Learning Objectives

Upon completion of this chapter, you will be able to:

1. Explain the control of the synthesis and secretion of thyroid hormones and parathyroid hormones, applying this to alterations in the control process (e.g., using thyroid hormones to treat obesity, Paget disease, etc.).
2. Describe the therapeutic actions, indications, pharmacokinetics, contraindications, most common adverse reactions, and important drug–drug interactions associated with thyroid and parathyroid agents.
3. Discuss the use of thyroid and parathyroid drugs across the lifespan.
4. Compare and contrast thyroid and parathyroid prototype drugs with agents in their class.
5. Outline nursing considerations, including important teaching points, for patients receiving drugs used to affect thyroid or parathyroid function.

Glossary of Key Terms

bisphosphonates: drugs used to block bone resorption and lower serum calcium levels in several conditions

calcitonin: hormone produced by the parafollicular cells of the thyroid; counteracts the effects of parathyroid hormone to maintain calcium levels

cretinism: lack of thyroid hormone in an infant; if untreated, leads to mental retardation

follicles: structural unit of the thyroid gland; cells arranged in a circle

hypercalcemia: excessive calcium levels in the blood

hyperparathyroidism: excessive parathormone

hyperthyroidism: excessive levels of thyroid hormone

hypocalcemia: calcium deficiency

hypoparathyroidism: rare condition of absence of parathyroid hormone; may be seen after thyroidectomy

hypothyroidism: lack of sufficient thyroid hormone to maintain metabolism

iodine: important dietary element used by the thyroid gland to produce thyroid hormone

levothyroxine: a synthetic salt of thyroxine (T4), a thyroid hormone; the most frequently used replacement hormone for treating thyroid disease

liothyronine: the L-isomer of triiodothyronine (T3), and the most potent thyroid hormone, with a short half-life of 12 hours

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liothyronine: the L-isomer of triiodothyronine (T3), and the most potent thyroid hormone, with a short half-life of 12 hours
This chapter reviews drugs that are used to affect the function of the thyroid and parathyroid glands. These two glands are closely situated in the middle of the neck and share a common goal of calcium homeostasis. Serum calcium levels need to be maintained within a narrow range to promote effective blood coagulation, as well as nerve and muscle function. In most respects, however, these glands are very different in structure and function.

**THE THYROID GLAND**

The thyroid gland is located in the middle of the neck, where it surrounds the trachea like a shield (Figure 37.1). Its name comes from the Greek words *thyros* (shield) and *eidos* (gland). It produces two hormones—thyroid hormone and calcitonin.

**Structure and Function**

The thyroid is a vascular gland with two lobes—one on each side of the trachea—and a small isthmus connecting the lobes. The gland is made up of cells arranged in circular follicles. The center of each follicle is composed of colloid tissue, in which the thyroid hormones produced by the gland are stored. Cells found around the follicle of the thyroid gland are called parafollicular cells (see Figure 37.1). These cells produce another hormone, calcitonin, which affects calcium levels and acts to balance the effects of the parathyroid hormone.

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**FIGURE 37.1** The thyroid and parathyroid glands. The basic unit of the thyroid gland is the follicle.
(PTH), parathormone. Calcitonin will be discussed later in connection with the parathyroid glands.

The thyroid gland produces two slightly different thyroid hormones, using iodine that is found in the diet: thyroxine, or tetraiodothyronine (T₄), so named because it contains four iodine atoms, which is given therapeutically in the synthetic form levothyroxine, and triiodothyronine (T₃), so named because it contains three iodine atoms, which is given in the synthetic form liothyronine. The thyroid cells remove iodine from the blood, concentrate it, and prepare it for attachment to tyrosine, an amino acid. A person must obtain sufficient amounts of dietary iodine to produce thyroid hormones. The thyroid hormone regulates the rate of metabolism—that is, the rate at which energy is burned—in almost all the cells of the body. The thyroid hormones affect heat production and body temperature; oxygen consumption and cardiac output; blood volume; enzyme system activity; and metabolism of carbohydrates, fats, and proteins. Thyroid hormone is also an important regulator of growth and development, especially within the reproductive and nervous systems. Because the thyroid has such widespread effects throughout the body, any dysfunction of the thyroid gland will have numerous systemic effects.

When thyroid hormone is needed in the body, the stored thyroid hormone molecule is absorbed into the thyroid cells, where the T₃ and T₄ are broken off and released into circulation. These hormones are carried on plasma proteins, which can be measured as protein-bound iodine (PBI) levels. The thyroid gland produces more T₄ than T₃. More T₄ is released into circulation, but T₃ is approximately four times more active than T₄. Most T₄ (with a half-life of about 12 hours) is converted to T₃ (with a half-life of about 1 week) at the tissue level.

