

# *Fluid and Electrolyte Emergencies and Common Disorders*

## Basic considerations:

- Physiology
- Normal values

## Emergencies and common disorders:

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| <ul style="list-style-type: none"> <li>• Acute water depletion</li> <li>• Acute water intoxication</li> <li>• Acute dehydration</li> <li>• Acute overhydration</li> <li>• Acute respiratory acidosis</li> <li>• Acute respiratory alkalosis</li> </ul> | <ul style="list-style-type: none"> <li>• Acute metabolic acidosis</li> <li>• Acute metabolic alkalosis</li> <li>• Hyponatremia</li> <li>• Hypernatremia</li> <li>• Hypokalemia</li> <li>• Hyperkalemia</li> <li>• Hypocalcemia</li> <li>• Hypercalcemia</li> <li>• Hypomagnesemia</li> <li>• Hypermagnesemia</li> </ul> |
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## Physiology

Body fluids being distributed in two compartments (Table 5.1):

1. Intracellular fluid – bounded by cell membrane
2. Extracellular fluid – fluid outside cells. Types:
  - i. Plasma of vascular system, and
  - ii. Interstitial (tissue) fluid – occupies extracellular tissues (spaces).
3. Transcellular fluid – separated from plasma by another epithelium, besides capillary endothelium, i.e. cerebrospinal fluid (CSF); serous fluids; synovial fluids; aqueous and vitreous humour; digestive juices of gastrointestinal tract; and urine volume and composition.

## Acute Water Depletion

Etiology	<ul style="list-style-type: none"> <li>• Inadequate intake due to – unconsciousness, exhaustion, esophageal obstruction, GI tract surgery – postoperatively</li> <li>• Loss of water due to – hot weather, fever, vomiting, diarrhea, diabetes insipidus, diabetes mellitus, diuretics.</li> </ul>
Diagnosis	Thirst, dry lips, flushed skin, oliguria, confusion, delirium, coma.
Investigation	Hemogram, serum electrolytes.
Management	<ul style="list-style-type: none"> <li>• IV dextrose 5% or dextrose saline 2–3 L/day. Caution – avoid overloading</li> <li>• Maintenance of intake/output charts</li> <li>• Oral fluids</li> <li>• Treatment of underlying cause.</li> </ul>

## Acute Water Intoxication

Etiology	<ul style="list-style-type: none"> <li>• Increased intake of water due to – excessive IV fluids especially isotonic dextrose (5%), water P/R.</li> </ul>
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	<ul style="list-style-type: none"> <li>• Decreased diuresis due to – insufficient renal function, CHF, cirrhosis with ascites.</li> </ul>
Diagnosis	Headache, nausea, and incoordination of movements are main features, vomiting, abdominal cramps, muscular weakness, drowsiness, coma.
Management	Restrict the water intake IV hypertonic saline solution – to promote shifting of ICF to ECF Treatment of cause.

### Acute Dehydration

It is defined as decrease in the volume of both ICF and ECF, with the corresponding rise in the concentration of ICF and ECF solute.

Pathogenesis	In the blood: Concentration of plasma electrolyte and protein – resulting in increased plasma osmolality Hypovolemia – reduced renal blood flow – resulting in dysuria.
Etiology	Reduced intake of water, i.e. unconscious, esophageal obstruction Loss of water, i.e. hot weather, fever, vomiting, diarrhea, diabetes insipidus.
Diagnosis	Thirst, dry lips, flushed skin, oliguria, confusion, delirium, coma.
Investigation	Serum electrolytes.
Management	IV fluids – Dextrose 2.5–5.0% sol. 2–3 L/day, Alt: – Ringer's (lactated) sol. Oral fluids (ORS, i.e. oral rehydration salts) Treatment of underlying cause.

### Acute Overhydration (syn. Dilution Syndrome)

It is defined as increase in the volume of both ICF and ECF, with the corresponding fall in the concentration of ICF and ECF solute.

Pathogenesis	In the blood: Water excess (overhydration) leads to increased body fluid, decreased plasma electrolyte and protein, reduced plasma osmolarity.
Etiology	Increased water intake, i.e. excessive IV fluids Decreased urinary excretion Ascites.
Diagnosis	Headache, nausea, vomiting, weakness, abdominal cramps, convulsions, coma.
Management	
Acute cases	IV hypertonic saline solution, to promote shifting of ICF fluid to ECF.

### Acute Respiratory Acidosis

It is defined as a decrease in pH (increased H<sup>+</sup>) of ECF, due to respiratory disorders.

Pathogenesis:	Hypoventilation → Elevated H <sub>2</sub> CO <sub>3</sub> → Elevated pCO <sub>2</sub> ↓
	Acidosis ← Lowered pH of ECF
Etiology	Anesthesia – inadequate ventilation

	Respiratory centre depression – CNS disorders, drugs Lung disorders – emphysema, acute asthma, acute pneumonia Trauma – head injury, spinal injury.
Diagnosis	Dyspnea, breathlessness, confusion, coma.
Management	<ul style="list-style-type: none"> <li>• Monitor <math>P_{CO_2}</math>, <math>P_{O_2}</math>, and pH of arterial blood</li> <li>• Endotracheal intubation</li> <li>• Ventilator with oxygen supply</li> <li>• IV fluids</li> <li>• Antidotes for anesthetics or drugs causing respiratory center depression</li> <li>• Bronchodilators</li> <li>• Tracheostomy may be required as an emergency measure.</li> </ul>
<b>Refer:</b>	The severe patient to the medical team.

