Electrolyte abnormalities

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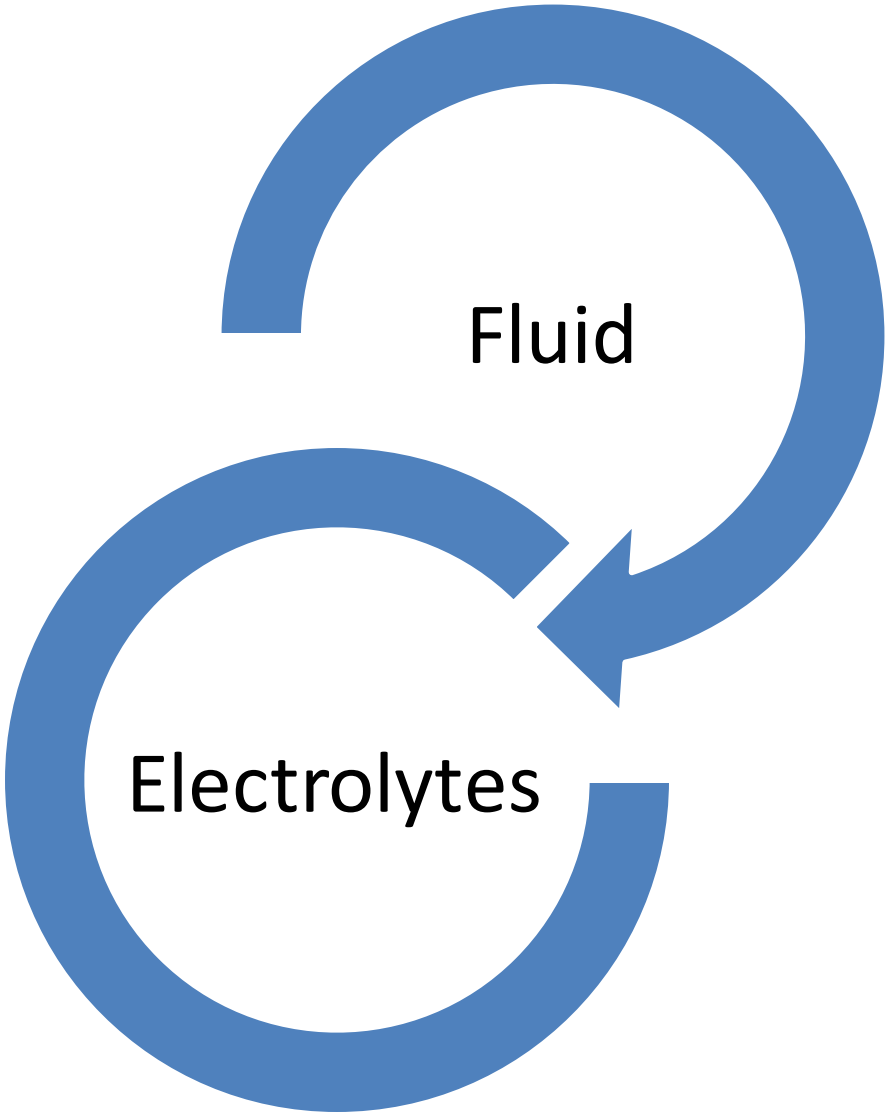
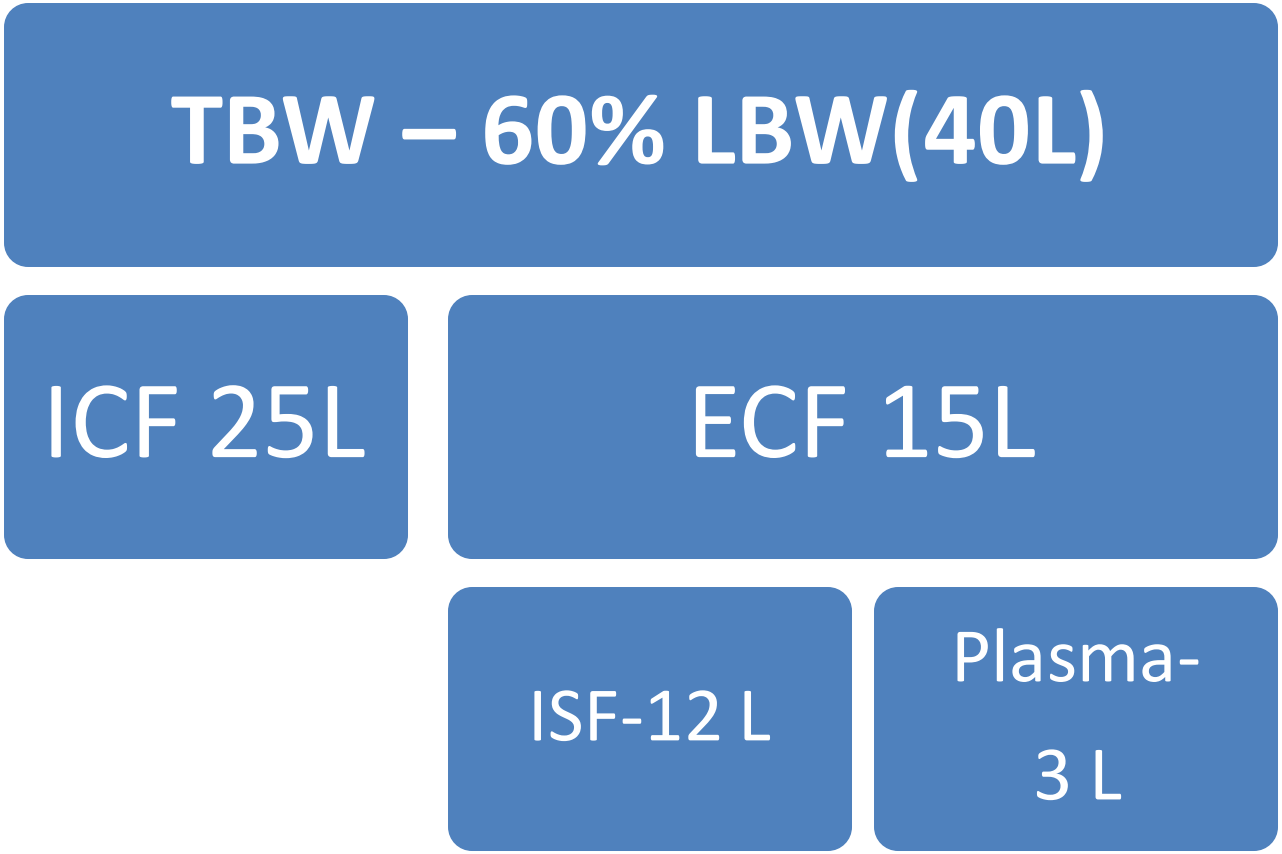