**Control**

Thyroid hormone production and release are regulated by the anterior pituitary hormone called thyroid-stimulating hormone (TSH). The secretion of TSH is regulated by thyrotropin-releasing hormone (TRH), a hypothalamic regulating factor. A delicate balance exists among the thyroid, the pituitary, and the hypothalamus in regulating the levels of thyroid hormone. See Chapter 36 for a review of the negative feedback system and the hypothalamic–pituitary axis. The thyroid gland produces increased thyroid hormones in response to increased levels of TSH. The increased levels of thyroid hormones send a negative feedback message to the pituitary to decrease TSH release and, at the same time, to the hypothalamus to decrease TRH release. A drop in TRH levels subsequently results in a drop in TSH levels, which in turn leads to a drop in thyroid hormone levels. In response to low blood serum levels of thyroid hormone, the hypothalamus sends TRH to the anterior pituitary, which responds by releasing TSH, which in turn stimulates the thyroid gland to again produce and release thyroid hormone. The rising levels of thyroid hormone are sensed by the hypothalamus, and the cycle begins again. This intricate series of negative feedback mechanisms keeps the level of thyroid hormone within normal limits.

**FIGURE 37.2** In response to low blood serum levels of thyroid hormone, the hypothalamus sends the thyrotropin-releasing hormone (TRH) to the anterior pituitary, which responds by releasing the thyroid-stimulating hormone (TSH) to the thyroid gland; it, in turn, responds by releasing the thyroid hormone (T₃ and T₄) into the bloodstream. The anterior pituitary is also sensitive to the increase in blood serum levels of the thyroid hormone and responds by decreasing production and release of TSH. As thyroid hormone production and release subside, the hypothalamus senses the lower serum levels, and the process is repeated by the release of TRH again. This intricate series of negative feedback mechanisms keeps the level of thyroid hormone within normal limits.

**Thyroid Dysfunction**

Thyroid dysfunction involves either underactivity (hypothyroidism) or overactivity (hyperthyroidism). This dysfunction can affect any age group. Box 37.1 explains use of thyroid agents across the lifespan.
**Box 37.1 Drug Therapy Across the Lifespan**

**Thyroid and Parathyroid Agents**

**Children**
Thyroid replacement therapy is required when a child is hypothyroid. Levothyroxine is the drug of choice in children. Dose is determined based on serum thyroid hormone levels and the response of the child, including growth and development. Dose in children tends to be higher than in adults because of the higher metabolic rate of the growing child. Usually, the starting dose to consider is 10 to 15 mcg/kg per day.

Regular monitoring, including growth records, is necessary to determine the accurate dose as the child grows. Maintenance levels at the adult dose usually occur after puberty and when active growing stops.

If an antithyroid agent is needed, propylthiouracil (PTU) is the drug of choice because it is less toxic. Unless other agents are ineffective, radioactive agents are not used in children because of the effects of radiation on chromosomes and developing cells.

Hypercalcemia is relatively rare in children, although it may be seen with certain malignancies. If a child develops a malignancy-related hypercalcemia, the bisphosphonates may be used, with dose adjustments based on age and weight. Serum calcium levels should be monitored very closely in the child and dose adjustments made as necessary.

**Adults**
Adults who require thyroid replacement therapy need to understand that this will be a lifelong replacement need. An established routine of taking the tablet first thing in the morning may help the patient to comply with the drug regimen. Levothyroxine is the drug of choice for replacement, but in some cases other agents may be needed. Periodic monitoring of thyroid hormone levels is necessary to ensure that dose needs have not changed.

If antithyroid drugs are needed, the patient’s underlying problems should be considered. Methimazole is associated with bone marrow suppression and more gastrointestinal and central nervous system effects than is PTU. Sodium iodide (I\textsuperscript{131}) should not be used in adults in their reproductive years unless they are aware of the possibility of adverse effects on fertility.

Alendronate and risedronate are commonly used drugs for osteoporosis and calcium lowering. Serum calcium levels need to be monitored carefully with any of the drugs that affect calcium levels. Patients should be encouraged to take calcium and vitamin D in their diet or as supplements in cases of hypocalcemia, and also for prevention and treatment of osteoporosis.

