Is This Patient Hypovolemic?

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Objective To review, systematically, the physical diagnosis of hypovolemia in adults.

Methods We searched MEDLINE (January 1966-November 1997), personal files, and bibliographies of textbooks on physical diagnosis and identified 10 studies investigating postural vital signs or the capillary refill time of healthy volunteers, some of whom underwent phlebotomy of up to 1150 mL of blood, and 4 studies of patients presenting to emergency departments with suspected hypovolemia, usually due to vomiting, diarrhea, or decreased oral intake.

Results When clinicians evaluate adults with suspected blood loss, the most helpful physical findings are either severe postural dizziness (preventing measurement of upright vital signs) or a postural pulse increment of 30 beats/min or more. The presence of either finding has a sensitivity for moderate blood loss of only 22% (95% confidence interval [CI], 6%-48%) but a much greater sensitivity for large blood loss of 97% (95% CI, 91%-100%); the corresponding specificity is 98% (95% CI, 97%-99%). Supine hypotension and tachycardia are frequently absent, even after up to 1150 mL of blood loss (sensitivity, 33%; 95% CI, 21%-47%, for supine hypotension). The finding of mild postural dizziness has no proven value. In patients with vomiting, diarrhea, or decreased oral intake, the presence of a dry axilla supports the diagnosis of hypovolemia (positive likelihood ratio, 2.8; 95% CI, 1.4-5.4), and moist mucous membranes and a tongue without furrows argue against it (negative likelihood ratio, 0.3; 95% CI, 0.1-0.6 for both findings). In adults, the capillary refill time and poor skin turgor have no proven diagnostic value.

Conclusions A large postural pulse change (≥30 beats/min) or severe postural dizziness is required to clinically diagnose hypovolemia due to blood loss, although these findings are often absent after moderate amounts of blood loss. In patients with vomiting, diarrhea, or decreased oral intake, few findings have proven utility, and clinicians should measure serum electrolytes, serum blood urea nitrogen, and creatinine levels when diagnostic certainty is required.

JAMA. 1999;281:1022-1029 www.jama.com

CLINICAL SCENARIOS

In each of the following clinical scenarios, clinicians need to identify which physical signs reliably and accurately indicate volume depletion or dehydration.

Case 1

A 54-year-old man, taking ibuprofen for knee arthritis, presents with a 1-day history of melena. Physical examination reveals a pulse of 80/min and blood pressure (BP) of 140/82 mm Hg when supine, and 115 and 132/86 mm Hg when standing. There is mild epigastric tenderness and hemoccult-positive stool. The hematocrit is 0.39.

Case 2

A 62-year-old woman has 6 months of episodic vertigo and unilateral hearing loss, attributed to Ménière disease. She begins treatment with hydrochlorothiazide, but during a follow-up visit 3 weeks later, she reports her dizziness is slightly worse since starting the medication. Her heart rate is 80/min and BP is 160/84 mm Hg when supine, 88 and 134/72 mm Hg when standing. She experiences slight dizziness when standing.

Case 3

An 82-year-old nursing home resident presents to the emergency department with a 1-day history of nausea and vomiting. Her underlying medical problems include dementia, coronary artery disease, atrial fibrillation, emphysema, and hypertension. She has been treated with aspirin, isosorbide dinitrate, furosemide, β-agonist inhalers, and lisinopril. The clinician diagnoses viral gastroenteritis or food poisoning because other members of the nursing home have an identical illness. On examination, the patient is afebrile, alert, and demonstrates normal speech and strength. Her mental status is no different from her baseline. The pulse is 75/min and the BP is 154/90 mm Hg supine, and 90 and 130/76 mm Hg when upright. The tongue, mucous membranes, and axillae are moist. Results of an examination of the heart, lungs, and abdomen and an electrocardiogram are normal.

WHY IS CLINICAL EXAMINATION IMPORTANT?

The term *volume depletion* describes the loss of sodium from the extracellular space (intravascular and interstitial fluid) that occurs after gastrointestinal hemorrhage, vomiting, diarrhea, and diuresis.