Fluid
Electrolytes


TBW – 60% LBW(40L)
ICF 25L
ECF 15L
ISF-12 L
Plasma-
3 L

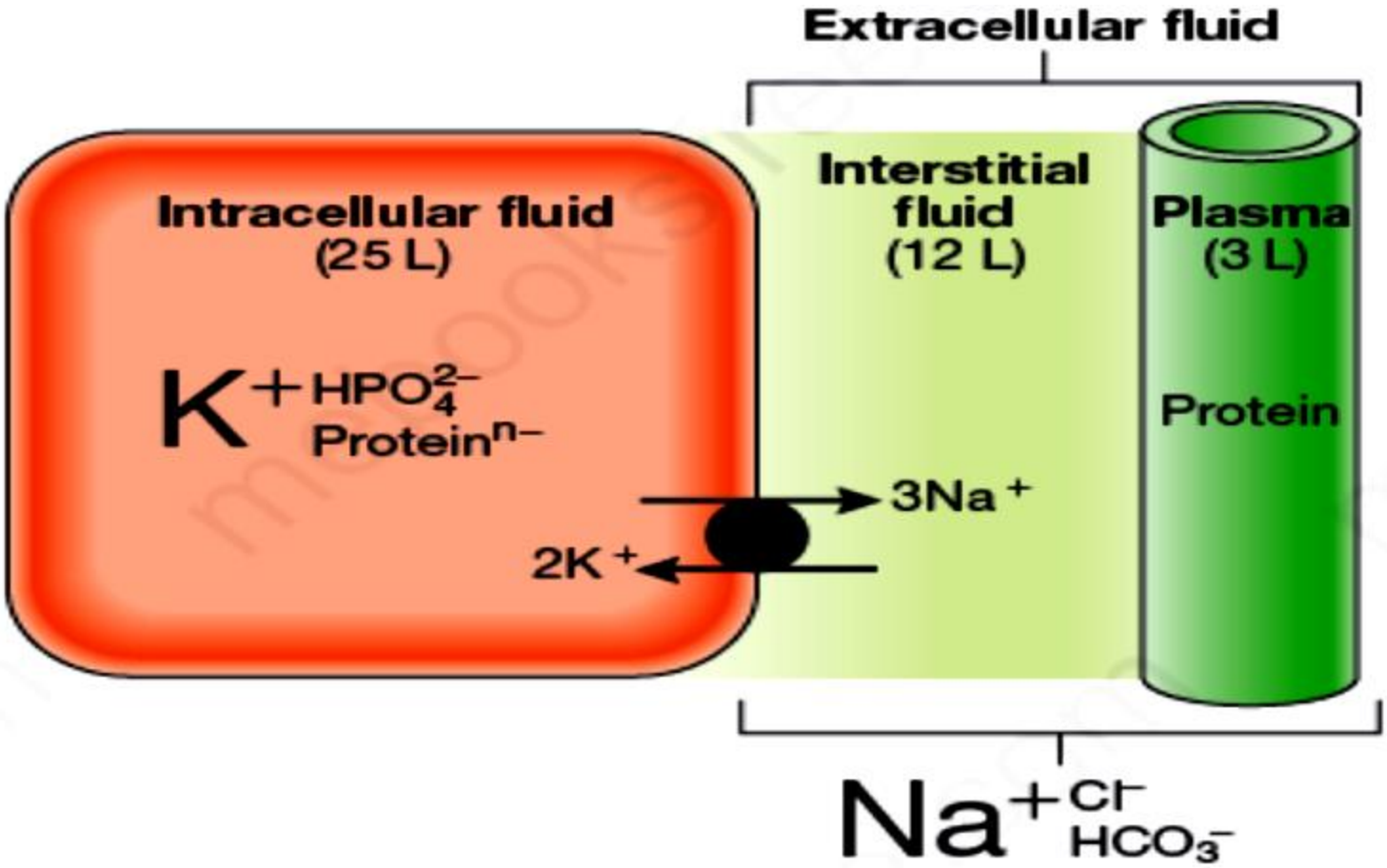


Fig. 14.1 Normal distribution of body water and electrolytes. Schematic representation of volume (L = litres) and composition (dominant ionic species only shown) of the intracellular fluid (ICF) and extracellular fluid (ECF) in a 70 kg male. The main difference in composition between the plasma and interstitial fluid (ISF) is the presence of appreciable concentrations of protein in the plasma but not the ISF. The Na/K differential is maintained by the Na,K-adenosine triphosphatase (ATPase) pump.

Hypo/Hyper voluaemia

14.4 Causes of hypovolaemia

Mechanism	Examples
Inadequate sodium intake	Environmental deprivation, inadequate therapeutic replacement
Gastrointestinal sodium loss	Vomiting, diarrhoea, nasogastric suction, external fistula
Skin sodium loss	Excessive sweating, burns
Renal sodium loss	Diuretic therapy, mineralocorticoid deficiency, tubulointerstitial disease
Internal sequestration*	Bowel obstruction, peritonitis, pancreatitis, crush injury
Reduced blood volume	Acute blood loss

*A cause of circulatory volume depletion, although total body sodium and water may be normal or increased.