### Acute Respiratory Alkalosis

It is defined as an increase in pH (decreased  $H^+$ ) of ECF, due to respiratory disorders.

Pathogenesis	Hyperventilation → Lowered $H_2CO_3$ → Lowered $P_{CO_2}$
Etiology	<p>Alkalosis ← Elevated pH of ECF</p> <p>Anxiety, fear</p> <p>Anesthesia – pulmonary hyperventilation</p> <p>High altitudes – hyperventilation</p> <p>Ventilator – faulty use (misuse)</p> <p>Acute asthma, acute pneumonia, pulmonary edema</p> <p>Trauma – head injury</p> <p>Drugs – salicylate poisoning.</p>
Diagnosis	Tetany, neuromuscular irritation Pallor Hypotension Respiratory arrest.
Management	Anxiety: By drugs/psychotherapy Tetany: By rebreathing exhaled air, that will increase $P_{CO_2}$ and lower pH Respiratory arrest – treated by insufflation of $CO_2$ .
<b>Refer:</b>	The severe patient to the medical team.

### Acute Metabolic Acidosis

It is defined as a decrease in pH (increased  $H^+$ ) of ECF, due to metabolic disorders.

Pathogenesis	Metabolic disorders lead to inadequate $H^+$ excretion, $HPO_4$ retention, $Na^+$ , $K^+$ , $Ca^{++}$ loss, metabolic acidosis.
Etiology	Starvation, diarrhea, ulcerative colitis, prolonged intestinal obstruction, diabetes mellitus with ketosis, renal insufficiency.
Diagnosis	Respiration – fast, noisy (hyperpnea) Pulse rate – increased Hypertension Urine – acidic.
Investigation	Plasma $HCO_3$ estimation – decreased.
Management	Removal of cause, i.e. insulin for control of diabetes IV fluids – Darrow's solution or saline and sodium lactate or $HCO_3$

IV electrolytes replacement  
 Renal insufficiency – ion exchange resins which bind  $K^+$ , reducing  $K^+$  ion concentration, by preventing absorption of  $K^+$  in the intestine or by hemodialysis or peritoneal hemolysis.

**Refer:** The severe patient to the medical team.

### Acute Metabolic Alkalosis

It is defined as an increase in pH (decreased  $H^+$ ) of ECF due to metabolic disorders.

**Pathogenesis** Metabolic disorders lead to increased excretion of  $H^+$ , retention of  $HCO_3$ , elevation of  $HCO_3$  in ECF, metabolic alkalosis.

**Etiology** Vomiting or gastric aspiration – in pyloric stenosis  
 Drugs – diuretics, corticoids.

**Diagnosis** Respiration – Cheyne-Stokes respiration with periods of apnea (5–30 sec)  
 Tetany – latent  
 Renal insufficiency.

**Management** Main aim: Replacement of potassium followed by normal saline  
 Plenty of water,  $K^+$ ,  $Na^+$ ,  $Cl^-$   
 IV fluids (water)  $K^+$ ,  $Na^+$ ,  $Cl^-$   
 No lactate or  $HCO_3$  to be given.

### Hypernatremia

It is defined as increased concentration of sodium (Na) in ECF.

**Etiology** Dehydration, nephritis, cirrhosis, congestive heart failure (CHF), burns, excess of IV isotonic (0.9%) solution given.

**Diagnosis** Puffiness of face, pitting edema over sacrum in severe cases, overweight  
 Infants: Raised tension in the anterior fontanelle, polyuria, edema.

**Investigation** Serum electrolytes.

**Management**

- Discontinue the saline infusion
- Orally water or IV fluids (dextrose and water or hypotonic NaCl sol) diuretics, salt restriction, stop electrolytes.

**Refer:** The severe patient to the medical team.

### Hyponatremia

It is defined as decreased concentration of sodium in ECF.

**Etiology**

- Traumatic – include surgical trauma
- Nausea, vomiting, diarrhea, excessive sweating in hot climate
- Intestinal obstruction, gastric aspiration
- Addison's disease, nausea, vomiting, diarrhea
- Nephritis
- CHF.

**Diagnosis** Face drawn, sunken eyes, dry skin, tongue dry and coated, hypotension, dark-colored urine of high specific gravity.

**Infants** Depressed anterior fontanelle.

**Investigation** Blood – FBC, U&E, LFTs, thyroid function, osmolarity  
 Urine – sodium and osmolarity  
 ECG  
 CXR  
 Ultrasonography.

**Management** Severe cases: Plasma or plasma expander  
 Isotonic saline solution (0.9%) IV

Less severe cases: Isotonic saline solution (0.9%) IV or Ringer's solution IV.

