Critical disturbances in the fluid, electrolyte, or acid-base balance of the body may have no outward signs or symptoms and only diagnosed by laboratory testing. It is important to note that the body will try to maintain volume at the expense of osmolarity, electrolytes, or pH. Nonspecific signs such as somnolence, confusion, or weakness may be the only hints of an underlying abnormality.

The otolaryngologic patient is particularly prone to such disturbances because of the effects of anaesthesia, parenteral feeding, and underlying medical diseases such as diabetes, heart failure, or diuretic therapy. The following lists and tables review some of these disturbances. Therapy must be individualized based on all underlying conditions and their pathophysiology.

**Nonspecific Signs of Fluid, Electrolyte, or Acid-Base Disturbances**

<table>
<thead>
<tr>
<th>Confusion</th>
<th>Muscle weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delirium</td>
<td>Hyperventilation</td>
</tr>
<tr>
<td>Hallucinations</td>
<td>Hypoventilation</td>
</tr>
<tr>
<td>Coma</td>
<td>Arrhythmias</td>
</tr>
<tr>
<td>Seizures</td>
<td>Abnormal reflexes</td>
</tr>
<tr>
<td>Lethargy</td>
<td></td>
</tr>
</tbody>
</table>

**Signs of Fluid Disturbances**

**Overhydration**

<table>
<thead>
<tr>
<th>Polyuria</th>
<th>Ascites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urine sodium &gt; 30 mEq/L</td>
<td>Peripheral edema</td>
</tr>
<tr>
<td>Pulmonary edema</td>
<td>Systolic hypertension</td>
</tr>
<tr>
<td>Distended neck veins</td>
<td>Elevated wedge pressure</td>
</tr>
</tbody>
</table>

**Dehydration**

<table>
<thead>
<tr>
<th>Oliguria</th>
<th>Thirst</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urine sodium &lt; 10 mEq/L</td>
<td>Tachycardia</td>
</tr>
<tr>
<td>Hypotension</td>
<td>Hemoconcentration</td>
</tr>
<tr>
<td>Poor skin turgor</td>
<td>Low wedge pressure</td>
</tr>
<tr>
<td>Sunken eyeballs</td>
<td></td>
</tr>
</tbody>
</table>
Hyperkalaemia

Cause

- Potassium-sparing diuretics
- Hypoaldosteronism - especially in diabetics
- Crush injury
- Renal failure
- Increased intake (salt substitutes)
- Acidosis
- Prostaglandin inhibitors

Therapy

Decrease intake
- Calcium gluconate: 1 ampule (10 mL = 940 mg) IV q 2 hr
- Glucose: 50 mL 50% dextrose plus insulin (crystalline zinc) 10 IU IV/SC
- Sodium bicarbonate: 1.2 g TID PO or 1 ampule IV q 4 hr to keep bicarbonate level > 25 mEq/L

- Loop diuretics: 40-80 mg furosemide (Lasix) or 50-100 mg ethacrynic acid (Edecrin) IV or PO. Do not use potassium-sparing diuretics such as spironolactone (Aldactone), hydrochlorothiazide and triamterene (Dyazide), or amiloride (Moduretic or Midamor).
- Exchange resins: 25-50 mg sodium polystyrene sulfanate (Kayexelate) PO or by enema 2-3 times a day
- Mineralocorticosteroids 0.1 mg fludrocortisone (Florinet) PO q 24 hr
- Dialysis: peritoneal or hemodialysis.

Table 31-1. Hyponatremia (Signs Are Those of Associated Fluid Status)

Pathogenesis

<table>
<thead>
<tr>
<th>Volume Status</th>
<th>Etiology</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Loss of sodium in excess of body water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume depletion</td>
</tr>
<tr>
<td>Renal losses: diuretics, nephritis, osmotic diuresis</td>
</tr>
<tr>
<td>Normal saline: ± 1 L IV q 4-6 hr if cardiac status satisfactory</td>
</tr>
<tr>
<td>Extra-renal losses: vomiting, diarrhea, thrid-space losses</td>
</tr>
<tr>
<td>Normal saline: ± 1 L IV q 4-6 hr if cardiac status satisfactory</td>
</tr>
</tbody>
</table>

Excess water

- Slight overhydration
  - Addison's disease
- Steroids
  - Myxedema
- Thyroxine
  - Inappropriate anti-diuretic syndrome
1. Fluid restriction (1 L/24 hr)
2. Hypertonic saline 300 mL of 3% saline over 4 hr
3. Loop diuretics
4. Dilantin 100 mg t.i.d.
5. Lithium 300 mg p.o. q.i.d.
6. Demeclocycline 300 mg q.i.d.

Excess sodium and excess water
   Overhydration with edema
      Congestive heart lung
1. Fluid restriction
   Nephrosis
2. Diuretics
   Cirrhosis
Lasix 40-100 mg IV q 12-24 hr
   Renal failure
Edecrin 50-100 mg IV q 12-24 hr.

Table 31-2. Causes of Hypernatremia

   Therapy depends on fluid status and must be individualized. One should calculate
   the fluid deficit and replace fluids gradually over 1-2 days to avoid cerebral edema or
   congestive heart failure. Specific therapy must then be directed at the underlying
   condition.