14.8 Causes of sodium and water excess

Mechanism	Examples
Impaired renal function	Primary renal disease
Primary hyperaldosteronism*	Conn's syndrome
Secondary hyperaldosteronism (see Fig. 14.5)	Congestive cardiac failure Cirrhotic liver disease Nephrotic syndrome Protein-losing enteropathy Malnutrition Idiopathic/cyclical oedema Renal artery stenosis*

*Conditions in this box *other than* primary hyperaldosteronism and renal artery stenosis are typically associated with generalised oedema.

14.3 Clinical features of hypovolaemia and hypervolaemia

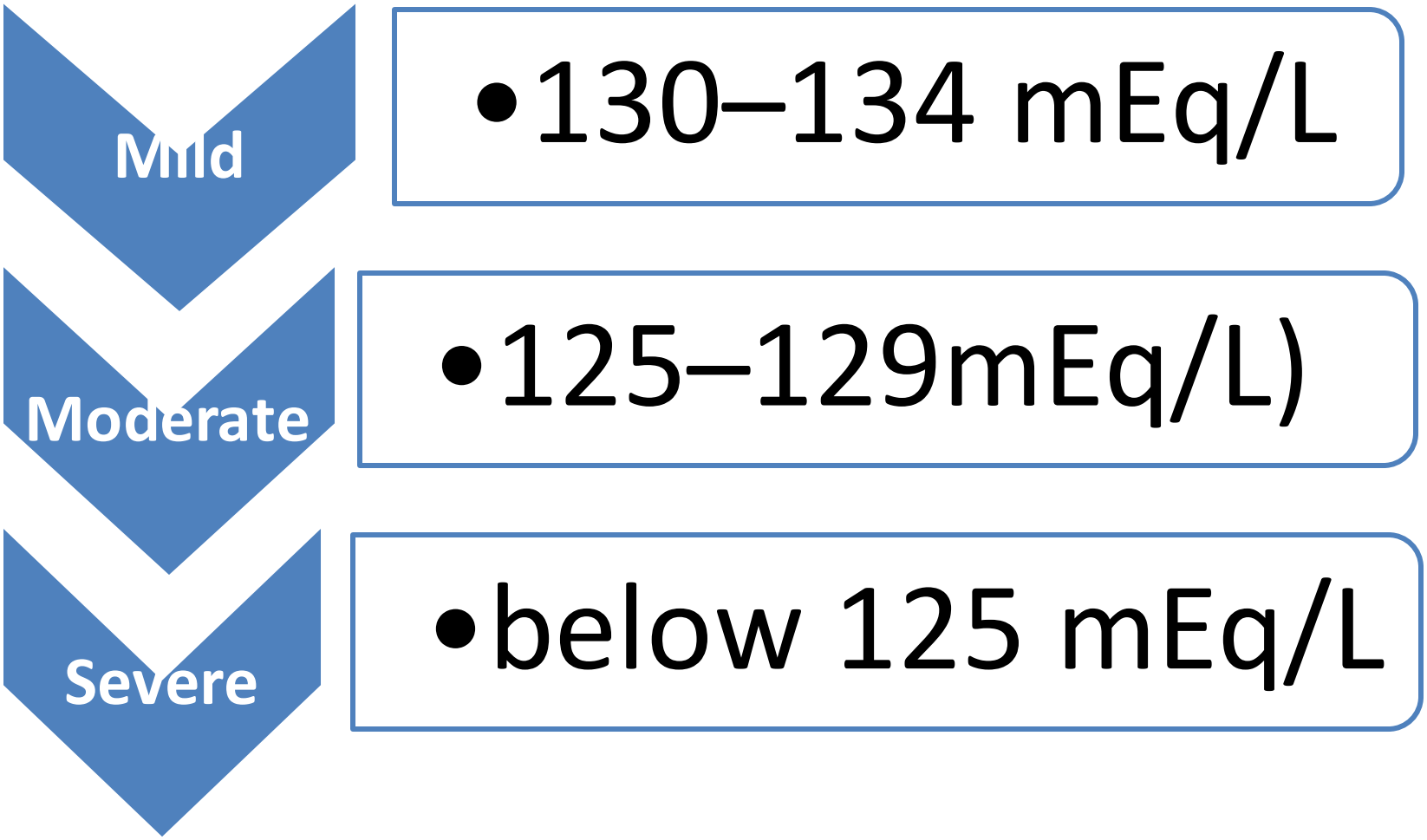
	Hypovolaemia	Hypervolaemia
Symptoms	Thirst Dizziness on standing Weakness	Ankle swelling Abdominal swelling Breathlessness
Signs	Postural hypotension Tachycardia Dry mouth Reduced skin turgor Reduced urine output Weight loss Delirium, stupor	Peripheral oedema Raised JVP Pulmonary crepitations Pleural effusion Ascites Weight gain Hypertension (sometimes)

(JVP = jugular venous pressure)