**Refer:** The severe patient to the medical team.

### Hyperkalemia

It is defined as increased  $K^+$  in ECF due to shift from ICF.

Etiology	Renal insufficiency – failure to excrete ingested potassium Trauma – crush injury Dehydration, burns, infection Drugs – digitalis poisoning.
Diagnosis	Muscular weakness, paralysis, diarrhea, abdominal distention, ventricular fibrillation, cardiac arrest.
Investigation	ECG: T waves – peaked and QRS complex widened.
Management	Monitor ECG Withhold potassium Cation exchange resins orally or by enema IV calcium (10 mL of 10% calcium gluconate) – as an antagonist ion IV $NaHCO_3$ Renal failure – hemodialysis or peritoneal dialysis to remove $K^+$ .

**Refer:** The severe patient to the medical (nephrology) team for emergency dialysis.

### Hypokalemia

It is defined as decreased  $K^+$  in ECF due to shift to ICF.

Etiology	Traumatic – including operative trauma Starvation – inadequate intake of potassium Gastrointestinal obstruction Steatorrhea – inadequate absorption Irritable bowel syndrome, gastroenteritis Diabetic coma – managed by insulin Saline solution – prolonged infusion Burns.
Diagnosis	Patient listless, drowsiness, speech impaired, muscular weakness, paralytic ileus, incontinence of urine, gasping respirations, hypotension, cardiac arrest.
Investigation	ECG: Shows lowering/inversion of T waves and prolonged QRST interval.
Management	<ul style="list-style-type: none"> <li>• Diet: Oral potassium in form of milk, meat extracts, fruit juices</li> <li>• Orally: KCl 2 g PO q.d.s.</li> <li>• Parenterally: IV potassium used with great caution, e.g. in impaired renal function with associated alkalosis: KCl 2 g in 0.5 L of 5% dextrose solution @20 drops/min. Max 3 g of potassium/24 hrly.</li> <li>• Darrow's solution – for impaired renal function without alkalosis.</li> <li>• Monitor the pulse rate during administration of potassium.</li> </ul>

**Refer:** The severe patient to the medical team.

### Hypercalcemia

Etiology	Hyperparathyroidism: Carcinoma breast, lungs, thyroid, kidney.
Diagnosis	Nausea, vomiting, thirst, polyuria, dehydration, anorexia, constipation, pain abdomen, muscular weakness, hangover, confusion, coma.

Investigation	Blood for FBC, U&E, LFTs, serum lipase Thyroid function tests ECG – bradycardia CXR – diagnostic.
Management	Removal of the cause Symptomatic treatment: <ul style="list-style-type: none"> <li>• Isotonic sodium chloride solution (0.9%) IV (excretion of <math>\text{Na}^+</math>) to be followed by excretion of <math>\text{Ca}^{++}</math></li> <li>• Diuretics: Furosemide may/may not be given along sodium chloride</li> <li>• IV fluids along with potassium and magnesium</li> <li>• Corticoids – used in case of carcinoma. Mithramycins are useful.</li> </ul>

**Refer:** The severe patient to the medical team.

### Hypocalcemia

Etiology	Hypoparathyroidism, renal insufficiency, rickets, malabsorption syndrome.
Diagnosis	Muscle cramps, abdominal cramps, tetany, convulsions dyspnea, polyuria, dwarfism.
Management	Removal of primary cause. Hypoparathyroidism – calcium with vitamin D. Tetany: <ul style="list-style-type: none"> <li>• Hypocalcemic tetany – calcium gluconate 1–2 g IV</li> <li>• Latent tetany – calcium chloride/gluconate/lactate/carbonate</li> </ul>

Preparations and routes of administration:

- Calcium chloride (27% calcium) routes: PO or IV (10% sol)
- Calcium gluconate (9% calcium) routes: PO, IM or IV (10% sol)
- Calcium lactate (13% calcium) routes: PO
- Precipitated calcium carbonate (40% calcium) route: PO only.

### Hypermagnesemia

Etiology	Renal insufficiency, excess $\text{Mg}^{++}$ intake as a cathartic.
Diagnosis	Muscle weakness, sedation, confusion, hypotension Death may occur due to respiratory failure.
Investigation	ECG: Increased PR interval, broadening of QRS complex and elevated T waves.
Management	<ul style="list-style-type: none"> <li>• Removal of cause – renal insufficiency</li> <li>• IV calcium gluconate/chloride – as an antagonist to <math>\text{Mg}^{++}</math></li> <li>• Dialysis – may be indicated.</li> </ul>

**Refer:** The severe patient to the medical team.

### Hypomagnesemia

Etiology	Chronic alcoholism, starvation, diarrhea, malabsorption syndrome, prolonged GI suction, hypoparathyroidism.
Diagnosis	Hyperirritability, spasticity, cardiac arrhythmias, convulsions, death.
Management	IV fluids IV $\text{MgCl}$ or $\text{MgSO}_4$ 10–40 mEq/day.

**Refer:** The severe patient to the medical team.

## References

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