Chapter 31

Drugs for Fluid-Balance, Electrolyte, and Acid-Base Disorders

Body Fluid Compartments

- Continuous exchange of fluids across membranes separating intracellular and extracellular fluid compartments
- Large molecules and those that are ionized less able to cross membranes

Figure 31.1 Major fluid compartments in the body.

Body Fluid Compartments

- Continuous exchange of fluids across membranes separating intracellular and extracellular fluid compartments
- Large molecules and those that are ionized less able to cross membranes

Control of Water Balance

- Essential to homeostasis
- Frequent indications for IV therapy include imbalances of
  - Body fluids
  - Electrolytes
  - Acid-base

Osmolality

- Concentration of osmotic solution
- Dependent on number of dissolved solutes in a body fluid
  - Usually sodium, glucose, or urea
- Normal osmolality is 275–295 mOsm/kg

Osmolality (continued)

- Changes in osmolality can cause water to move to different compartments
  - Greatest contributor is sodium
  - Sodium controlled by hormone aldosterone
- Tonicity is relative concentration of intravenous fluid
  - General term, not precise measurement
Osmosis

- Water moves from areas of low osmolality to areas of high osmolality
- Hypertonic intravenous fluid
  - Water moves from interstitial space to plasma.
- Hypotonic intravenous fluid
  - Water moves from plasma to interstitial space.
- Isotonic intravenous fluid
  - No fluid shift

Fluid Balance

- Achieved through complex mechanisms
- Most important regulator of fluid intake is thirst
- Primary regulators of fluid output: kidneys
  - Renin-angiotensin mechanism
  - Aldosterone
  - Antidiuretic hormone (ADH)

Fluid-Balance Disorders

- Deficit-fluid-balance disorders
  - Can cause dehydration or shock
  - Treated with oral or intravenous fluids
- Excess-fluid-balance disorders
  - Treated with diuretics

Intravenous Fluid Therapy

- Replaces fluids and electrolytes
  - Uses crystalloids and colloids
- Causes of water and electrolyte loss
  - Gastrointestinal fluid loss, vomiting, diarrhea, laxatives, suctioning
  - Perspiration, burns, hemorrhage, excessive diuresis, ketoacidosis

Crystalloids

- Contain electrolytes
- Used to replace fluids and promote urine output
- Capable of leaving plasma and moving to interstitial spaces and intracellular fluid
- Compartment entered depends on tonicity of intravenous fluid
Colloids

- Molecules too large to easily cross capillary membrane
  - Stay in intravascular space
  - Rapidly expand plasma volume
- Draw water from intracellular fluid and interstitial spaces into plasma
  - Increases osmotic pressure

Electrolytes

- Positively or negatively charged inorganic molecules
- Essential to
  - Nerve conduction, membrane permeability
  - Water balance, other critical body functions

Important Electrolytes

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Chemical Formula</th>
<th>Cation</th>
<th>Anion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium chloride</td>
<td>CaCl₂</td>
<td>Ca²⁺</td>
<td>2Cl⁻</td>
</tr>
<tr>
<td>Sodium phosphate</td>
<td>Na₂HPO₄</td>
<td>Na⁺</td>
<td>HPO₄²⁻</td>
</tr>
<tr>
<td>Potassium chloride</td>
<td>KCl</td>
<td>K⁺</td>
<td>Cl⁻</td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>NaHCO₃</td>
<td>Na⁺</td>
<td>HCO₃⁻</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>NaCl</td>
<td>Na⁺</td>
<td>Cl⁻</td>
</tr>
<tr>
<td>Sodium sulfate</td>
<td>Na₂SO₄</td>
<td>Na⁺</td>
<td>SO₄²⁻</td>
</tr>
</tbody>
</table>

Sodium

- Essential for maintaining osmolality, water balance, acid-base balance

Electrolyte Imbalances

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Abnormal Serum Value (mEq/L)</th>
<th>Supportive Treatment*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>140-150</td>
<td>Normal renal function</td>
</tr>
<tr>
<td>Chloride</td>
<td>103-108</td>
<td>Normal renal function</td>
</tr>
<tr>
<td>Magnesium</td>
<td>2.2-3.0</td>
<td>Normal renal function</td>
</tr>
<tr>
<td>Calcium</td>
<td>8.5-10.0</td>
<td>Normal renal function</td>
</tr>
</tbody>
</table>

Sodium and Water Regulation

- Water travels with or toward sodium.
- Sodium movement is link between water retention, blood volume, and blood pressure
- Regulated by kidneys and aldosterone
- Sodium is major electrolyte in extracellular fluid
Hypernatremia

- Sodium level above 145 mEq/L
- Most commonly caused by kidney disease
- Sodium accumulates
  - Decreased excretion
  - High, net-water loss (watery diarrhea, fever, burns)
  - High doses of glucocorticoids or estrogens

Physiology of Hypernatremia

- Elevated sodium increases osmolality of the plasma
  - Draws fluid from interstitial spaces and cells
  - Causes cellular dehydration
- Signs and symptoms
  - Thirst, fatigue, weakness, muscle twitching
  - Convulsions, altered mental status, decreased level of consciousness