Thyroid replacement therapy is necessary during pregnancy for women who have been maintained on this regimen. It is not uncommon for hypothyroidism to develop during pregnancy. Levothyroxine is again the drug of choice.

If an antithyroid drug is essential during pregnancy, PTU is the drug of choice because it is less likely to cross the placenta and cause problems for the fetus. Radioactive agents should not be used. Bisphosphonates should be used during pregnancy only if the benefit to the mother clearly outweighs the potential risk to the fetus. Nursing mothers who need thyroid replacement therapy should continue with their prescribed regimen and report any adverse reactions in the baby. Bisphosphonates and antithyroid drugs should not be used during lactation because of the potential for adverse reactions in the baby; another method of feeding the baby should be used.

**Older Adults**
Because the signs and symptoms of thyroid disease mimic many other problems that are common to older adults—hair loss, slurred speech, fluid retention, heart failure, and so on—it is important to screen older adults for thyroid disease carefully before beginning any therapy. The dose should be started at a very low level and increased based on the patient response. Levothyroxine is the drug of choice for hypothyroidism. Periodic monitoring of thyroid hormone levels, as well as cardiac and other responses, is essential with this age group.

If antithyroid agents are needed, sodium iodide (I\textsuperscript{131}) may be the drug of choice because it has fewer adverse effects than the other agents and surgery. The patient should be monitored closely for the development of hypothyroidism, which usually occurs within a year after initiation of antithyroid therapy.

Older adults may have dietary deficiencies related to calcium and vitamin D. They should be encouraged to eat dairy products and foods high in calcium and to supplement their diet if necessary. Postmenopausal women, who are prone to develop osteoporosis, may want to consider hormone replacement therapy and calcium supplements to prevent osteoporosis. Many postmenopausal women, and some older men, respond well to the effect of bisphosphonates in moving calcium back into the bone. They need specific instructions on the proper way to take these drugs and may not be able to comply with the restrictions about staying upright and swallowing the tablet with a full glass of water.

Older adults have a greater incidence of renal impairment, and kidney function should be evaluated before starting any of these drugs. Bisphosphonates should be used in lower doses in patients with moderate renal impairment and are not recommended for those who have severe renal impairment. With any of these drugs, regular monitoring of calcium levels is important to ensure that therapeutic effects are achieved with a minimum of adverse effects.
Hypothyroidism

**Hypothyroidism** is a lack of sufficient levels of thyroid hormones to maintain a normal metabolism. This condition occurs in a number of pathophysiological states:

- Absence of the thyroid gland
- Lack of sufficient iodine in the diet to produce the needed level of thyroid hormone
- Lack of sufficient functioning thyroid tissue due to tumor or autoimmune disorders
- Lack of TSH due to pituitary disease
- Lack of TRH related to a tumor or disorder of the hypothalamus

Hypothyroidism is the most common type of thyroid dysfunction. It is estimated that approximately 5% to 10% of women older than 50 years of age are hypothyroid. Hypothyroidism is also a common finding in elderly men. The symptoms of hypothyroidism can be varied and vague, such as obesity and fatigue (Box 37.2), and are frequently overlooked or mistaken for signs of normal aging (Table 37.1).

Children who are born without a thyroid gland or who have a nonfunctioning gland develop a condition called **cretinism**. If untreated, these children will have poor growth and development and mental retardation because of the lack of thyroid hormone stimulation. Severe adult hypothyroidism is called **myxedema**. Myxedema usually develops gradually as the thyroid slowly stops functioning. It can develop as a result of autoimmune thyroid disease (Hashimoto disease), viral infection, or overtreatment with antithyroid drugs or because of surgically removing or irradiation of the thyroid gland. Patients with myxedema exhibit many signs and symptoms. Hypothyroidism is treated with replacement thyroid hormone therapy.

Hyperthyroidism

**Hyperthyroidism** occurs when excessive amounts of thyroid hormones are produced and released into the circulation. Graves disease, a poorly understood condition that is thought to be an autoimmune problem, is the most common cause of hyperthyroidism. Goiter (enlargement of the thyroid gland) is an effect of hyperthyroidism, which occurs when the thyroid is overstimulated by TSH. This can happen if the thyroid gland does not make sufficient thyroid hormones to turn off the hypothalamus and anterior pituitary; in the body’s attempt to produce the needed amount of thyroid hormone, the thyroid is continually stimulated by increasing levels of TSH. Additional signs and symptoms of hyperthyroidism can be found in Table 37.1.

