritis is likely to increase the use and success rate of oral rehydration.[6]

The clinical problem is to distinguish the mild to moderately dehydrated child, in whom adequate fluid intake can be achieved with oral rehydration solution therapy, from the more seriously dehydrated child requiring intravenous hydration and

Skin turgor

- Use the thumb and index finger to pinch a small skin fold on the lateral abdominal wall at the level of the umbilicus, release promptly, and measure time to return to normal.
- Report as immediate, slightly delayed, or prolonged.

Capillary refill time

- Warm ambient temperature, arm at the level of the heart.
- Compress palmar surface of the distal fingertip, release immediately after the capillary bed blanches.
- Normal for non-dehydrated children is < 1.5 to 2 seconds.

Figure. Key signs in young children with suspected dehydration.

Table 4. Dehydration Assessment Scale.

Variable/Sign	Dehydration		
	Mild (4%-5%)	Moderate (6%-9%)	Severe (≥10%)
General appearance	Thirsty, restless, alert	Thirsty, drowsy, postural hypotension	Drowsy, limp, cold, sweaty, cyanotic extremities
Radial pulse	Normal rate and strength	Rapid and weak	Rapid, thready, sometimes impalpable
Respirations	Normal	Deep, may be rapid	Deep and rapid
Anterior fontanelle	Normal	Sunken	Very sunken
Systolic blood pressure	Normal	Normal or low	Low
Skin elasticity	Pinch retracts immediately	Pinch retracts slowly	Pinch retracts very slowly
Eyes	Normal	Sunken	Grossly sunken
Tears	Present	Absent	Absent
Mucous membranes	Moist	Dry	Very dry

Adapted from Steiner et al.[1] Level of classification may be classified as none, some (mild or moderate dehydration), or severe.

consideration for admission. More aggressive measures may be required if excessive fluid loss or dehydration is evident or if patients are at risk of dehydration (eg, infants, immunosuppressed patients, patients with comorbid disease). Such patients may benefit from hospital admission and intravenous fluids, in addition to oral rehydration solution with isotonic electrolyte solutions containing glucose or starch.

The most accurate indicator of the magnitude of dehydration appears to be the percentage of loss of body weight, a measure usually unavailable in the ED, so estimates of the degree of dehydration must be made from clinical data. Diagnostic criteria published by WHO[7] and a practice measure on the management of acute gastroenteritis published by the American Academy of Pediatrics (AAP)[8] (now retired in deference to the more recent Centers for Disease Control and Prevention guidelines[9]) are widely referenced. These classification systems differ slightly, and categorizing severity can be difficult if the child has signs and symptoms that fit into more than 1 category.

The authors reference a strategy using groups of signs and symptoms to predict the percentage of loss of body weight (Table 2) and then treating patients by degree of dehydration. The WHO classification, designed for health care workers in developing countries with limited health care resources and high diarrhea-related morbidity and mortality, has proven to be effective in the triage of patients with acute diarrheal illness,[10] whereas the AAP classification has been less well studied. The authors' classification scheme, although reasonable, has also not been prospectively evaluated.

TAKE-HOME MESSAGE

Prolonged capillary refill time, abnormal skin turgor, and abnormal respiratory pattern are the 3 best signs of dehydration; groups of signs and the use of clinical scales are more accurate in defining extent. Laboratory tests are helpful only when results are markedly abnormal, and none are considered definitive for dehydration. Use of physical findings can help identify children with no, mild, or moderate dehydration, all of whom are likely to respond well to oral rehydration solution therapy.

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EBEM TEACHING POINT

Random-effects modeling. Random-effects modeling is a statistical technique used to combine data from disparate analyses for summary analysis (eg, meta-analysis). Both within-study sampling error (variance) and between-studies variation are included in the assessment of the uncertainty (CI) of the results of a meta-analysis. As the authors of this study reported, whenever there is significant heterogeneity among the results of the included studies, random-effects models give wider CIs than fixed-effect modeling.

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