

CHAPTER 24

Antihypertensive Agents

NDEG 26 A – Pharmacology I
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$$\text{Blood pressure} = \text{CO} \times \text{SVR}$$

- CO = cardiac output
- SVR = systemic vascular resistance

Hypertension = high blood pressure

Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7) May 2003

JNC-7

Four stages, based on BP measurements

- Normal
- Prehypertension
- Stage 1 hypertension
- Stage 2 hypertension

TABLE 24-1
CLASSIFICATION AND MANAGEMENT OF BLOOD PRESSURE

BP Classification	SBP* mm Hg	DBP* mm Hg	Lifestyle Modification	Initial Drug Therapy	
				Without Compelling Indications†	With Compelling Indications†
Normal	<120	and <80	Encourage		
Prehypertension	120-139	or 80-89	Yes	No antihypertensive drug indicated	Drug(s) for compelling indications†
Stage 1 hypertension	140-159	or 90-99	Yes	Thiazide-type diuretics for most; may consider ACE inhibitors, ARB, BB, CCB, or combination	Drug(s) for the compelling indications†; other antihypertensive drugs (diuretics, ACE inhibitors, ARB, BB, CCB) prn
Stage 2 hypertension	≥160	or ≥100	Yes	Two-drug combination for most‡ (usually thiazide-type diuretic and ACE inhibitors, ARB, BB, or CCB)	

From U.S. Department of Health and Human Services: *Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7)*, Washington, DC, 2003, National Institutes of Health.

*Treatment determined by highest BP category.

†Compelling indications include heart failure, post-MI, high cardiovascular risk, diabetes mellitus, chronic kidney disease, and recurrent stroke prevention.

‡Treat patients with chronic kidney disease or diabetes to BP goal of <130/90 mm Hg.

Initial combined therapy should be used cautiously in those at risk for orthostatic hypotension.

BP: Blood pressure; SBP: systolic blood pressure; DBP: diastolic blood pressure; ACE: angiotensin converting enzyme; ARB: angiotensin II receptor blocker; BB: beta-adrenergic blocker; CCB: calcium channel blocker.

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Table 24-1 Classification and Management of Blood Pressure

Classification of BP

Hypertension can also be defined by its cause

- Unknown cause
 - Essential, idiopathic, or primary hypertension
 - 90% of the cases
- Known cause
 - Secondary hypertension
 - 10% of the cases

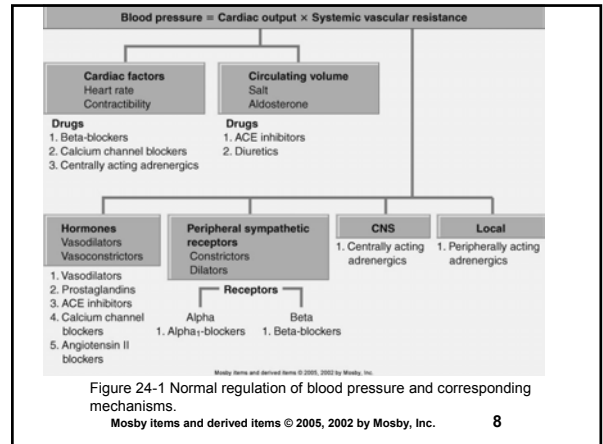


Figure 24-1 Normal regulation of blood pressure and corresponding mechanisms.

Compelling Indications

- Post-MI
- High cardiovascular risk
- Heart failure
- Diabetes mellitus
- Chronic kidney disease
- Cerebrovascular disease

JNC-7: Significant Changes

- High diastolic BP (DBP) is no longer considered to be more dangerous than high systolic BP (SBP)
- Studies have shown that elevated SBP is strongly associated with heart failure, stroke, and renal failure

JNC-7: Significant Changes (cont'd)

- For those older than age 50, SBP is a more important risk factor for cardiovascular disease (CVD) than DBP
- “Prehypertensive” BPs are no longer considered “high normal” and require lifestyle modifications to prevent CVD

JNC-7: Significant Changes (cont'd)

- Thiazide-type diuretics should be the initial drug therapy for most patients with hypertension (alone or with other drug classes)
- The previous labels of “mild,” “moderate,” and “severe” have been dropped

Cultural Considerations

- Beta-blockers and ACE inhibitors have been found to be more effective in Caucasian patients than African American patients
- CCBs (Calcium Channel Blockers) and diuretics have been shown to be more effective in geriatric and African American patients than in Caucasian patients

Antihypertensive Agents - Medications used to treat hypertension

Categories

- Adrenergic agents
- Angiotensin converting enzyme (ACE) inhibitors
- Angiotensin II receptor blockers (ARBs)
- Calcium channel blockers (CCBs)
- Diuretics
- Vasodilators

Adrenergic Agents

- Centrally and peripherally acting adrenergic neuron blockers
- Centrally acting alpha₂-receptor agonists
- Peripherally acting alpha₁-receptor agonists

