

**Chapter 31: Fluids, Electrolytes, and Acid-Base Balance**

**Part I**

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**

Confusion	Muscle weakness
Delirium	Hyperventilation
Hallucinations	Hypoventilation
Coma	Arrhythmias
Seizures	Abnormal reflexes
Lethargy	

**Signs of Fluid Disturbances**

**Overhydration**

Polyuria	Ascites
Urine sodium > 30 mEq/L	Peripheral edema
Pulmonary edema	Systolic hypertension
Distended neck veins	Elevated wedge pressure

**Dehydration**

Oliguria	Thirst
Urine sodium < 10 mEq/L	Tachycardia
Hypotension	Hemoconcentration
Poor skin turgor	Low wedge pressure
Sunken eyeballs	

## 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

##### Volume Status

##### Etiology

#### Therapy

##### Loss of sodium in excess of body water

##### Volume depletion

Renal losses: diuretics, nephritis, osmotic diuresis

Normal saline:  $\pm 1$  L IV q 4-6 hr if cardiac status satisfactory

Extra-renal losses: vomiting, diarrhea, third-space losses

Normal saline:  $\pm 1$  L IV q 4-6 hr if cardiac status satisfactory

##### 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 Dihydroxycholesterol 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
9. Indomethacin 25 mg p.o. q 6 hr.

Table 31-4. Acid-Base Disturbances

Disturbance	pH	Hydrogen ion	pCO <sub>2</sub>	bicarbonate
Metabolic acidosis	low	high	low	low*
Metabolic alkalosis	high	low	high	high*
Respiratory acidosis	low	high	high*	high
Respiratory alkalosis	high	low	low*	low
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  
Pain  
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**

hyperlimentation  
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.