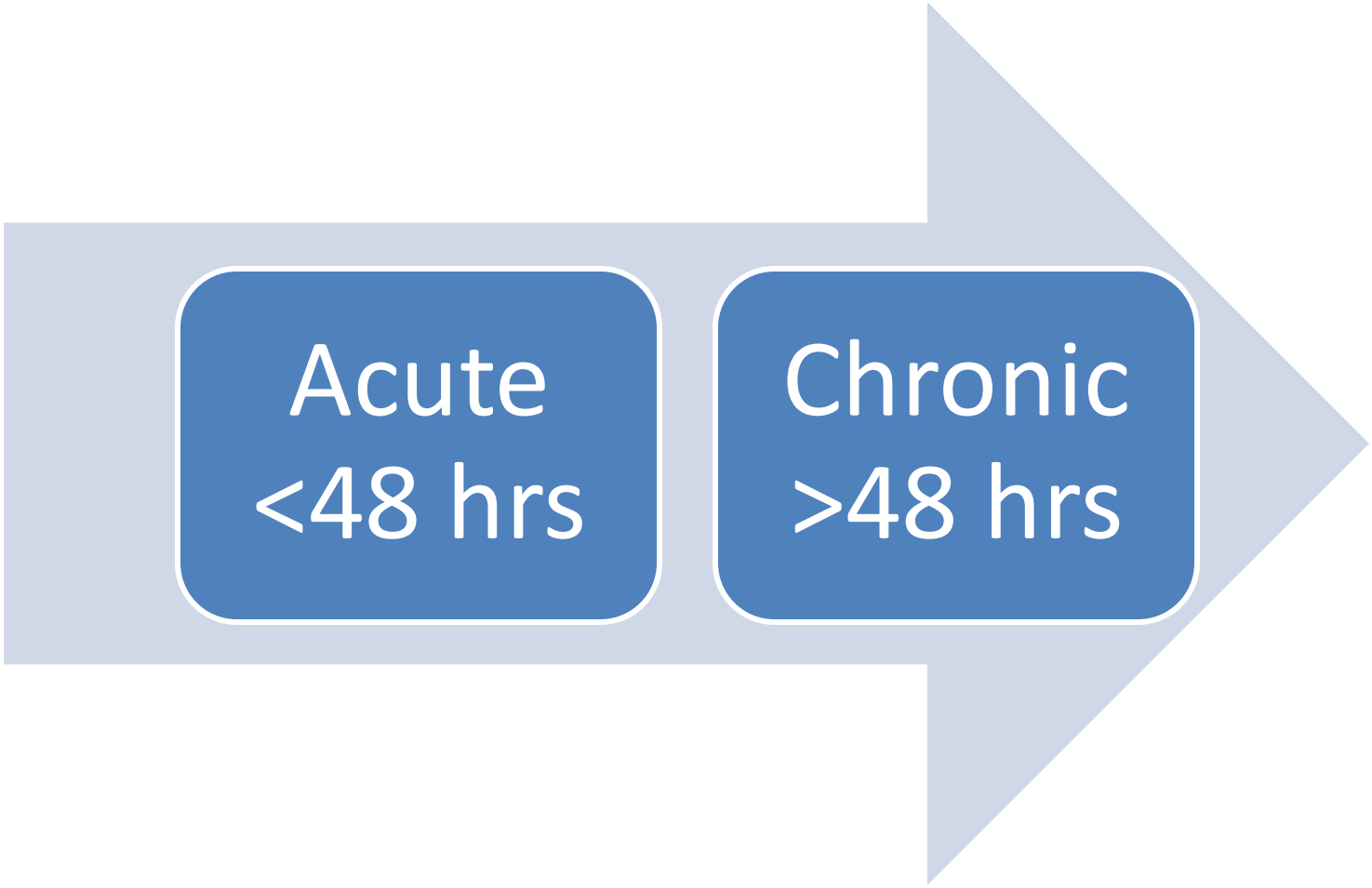
DISORDERS OF SODIUM CONCENTRATION

Normal	• 135-145meq/L
Hypo	• <135meq/L
Hyper	• >145meq/L

On Biochemical Level



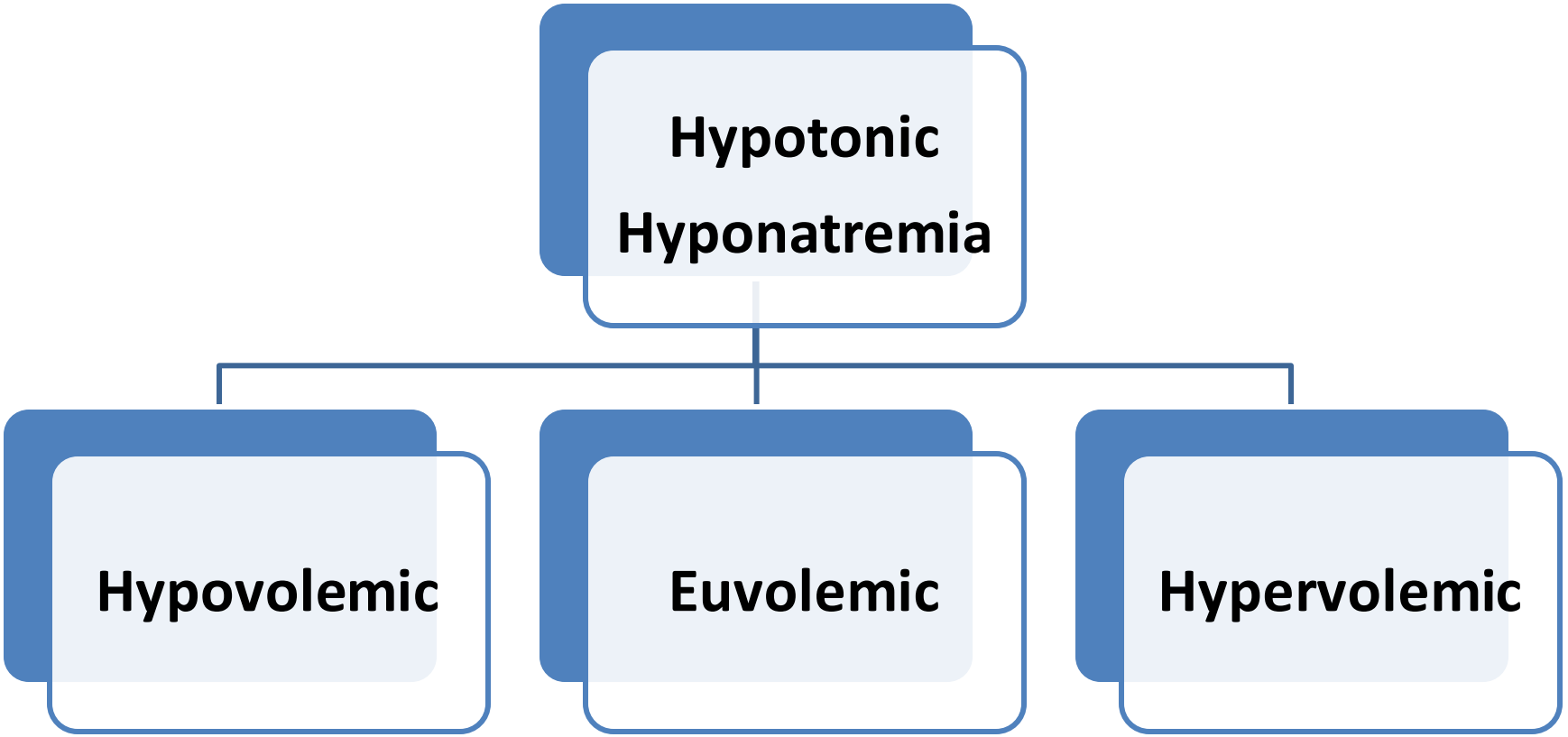
On chronicity



On serum Osmolality

Isotonic Hyponatremia	Hypertonic Hyponatremia	Hypotonic Hyponatremia

Hypotonic Hyponatremia



Causes of Hyponatremia

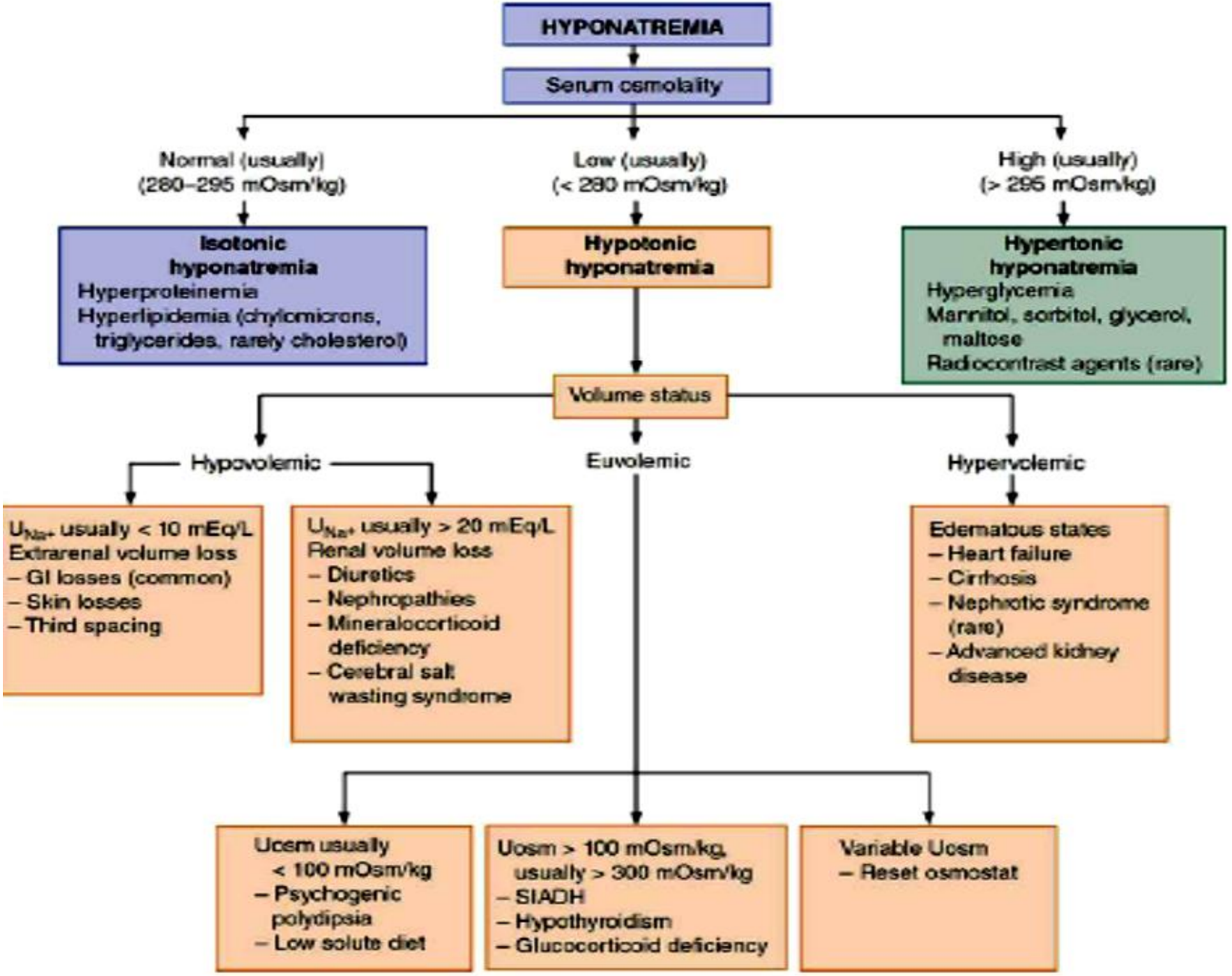
14.10 Causes of hyponatraemia

Volume status	Examples
Hypovolaemic	Renal sodium losses: Diuretic therapy (especially thiazides) Adrenocortical failure Gastrointestinal sodium losses: Vomiting Diarrhoea Skin sodium losses: Burns
Euvolaemic	Primary polydipsia Excessive electrolyte-free water infusion SIADH Hypothyroidism
Hypervolaemic	Congestive cardiac failure Cirrhosis Nephrotic syndrome Chronic kidney disease (during free water intake)

(SIADH = syndrome of inappropriate antidiuretic hormone (vasopressin) secretion; see Box 14.11).