Adrenergic Agents (cont'd)

- Peripherally acting beta-receptor blockers (beta-blockers)—both cardioselective (beta₁-receptors) and nonselective (both beta₁- and beta₂- receptors)
- Peripherally acting dual alpha₁- and beta-receptor blockers

Adrenergic Agents: Mechanism of Action

- Centrally and peripherally acting adrenergic neuron blocker
 - Depletes norepinephrine stores in neurotransmitter storage vesicles
 - SNS is not stimulated (beta-receptors in the heart and alpha₁-receptors in blood vessels)
- Result: decreased blood pressure

Centrally and Peripherally Acting Neuron Blocker

- Reserpine
 - The only centrally and peripherally acting neuron blocker still available in the United States

Adrenergic Agents: Mechanism of Action

- Centrally acting α_2 -receptor agonists
 - Stimulate α_2 -adrenergic receptors in the brain
 - Sympathetic outflow from the CNS is decreased
 - Norepinephrine production is decreased
- Result: decreased blood pressure

Adrenergic Agents: **Centrally** Acting α_2 -Receptor Agonists

- clonidine (Catapres)
- guanfacine (Tenex)
- methyldopa (Aldomet)
 - Drug of choice for hypertension in pregnancy

Adrenergic Agents: Mechanism of Action

Peripherally acting α_1 -receptor antagonists

- Block the α_1 -adrenergic receptors
- The SNS is *not* stimulated

Result: *decreased* blood pressure

Adrenergic Agents: Mechanism of Action (cont'd)

- Stimulation of α_1 -adrenergic receptors causes *hypertension*
- Blocking α_1 -adrenergic receptors causes decreased blood pressure

Adrenergic Agents: **Peripherally** Acting α_1 -Receptor Agonists

- doxazosin (Cardura)
- prazosin (Minipress)
- terazosin (Hytrin)

Adrenergic Agents

Indications

- Adrenergic neuronal blockers (centrally and peripherally acting neuron blocker)
 - Treatment of hypertension, either alone or with other agents
 - Seldom used because of frequent side effects

Adrenergic Agents

Indications (cont'd)

- Centrally acting α_2 -receptor agonists
 - Treatment of hypertension, either alone or with other agents
 - Usually used after other agents have failed due to side effects

Adrenergic Agents

Indications (cont'd)

- Centrally acting α_2 -receptor agonists
 - Also may be used for treatment of severe dysmenorrhea, menopausal flushing, glaucoma
 - **Clonidine** is useful in the management of withdrawal symptoms in opioid- or nicotine-dependent persons

Adrenergic Agents (cont'd)

Indications (cont'd)

- Peripherally acting α_1 -receptor agonists
 - Treatment of hypertension
 - Relief of symptoms of BPH
 - Management of severe HF when used with cardiac glycosides and diuretics

Adrenergic Agents

Side Effects

Most common: Dry mouth Drowsiness
 Sedation Constipation

Other: Headaches Sleep disturbances
 Nausea Rash
 Cardiac disturbances
 (palpitations)

HIGH INCIDENCE OF
ORTHOSTATIC HYPOTENSION

Adrenergic Agents

- Beta-blockers
 - Act in the periphery
 - Reduce heart rate due to β_1 -blockade
 - Examples: propranolol (Inderal), atenolol (Tenormin)

Adrenergic Agents (cont'd)

- Dual α_1 - and β -receptor blockers
 - Act in the periphery at heart and blood vessels
 - Reduce heart rate (β_1 -receptor blockade)
 - Cause vasodilation (α_1 -receptor blockade)
 - Examples: labetalol (Normodyne), carvedilol (Coreg)

Angiotensin Converting Enzyme Inhibitors

- (ACE inhibitors, or ACEIs)
- Large group of safe and effective drugs
- Often used as first-line agents for HF and hypertension
- May be combined with a thiazide diuretic or calcium channel blocker

ACE Inhibitors: Mechanism of Action

- RAAS: renin angiotensin-aldosterone system
- When the enzyme angiotensin I is converted to angiotensin II, the result is potent vasoconstriction and stimulation of aldosterone
 - Result of vasoconstriction: increased systemic vascular resistance and increased afterload
 - Result: increased BP

ACE Inhibitors: Mechanism of Action (cont'd)

- Aldosterone stimulates water and sodium resorption
- Result: increased blood volume, increased preload, and increased BP

ACE Inhibitors: Mechanism of Action (cont'd)

- ACE inhibitors block the angiotensin converting enzyme, thus preventing the formation of angiotensin II
- Also prevent the breakdown of the vasodilating substance, bradykinin
- Result: decreased systemic vascular resistance (afterload), vasodilation, and therefore decreased blood pressure

ACE Inhibitors: Indications

- Hypertension
- HF (either alone or in combination with diuretics or other agents)
- Slows progression of left ventricular hypertrophy after an MI
- Renal protective effects in patients with diabetes
 - Drugs of choice in hypertensive patients with HF

ACE Inhibitors (cont'd)

- captopril (Capoten)
 - Very short half-life
- enalapril (Vasotec)
 - Available in oral and parenteral forms
- lisinopril (Prinivil and Zestril) and quinapril (Accupril)
 - Newer agents, long half-lives, once-a-day dosing
- Several other agents available

ACE Inhibitors: Side Effects

Fatigue Dizziness
Headache Mood changes
Impaired taste Possible hyperkalemia

Dry, nonproductive cough, which reverses when therapy is stopped

NOTE: First-dose hypotensive effect may occur!

