Electrolyte and Acid-Base Disorders

Composition of Body Fluids:

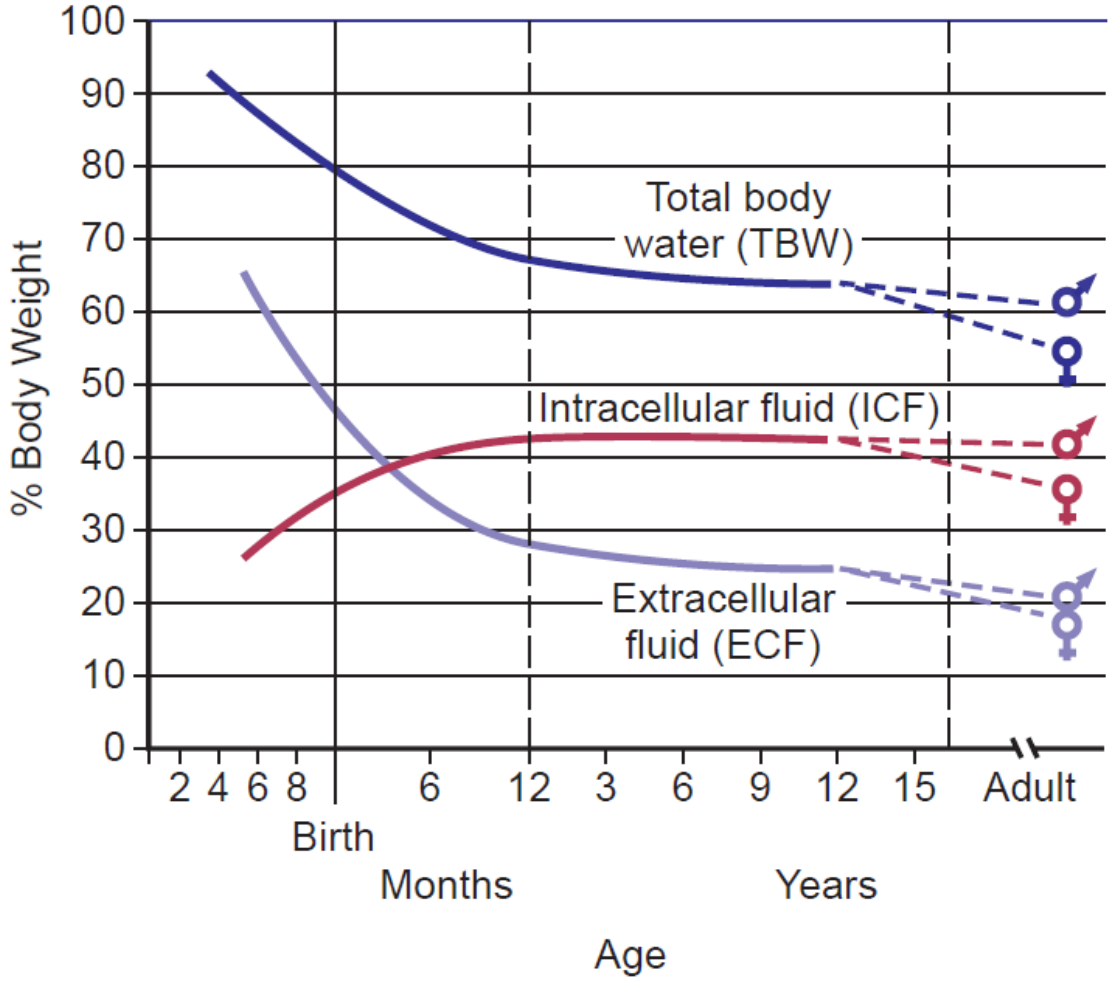


Fig. 68.1 Total body water, intracellular fluid, and extracellular fluid as a percentage of body weight as a function of age. *(From Winters*

Composition of Body Fluids:

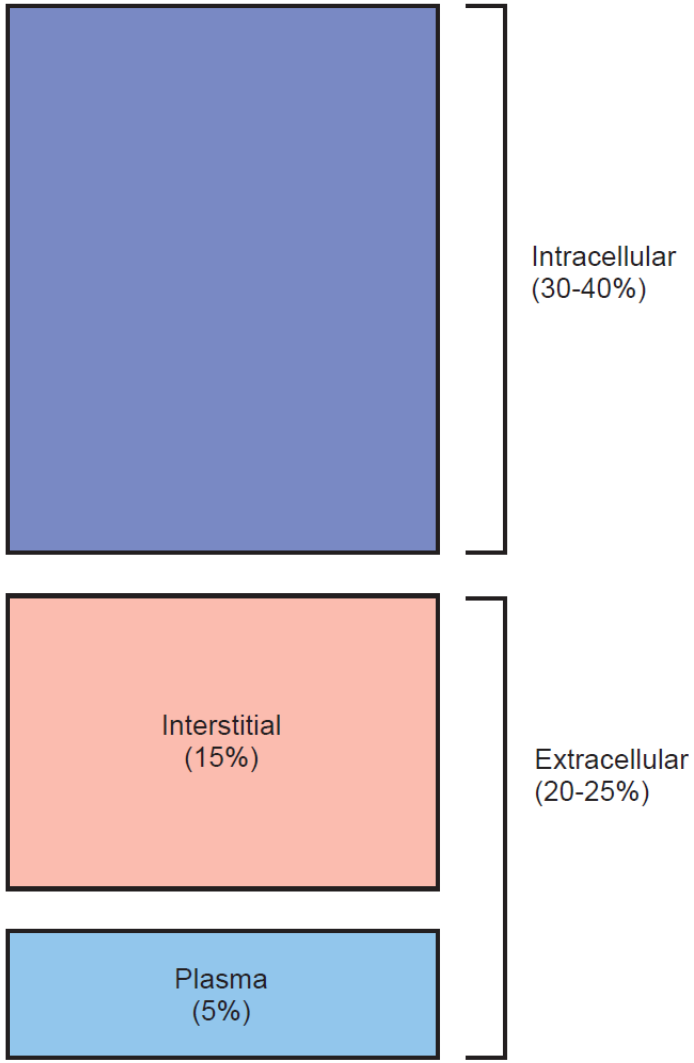


Fig. 68.2 Compartments of total body water, expressed as percentages of body weight, in an older child or adult.