Treatment of Hypernatremia

- Can be treated with low-salt diet
- Acute hypernatremia treated with hypotonic intravenous fluids or diuretics

Hyponatremia

- Sodium level below 135 mEq/L
- Caused by excessive dilution of plasma
  - Excessive antidiuretic hormone (ADH) secretion
  - Excess administration of hypotonic intravenous solution
- Vomiting, diarrhea, gastrointestinal suctioning, diuretic use

Symptoms of Hyponatremia

- Early symptoms
  - Nausea, vomiting, anorexia, abdominal cramping
- Later signs
  - Altered neurologic function such as confusion, lethargy, convulsions, coma, muscle twitching, tremors
Treatment of Hyponatremia

- Hyponatremia caused by excessive dilution
  - Treat with loop diuretics to cause an isotonic diuresis.
- Hyponatremia caused by sodium loss
  - Treat with oral sodium chloride or intravenous fluids containing salt.
    - Normal saline
    - Lactated Ringers

Potassium Balance

- Essential for
  - Proper nerve and muscle function
  - Maintaining acid-base balance
- Influenced by aldosterone
  - For each sodium ion reabsorbed, one potassium ion secreted into renal tubules
- Imbalances can be serious, even fatal

Hyperkalemia

- Potassium level above 5 mEq/L
- Caused by high consumption of potassium-rich food, dietary supplements
- Risk with client taking potassium-sparing diuretics
- Accumulates when renal disease causes decreased excretion

Symptoms of Hyperkalemia

- Most serious are dysrhythmias and heart block
- Other symptoms are muscle twitching, fatigue, paresthesias, dyspnea, cramping, diarrhea

Treatment of Hyperkalemia

- Restrict dietary sources
- Decrease dose of potassium-sparing diuretics
- Administer glucose and insulin.
- Administer calcium to counteract potassium toxicity on heart
- Administer polystyrene sulfonate (Kayexalate) and sorbitol to decrease potassium levels

Hypokalemia

- Potassium level below 3.5 mEq/L
- Caused by
  - High doses of loop diuretics
  - Strenuous muscle activity
  - Severe vomiting or diarrhea
**Symptoms of Hypokalemia**

- Neurons and muscle fibers most sensitive to potassium loss
- Muscle weakness, lethargy, anorexia, dysrhythmias, cardiac arrest

**Treatment of Hypokalemia**

- Mild—increase dietary intake
- Severe—give oral or parenteral potassium supplements

**Alkalosis and Acidosis**

- Acidosis is excess acid (pH below 7.35)
- Alkalosis is excess base (pH above 7.45)
- Both symptoms of underlying disorder
- Both may be fatal if not treated rapidly
- Body uses buffers to maintain overall pH within narrow limits
- Kidneys and lungs collaborate to remove excess metabolic acid

**Acidosis**

- May be respiratory, caused by hypoventilation
- May be metabolic
  - Causes: diarrhea, kidney failure, diabetes, excess alcohol, starvation
Pharmacotherapy of Acidosis

- Symptoms affect central nervous system
  - Lethargy, confusion, coma
  - Deep, rapid respirations in attempt to blow off excess acid
- Goal is to quickly reverse effects of excess acid in blood
- Administration of sodium bicarbonate is appropriate pharmacotherapy

Alkalosis

- May be respiratory
  - Cause: hyperventilation due to asthma, anxiety, high altitude
- May be metabolic
  - Prolonged constipation, excess sodium bicarbonate, diuretics that cause potassium depletion, severe vomiting

Pharmacotherapy of Alkalosis

- Symptoms are due to central-nervous-system stimulation
  - Nervousness, hyperactive reflexes, convulsions
  - Slow, shallow respirations in attempt to retain acid
- Treatment
  - Administration of ammonium chloride (severe cases)
  - Administration of sodium chloride with potassium chloride (mild cases)

Role of the Nurse

- Monitoring client’s condition
- Providing client education
- Obtaining medical, surgical, and drug history
- Assessing lifestyle and dietary habits
- Obtaining description of symptomology and current therapies

Colloidal solutions

- Monitor fluid-volume status (both deficit and excess)
- Assess neurologic status and urinary output
- Report hematocrit below 30% to physician immediately
- Teach client to report bleeding, hypersensitivity, or fluid-volume overload

Sodium Replacement Therapy

- Assess sodium and electrolyte balance
- Be alert for signs of hyponatremia and hypernatremia
- Monitor serum sodium levels, urine specific gravity, serum and urine osmolality
- Client should report symptoms that may relate to fluid overload
- Client should drink water or balanced sports drinks to replenish lost fluids and electrolytes
Potassium-Replacement Therapy

- Monitor for cardiac abnormalities
- Contraindicated in cases of severe renal impairment
- Do not use with potassium-sparing diuretics
- Contraindicated in acute dehydration, heat cramps, clients with digoxin intoxication with AV-node disturbance
- Take with meals to avoid irritating GI tract

Sodium Bicarbonate Therapy

- Monitor arterial blood-gas reports
- Use cautiously in clients with cardiac disease or renal impairment
- Clients should use alternative OTC antacids to prevent excess sodium or bicarbonate from being absorbed into systemic circulation