Angiotensin II Receptor Blockers

- (A II blockers, or ARBs)
- Newer class
- Well tolerated
- Do not cause a dry cough

Angiotensin II Receptor Blockers: Mechanism of Action

- Allow angiotensin I to be converted to angiotensin II, but block the receptors that receive angiotensin II
- Block vasoconstriction and release of aldosterone

Angiotensin II Receptor Blockers

- losartan (Cozaar, Hyzaar)
- valsartan (Diovan)

Angiotensin II Receptor Blockers: Indications

- Hypertension
- Adjunctive agents for the treatment of HF
- May be used alone or with other agents such as diuretics
- Used primarily in patients who cannot tolerate ACE inhibitors

Angiotensin II Receptor Blockers: Side Effects

- Upper respiratory infections
- Headache
- May cause occasional dizziness, inability to sleep, diarrhea, dyspnea, heartburn, nasal congestion, back pain, fatigue
- Hyperkalemia much less likely to occur

Calcium Channel Blockers: Mechanism of Action

- Cause smooth muscle relaxation by blocking the binding of calcium to its receptors, preventing muscle contraction
- This causes decreased peripheral smooth muscle tone and decreased systemic vascular resistance
- Result: decreased blood pressure

Calcium Channel Blockers

- Benzothiazepines
 - diltiazem (Cardizem, Dilacor)
- Phenylalkamines
 - verapamil (Calan, Isoptin)
- Dihydropyridines
 - amlodipine (Norvasc), bepridil (Vascor), nicardipine (Cardene)
 - nifedipine (Procardia), nimodipine (Nimotop)

Calcium Channel Blockers (cont'd)

Indications

- Angina
- Hypertension
- Dysrhythmias
- Migraine headaches
- Raynaud's disease

Calcium Channel Blockers: Side Effects

- Cardiovascular
 - Hypotension, palpitations, tachycardia
- Gastrointestinal
 - Constipation, nausea
- Other
 - Rash, flushing, peripheral edema, dermatitis

Diuretics

- Decrease the plasma and extracellular fluid volumes
- Results: Decreased preload
 Decreased cardiac output
 Decreased total peripheral resistance
- Overall effect: Decreased workload of the heart, and decreased blood pressure

Vasodilators: Mechanism of Action

- Directly relax arteriolar smooth muscle
- Result: decreased systemic vascular response, decreased afterload, and *peripheral vasodilation*

Antihypertensive Agents Vasodilators

- diazoxide (Hyperstat)
- hydralazine HCl (Apresoline)
- minoxidil (Loniten, Rogaine)
- sodium nitroprusside (Nipride, Nitropress)

Vasodilators: Indications

- Treatment of hypertension
- May be used in combination with other agents
- Intravenous sodium nitroprusside and diazoxide are reserved for the management of hypertensive emergencies - The effects of occur within 2 minutes of initiation of the infusion.

Vasodilators: Side Effects

- Hydralazine
 - Dizziness, headache, anxiety, tachycardia, nausea and vomiting, diarrhea, anemia, dyspnea, edema, nasal congestion
- Sodium nitroprusside
 - Bradycardia, hypotension, possible cyanide toxicity

Nursing Implications

- Before beginning therapy, obtain a thorough health history and head-to-toe physical examination
- Assess for contraindications to specific antihypertensive agents
- Assess for conditions that require cautious use of these agents

Nursing Implications

- Educate patients about the importance of not missing a dose and taking the medications exactly as prescribed
- Patients should never double up on doses if a dose is missed; check with physician for instructions on what to do if a dose is missed
- Monitor BP during therapy; instruct patients to keep a journal of regular BP checks

Nursing Implications

- Instruct patients that these drugs should not be stopped abruptly because this may cause a rebound hypertensive crisis, and perhaps lead to stroke
- Oral forms should be given with meals so that absorption is more gradual and effective
- Administer IV forms with extreme caution and use an IV pump

Nursing Implications

- Remind patients that medication is only part of therapy. Encourage patients to watch their diet, stress level, weight, and alcohol intake
- Patients should avoid smoking and eating foods high in sodium
- Encourage supervised exercise

Nursing Implications

- Instruct patients to change positions slowly to avoid syncope from postural hypotension
- Patients should report unusual shortness of breath; difficulty breathing; swelling of the feet, ankles, face, or around the eyes; weight gain or loss; chest pain; palpitations; or excessive fatigue