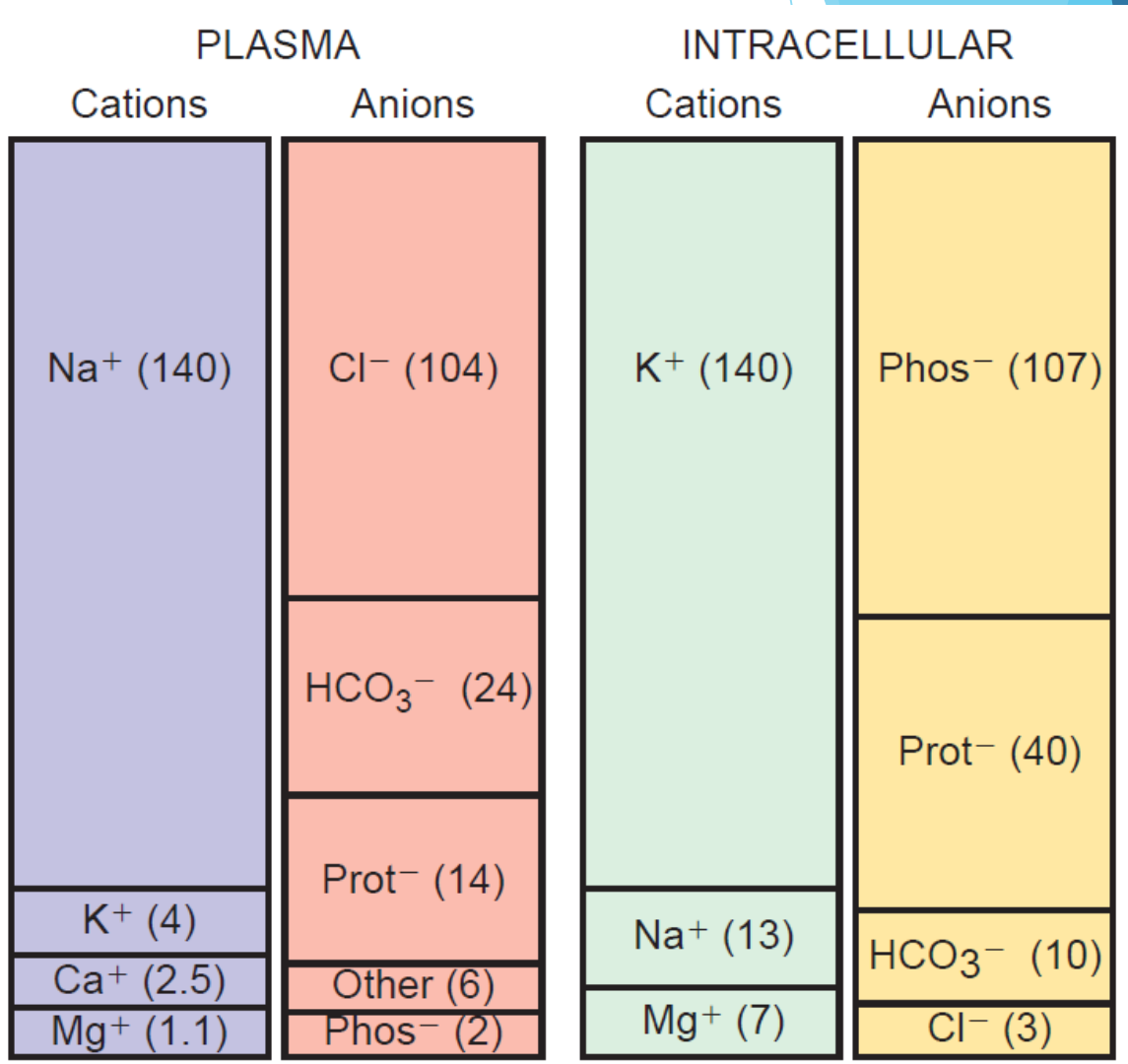


Fig. 68.3 Concentrations of the major cations and anions in the intracellular space and the plasma, expressed in mEq/L.

$$\text{Osmolality} = 2 \times [\text{Na}] + [\text{glucose}]/18 + [\text{BUN}]/2.8$$

$$\text{Effective osmolality} = 2 \times [\text{Na}] + [\text{glucose}]/18$$

$$[\text{Na}]_{\text{corrected}} = [\text{Na}]_{\text{measured}} + 1.6 \times ([\text{glucose}] - 100\ \text{mg/dL})/100$$

Blood anion gap = [Na^+] − [Cl^- + HCO_3^-].

Values of < 12 ⟶ absence of an anion gap.
Values of > 20 ⟶ presence of an anion gap.

Urine anion gap = ([urine Na^+ + urine K^+] − urine Cl^-)

HYPOKALEMIA:

Table 68.5 Causes of Hypokalemia

SPURIOUS LABORATORY VALUE
High white blood cell count

TRANSCELLULAR SHIFTS
Alkalemia
Insulin
α-Adrenergic agonists
Drugs/toxins (theophylline, barium, toluene, cesium chloride, hydroxychloroquine)
Hypokalemic periodic paralysis (OMIM 170400)
Thyrotoxic period paralysis
Refeeding syndrome

DECREASED INTAKE
Anorexia nervosa

EXTRARENAL LOSSES
Diarrhea
Laxative abuse
Sweating
Sodium polystyrene sulfonate (Kayexalate) or clay ingestion

RENAL LOSSES
With Metabolic Acidosis
Distal renal tubular acidosis (OMIM 179800/602722/267300)
Proximal renal tubular acidosis (OMIM 604278)*
Ureterosigmoidostomy
Diabetic ketoacidosis

Without Specific Acid–Base Disturbance
Tubular toxins: amphotericin, cisplatin, aminoglycosides
Interstitial nephritis
Diuretic phase of acute tubular necrosis
Postobstructive diuresis
Hypomagnesemia
High urine anions (e.g., penicillin or penicillin derivatives)