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In contrast, the term *dehydration* refers to losses of intracellular water that ultimately cause cellular desiccation and elevate the plasma sodium concentration and osmolality.[1] This distinction is important to clinicians (patients with volume depletion exhibit prominent circulatory instability and should receive 0.9% saline rapidly, whereas those with pure dehydration may lack circulatory instability and should receive 5% dextrose, usually more slowly). Most patients presenting with dehydration, however, also have volume depletion. Moreover, in most clinical studies of related physical findings, investigators lump the 2 disorders together, by using as a combined criterion standard either the presence of an elevated serum urea nitrogen–creatinine ratio (a measure of volume depletion) or an elevated serum sodium level or osmolality (a measure of dehydration). We will use the term *hypovolemia* to collectively refer to both conditions.

Gastrointestinal tract hemorrhage, the prototype of volume depletion, is a common and important problem. Hospitalizations for upper gastrointestinal tract hemorrhage occur in 150/100 000 population per year[2] and are associated with a case fatality rate of 3% to 10%.[2,3] Hypernatremia, the hallmark of dehydration, affects primarily elderly patients with infections and poor access to water, accounting for less than 1% of hospital admissions but associated with a mortality rate exceeding 40%.[4,5] Risk factors for hypovolemia in the elderly include female sex, age older than 85 years, having more than 4 chronic medical conditions, taking more than 4 medications, and being confined to bed.[6]

Clinical examination attempts to address (1) whether the patient's symptoms are related to hypovolemia and (2) how severely hypovolemic the patient is. In case 1, symptoms and laboratory data do not gauge the severity of the gastrointestinal tract hemorrhage. For example, the presence of melena has been associated with both insignificant (as little as 100 mL of blood loss)[7] and massive hemorrhage.[8] The admission hematocrit also correlates poorly with the degree of blood loss and overall mortality,[3-10] especially in cases of persistent or recurrent bleeding, because a decrease in hematocrit is often delayed 24 to 72 hours after hemorrhage.[11-13] In 1 large study,[3] however, postural vital signs were a significant univariate predictor of mortality and complications. By influencing decisions to hospitalize the patient with hemorrhage, perhaps even in the intensive care unit, postural vital signs may be useful to the clinician. But how accurate are they and which component of the postural change, pulse or BP, provides more meaningful information?

In case 2, the clinician recognizes that hydrochlorothiazide may benefit patients with Ménière disease[14] but also wonders if the diuretic could be causing volume depletion and aggravating her dizziness. How significant is the postural decrease in systolic BP of 26 mm Hg and the mild postural dizziness?

Finally, case 3 differs from case 1 in that the fluid losses are not directly from the vascular space and that emesis typically has only one third the sodium concentration of serum. How reliable are findings of postural vital signs, capillary refill, and moist axilla, tongue, and mucous membranes in this patient?

Table 1. Phlebotomy Studies in Normovolemic Individuals*

Source, y	No. of Subjects	Amount of Blood Removed, mL
Moderate†		
Knopp et al,[24] 1980	44	500
Baraff and Schriger,[25] 1992	100	450
Witting et al,[26] 1994	292	450
	44	450
Ralston et al,[27] 1961	16	530-590
Warren et al,[28] 1945	8	4.1-8.5 per kg
Large†		
Knopp et al,[24] 1980	44	1000
Shenkin et al,[29] 1944	11	1029 ± 81
Wallace and Sharpey-Schafer,[30] 1941	25	9-16 per kg
Skillman et al,[31] 1967	9	764 ± 93
Bergenwald et al,[32] 1977	16	900
Ralston et al,[27] 1961	3	920

*Mean age range of participants in these studies was 25 to 44 years. The exceptions are Warren et al[28] who did not provide age information and Witting et al[26] who had 292 subjects who were younger than 65 years and 44 subjects who were older than 65 years.
†Moderate was defined as 450 to 630 mL; large, 630 to 1150 mL.

METHODS

Using the MEDLINE database for articles from January 1966 to November 1997, an author (S.M.) used 3 search strategies, all limited to the English language and to humans 16 years or older, to retrieve all relevant publications on the bedside diagnosis of hypovolemia. The first strategy used the search terms *dehydration/di* or *hypotension*, *orthostatic* or *tilt-table test*. The second strategy used *exp dehydration* or *exp hypotension*, *orthostatic* or *exp heart rate* and *exp physical examination* or *exp medical history taking* or *exp professional competence* or *exp "sensitivity and specificity"* or *reproducibility of results* or *observer variation* or *diagnostic tests*, *routine* or *exp decision support techniques* or *Bayes theorem*. Finally, textword searches were completed for *skin turgor* or *acute blood loss* or *orthostatic vital signs* or (*postural* and *pulse*). Based on review of titles and abstracts, relevant publications were retrieved. To complete the search, this author reviewed the bibliographies of these articles and those of textbooks on physical diagnosis. Studies of the physical diagnosis of hypovolemia in infants and children were not included in this review.[15-23]