Nursing Implications

- Men taking these agents may not be aware that **impotence** is an expected effect. This may influence compliance with drug therapy
- If patients are experiencing serious side effects, or believe that the dose or medication needs to be changed, they should contact their physician immediately

Nursing Implications

- Hot tubs, showers, or baths; hot weather; prolonged sitting or standing; physical exercise; and alcohol ingestion may aggravate low blood pressure, leading to fainting and injury. Patients should sit or lie down until symptoms subside.
- Patients should not take any other medications, including OTC drugs, without first getting the approval of their physician

Nursing Implications

- Educate about lifestyle changes that may be needed
 - Weight loss
 - Stress management
 - Supervised exercise

Nursing Implications

- Monitor for side/adverse effects (dizziness, orthostatic hypotension, fatigue) and for toxic effects
- Monitor for therapeutic effects
 - Blood pressure should be maintained at less than 140/90 mm Hg
 - If a patient with hypertension also has diabetes or renal disease, the BP goal is <130/80 mm Hg (*JNC-7*)

CHAPTER 25

Diuretic Agents

Diuretic Agents

- Drugs that accelerate the rate of urine formation
- Result: removal of sodium and water

Sodium

- Where sodium goes, water follows
 - 20% to 25% of all sodium is reabsorbed into the bloodstream in the loop of Henle
 - 5% to 10% in the distal tubules
 - 3% in collecting ducts
- If water is not absorbed, it is excreted as urine

Diuretic Agents: Categories

- Carbonic anhydrase inhibitors (CAIs)
- Loop diuretics
- Osmotic diuretics
- Potassium-sparing diuretics
- Thiazide and thiazide-like diuretics

Carbonic Anhydrase Inhibitors (CAIs)

- acetazolamide (Diamox)
- methazolamide
- dichlorphenamide

Carbonic Anhydrase Inhibitors: Mechanism of Action

- The enzyme carbonic anhydrase helps to make H^+ ions available for exchange with sodium and water in the proximal tubules
- CAIs block the action of carbonic anhydrase, thus preventing the exchange of H^+ ions with sodium and water

Carbonic Anhydrase Inhibitors: Mechanism of Action (cont'd)

- Inhibition of carbonic anhydrase reduces H^+ ion concentration in renal tubules
- As a result, there is increased excretion of bicarbonate, sodium, water, and potassium
- Resorption of water is decreased and urine volume is increased

Carbonic Anhydrase Inhibitors: Indications

- Adjunct agents in the long-term management of open-angle glaucoma
- Used with miotics to lower intraocular pressure before ocular surgery in certain cases
- Also useful in the treatment of:
 - Glaucoma
 - Edema
 - Epilepsy
 - High-altitude sickness

Carbonic Anhydrase Inhibitors: Indications (cont'd)

- Acetazolamide is used in the management of edema secondary to HF when other diuretics are not effective
- CAIs are less potent diuretics than loop diuretics or thiazides—the metabolic acidosis they induce reduces their diuretic effect in 2 to 4 days

Carbonic Anhydrase Inhibitors: Side Effects

- Metabolic acidosis
- Anorexia
- Hematuria
- Photosensitivity
- Drowsiness
- Paresthesias
- Urticaria
- Melena

Loop Diuretics

- bumetanide (Bumex)
- ethacrynic acid (Edecrin)
- furosemide (Lasix)

Loop Diuretics: Mechanism of Action

- Act directly on the ascending limb of the loop of Henle to inhibit sodium and chloride resorption
- Increase renal prostaglandins, resulting in the dilation of blood vessels and reduced peripheral vascular resistance

Loop Diuretics: Drug Effects

- Potent diuresis and subsequent loss of fluid
- Decreased fluid volume causes:
 - Reduced BP
 - Reduced pulmonary vascular resistance
 - Reduced systemic vascular resistance
 - Reduced central venous pressure
 - Reduced left ventricular end-diastolic pressure
- Potassium depletion

Loop Diuretics: Indications

- Edema associated with HF or hepatic or renal disease
- Control of hypertension
- Increase renal excretion of calcium in patients with hypercalcemia

Loop Diuretics: Side Effects

<u>Body System</u>	<u>Effect</u>
CNS	Dizziness, headache, tinnitus, blurred vision
GI	Nausea, vomiting, diarrhea

Loop Diuretics: Side Effects (cont'd)

<u>Body System</u>	<u>Effect</u>
Hematologic	Agranulocytosis, neutropenia, thrombocytopenia
Metabolic	Hypokalemia, hyperglycemia, hyperuricemia

Osmotic Diuretics

- mannitol (Osmitol)

Osmotic Diuretics: Mechanism of Action

- Work in the proximal tubule
- Nonabsorbable, producing an osmotic effect
- Pull water into the blood vessels and nephrons from the surrounding tissues