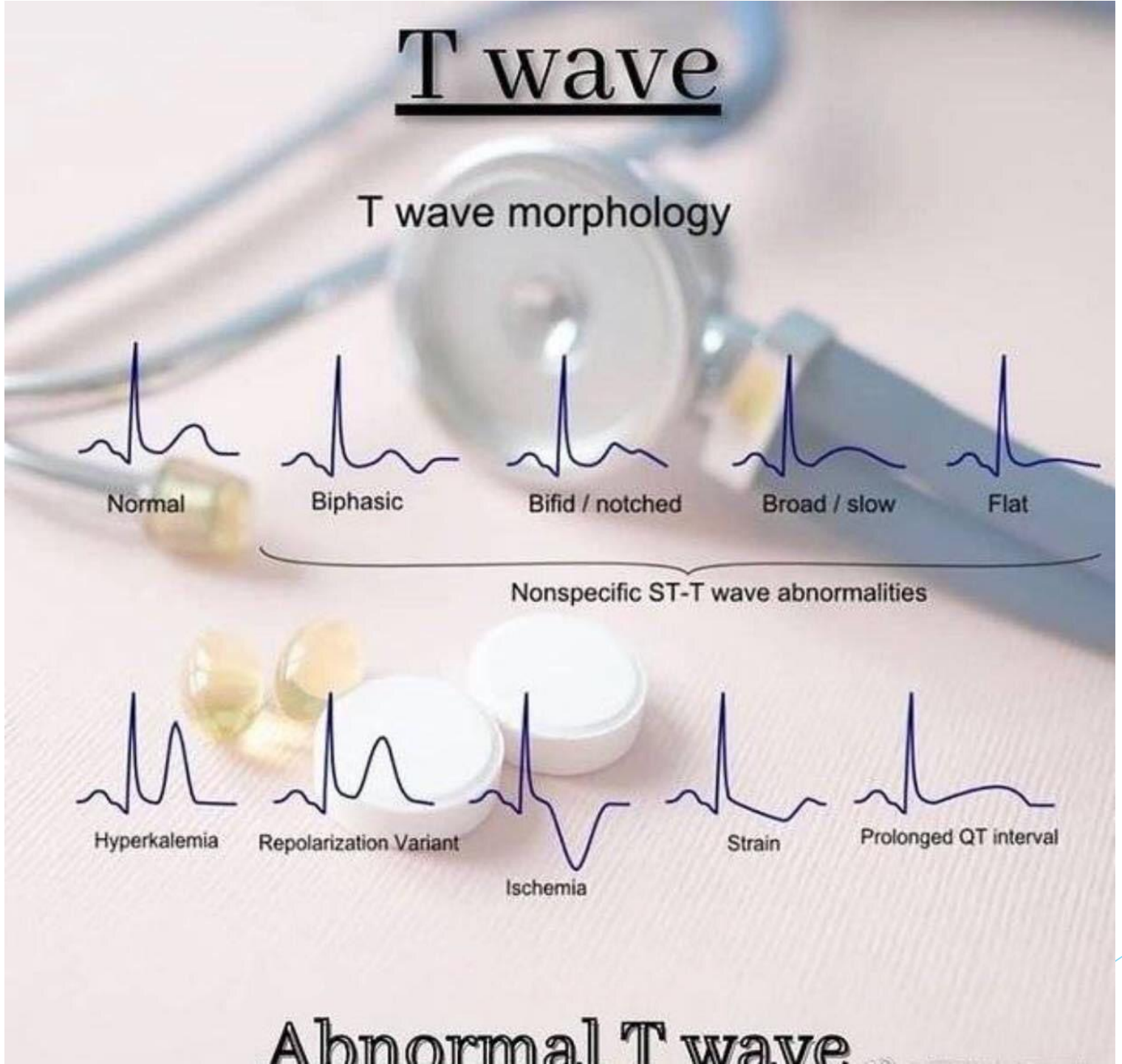
With Metabolic Alkalosis
Low urine chloride
- Emesis or nasogastric suction
- Chloride-losing diarrhea (OMIM 214700)
- Cystic fibrosis (OMIM 219700)
- Low-chloride formula
- Posthypercapnia
- Previous loop or thiazide diuretic use

High urine chloride and normal blood pressure
- Gitelman syndrome (OMIM 263800)
- Bartter syndrome (OMIM 241200/607364/602522/601678/300971/601198/613090)
- Autosomal dominant hypoparathyroidism (OMIM 146200)
- EAST syndrome (OMIM 612780)
- Loop and thiazide diuretics (current)

High urine chloride and high blood pressure
- Adrenal adenoma or hyperplasia
- Glucocorticoid-remediable aldosteronism (OMIM 103900)
- Renovascular disease
- Renin-secreting tumor
- 17β-Hydroxylase deficiency (OMIM 202110)
- 11β-Hydroxylase deficiency (OMIM 202010)
- Cushing syndrome
- 11β-Hydroxysteroid dehydrogenase deficiency (OMIM 218030)
- Licorice ingestion
- Liddle syndrome (OMIM 177200)

*Most cases of proximal renal tubular acidosis are not caused by this primary genetic disorder. Proximal renal tubular acidosis is usually part of Fanconi syndrome, which has multiple etiologies.

EAST, Epilepsy, ataxia, sensorineural hearing loss, and tubulopathy; OMIM, database number from the Online Mendelian Inheritance in Man (http://www.ncbi.nlm


T wave
T wave morphology
Normal
Biphasic
Bifid / notched
Broad / slow
Flat
Nonspecific ST-T wave abnormalities
Hyperkalemia
Repolarization Variant
Ischemia
Strain
Prolonged QT interval
Abnormal T wave

Urinary K^+ losses can be assessed with a 24 hr urine collection, spot K^+:creatinine ratio, fractional excretion of K+, or calculation of the *transtubular K+ gradient*(TTKG), which is the most widely used approach in children:

$$\mathbf{TTKG = [K]_{urine} / [K]_{plasma} \times (plasma\ osmolality / urine\ osmolality)}$$

where $[K]_{urine}$ = urine potassium concentration and $[K]_{plasma}$ = plasma potassium concentration.