Two types of studies are presented. The first group (**TABLE 1**) investigated the postural vital signs and capillary refill time in healthy volunteers, some of whom underwent phlebotomy of up to 1150 mL of blood. Despite their limitations, these studies are included because they are the only studies that compare physical signs with objective measurements of blood loss. A second set (**TABLE 2**) included patients presenting to emergency departments with suspected hypovolemia, usually due to vomiting, diarrhea, or decreased oral intake. Two authors (S.M. and W.B.A.) independently graded these studies A, B, or C, according to the criteria that appear in the footnote of Table 2. There was complete agreement regarding classification.

A random effects model was used to generate summary measures and confidence intervals (CIs).[37,38] The model was appropriate because the studies of pulse and pressure change in normovolemic individuals were representative of all such investigations and included a broad mix of relevant subjects. For studies of diagnostic accuracy, the random effects summary measures provided suitable benchmarks for clinicians' use in actual practice and avoided errors when testing for homogeneity among a number of investigations. Calculations of sensitivity and specificity derive from graphs or tabulated data that appear in the original article or were available from the authors of the studies.[26,34,35] Those phlebotomy studies that described their results only as mean and SDs of the postural change in heart rate and BP, before and after phlebotomy, were reviewed but excluded from the calculations of sensitivity and specificity.[39-42] We used the method of Simel et al[43] to calculate CIs for the likelihood ratios (LRs).

RESULTS

Postural Vital Signs

When obtaining postural vital signs, clinicians should wait 2 minutes before measuring the supine vital signs and 1 minute after standing before measuring the upright vital signs, based on investigations of healthy individuals discussed below. Sitting instead of standing up the patient markedly reduces the clinician's ability to detect the postural changes induced by blood loss.[24] Clinicians who count the pulse for 30 seconds and double the result are more accurate than those using only 15 seconds.[44]

Within 1 to 2 minutes after standing up from the supine position, about 7 to 8 mL/kg of blood shifts to the lower body, causing the thoracic blood volume, stroke volume, and cardiac output to decrease and circulating norepinephrine levels and systemic vascular resistance to increase.[40,41,45-48] As revealed in TABLE 3, which presents data from 25 studies that investigated the postural vital signs of more than 3500 normovolemic individuals (ie, during the tilt test, moving from supine to upright positions by active standing in 97%, by tilt table in 3%), the most prominent finding is an increment in heart rate of 10.9/min (95% CI, 8.9-12.8/min). This increase usually stabilizes after 45 to 60 seconds in the upright position.[24,45,52,54] The systolic BP

Table 2. Clinical Studies of Hypovolemia*

Source, y	Grade of Study*	No. of Subjects	Age, Mean (Range), y	Patient Population	Physical Finding	Criterion Standard for Hypovolemia	Reason Study Not Grade A
Eaton et al,[33] 1994	A	86	80 (70-98)	Patients older than 70 y admitted with acute medical conditions	Dry axilla	Serum urea nitrogen–creatinine ratio >25 or plasma osmolarity >295 mmol/kg of H_2O	
Gross et al,[34] 1992	B	38	82† (61-98)	Stable patients older than 60 y in the emergency department with suspected fluid and electrolyte problems	Dry mucous membranes, dry tongue, tongue furrows, confusion, weakness, nonfluent speech, sunken eyes	Elevated serum urea nitrogen–creatinine ratio, serum osmolality, or serum sodium	N<50
Johnson et al,[35] 1995	C	23	NA (18-31)	Pregnant women in the emergency department with hyperemesis gravidarum and normal serum electrolyte and creatinine levels	Postural vital signs	≥5% Weight gain after rehydration	Convenience sample
Schriger and Baraff,[36] 1991	C	32	44 (17-90)	Adults in the emergency department with decreased oral intake, vomiting, diarrhea, or blood loss,‡ and suspected hypovolemia	Capillary refill time	Hypotension or postural pulse increment >20 beats/min or diastolic blood pressure decrement >15 mm Hg	Criterion standard was postural vital signs or hypotension; question blinding from criterion standard