Osmotic Diuretics: Drug Effects

- Reduced cellular edema
- Increased urine production, causing diuresis
- Rapid excretion of water, sodium, and other electrolytes, as well as excretion of toxic substances from the kidney
- Reduced excessive intraocular pressure

Osmotic Diuretics: Indications

- Used in the treatment of patients in the early, oliguric phase of ARF
- To promote the excretion of toxic substances
- Reduction of intracranial pressure
- Treatment of cerebral edema

Osmotic Diuretics: Side Effects

- Convulsions
- Thrombophlebitis
- Pulmonary congestion
- Also headaches, chest pains, tachycardia, blurred vision, chills, and fever

Potassium-Sparing Diuretics

- amiloride (Midamor)
- spironolactone (Aldactone)
- triamterene (Dyrenium)

Potassium-Sparing Diuretics: Mechanism of Action

- Work in collecting ducts and distal convoluted tubules
- Interfere with sodium-potassium exchange
- Competitively bind to aldosterone receptors
- Block the resorption of sodium and water usually induced by aldosterone

Potassium-Sparing Diuretics: Drug Effects

- Prevent potassium from being pumped into the tubule, thus preventing its secretion
- Competitively block the aldosterone receptors and inhibit its action
- The excretion of sodium and water is promoted

Potassium-Sparing Diuretics: Indications

- spironolactone and triamterene
 - Hyperaldosteronism
 - Hypertension
 - Reversing the potassium loss caused by potassium-losing drugs
- amiloride
 - Treatment of HF

Potassium-Sparing Diuretics: Side Effects

<u>Body System</u>	<u>Effect</u>
CNS	Dizziness, headache
GI	Cramps, nausea, vomiting, diarrhea
Other	Urinary frequency, weakness **hyperkalemia**

Potassium-Sparing Diuretics: Side Effects (cont'd)

- spironolactone
- Gynecomastia
 - Amenorrhea
 - Irregular menses
 - Postmenopausal bleeding

Thiazide and Thiazide-like Diuretics

- Thiazide diuretics
 - hydrochlorothiazide (Esidrix, HydroDIURIL)
 - chlorothiazide (Diuril)
 - trichlormethiazide (Metahydrin)
- Thiazide-like diuretics
 - chlorthalidone (Hygroton)
 - metolazone (Mykrox, Zaroxolyn)

Thiazide and Thiazide-like Diuretics: Mechanism of Action

- Inhibit tubular resorption of sodium and chloride ions
- Action primarily in the ascending loop of Henle and early distal tubule
- Result: water, sodium, and chloride are excreted
- Potassium is also excreted to a lesser extent
- Dilate the arterioles by direct relaxation

Thiazide and Thiazide-like Diuretics: Drug Effects

- Lowered peripheral vascular resistance
- Depletion of sodium and water

Thiazide and Thiazide-like Diuretics: Indications

- Hypertension (one of the most prescribed group of agents for this)
- Edematous states
- Idiopathic hypercalciuria
- Diabetes insipidus
- Adjunct agents in treatment of HF, hepatic cirrhosis

Thiazide and Thiazide-like Diuretics: Side Effects

Body System

Effect

CNS

Dizziness, headache, blurred vision, paresthesias, decreased libido

GI

Anorexia, nausea, vomiting, diarrhea

Thiazide and Thiazide-like Diuretics: Side Effects (cont'd)

Body System

Effect

GU

Impotence

Integumentary

Urticaria, photosensitivity

Metabolic

Hypokalemia, glycosuria, hyperglycemia

Nursing Implications

- Perform a thorough patient history and physical examination
- Assess baseline fluid volume status, intake and output, serum electrolyte values, weight, and vital signs—especially postural BPs
- Assess for disorders that may contraindicate or necessitate cautious use of these agents

Nursing Implications

- Instruct patients to take in the morning as much as possible to avoid interference with sleep patterns
- Monitor serum potassium levels during therapy
- Potassium supplements are usually not recommended when potassium levels exceed 3 mEq/L

Nursing Implications

- Teach patients to maintain proper nutritional and fluid volume status
- Teach patients to eat more potassium-rich foods when taking any but the potassium-sparing agents
- Foods high in potassium include bananas, oranges, dates, raisins, plums, fresh vegetables, potatoes, meat, and fish

Nursing Implications

- Patients taking diuretics along with a digitalis preparation should be taught to monitor for digitalis toxicity
- Diabetic patients who are taking thiazide and/or loop diuretics should be told to monitor blood glucose and watch for elevated levels

Nursing Implications

- Teach patients to change positions slowly, and to rise slowly after sitting or lying to prevent dizziness and possible fainting related to orthostatic hypotension
- Encourage patients to keep a log of their daily weight
- Encourage patients to return for follow-up visits and labwork

Nursing Implications

- Patients who have been ill with nausea, vomiting, and/or diarrhea should notify their physician because fluid loss may be dangerous
- Signs and symptoms of hypokalemia include muscle weakness, constipation, irregular pulse rate, and overall feeling of lethargy