Hyperthyroidism may be treated by surgical removal of the gland or portions of the gland, treatment with radiation to destroy parts or all of the gland, or drug treatment to block the production of **thyroxine** in the thyroid gland or to destroy parts or all of the gland. The metabolism of these patients then must be regulated with replacement thyroid hormone therapy.

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**BOX 37.2 The Evidence**

**Thyroid Hormones for Obesity**

Treatment trends for obesity have changed over the years. Not long ago, one of the suggested treatments was the use of thyroid hormone. The thinking was that obese people had slower metabolic rates and therefore would benefit from a boost in metabolism from extra thyroid hormone.

If an obese patient is truly hypothyroid, this might be a good idea. Unfortunately, many of the patients who received thyroid hormone for weight loss were not tested for thyroid activity and ended up with excessive thyroid hormone in their systems. This situation triggered a cascade of events. The exogenous thyroid hormone disrupted the hypothalamic–pituitary–thyroid control system, resulting in decreased production of thyrotropin-releasing hormone (TRH) and thyroid-stimulating hormone (TSH) as the hypothalamus and pituitary sensed the rising levels of thyroid hormone. Because the thyroid was no longer stimulated to produce and secrete thyroid hormone, thyroid levels would actually fall. Lacking stimulation by TSH, the thyroid gland would start to atrophy. If exogenous thyroid hormone were stopped, the atrophied thyroid would not be able to immediately respond to the TSH stimulation and produce thyroid hormone. Ultimately, these patients experienced an endocrine imbalance. What’s more, they also did not lose weight—and in the long run may actually have gained weight as the body’s compensatory mechanisms tried to deal with the imbalances.

Today, thyroid hormone is no longer considered a good choice for treating obesity. Other drugs have come and gone, and new drugs are released each year to attack other aspects of the problem. Many patients, especially middle-aged people who may recall that thyroid hormone was once used for weight loss, ask for it as an answer to their weight problem. Patients have even been known to “borrow” thyroid replacement hormones from others for a quick weight loss solution or to order the drug over the Internet without supervision or monitoring.

Obese patients need reassurance, understanding, and education about the risks of borrowed thyroid hormone. Insistent patients should undergo thyroid function tests. If the results are normal, patients should receive teaching about the controls and actions of thyroid hormone in the body and an explanation of why taking these hormones can cause problems. Obesity is a chronic and frustrating problem that poses continual challenges for health care providers.
KEY POINTS

➧ The thyroid gland uses iodine to produce the thyroid hormones that regulate body metabolism.

➧ Control of the thyroid gland involves an intricate balance among TRH, TSH, and circulating levels of thyroid hormone.

➧ Hypothyroidism is treated with replacement thyroid hormone; hyperthyroidism is treated with thioamides or iodines.

THYROID AGENTS

When thyroid function is low, thyroid hormone needs to be replaced to ensure adequate metabolism and homeostasis in the body. When thyroid function is too high, the resultant systemic effects can be serious, and the thyroid will need to be removed or destroyed pharmacologically. Then the hormone normally produced by the gland will need to be replaced with thyroid hormone. Thyroid agents include thyroid hormones and antithyroid drugs, which are further classified as thioamides and iodine solutions. Table 37.2 includes a complete list of each type of thyroid agent.

Thyroid Hormones

Several replacement hormone products are available for treating hypothyroidism. These hormones replace the low or absent levels of natural thyroid hormone and suppress the overproduction of TSH by the pituitary. The products can contain both natural and synthetic thyroid hormone. Levothyroxine (Synthroid, Levoxyl, Levothroid), a synthetic salt of T4, is the most frequently used replacement hormone because of its predictable bioavailability and reliability. Desiccated thyroid (Armour Thyroid and others) is prepared from dried animal thyroid glands and contains both T3 and T4; although the ratio of the hormones is unpredictable and the required dose and effects vary widely, this drug is inexpensive, making it attractive to some. Additional thyroid hormones include liothyronine (Cytomel, Triostat), a synthetic salt of T3, and liotrix (Thyrolar), a synthetic preparation of T4 and T3 in a standard 4:1 ratio.

Therapeutic Actions and Indications

The thyroid replacement hormones increase the metabolic rate of body tissues, increasing oxygen consumption, respiration, heart rate, growth and maturation, and the metabolism of fats, carbohydrates, and proteins. They are indicated for replacement therapy in hypothyroid states, treatment of myxedema coma, suppression of TSH in the treatment and prevention of goiters, and management of thyroid cancer. In conjunction with antithyroid drugs, they also are indicated to treat thyroid toxicity, prevent goiter formation during thyroid overstimulation, and treat thyroid overstimulation during pregnancy. See Table 37.2 for usual indications for each drug.