*NA indicates not available. Grading was determined by these traits: A, an independent, blind comparison of a defined physical sign with an acceptable criterion standard of hypovolemia in more than 50 consecutive patients suspected of having hypovolemia; B, same traits as A but there were fewer than 50 consecutive patients suspected of having volume depletion; C, all other studies, including those using a criterion standard of uncertain validity, a physical finding not clearly defined, a comparison that was not blinded, or a selection of patients dependent on either the physical finding or criterion standard. An acceptable criterion standard was a chemical measure (either elevated serum sodium, osmolality, blood urea nitrogen, or blood urea nitrogen–creatinine ratio) or percentage of weight gain after the patient had received parenteral fluids.
†Median age instead of mean age.
‡Total number of subjects with blood loss equaled 6.

drops slightly by 3.5 mm Hg (95% CI, −1.5 to −5.5 mm Hg), stabilizing 1 to 2 minutes after standing,[45,54] whereas the diastolic BP increases by 5.2 mm Hg (95% CI, 2.8-7.6 mm Hg).

The variability of the postural pulse increment observed in these studies is in part attributable to the patients' ages and perhaps to the physical examination method. In Table 3, the mean age from each study correlates inversely with the observed mean pulse increment (r, −0.50; P = .02; Table 3). Other studies[47,56,57,61,62] also confirm that as patients age, the pulse increment becomes smaller, although no obvious cutpoint exists that allows the clinician to stratify patients. The duration of supine rest before the patient stands might also affect variability of the pulse change, based on the 1 outlier study in Table 3,[25] which demonstrated a mean postural pulse increment of only 2 beats/min and used the shortest time of supine rest before having the patient stand (only 1 minute; all other studies waited at least 2 minutes). Longer periods of supine rest before standing may produce a greater immediate pulse increment, perhaps by causing a greater transfer of blood to the legs and decrement in cardiac output.[48,63] Aside from the patient's age and period of supine rest, however, no other trend was evident. There was no clear relationship between the postural pulse increment and period of supine rest beyond 2 minutes, resting supine pulse rate, time upright before vital signs measurement (all >45 seconds), technique of pulse measurement (palpation vs automated), setting of the study (emergency department, prephlebotomy vs other), or method of assuming the upright posture (active stand vs tilt table).

Based on the studies in Table 3 that enrolled more than 25 individuals and presented tabulated data (n = 774), the specificity of a postural pulse increment of 30/min or more (ie, the most common threshold used in clinical studies) was 96% (95% CI, 92%-98%).

Postural hypotension, defined as a decrement in systolic BP of more than 20 mm Hg after standing from the supine position, occurs in up to 10% of normovolemic individuals younger than 65 years[26] and in 11% to 30% older than 65 years.[64-71] Postural hypotension is more likely if the patient has supine systolic hypertension,[58,67,68,71-73] but is not more likely, surprisingly, if the patient takes cardiovascular or psychotropic medications.[47,65,68,71,74] Finally, the symptom of mild or moderate postural dizziness is a poor predictor of postural hypotension in most studies.[56,67,70]

Pathogenesis and Definition of Other Physical Findings

The capillary refill time is determined by compressing the distal phalanx of the patient's middle finger, positioned level with