14.12 Symptoms and severity of hyponatraemia

Severity	Serum sodium	Symptoms
Mild	130–135 mmol/L	None
Moderate	125–129 mmol/L	Nausea Delirium Headache
Severe	< 124 mmol/L	Vomiting Somnolence Seizures Coma Cardiorespiratory arrest


HYPONATREMIA
Serum osmolality
Normal (usually)
(280–295 mOsm/kg)
Low (usually)
(< 280 mOsm/kg)
High (usually)
(> 295 mOsm/kg)
Isotonic hyponatremia
Hyperproteinemia
Hyperlipidemia (chylomicrons, triglycerides, rarely cholesterol)
Hypotonic hyponatremia
Hypertonic hyponatremia
Hyperglycemia
Mannitol, sorbitol, glycerol, maltose
Radiocontrast agents (rare)
Volume status
Hypovolemic
Euvolemic
Hypervolemic
U_{Na+} usually < 10 mEq/L
Extrarenal volume loss
– GI losses (common)
– Skin losses
– Third spacing
U_{Na+} usually > 20 mEq/L
Renal volume loss
– Diuretics
– Nephropathies
– Mineralocorticoid deficiency
– Cerebral salt wasting syndrome
Edematous states
– Heart failure
– Cirrhosis
– Nephrotic syndrome (rare)
– Advanced kidney disease
Uosm usually < 100 mOsm/kg
– Psychogenic polydipsia
– Low solute diet
Uosm > 100 mOsm/kg, usually > 300 mOsm/kg
– SIADH
– Hypothyroidism
– Glucocorticoid deficiency
Variable Uosm
– Reset osmostat

Management

PRETREATMENT EVALUATION

- Determine the duration of hyponatremia
- Determine the severity (degree) of hyponatremia
- Determine the severity of symptoms
- Determine the need for hospitalization

Determine the duration of hyponatremia

Therapy for hyponatremia depends in part upon the acuity:

> Acute – If the hyponatremia has developed over a period of less than 48 hours.

> Chronic – If it is known that hyponatremia has been present for more than 48 hours, or if the duration is unclear.

Determine the severity (degree) of hyponatremia

- Severe hyponatremia – A serum sodium concentration of <125 mEq/L
- Moderate hyponatremia – A serum sodium concentration of 125 to 129 mEq/L
- Mild hyponatremia – A serum sodium concentration of 130 to 134 mEq/L

Determine the severity of symptoms

- Severe symptoms
- Mild to moderate symptoms
- Asymptomatic

Determine the need for hospitalization

- Those with acute hyponatremia
- Most patients with severe hyponatremia (ie, serum sodium less than 125 mEq/L)
- Most patients with symptomatic hyponatremia

GOALS OF THERAPY

- Prevent a further decline in serum sodium
- Prevent brain herniation
- Relieve symptoms of hyponatremia
- Avoid overcorrection

Goal rate of correction

If hyponatraemia

- has developed rapidly (< 48 hours) and
- there are signs of cerebral oedema, such as obtundation or convulsions,
- sodium levels should be restored rapidly to normal by infusion of hypertonic (3%) sodium chloride.
- A common approach is to give an initial bolus of 150 mL over 20 minutes, which may be repeated once or twice over the initial hours of observation, depending on the neurological response and rise in plasma sodium.

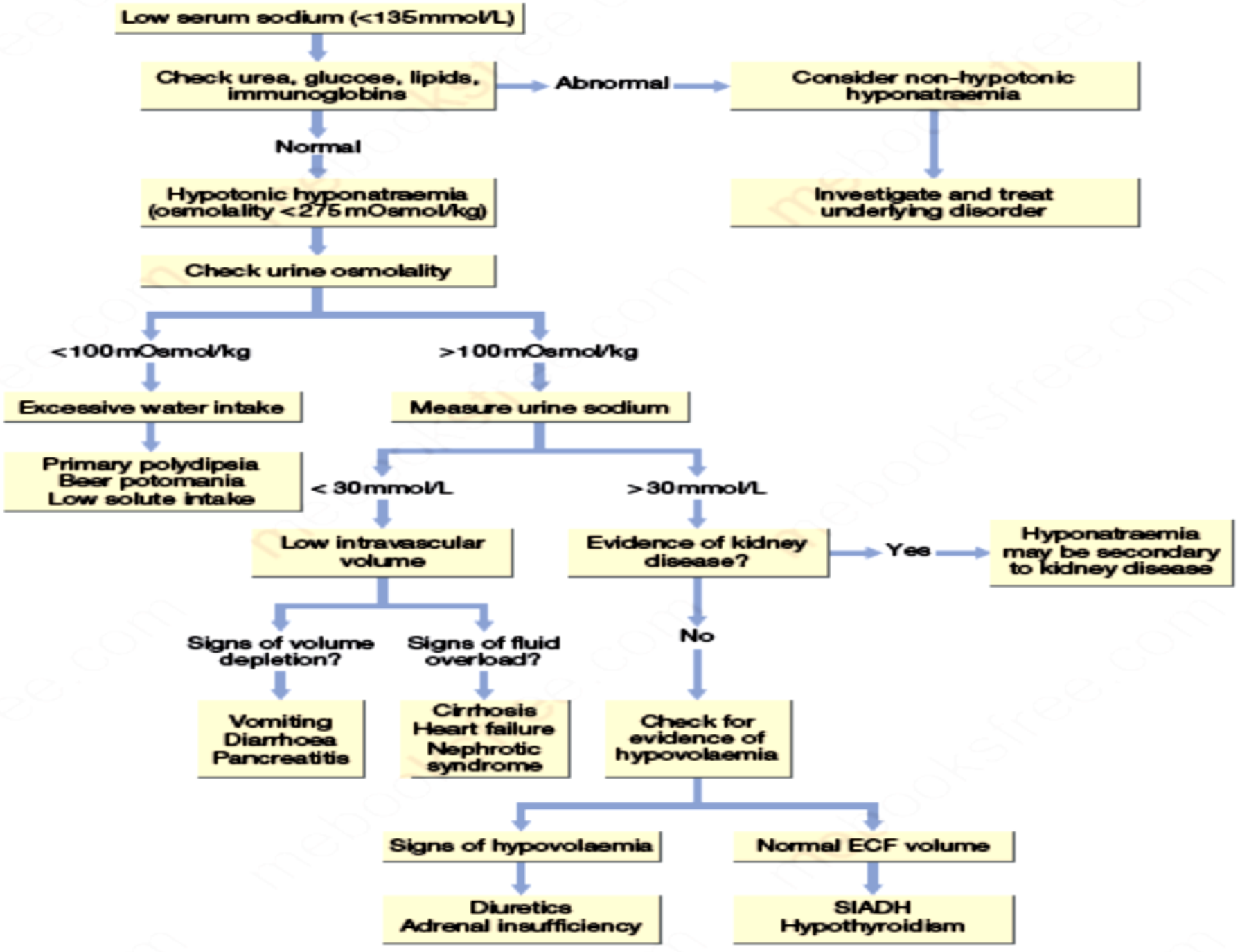
Formulas that may help: How much sodium does the patient need?