Nursing Implications

- Instruct patients to notify the physician immediately if they experience rapid heart rates or syncope (reflects hypotension or fluid loss)
- A weight gain of 2 or more pounds a day or 5 or more pounds a week should be reported immediately

Nursing Implications

Excessive consumption of licorice can lead to an additive hypokalemia in patients taking thiazides

Nursing Implications

Monitor for adverse effects

- Metabolic alkalosis,
- Drowsiness
- Lethargy
- Hypokalemia
- Tachycardia
- Hypotension
- leg cramps
- restlessness, decreased mental alertness

Nursing Implications

- Monitor for therapeutic effects
 - Reduction in edema, fluid volume overload, HF
 - Reduction of hypertension
 - Return to normal intraocular pressures –
 - The physician would examine the fundus of a patient's eyes during antihypertensive therapy, because it is a more reliable indicator than blood pressure readings of the long-term effectiveness of treatment.

CHAPTER 26

Fluids and Electrolytes

Fluid Balance

- Total body water
- 60% of adult human body is water
- Three main compartments
 - Intracellular fluid (ICF)
 - Interstitial fluid (ISF)
 - Plasma volume (PV)

Fluid Balance

- Intravascular fluid (IVF)
 - Fluid inside blood vessels
- Extravascular fluid (EVF)
 - Fluid outside blood vessels

Fluid Balance

- *Extracellular* volume
 - Plasma
 - Interstitial fluid (ISF): fluid in space between cells, tissues, and organs
- *Extravascular* volume
 - ISF (interstitial fluid)
 - ICF (intercellular fluid)

Fluid Balance

- Plasma proteins exert constant osmotic pressure
 - Colloid oncotic pressure (COP)
 - Normally 24 mm Hg
- ISF exerts hydrostatic pressure (HP)
 - Normally 17 mm Hg

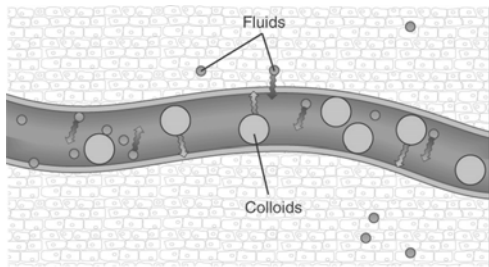


Figure 26-2 Colloid osmotic pressure (oncotic pressure). As shown, the colloids inside the blood vessel are too large to pass through the vessel wall. The resulting oncotic pressure exerted by the colloids draws fluid from the surrounding tissues and other extravascular spaces into the blood vessels and also keeps fluid inside the blood vessel.

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Fluid Balance

- Edema
- Dehydration and fluid loss

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TABLE 26-2

TYPES OF DEHYDRATION

Type of Dehydration	Characteristics
Hypertonic	Caused when water loss is greater than sodium loss, resulting in a concentration of solutes outside the cells and causing the fluid inside the cells to move to the extracellular space, thus dehydrating the cells. <i>Example:</i> Elevated temperature resulting in perspiration.
Hypotonic	Caused when sodium loss is greater than water loss, resulting in higher concentrations of solute inside the cells, thus pulling fluid from outside the cells (plasma and interstitial spaces) into the cells. <i>Examples:</i> Renal insufficiency and inadequate aldosterone secretion.
Isotonic	Caused by a loss of sodium and water from the body, resulting in a decrease in the volume of ECF. <i>Examples:</i> Diarrhea and vomiting.

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Table 26-2 Types of dehydration

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TABLE 26-3

CONDITIONS LEADING TO FLUID LOSS OR DEHYDRATION AND ASSOCIATED CORRESPONDING SYMPTOMS*

Condition	Associated Symptoms
Bleeding	Tachycardia and hypotension
Bowel obstruction	Reduced perspiration and mucous secretions
Diarrhea	Reduced urine output (oliguria)
Fever	Dry skin and mucous membranes
Vomiting	Reduced lacrimal (tears) and salivary secretions

*NOTE: There may be overlap involving more than one of the symptoms depending on the patient's specific condition.

Table 26-3 Conditions leading to fluid loss or dehydration and associated corresponding symptoms

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Fluids and Electrolytes: Crystalloids

- Fluids that supply water and sodium
- Help to maintain osmotic gradient between extravascular and intravascular compartments
- Plasma-volume expanders due to sodium concentrations
- Do not contain proteins (colloids)
- Contain fluids and electrolytes that are normally found in the body

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Fluids and Electrolytes: Crystalloids (cont'd)

- Better for treating dehydration rather than expanding plasma volume
- Used as maintenance fluids
 - Compensate for insensible fluid losses
 - To replace fluids
 - To manage specific fluid and electrolyte disturbances
 - Promote urinary flow

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Fluids and Electrolytes: Crystalloids (cont'd)