Table 3. Postural Change in Vital Signs of Normovolemic Adults*

Source, y	No. of Subjects	Age, Mean (Range), y	Pulse Change, beats/min	Systolic Blood Pressure Change, mm Hg	Diastolic Blood Pressure Change, mm Hg
Tell et al,[49] 1988	916	. . . (14-16)	+14.0 (14.8)	−5.2 (8.6)	+10.2 (12.4)
Honda et al,[50] 1977	496	16.5 (. . .)	+8.3 (8.8)	−9.5 (9.4)	+3.7 (11.9)
Horam and Roscelli,[51] 1992	34	. . . (16-19)	+18.4 (8.4)	+0.8 (7.4)	+8.3 (6.7)
Borst et al,[52] 1982	10	21 (. . .)	+15 (13)	+2 (5)	+19 (8)
Kaijser and Sachs,[53] 1985	14	. . . (20-26)	+16 (8)	−1 (6)	+4 (5)
Moore and Newton,[54] 1986	50	. . . (25-35)	+12.6 (11.7)	−12.1 (7.4)	−3.5 (6.1)
Baraff and Schriger,[25] 1992	104	32 (. . .)	+2 (7)	−2 (6)	+4 (7)
Green and Metheny,[39] 1947	25	32 (18-46)	+9 (7)	−5 (8.1)	+12 (9.3)
Currens,[55] 1948	1000	33.2 (. . .)	+13.2 (. . .)	. . .	. . .
Koziol-McLain et al,[56] 1991	132	34.1 (. . .)	+17.2 (11.1)	+2.8 (11.4)	+9.2 (7.8)
Knopp et al,[24] 1980	79	36 (17-55)	+18.4 (. . .)	−2.8 (. . .)	+16.4 (. . .)
Tuckman and Shillingford,[48] 1966	9	37 (. . .)	+13 (12)	+1 (8)	+7 (7)
Streeten et al,[46] 1988	92	. . . (18-64)	+12.3 (4.8)	−6.5 (4.8)	+5.6 (3.8)
Wong et al,[40] 1989	27	41.4 (. . .)	+14.6 (5.7)	. . .	. . .
Kaijser and Sachs,[53] 1985	18	42.5 (38-47)	+13 (8)	−2 (8)	+6 (8)
Dambrink and Wieling,[57] 1987	10	. . . (60-69)	+10 (9.5)	−2 (12.6)	+9 (9.5)
Kaijser and Sachs,[53] 1985	15	67 (. . .)	+11 (8)	+9 (20)	+3 (13)
Dambrink and Wieling,[57] 1987	10	. . . (70-79)	+11 (6.3)	−9 (12.6)	+2 (3.2)
Baraff and Schriger,[25] 1992	96	76.5 (. . .)	+1 (7)	−5 (12)	−2 (7)
Green and Metheny,[39] 1947	13	80 (. . .)	+2 (5.5)	−9 (12)	−5 (7.7)
Dambrink and Wieling,[57] 1987	10	. . . (80-89)	+8 (3.2)	−5 (9.5)	+4 (6.3)
Lipsitz et al,[58] 1985	15	87 (. . .)	+12 (7.5)	−3 (16)	. . .
Levitt et al,[59] 1992	21	. . .	+6.8 (7.8)	−2.5 (8.0)	+5.3 (9.9)
Schneider and Truesdell,[60] 1922	144	. . .	+13.8 (7.1)	. . .	. . .
Schneider and Truesdell,[60] 1922	204	. . .	+12.5 (8.5)	+5.3 (. . .)	. . .
Summary measure†	NA	NA	+10.9 (8.9-12.8)	−3.5 (−1.5,−5.5)	+5.2 (2.8-7.6)

*Ellipses indicate data not available from the study. Values are expressed as mean (SD) upright minus resting supine value.
†Expressed as random effects summary measure (95% confidence interval).

the heart, for 5 seconds and then timing the return of normal color to the finger. With an ambient temperature of 21°C, the upper limits of normal for the refill time are 2 seconds for children and adult men, 3 seconds for adult women, and 4 seconds for the elderly.[75]

Poor skin turgor refers to the slow return of skin to its normal position after being pinched between the examiner's thumb and forefinger.[76] The protein elastin, which is responsible for the recoil of skin, is markedly affected by moisture content. As little as 3.4% loss in wet weight may prolong the recoil time 40-fold.[76] Elastin deteriorates with age, suggesting that the recoil of skin normally declines with age, although this has never been formally studied to the authors' knowledge. No studies on the normal recoil time nor precise definitions of technique could be found.

Cellular dehydration, interstitial space dehydration, and poor perfusion are presumably responsible for many of the other classic signs of hypovolemia, such as longitudinal tongue furrows, dry mucous membranes, dry axillae, and sunken eyes. No studies on the pathogenesis of these findings, however, could be found.

Precision of Physical Signs

Reproducible measurements of BP depend on many variables, including the examiner's technique, the patient examined, and various observer biases and errors, all of which are thoroughly reviewed in another article.[77]

Outside of an extensive literature devoted to patients with syncope that uses different methods and end points than those discussed in this article, the few studies of tilt test reproducibility focus more on biological variation (ie, reproducibility of the test when repeated days later) than on immediate interobserver reproducibility. In 1 study, which measured postural vital signs of 911 elderly nursing home residents 4 times during the day, postural hypotension was present only 1 of the 4 times in 18.3% of the residents, 2 or 3 times in 19.9%, and all 4 times in only 13.3%.[68] Postural hypotension is more reproducible in the morning than afternoon[68,78] or if the patient's cardiovascular medications are withheld (which tends to unmask supine systolic hypertension, a known risk factor for postural hypotension).[58,73]