- Sodium deficit = Total body water x (desired Na – actual Na)

- Total body water is estimated as lean body weight x 0.5 for women or 0.6 for men

Example

- 60 kg woman with sodium level of 116
- How much sodium will bring him up to 124 in the next 24 hours?
- Sodium needed = 0.5 x 60 x (124-116) = 240
- Hypertonic saline contains 500 mEq/L of sodium
- Normal saline contains 154 mEq/L of sodium



Algorithm for the diagnosis of hyponatraemia. (ECF = extracellular fluid; SIADH = syndrome of inappropriate antidiuretic hormone

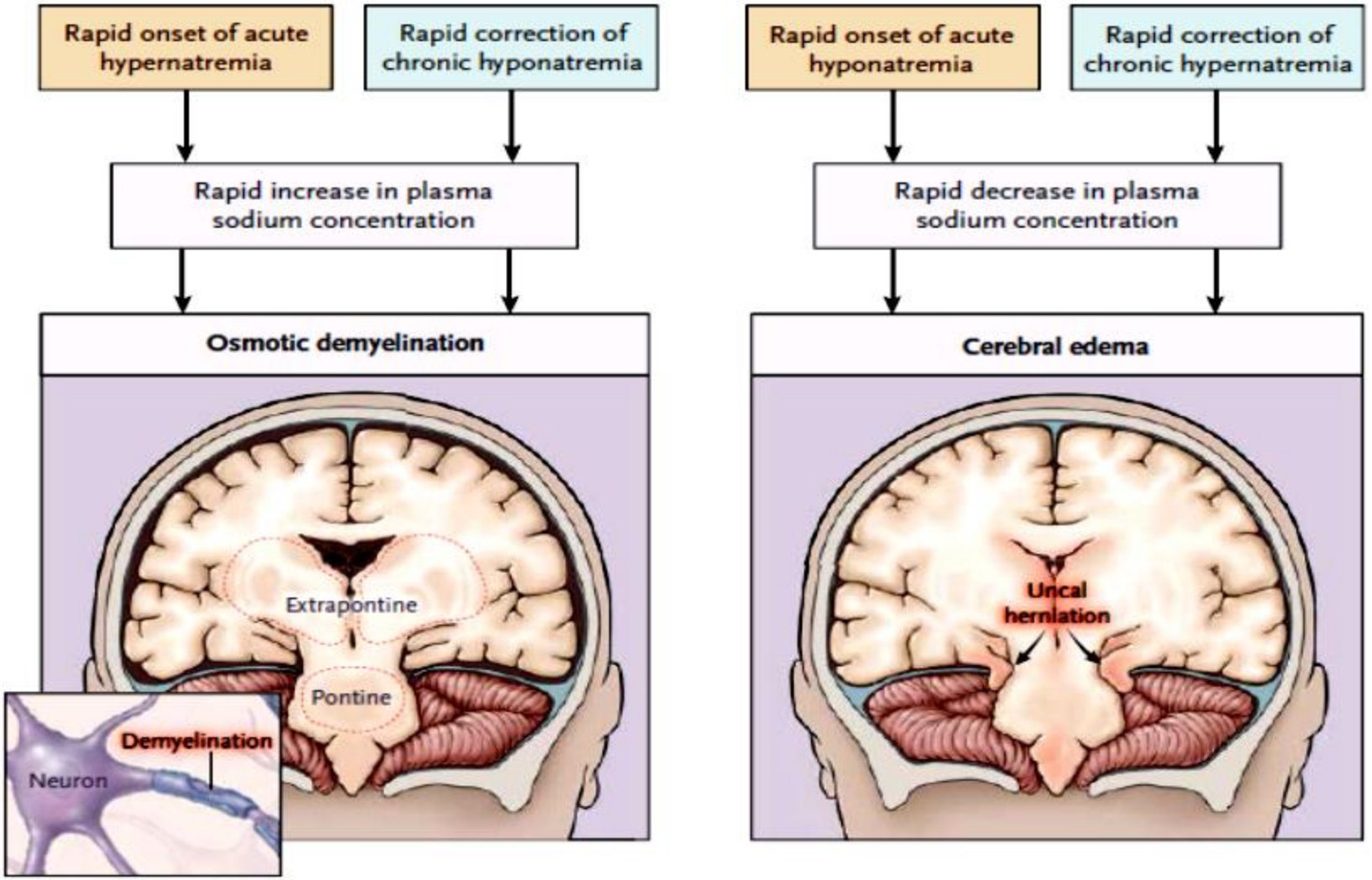


Figure 3. Consequences of Rapid Changes in the Plasma Sodium Concentration.

Both a rapid onset and a rapid correction of hyponatremia and hypernatremia can cause brain damage. A rapid increase in the level of plasma sodium, either from acute hypernatremia or from rapid correction of chronic hyponatremia, can cause osmotic demyelination. Cerebral edema is a complication of acute hyponatremia and of rapid correction of chronic hypernatremia in children.