Pharmacokinetics

These drugs are well absorbed from the gastrointestinal (GI) tract and bound to serum proteins. Because it contains only
T₃, liothyronine has a rapid onset and a long duration of action. Deiodination of the drugs occurs at several sites, including the liver, kidney, and other body tissues. Elimination is primarily in the bile. Thyroid hormone does not cross the placenta and seems to have no effect on the fetus. Thyroid replacement therapy should not be discontinued during pregnancy, and the need for thyroid replacement often becomes apparent or increases during pregnancy. Thyroid hormone does enter breast milk in small amounts. Caution should be used during lactation.

**TABLE 37.2 DRUGS IN FOCUS**

<table>
<thead>
<tr>
<th>Drug Name</th>
<th>Dosage/Route</th>
<th>Usual Indications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Thyroid Hormones</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| levothyroxine (Synthroid, Levoxyl, Levothroid, others) | Adult: 0.05–0.2 mg/d PO  
Pediatric: 0.025–0.4 mg/d PO | Replacement therapy in hypothyroidism; suppression of thyroid-stimulating hormone (TSH) release; treatment of myxedema coma and thyrotoxicosis |
| liothyronine (Cytomel, Triostat) | Adult: 25–100 mcg/d PO  
Pediatric: 20–50 mcg/d PO | Replacement therapy in hypothyroidism; suppression of TSH release; treatment of thyrotoxicosis; synthetic hormone used in patients allergic to desiccated thyroid |
| liotrix (Thyrolar)         | Adult: 60–120 mg/d PO  
Pediatric: 25–150 mcg/d PO based on age and weight | Replacement therapy in hypothyroidism; suppression of TSH release; treatment of thyrotoxicosis |
| thyroid desiccated (Armour Thyroid) | Adult: 60–120 mg/d PO  
Pediatric: 15–90 mg/d PO | Replacement therapy in hypothyroidism; suppression of TSH release; treatment of thyrotoxicosis |
| **Antithyroid Agents**     |                                    |                                                                                   |
| **Thioamides**             |                                    |                                                                                   |
| methimazole (Tapazole)     | Adult: 15 mg/d PO initially, up to 30–60 mg/d may be needed; maintenance, 5–15 mg/d PO  
Pediatric: 0.4 mg/kg per day PO initially; maintenance, 15–20 mg/m² per day PO in three divided doses | Treatment of hyperthyroidism |
| propylthiouracil           | Adult: 300–900 mg/d PO initially; maintenance, 100–150 mg/d PO  
Pediatric: 50–300 mg/d PO based on age and response | Treatment of hyperthyroidism |
| **Iodine solutions**       |                                    |                                                                                   |
| sodium iodide¹³¹ (generic, radioactive iodine) | Adult (>30 yr): 4–10 millicuries PO as needed | Treatment of hyperthyroidism; thyroid blocking in radiation emergencies; destruction of thyroid tissue in patients who are not candidates for surgical removal of the gland |
| strong iodine solution, potassium iodide (Thyro-Block) | Adult: one tablet, or 2–6 drops (gtt) PO daily to t.i.d.  
Pediatric (>1 yr): adult dose  
Pediatric (<1 yr): ½ tablet or 3 gtt PO daily to t.i.d. | Treatment of hyperthyroidism, thyroid blocking in radiation emergencies; presurgical suppression of the thyroid gland, treatment of acute thyrotoxicosis until thiouamide levels can take effect |

**Contraindications and Cautions**

These drugs should not be used with any known allergy to the drugs or their binders to prevent hypersensitivity reactions, during acute thyrotoxicosis (unless used in conjunction with antithyroid drugs), or during acute myocardial infarction (unless complicated by hypothyroidism) because the thyroid hormones could exacerbate these conditions. Caution should be used during lactation because the drug enters breast milk and could suppress the infant’s thyroid production, and with
hypoadrenal conditions such as Addison disease. Liothyronine and liotrix have a greater incidence of cardiac side effects and are not recommended for use in patients with potential cardiac problems or patients who are prone to anxiety reactions.

Adverse Effects

When the correct dose of the replacement therapy is being used, few if any adverse effects are associated with these drugs. Skin reactions and loss of hair are sometimes seen, especially during the first few months of treatment in children. Symptoms of hyperthyroidism may occur as the drug dose is regulated. Some of the less predictable effects are associated with cardiac stimulation (arrhythmias, hypertension), central nervous system (CNS) effects (anxiety, sleeplessness, headache), and difficulty swallowing (taking the drug with a full glass of water may help).