In acutely ill elderly patients, interobserver agreement for axillary sweating (dry vs moist) was moderate (κ, 0.50; 80% simple agreement).[33] In addition, the clinician's assessment of axillary moisture correlated well with the weight gain of a piece of preweighed tissue paper applied to the patient's axilla for 15 minutes.[33] Using stopwatches, the measurements of capillary refill time by 2 observers were within 0 to 0.3 seconds of each other.[75]

Table 4. Diagnostic Accuracy of Vital Signs for Acute Blood Loss*

Finding	Source, y	Moderate Blood Loss, Sensitivity (95% CI),%	Large Blood Loss, Sensitivity (95% CI),%	Before Blood Loss, Specificity (95% CI),%
Postural pulse increment ≥30/min or severe postural dizziness†	Knopp et al,[24] 1980	57	98	98
	Shenkin et al,[29] 1944	. . .	100	. . .
	Baraff and Schriger,[25] 1992	8	. . .	100
	Witting et al,[26] 1994	14	. . .	99
	Summary measure‡	22 (6-48)	97 (91-100)	98 (97-99)
Postural hypotension (>20 mm Hg decrease in SBP)†§ Age ≤65 y	Baraff and Schriger,[25] 1992	7	. . .	98
	Witting et al,[26] 1994	9	. . .	90
	Summary measure‡	9 (6-12)	. . .	94 (84-99)
Age ≥65 y	Witting et al,[26]‖ 1994	27 (14-40)	. . .	86 (76-97)
Supine tachycardia (pulse >100/min)	Ralston et al,[27] 1961	0	0	100
	Shenkin et al,[29] 1944	. . .	9	91
	Wallace and Sharpey-Schafer,[30] 1941	. . .	16	100
	Skillman et al,[31] 1967	. . .	0	100
	Summary measure‡	0 (0-42)	12 (5-24)	96 (88-99)
Supine hypotension (SBP <95 mm Hg)	Warren et al,[28] 1945	13	. . .	100
	Shenkin et al,[29] 1944	. . .	36	100
	Wallace and Sharpey-Schafer,[30] 1941	. . .	32	96
	Skillman et al,[31] 1967	. . .	56	100
	Bergenwald et al,[32] 1977	. . .	13	. . .
	Summary measure‡	13 (0-50)	33 (21-47)	97 (90-100)

*CI indicates confidence interval; SBP, systolic blood pressure. Ellipses indicate data not available from the study. Moderate blood loss was defined as 450 to 630 mL and large, 630 to 1150 mL.
†"Postural" indicates change from supine to standing position.
‡Summary measures calculated with random effects model.
§Excludes those patients unable to stand because of severe dizziness.
‖Since this is the only study for age 65 years and older, it is expressed as a summary measure.

Accuracy of Physical Signs for Acute Blood Loss

TABLE 4 reveals that the 2 most valuable observations from the tilt test are either a postural pulse increment of 30/min or more or the inability of the patient to stand for vital signs because of severe dizziness. After blood loss of 450 to 630 mL, only 1 in 5 patients demonstrate these findings. The sensitivity increases to 97% (95% CI, 91%-100%) after 630 mL to 1150 mL blood loss. The specificity is 98% (95% CI, 97%-99%), a value similar to that generated from the studies in Table 3. Either of these findings is durable after hemorrhage, lasting at least 12 to 72 hours if intravenous fluids are withheld.[11,30,39] If the patient sits instead of stands up from the supine position, the sensitivity decreases, being 39%[24] and 78%[30] in 2 studies after 1000 mL of hemorrhage. Because the studies of large blood loss (630-1150 mL) enrolled younger healthy individuals, the sensitivity may also be lower in elderly patients or those taking medications such as β-blockers. The patient complaint of postural dizziness, not severe enough to prevent standing and accompanied by a pulse increment lower than 30/min, has little predictive value.[26,56]

After excluding those unable to stand for vital signs, postural hypotension (a more than 20-mm Hg decrease in systolic BP) has little additional predictive value. Its sensitivity for 450 to 630 mL of blood loss is only 9% in those younger than 65 years and 27% in those older than 65 years. These numbers are similar to the false-positive rates in some studies of the same age groups, 10% (<65 years)[26] and 28% (>65 years),[71] resulting in positive LRs close to unity. There are insufficient data to address the value of isolated postural hypotension after 630 to 1150 mL of blood loss.