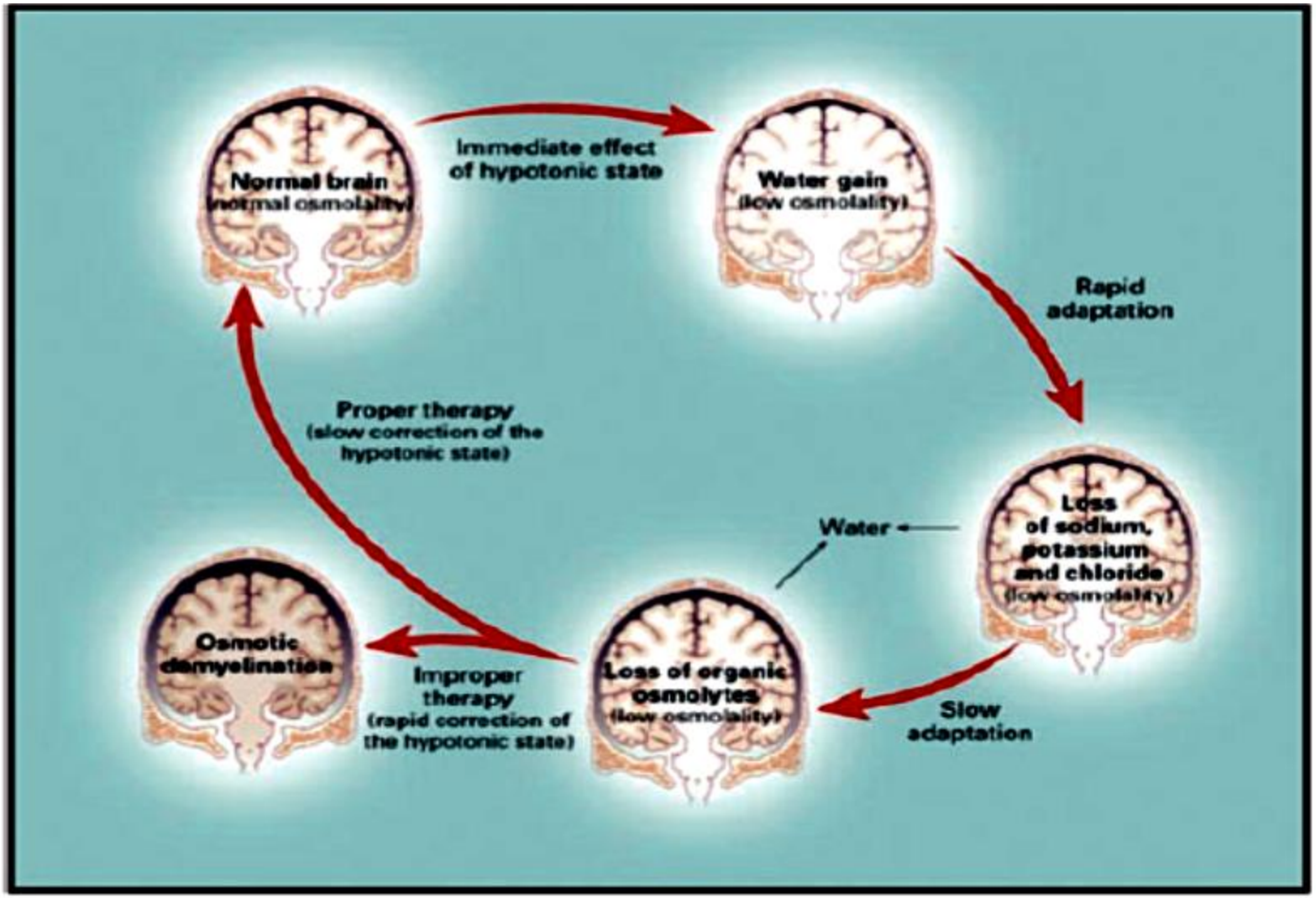


FIGURE 2: Adaptation of the brain to hypotonicity. Reproduced with permission from Massachusetts Medical Society, Copyright © 2000 Adrogue HJ & Madias NE. Hyponatremia. *New England Journal of Medicine* 2000 342 1581–1589.

Summary of Hyponatremia

- Hyponatremia has variety of causes
- Treatment is based on symptoms
  - Severe symptoms = Hypertonic Saline
  - Mild or no symptoms = Fluid restriction
- Overcorrection, more than 12 mEq increase in 24 hours must be avoided with monitoring
- Serum Osmolality, Urine Osmolality and Urine sodium concentration are initial tests to order

Hypernatremia

14.13 Causes of hypernatraemia

Volume status	Examples
Hypovolaemic	Renal sodium losses: Diuretic therapy (especially osmotic diuretic, or loop diuretic during water restriction) Glycosuria (hyperglycaemic hyperosmolar state, p. 738) Gastrointestinal sodium losses: Colonic diarrhoea Skin sodium losses: Excessive sweating
Euvolaemic	Diabetes insipidus (central or nephrogenic) (p. 687)
Hypervolaemic	Enteral or parenteral feeding Intravenous or oral salt administration Chronic kidney disease (during water restriction)

Symptoms of Hypernatremia

- Initial symptoms include lethargy, weakness and irritability
- Can progress to twitching, seizures, obtundation or coma
- Resulting decrease in brain volume can lead to rupture of cerebral veins leading to hemorrhage
- Severe symptoms usually occur with rapid increase to sodium concentration of 158 mEq or more
- Sodium concentration greater than 180 mEq are associated with high mortality

- Treatment of hypernatraemia depends on both the rate of development and the underlying cause.

Treatment of Hypernatremia

- First, calculate water deficit
- Water deficit = CBW x ((plasma Na/desired Na level)-1)
- CBW = current body water assumed to be 50% of body weight in men and 40% in women
- So let's do a sample calculation:
- 60 kg woman with 168 mEq/L
- How much water will it take to reduce her sodium to 140 mEq/L

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- 60 kg woman with 168 mEq/L
- How much water will it take to reduce her sodium to 140 mEq/L

Summary of Hypernatremia

- Loss of thirst usually has to occur to produce hypernatremia
- Rate of correction same as hyponatremia
- D5 water infusion is typically used to lower sodium level
- Same diagnostic labs used: Serum osmolality, Urine osmolality and Urine sodium
- Beware of overcorrection as cerebral edema may develop