Ammonium Chloride Therapy

- Assess pH in arterial blood-gas levels prior to administration
- Contraindicated in presence of liver disease
- Infuse slowly to avoid ammonium toxicity and decrease irritation to veins

Fluid-Replacement Agents—Colloids

- **Prototype drug**: dextran 40 (Gentran 40, Hyskon, 10% LMD, Rheomacrodex)
- **Mechanism of action**: to raise oncotic pressure of blood; expands plasma volume within minutes of administration
- **Primary use**: as fluid replacement with hypovolemic shock from hemorrhage, surgery, severe burns
- **Adverse effects**: hypersensitivity reactions, fluid overload, hypertension

Electrolytes

- **Prototype drug**: sodium chloride
- **Mechanism of action**: as electrolyte/sodium supplement
- **Primary use**: to treat hyponatremia when serum levels fall below 130 mEq/L
- **Adverse effects**: hypernatremia and pulmonary edema

Electrolytes (continued)

- **Prototype drug**: potassium chloride
- **Mechanism of action**: as electrolyte/potassium supplement
- **Primary use**: to prevent or treat hypokalemia
- **Adverse effects**: GI irritation, hyperkalemia; contraindicated in clients with chronic renal failure or those taking potassium-sparing diuretic
Acid-Base Agents

- **Prototype drug**: sodium bicarbonate
- **Mechanism of action**: to raise pH of body fluids
- **Primary use**: to correct metabolic acidosis
- **Adverse effects**: metabolic alkalosis caused by receiving too much bicarbonate ion and hypokalemia

Acid-Base Agents (continued)

- **Prototype drug**: ammonium chloride
- **Mechanism of action**: to decrease pH of body fluids
- **Primary use**: to reverse severe metabolic alkalosis
- **Adverse effect**: acidosis

Crystalloids

- **Intravenous solutions**
  - Contain electrolytes and other agents
  - Mimic body’s extracellular fluid

Crystalloids (continued)

- **Used to replace depleted fluids and to promote urine output**
- **Examples**: normal saline, 5% dextrose in water

Colloids

- **Proteins, starches, other large molecules**
- **Too large to easily cross capillary membranes**
- **Draw water molecules from cells and tissues into plasma**

Colloids (continued)

- **Sometimes called plasma-volume expanders**
- **Examples**: albumin, dextran 40
Electrolytes

• Small, charged molecules essential to homeostasis
• Imbalances must be quickly corrected.
• Examples: sodium and potassium

Acid-Base Agents

• Acidosis (excess acid) and alkalosis (excess base)
  – Symptoms of underlying disorder
• Acidic and basic agents correct pH imbalances in body fluids.
• Examples: sodium bicarbonate (corrects acidosis); ammonium chloride (corrects alkalosis)

Drug Therapy for Fluid-Balance, Electrolyte, and Acid-Base Disorders

• Assessment
  – Complete health history
  – Assess for presence of fluid-volume deficit
  – Obtain CBC, serum electrolytes, renal function studies

• Nursing diagnoses
  – Risk for injury
  – Deficient fluid volume
  – Decreased cardiac output

• Planning—client will
  – Report effects: itching, shortness of breath, flushing, cough, heart palpitations.
  – Exhibit signs of normal fluid volume
  – Demonstrate an understanding of drug’s action

• Implementation
  – Monitor hemodynamic status every 15 to 60 minutes.
  – Monitor for
    • Hypersensitivity reactions
    • Circulatory overload
    • Changes in CBC results
### Drug Therapy for Fluid-Balance, Electrolyte, and Acid-Base Disorders

**Evaluation**
- Client is free of itching, shortness of breath, flushing, cough, heart palpitations
- Client’s blood pressure and urinary output are within normal limits
- Client’s electrolyte levels are within normal limits
- Client is able to describe drug side effects and precautions

### Selected Crystalloid IV Solutions

**Table 31.1 Selected Crystalloid IV Solutions**

<table>
<thead>
<tr>
<th>Solution</th>
<th>Composition</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lactated Ringer’s</td>
<td>1165 mmol/L Na, 197 mmol/L Cl, 110 mmol/L Ca, 13 mmol/L Mg</td>
<td>For hypovolemic shock</td>
</tr>
<tr>
<td>Normal Saline</td>
<td>154 mmol/L Na, 58 mmol/L Cl, 2 mmol/L Ca, 2 mmol/L Mg</td>
<td>For volume expansion</td>
</tr>
</tbody>
</table>

### Selected Colloid IV Solutions

**Table 31.2 Selected Colloid IV Solutions**

<table>
<thead>
<tr>
<th>Solution</th>
<th>Composition</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albumin 5%</td>
<td>6.25% albumin</td>
<td>For hypoalbuminemia</td>
</tr>
<tr>
<td>Dextran 40</td>
<td>60% dextran</td>
<td>For hypovolemic shock</td>
</tr>
<tr>
<td>HES 130/0.4</td>
<td>130% hydroxyethyl starch</td>
<td>For hypovolemic shock</td>
</tr>
</tbody>
</table>