Supine tachycardia (pulse >100/min) is a specific but insensitive indicator of blood loss (96% specificity). Thus, patients without supine tachycardia can still have significant blood loss. In contrast, bradycardia occurs frequently after significant blood loss, often immediately preceding the decrease in systemic vascular resistance and the fainting that may occur.[11,27-32,39,79-81] One study[80] showed a strong correlation between the decrease in heart rate after blood loss and the maximal decrease in BP (r, 0.79), and, in hypotensive patients receiving fluid resuscitation, the pulse may paradoxically rise initially.[81]

In patients with suspected blood loss, supine hypotension (systolic BP <95 mm Hg) is a specific finding of hypovolemia (97% specificity), although it is insensitive to both moderate blood loss of 450 to 630 mL (13% sensitivity) and more significant loss of 630 to 1150 mL (33% sensitivity).

Using the age- and sex-specific upper limits of normal for capillary refill time defined earlier, a prolonged refill time does not accurately predict 450 mL of blood loss (6% sensitivity and 93% specificity) and yields a positive LR of 1.0.[36] If the clinician instead uses an arbitrary upper limit of 2 seconds, diagnostic performance is no better (11% sensitivity, 89% specificity, positive LR, 1.0).[36]

Accuracy of Physical Signs for Other Causes of Hypovolemia

TABLE 5 reviews the sensitivity and specificity of various physical signs for the diagnosis of hypovolemia derived from studies of individuals usually presenting to emergency departments with vomiting, decreased oral intake, or diarrhea. Except for 1 study,[35] which enrolled young women with hyperemesis gravidarum, these studies generally recruited older adults.

The finding of a dry axilla increases the probability of hypovolemia (positive LR, 2.8; 95% CI, 1.4-5.4), although it is an insensitive physical sign (50% sensitivity).[33] The finding of a moist axilla decreases the probability of volume depletion only slightly (negative LR, 0.6; 95% CI, 0.4-1.0).

In the study by Johnson et al[35] of 23 women with hyperemesis gravidarum, nei-

Table 5. Diagnostic Accuracy of Physical Signs for Hypovolemia Not Due to Blood Loss*

Physical Finding	Source, y	Grade of Study	Definition of Abnormal Finding	Sensitivity, %	Specificity, %	Positive LR (95% CI)	Negative LR (95% CI)
Postural vital signs	Johnson et al,[35] 1995	C	Pulse increment >30 beats/min	43	75	1.7 (0.7-4.0)	0.8 (0.5-1.3)
	Johnson et al,[35] 1995	C	Postural hypotension (systolic blood pressure decline >20 mm Hg)	29	81	1.5 (0.5-4.6)	0.9 (0.6-1.3)
Skin, eyes, and mucous membranes	Eaton et al,[33] 1994	A	Dry axilla	50	82	2.8 (1.4-5.4)	0.6 (0.4-1.0)
	Gross et al,[34] 1992	B	Mucous membranes of mouth and nose dry	85	58	2.0 (1.0-4.0)	0.3 (0.1-0.6)
	Gross et al,[34] 1992	B	Tongue dry	59	73	2.1 (0.8-5.8)	0.6 (0.3-1.0)
	Gross et al,[34] 1992	B	Longitudinal furrows on tongue	85	58	2.0 (1.0-4.0)	0.3 (0.1-0.6)
	Gross et al,[34] 1992	B	Sunken eyes	62	82	3.4 (1.0-12.2)	0.5 (0.3-0.7)
Neurological findings	Gross et al,[34] 1992	B	Confusion present	57	73	2.1 (0.8-5.7)	0.6 (0.4-1.0)
	Gross et al,[34] 1992	B	Upper or lower extremity weakness present	43	82	2.3 (0.6-8.6)	0.7 (0.5-1.0)
	Gross et al,[34] 1992	B	Speech not clear or expressive	56	82	3.1 (0.9-11.1)	0.5 (0.4-0.8)
Capillary refill time	Schriger and Baraff,[36] 1991	C	Capillary refill time greater than age- and sex-specific upper normal limit (see "Results")	34	95	6.9 (3.2-14.9)	0.7 (0.5-0.9)

*LR indicates likelihood ratio; CI, confidence interval. See Table 2 footnotes for grading determinations.

ther postural hypotension nor a postural pulse increment of more than 30/min was particularly helpful (Table 5). In this study, however, the specificity of a pulse increment of more than 30/min was unusually low (75%). One possible reason for this could be the authors' definition of dehydration (≥5% weight gain after 12 hours of rehydration), which led them to classify as nondiseased the dehydrated women with less than 5% weight gain, thus devaluing the specificity calculation. Alternatively, the postural pulse increment may be less specific because of pregnancy.