Clinically Important Drug–Drug Interactions

Decreased absorption of the thyroid hormones occurs if they are taken concurrently with cholestyramine. If this combination is needed, the drugs should be taken 2 hours apart.

The effectiveness of oral anticoagulants is increased if they are combined with thyroid hormone. Because this may lead to increased bleeding, the dose of the oral anticoagulant should be reduced and the bleeding time checked periodically.

Decreased effectiveness of digitalis glycosides can occur when these drugs are combined. Consequently, digitalis levels should be monitored, and increased dose may be required.

Theophylline clearance is decreased in hypothyroid states. As the patient approaches normal thyroid function, theophylline dose may need to be adjusted frequently.

Prototype Summary: Levothyroxine

**Indications:** Replacement therapy in hypothyroidism; pituitary TSH suppression in the treatment of euthyroid goiters and in the management of thyroid cancer; thyrotoxicosis in conjunction with other therapy.

**Actions:** Increases the metabolic rate of body tissues, increasing oxygen consumption, respiration, and heart rate; the rate of fat, protein, and carbohydrate metabolism; and growth and maturation.

**Pharmacokinetics:**

<table>
<thead>
<tr>
<th>Route</th>
<th>Onset</th>
<th>Peak</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO</td>
<td>Slow</td>
<td>1–3 wk</td>
<td>1–3 wk</td>
</tr>
<tr>
<td>IV</td>
<td>6–8 h</td>
<td>24–48 h</td>
<td>unknown</td>
</tr>
</tbody>
</table>

T$_{1/2}$: 6 to 7 days; metabolized in the liver and excreted in the bile.

**Adverse effects:** Tremors, headache, nervousness, palpitations, tachycardia, allergic skin reactions, loss of hair in the first few months of therapy in children, diarrhea, nausea, vomiting.

**Nursing Considerations for Patients Receiving Thyroid Hormones**

**Assessment: History and Examination**

- Assess for history of allergy to any thyroid hormone or binder, lactation, Addison disease, acute myocardial infarction not complicated by hypothyroidism, and thyrotoxicosis, which could be contraindications or cautions to use of the drug.
- Assess for the presence of any skin lesions; orientation and affect; baseline pulse, blood pressure, and electrocardiogram (ECG); respiration and adventitious sounds; and thyroid function tests, to determine baseline status before beginning therapy and for any potential adverse effects.

Refer to the Critical Thinking Scenario for a full discussion of nursing care for a patient who is receiving a thyroid hormone.

**Nursing Diagnoses**

Nursing diagnoses related to drug therapy might include the following:

- Decreased Cardiac Output related to cardiac effects
- Imbalanced Nutrition: Less Than Body Requirements related to changes in metabolism
- Ineffective Tissue Perfusion related to thyroid activity
- Deficient Knowledge regarding drug therapy

**Implementation With Rationale**

- Administer a single daily dose before breakfast each day to ensure consistent therapeutic levels.
- Administer with a full glass of water to help prevent difficulty swallowing.
- Monitor response carefully when beginning therapy to adjust dose according to patient response.
- Monitor cardiac response to detect cardiac adverse effects.
- Assess patient carefully to detect any potential drug–drug interactions if giving thyroid hormone in combination with other drugs.
- Arrange for periodic blood tests of thyroid function to monitor the effectiveness of the therapy.
- Provide thorough patient teaching, including drug name, dosage and administration, measures to avoid adverse effects, warning signs of problems, and the need for regular evaluation if used for longer than recommended, to enhance patient knowledge of drug therapy and promote compliance.

**Evaluation**

- Monitor patient response to the drug (return of metabolism to normal, prevention of goiter).
- Monitor for adverse effects (tachycardia, hypertension, anxiety, skin rash).
- Evaluate the effectiveness of the teaching plan (patient can name drug, dosage, adverse effects to watch for, and specific measures to avoid them).
THE SITUATION

H.R., a 38-year-old white woman, complains of “exhaustion, lethargy, and sleepiness.” Her past history is sketchy, her speech seems slurred, and her attention span is limited. Mr. R., her husband, reports feeling frustrated with H.R., stating that she has become increasingly lethargic, disorganized, and uninvolved at home. He also notes that she has gained weight and lost interest in her appearance. Physical examination reveals the following remarkable findings: pulse rate, 52/minute; blood pressure, 90/62 mm Hg; temperature, 96.8°F (oral); pale, dry, and thick skin; periorbital edema; thick and asymmetric tongue; height, 5 ft 5 in; weight, 165 lb. The immediate impression is that of hypothyroidism. Laboratory tests confirm this revealing elevated TSH and very low levels of triiodothyronine (T3) and thyroxine (T4).