- Normal saline (0.9% sodium chloride)
- Half normal saline (0.45% sodium chloride)
- Hypertonic saline (3% sodium chloride)
- Lactated Ringer's
- D₅W
- Plasma-Lyte

Fluids and Electrolytes: Crystalloids (cont'd)

- Indications include:
 - Acute liver failure
 - Acute nephrosis
 - Burns
 - Shock
 - Renal dialysis
 - Many other conditions

Fluids and Electrolytes: Crystalloids (cont'd)

- Side/adverse effects
 - May cause edema, especially peripheral or pulmonary
 - May dilute plasma proteins, reducing COP
 - Effects may be short-lived
 - Many other effects

Fluids and Electrolytes: Colloids

- Increase COP
- Move fluid from interstitial compartment to plasma compartment (when plasma protein levels are low)
 - Dextran 40 or 70 (a glucose solution)
 - Hetastarch (synthetic, derived from cornstarch)
 - 5% or 25% albumin (from human donors)

Fluids and Electrolytes: Colloids (cont'd)

- Indications
 - Treat a wide variety of conditions
 - Superior to crystalloids in PV expansion, but more expensive

Fluids and Electrolytes: Colloids (cont'd)

Side effects/adverse effects

- Usually safe
- Disadvantages
 - May cause altered coagulation, resulting in bleeding
 - Have no clotting factors or oxygen-carrying capacity
 - Few others

Fluids and Electrolytes: Blood Products

Oxygen-carrying resuscitation fluids

- Only class of fluids that are able to carry oxygen
- Increase tissue oxygenation
- Increase plasma volume
- Most expensive and least available fluid because they require human donors

TABLE 26-7
BLOOD PRODUCTS

Product	Dosage	Cost*
Cryoprecipitate	1 unit	1
FFP		1.7×
PRBCs		2.2×
PPF		1
Whole blood		3.3×

*Using the cost of cryoprecipitate as the means of comparison. FFP, Fresh frozen plasma; PRBC, packed red blood cell; PPF, plasma protein fractions.

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Table 26-7 Blood Products

Fluids and Electrolytes: Blood Products (cont'd)

- Increase COP and PV
 - Pull fluid from extravascular space into intravascular space (plasma expanders)
 - RBC products also carry oxygen
 - Increase body's supply of various products (such as clotting factors, hemoglobin)

Fluids and Electrolytes: Blood Products (cont'd)

Indications

- Cryoprecipitate and plasma protein factors (PPF)
 - Management of acute bleeding (>50% slow blood loss or 20% acutely)
- Fresh frozen plasma (FFP)
 - Increase clotting factor levels in patients with demonstrated deficiency

Fluids and Electrolytes: Blood Products (cont'd)

Indications

- PRBCs and whole blood
 - To increase oxygen-carrying capacity in patients with anemia, substantial hemoglobin deficits, and for blood loss >25% of total blood volume

TABLE 26-9
**SUGGESTED GUIDELINES FOR BLOOD PRODUCTS:
MANAGEMENT OF BLEEDING**

Amount of Blood Loss	Fluid of Choice
≤20% (slow loss)	Crystalloids
20%-50% (slow loss)	Nonprotein plasma expanders (dextran and hetastarch)
>50% (slow loss) or 20% (acutely)	Whole blood or PPF and FFP
≥80% lost	As above, but for every 5 units of blood given, administer 1-2 units of FFP and 1-2 units of platelets to prevent the hemodilution of clotting factors and bleeding

PPF, Plasma protein fraction; FFP, fresh frozen plasma.

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Table 26-9 Suggested guidelines for blood products: management of bleeding

Fluids and Electrolytes: Blood Products

- Side/adverse effects
 - Incompatibility with recipient's immune system
 - Transfusion reaction
 - Anaphylaxis
 - Transmission of pathogens to recipient (hepatitis, HIV)

Electrolytes

- Principal ECF electrolytes
 - Sodium cations (Na^+)
 - Chloride cations (Cl^-)
- Principal ICF electrolyte
 - Potassium (K^+)
- Others
 - Calcium, magnesium, phosphorus

Electrolytes: Potassium

- Most abundant positively charged electrolyte inside cells
- 95% of body's potassium is intracellular
- Potassium content outside of cells ranges from 3.5 to 5 mEq/L
- Potassium levels are critical to normal body function

Electrolytes: Potassium (cont'd)

- Potassium obtained from foods
 - Fruit and fruit juices, fish, vegetables, poultry, meats, dairy products
- Excess dietary potassium excreted via kidneys
 - Impaired kidney function leads to higher serum levels, possibly toxicity

Electrolytes: Potassium (cont'd)

Hyperkalemia: excessive serum potassium
serum potassium level >5 mEq/L

- | | |
|-------------------------------|----------------------|
| • Potassium supplements | • Burns |
| • ACE inhibitors | • Trauma |
| • Renal failure | • Metabolic acidosis |
| • Excessive loss from cells | • Hyperaldosteronism |
| • Potassium-sparing diuretics | |