In another study of 202 individuals with acute illnesses, investigators used multiple analysis of variance to identify which clinical findings best explained the variation in total body water deficit, as calculated from the patient's serum osmolality.[59] The finding of a dry axilla was significantly associated with level of dehydration ($P = .03$). The postural pulse increment was also significantly associated but only weakly so (r, 0.22; $P = .02$).[59] The mean water deficit in this study was only 3.9%, correlating with a 140-mL deficit from the vascular space (or about 250 mL of blood), a level below that in the phlebotomy studies discussed earlier. This study found no association between dehydration and postural changes of systolic BP.

In Table 5, the capillary refill time seems to perform impressively, especially when the capillary refill time is prolonged (positive LR, 6.9).[36] However, the criterion standard in this study was the supine and postural vital signs, raising the question whether capillary refill time has any incremental diagnostic value. Another study found no correlation between capillary refill time, tested over the patella, and objective measures of hypovolemia.[34]

In a study of 55 elderly patients presenting with suspected hypovolemia, the 7 physical signs of confusion, extremity weakness, nonfluent speech, dry mucous membranes, dry tongue, furrowed tongue, and sunken eyes correlated best with measurement of the serum sodium and serum urea nitrogen–creatinine ratio (Table 5).[34] Based on the CIs of the LRs, however, none of these findings is particularly helpful when present in isolation. Combinations of findings may be more helpful—on average, patients with severe and moderate hypovolemia had 5.7 and 3.9, respectively, of these 7 signs, whereas those without dehydration had only 1.3—but this requires validation.[34] The most helpful negative findings, arguing against hypovolemia, are moist mucous membranes, absence of sunken eyes, and absence of furrows on the tongue.

Another study found no correlation between degree of hypovolemia and dryness of mucous membranes.[59] In adults, 2 studies have found poor skin turgor to have no diagnostic value.[34,59]

THE BOTTOM LINE

When obtaining postural vital signs, clinicians should wait at least 2 minutes before measuring the supine vital signs and 1 minute after standing before measuring the upright vital signs. Counting the pulse for 30 seconds and doubling the result is more accurate than 15 seconds of observation.[44] In normovolemic individuals, a postural pulse increment of more than 30 beats/min is uncommon, affecting only about 2% to 4% of individuals.

When evaluating patients with suspected blood loss, the most helpful physical findings are severe postural dizziness (preventing measurement of upright vital signs) or a postural pulse increment of 30 beats/min or more. Having the patient sit instead of stand reduces the sensitivity of the tilt test. After excluding those unable to stand, postural hypotension has no incremental diagnostic value.

Supine hypotension and tachycardia are frequently absent, even with more than 1000 mL of blood loss, and the symptom of mild postural dizziness has no proven diagnostic value. Bradycardia is common after significant blood loss.

Rigorous conclusions about the role of physical examination in assessing the volume and hydration status of patients with vomiting, diarrhea, or decreased oral intake are difficult to make because there are few studies. Severe postural dizziness or a postural pulse increment of 30 beats/min or more should be just as accurate as after blood loss, although 1 study of the pulse increment in patients with hyperemesis gravidarum failed to confirm this. A dry axilla supports the diagnosis of hypovolemia in the elderly, and moist mucous membranes and a tongue without furrows argue against it. However, clinicians should recall that the criterion standard of hypovolemia in these studies—simple serum chemistry measurements—is easily accessible to clinicians. When applying these findings to practice, until further data are available, clinicians should have a low threshold for ordering tests of serum electrolytes, serum blood urea nitrogen, and creatinine. In adults, the capillary refill time and poor skin turgor have no proven diagnostic value.

Case 1 demonstrates a postural pulse increment of more than 30 beats/min, suggesting significant blood loss. The clinician should admit this patient to the hospital for fluid resuscitation and further testing. In case 2, postural hypotension and mild postural dizziness lack the specificity necessary to condemn the diuretic at this time. The clinician should continue the diuretic if he believes the patient's dizziness resembles inner-ear vertigo. Finally, despite the negative physical examination findings in case 3, this patient has many risk factors for significant hypovolemia, and the clinician should measure the serum blood urea nitrogen, creatinine, and electrolytes before making the decision to discharge the patient.

Acknowledgment: We thank Kenneth Goldberg, MD, and Bill Yarger, MD, for their comments.

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