Synthroid, 0.2 mg daily PO, is prescribed.

CRITICAL THINKING

What teaching plans should be developed for this patient? What interventions would be appropriate in helping Mr. and Mrs. R. accept the diagnosis and the pathophysiological basis for Mrs. R’s complaints and problems? What body image changes will H.R. experience as her body adjusts to the thyroid therapy? How can H.R. be helped to adjust to these changes and re-establish her body image and self-concept?

DISCUSSION

Hypothyroidism develops slowly. With it comes fatigue, lethargy, and lack of emotional affect—conditions that result in the patient’s losing interest in appearance, activities, and responsibilities. In this case, the patient’s husband, not knowing that there was a physical reason for the problem, became increasingly frustrated and even angry. Mr. R. should be involved in the teaching program so that his feelings can be taken into consideration. Any teaching content should be written down for later reference. (When H.R. starts to return to normal, her attention span and interest should return; anything that was missed or forgotten can be referred to in the written teaching program.)

H.R. may be encouraged to bring a picture of herself from a year or so ago to help her to understand and appreciate the changes that have occurred. Many patients are totally unaware of changes in their appearance and activity level because the disease progresses so slowly and brings on lethargy and lack of emotional affect.

The teaching plan should include information about the function of the thyroid gland and the anticipated changes that will be occurring to H.R. over the next week and beyond. The importance of taking the medication daily should be emphasized. The need to return for follow-up to evaluate the effectiveness of the medication and the effects on her body should also be stressed. Both H.R. and her husband will need support and encouragement to deal with past frustrations and the return to normal. Lifelong therapy will probably be needed, so further teaching will be important once things have stabilized.

NURSING CARE GUIDE FOR H.R.: THYROID HORMONE

Assessment: History and Examination

Review the patient’s history for allergies to any of these drugs, Addison disease, acute myocardial infarction not complicated by hypothyroidism, lactation, and thyrotoxicosis. Focus the physical examination on the following:

Neurological: orientation and affect
Skin: color and lesions
CV: pulse, cardiac auscultation, blood pressure, and electrocardiogram finding
Respiratory: respirations, adventitious sounds
Hematological: thyroid function tests

Nursing Diagnoses

Decreased Cardiac Output related to cardiac effects
Imbalanced Nutrition: Less Than Body Requirements related to effects on metabolism
Ineffective Tissue Perfusion related to thyroid effects
Deficient Knowledge regarding drug therapy

Implementation

Administer the drug once a day before breakfast with a full glass of water.
Provide comfort, safety measures (e.g., temperature control, rest as needed, safety precautions).
Provide support and reassurance to deal with drug effects and lifetime need.
Provide patient teaching regarding drug name, dosage, adverse effects, precautions, and warning signs to report.

Evaluation

Evaluate drug effects: return of metabolism to normal; prevention of goiter.
Monitor for adverse effects: anxiety, tachycardia, hypertension, skin reaction.
Monitor for drug–drug interactions as indicated for each drug. Evaluate the effectiveness of the patient teaching program and comfort and safety measures.
Antithyroid Agents

Drugs used to block the production of thyroid hormone and to treat hyperthyroidism include the thioamides and iodide solutions (Table 37.2). Although these groups of drugs are not chemically related, they both block the formation of thyroid hormones within the thyroid gland (see Therapeutic Actions and Indications).

Therapeutic Actions and Indications

The Thioamides

Thioamides lower thyroid hormone levels by preventing the formation of thyroid hormone in the thyroid cells, which lowers the serum levels of thyroid hormone. They also partially inhibit the conversion of T4 to T3 at the cellular level. These drugs are indicated for the treatment of hyperthyroidism. Thioamides include propylthiouracil (PTU) and methimazole (Tapazole).