Electrolytes: Potassium (cont'd)

Hypokalemia: deficiency of potassium
serum potassium level <3.5 mEq/L

Excessive potassium loss (rather than poor dietary intake)

- | | |
|-------------------|-------------------------------|
| • Alkalosis | • Burns |
| • Corticosteroids | • Loop and thiazide diuretics |
| • Crash diets | • Vomiting |
| • Diarrhea | • Malabsorption |
| • Ketoacidosis | • Large amounts of licorice |

BOX 26-1**Symptoms of Hypokalemia****Early**

Anorexia
 Hypotension
 Lethargy
 Mental confusion
 Muscle weakness
 Nausea

Late

Cardiac dysrhythmias
 Neuropathy
 Paralytic ileus
 Secondary alkalosis

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Box 26-1 Symptoms of Hypokalemia

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Electrolytes: Potassium (cont'd)

Potassium is responsible for:

- Muscle contraction
- Transmission of nerve impulses
- Regulation of heartbeat
- Maintenance of acid-base balance
- Isotonicity
- Many other functions in the body

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Electrolytes: Potassium (cont'd)**Main indication**

- Treatment or prevention of potassium depletion when dietary means are inadequate

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Electrolytes: Potassium (cont'd)**Side/adverse effects**

- Oral preparations
 - Diarrhea, nausea, vomiting, GI bleeding, ulceration
- IV administration
 - Pain at injection site
 - Phlebitis
- Excessive administration
 - Hyperkalemia
 - Toxic effects

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Electrolytes: Potassium (cont'd)**Hyperkalemia**

- Muscle weakness, paresthesia, paralysis, cardiac rhythm irregularities (leading to possible ventricular fibrillation and cardiac arrest)

Treatment

- IV sodium bicarbonate, calcium salts, dextrose with insulin
- Sodium polystyrene sulfonate (Kayexalate) or hemodialysis to remove excess potassium

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Electrolytes: Sodium

- Most abundant positively charged electrolyte outside cells
- Normal concentration outside cells is 135 to 145 mEq/L
- Maintained through dietary intake of sodium chloride
 - Salt, fish, meats, foods flavored or preserved with salt

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Electrolytes: Sodium (cont'd)

Hyponatremia: sodium loss or deficiency; serum levels <135 mEq/L

- Symptoms
 - Lethargy, stomach cramps, hypotension, vomiting, diarrhea, seizures
- Causes
 - Same causes as hypokalemia; also excessive perspiration (during hot weather or physical work), prolonged diarrhea or vomiting, or renal disorders

Electrolytes: Sodium (cont'd)

Hypernatremia: sodium excess; serum levels >145 mEq/L

- Symptoms
 - Water retention (edema), hypertension
 - Red, flushed skin; dry, sticky mucous membranes, increased thirst, elevated temperature, decreased urine output
- Causes
 - Poor renal excretion stemming from kidney malfunction; inadequate water consumption and dehydration

Electrolytes: Sodium (cont'd)

Sodium is responsible for:

- Control of water distribution
- Fluid and electrolyte balance
- Osmotic pressure of body fluids
- Participates in acid-base balance

Electrolytes: Sodium (cont'd)

Main indication

- Treatment or prevention of sodium depletion when dietary measures are inadequate
- Mild
 - Treated with oral sodium chloride and/or fluid restriction
- Severe
 - Treated with intravenous normal saline or lactated Ringer's solution

Electrolytes: Sodium (cont'd)

Sodium: side/adverse effects

- Oral administration
 - Nausea, vomiting, cramps
- IV administration
 - Venous phlebitis

Nursing Implications

- Assess baseline fluid volume and electrolyte status
- Assess baseline vital signs
- Assess skin, mucous membranes, daily weights, I&O
- Before giving potassium, assess ECG
- Assess for contraindications to therapy
- Assess transfusion history
- Establish venous access as needed

Nursing Implications

- Monitor serum electrolyte levels during therapy
- Monitor infusion rate, appearance of fluid or solution, infusion site
- Observe for infiltration, other complications of IV therapy

Nursing Implications

- Parenteral infusions of potassium must be monitored closely
 - Rate should not exceed 20 mEq/hour
 - NEVER give as an IV bolus or undiluted
- Oral forms of potassium
 - Must be diluted in water or fruit juice to minimize GI distress or irritation
 - Monitor for complaints of nausea, vomiting, GI pain, or GI bleeding

Nursing Implications

- Administer colloids slowly
- Monitor for fluid overload and possible heart failure
- For blood products, follow administration procedures closely
- Monitor closely for signs of transfusion reactions

Nursing Implications

- Monitor for therapeutic response
 - Normal lab values
 - RBCs, WBC, H&H, electrolyte levels
 - Improved fluid volume status
 - Increased tolerance to activities
- Monitor for adverse effects