   Water loss in excess of sodium loss

   Central or nephrogenic diabetes insipidus
   Vomiting
   Diarrhea
   Severe burns
   Osmotic diuresis (calcium, glucose, IVP dye)
   Excessive insensible losses

      Inadequate water intake

      Hypothalamic disease
      Stupor

      Administration of sodium in excess of water

      Excessive salt ingestion IV or p.o.
      Dialysis

      Sodium retention

      Cushing's syndrome
      Hyperaldosteronism
Loss of renal concentration ability

Uremia
Hypokalemia
Lithium therapy
Methoxyflurane anesthesia
Sickle cell anemia
Multiple myeloma
Hypercalcemia.

Hypocalcemia

Causes

Hypoparathyroidism: iatrogenic, idiopathic.
Pseudohypoparathyroidism
Pancreatitis
Renal failure
Hypomagnesemia
Vitamin D deficiency
Malabsorption
Hypoalbuminemia (does not need therapy).

Therapy

1. Acute therapy: 10 mL of 10% calcium chloride or calcium gluconate IV repeat of 8-12 hr as needed.

2. Chronic therapy: (a) calcium 1 g p.o. t.i.d.

(b) Vitamin D 50,000 units, or Dihydrotachysterol 0.125 mg to 0.4 mg/day

(c) Magnesium (if deficient) 2 mL magnesium sulphate IM p.r.n.

Table 31-3. Hypercalcemia

Causes

Hyperparathyroidism
Ectopic parathyroid hormone secretion
Bony metastases
Milk alkali syndrome
Vitamin D toxicity
Sarcoid
Tuberculosis
Therapy (to be individualized)

1. Parathyroidectomy
2. Hydration: oral fluids as tolerated
3. Saline 1-2 L IV q 2-4 hr (watch cardiac status)
4. Loop diuretics Lasix 40 mg, Edecrin 50 mg IV or p.o.
5. Phosphate 250-500 mg p.o. q 6 hr (as Neutra-Phos)
6. Steroids 100 mg Solu-Cortef IV q 8 hr or 25 mg cortisone acet. q 6 hr
7. Mithramycin 15-25 microg/kg IV q 24-48 hr
8. Indomethacin 25 mg p.o. q 6 hr.

Table 31-4. Acid-Base Disturbances

<table>
<thead>
<tr>
<th>Disturbance</th>
<th>pH</th>
<th>Hydrogen ion</th>
<th>pCO₂</th>
<th>bicarbonate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metabolic acidosis</td>
<td>low</td>
<td>high</td>
<td>low</td>
<td>low*</td>
</tr>
<tr>
<td>Metabolic alkalosis</td>
<td>high</td>
<td>low</td>
<td>high</td>
<td>high*</td>
</tr>
<tr>
<td>Respiratory acidosis</td>
<td>low</td>
<td>high</td>
<td>high*</td>
<td>high</td>
</tr>
<tr>
<td>Respiratory alkalosis</td>
<td>high</td>
<td>low</td>
<td>low*</td>
<td></td>
</tr>
</tbody>
</table>

Normal range 7.35-7.45 36-45 mEq/L 35-45 mmHg 22-26 mEq/L.

* Primary abnormality.

Causes of Metabolic Alkalosis

Diuretics
Vomiting
Diarrhea
Antacid therapy
Hyperaldosteronism
Gastrointestinal fistula.

Therapy

Potassium chloride to maintain K level above 3.5 mEq/L, fluids, carbonic anhydrase inhibitors (acetazolamide - Diamox - 250 mg p.o. q.i.d.). Treat underlying condition.

Causes of Respiratory Acidosis

Acute

General anesthesia
Cardiac arrest
Sedation
Pulmonary edema
Severe pneumonia
Bronchospasm
Laryngospasm
Foreign body aspiration
Mechanical ventilation.

Chronic

Alveolar hypoventilation
Obstructive pulmonary disease
Brain tumor
Respiratory muscle weakness or nerve damage
Restrictive lung disease.

Therapy

Directed at improving respiratory gas exchange.

Causes of Respiratory Alkalosis

(Produced by hyperventilation)

Anxiety
Hysteria
Oain
Fever
Salicylate intoxication
Stroke
CNS trauma, infection, tumor.
Congestive heart failure
Pneumonia
Hypoxia
Hepatic insufficiency
Gram-negative sepsis
Mechanical ventilators.

Therapy

Treat underlying condition, increase "dead space" if on ventilator.

Causes of Metabolic Acidosis

Increased Anion Gap

Increased Organic Acid Production

lactic acidosis
diabetic ketoacidosis
starvation ketosis
alcoholic ketoacidosis
Inability to Excrete Inorganic Acids

chronic renal failure
acute renal failure

Ingestion of Exogenous Acids

salicylates
methanol
paraldehyde
ethylene glycol

Normal Anion Gap

Loss of Bicarbonate

GI tract loss
ureterosigmoidostomy
renal tubular acidosis
uremia (early)
carbonic anhydrase inhibitor therapy
hypoaldosteronism
corection of chronic respiratory alkalosis

Chloride Therapy

hyperalimentation
ammonium chloride
lysine hydrochloride
arginine hydrochloride

Administration of Acids with Rapid Renal Clearances of Unmeasured Ions

sulfuric acid
phosphoric acid
sulfur containing amino acids.

Therapy

Bicarbonate therapy to raise pH above 7.3-7.35 and treat underlying abnormality.

Electrocardiographic Abnormalities of Electrolyte Abnormalities

Hyperkalemia

Peaked T wave
Prolonged QRS
Sinus arrest
Ventricular sine wave

**Hypokalemia**

Prolonged QT interval
ST segment depression
U waves

**Hypocalcemia**

Lengthened QT segment (Normal T wave duration)

**Hypercalcemia**

Shortened QT interval.