The urine osmolality must be greater than the serum osmolality for the result of this calculation to be valid.

A TTKG >4 in the presence of hypokalemia suggests excessive urinary losses of K+.

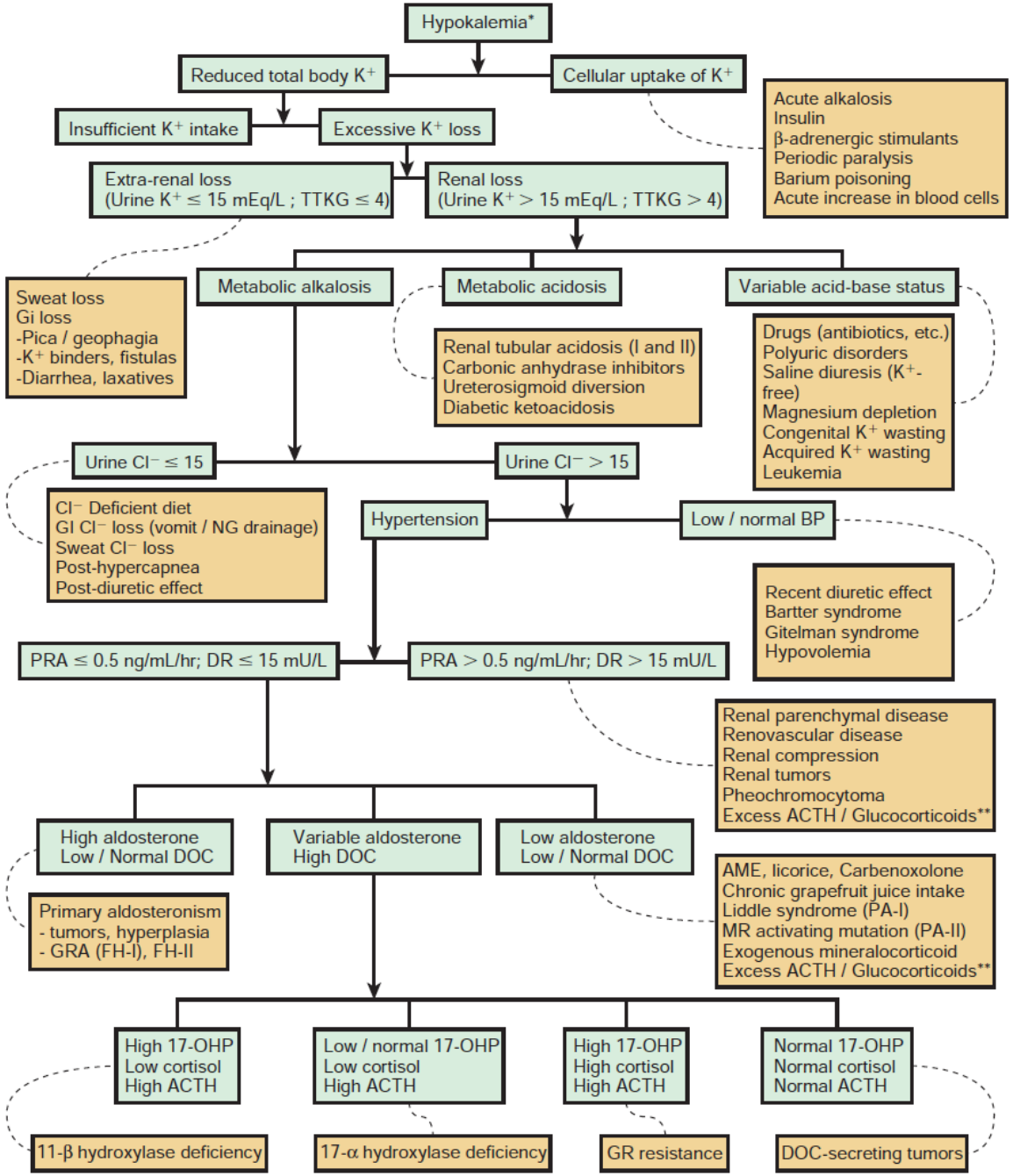


Fig. 68.4 **Diagnostic algorithm to evaluate persistent hypokalemia.** *Spurious hypokalemia must be excluded. **Hypokalemia is uncommon in uncomplicated edematous disorders and in conditions associated with excessive glucocorticosteroids. Conditions associated with high circulating levels of glucocorticosteroids often have normal renin activity. 17-OHP, 17-Hydroxyprogesterone; ACTH, adrenocorticotropic hormone; AME,