Iodine Solutions

Low doses of iodine are needed in the body for the formation of thyroid hormone. High doses, however, block thyroid function. Therefore, iodine preparations are sometimes used to treat hyperthyroidism but are not used as often as the ones were in the clinical setting (see Pharmacokinetics). The iodine solutions cause the thyroid cells to become over saturated with iodine and stop producing thyroid hormone. In some cases, the thyroid cells are actually destroyed. Radioactive iodine (sodium iodide I131) is taken up into the thyroid cells, which are then destroyed by the beta-radiation given off by the radioactive iodine. Except during radiation emergencies, the use of sodium iodide is reserved for those patients who are not eligible for surgery, women who cannot become pregnant, and elderly patients with such severe, complicating conditions that immediate thyroid destruction is needed. Iodine solutions include strong iodine solution, potassium iodide (Thyro-Block), and sodium iodide I131 (generic). See Table 37.2 for usual indications for each drug.

Pharmacokinetics

Thioamides

These drugs are well absorbed from the GI tract and are then concentrated in the thyroid gland. The onset and duration of PTU varies with each patient. Methimazole has an onset of action of 30 to 40 minutes and peaks in about 60 minutes. Some excretion can be detected in the urine. Methimazole crosses the placenta and is found in a high ratio in breast milk. PTU has a low potential for crossing the placenta and for entering breast milk (see Contraindications and Cautions).

Iodine Solutions

These drugs are rapidly absorbed from the GI tract and widely distributed throughout the body fluids. Excretion occurs through the urine. Strong iodine products, potassium iodide, and sodium iodide are taken orally and have a rapid onset of action, with effects seen within 24 hours and peak effects seen in 10 to 15 days. The effects are short lived and may even precipitate further thyroid enlargement and dysfunction (see Adverse Effects). For this reason, and because of the
availability of the more predictable thioamides, iodides are not used as often as they once were in the clinical setting. The strong iodine products cross the placenta and are known to enter breast milk, but the effects on the neonate are not known. Sodium iodide I\textsuperscript{131} enters breast milk and is rated pregnancy category X (see Contraindications and Cautions).

**Contraindications and Cautions**

Antithyroid agents are contraindicated in the presence of any known allergy to antithyroid drugs to prevent hypersensitivity reactions and during pregnancy because of the risk of adverse effects on the fetus and the development of cretinism. (If an antithyroid drug is absolutely essential and the mother has been informed about the risk of cretinism in the infant, PTU is the drug of choice, but caution should still be used.) Another method of feeding the baby should be chosen if an antithyroid drug is needed during lactation because of the risk of antithyroid activity in the infant, including the development of a neonatal goiter. (Again, if an antithyroid drug is needed, PTU is the drug of choice.)

Use of strong iodine products is also contraindicated with pulmonary edema or pulmonary tuberculosis.

**Safe Medication Administration**

Name confusion has been reported between propylthiouracil (PTU) and Purinethol (mercaptopurine), an antineoplastic agent. Serious adverse effects could occur. Use extreme caution when using these drugs.

**Adverse Effects**

**Thioamides**

The adverse effects most commonly seen with thioamides are the effects of thyroid suppression: drowsiness, lethargy, bradycardia, nausea, skin rash, and so on. PTU is associated with nausea, vomiting, and GI complaints. GI effects are somewhat less pronounced with methimazole, so it may be the drug of choice for patients who are unable to tolerate PTU. Methimazole is also associated with bone marrow suppression, so the patient using this drug must have frequent blood tests to monitor for this effect.

**Iodine Solutions**

The most common adverse effect of iodine solutions is hypothyroidism; the patient will need to be started on replacement thyroid hormone to maintain homeostasis. Other adverse effects include iodism (metallic taste and burning in the mouth, sore teeth and gums, diarrhea, cold symptoms, and stomach upset), staining of teeth, skin rash, and the development of goiter.

Sodium iodide (radioactive I\textsuperscript{131}) is usually reserved for use in patients who are older than 30 years of age because of the adverse effects associated with the radioactivity.

**Clinically Important Drug-Drug Interactions**

**Thioamides**

An increased risk for bleeding exists when PTU is administered with oral anticoagulants. Changes in serum levels of theophylline, metoprolol, propranolol, and digoxin may lead to changes in the effects of PTU as the patient moves from the hyperthyroid to the euthyroid state.

**Iodine Solutions**

Because the use of drugs to destroy thyroid function moves the patient from hyperthyroidism to hypothyroidism, patients who are taking drugs that are metabolized differently in hypothyroid and hyperthyroid states or have a small margin of safety that could be altered by the change in thyroid function should be monitored closely. These drugs include anticoagulants, theophylline, digoxin, metoprolol, and propranolol.

**Prototype Summary: Propylthiouracil**

**Indications:** Treatment of hyperthyroidism.

**Actions:** Inhibits the synthesis of thyroid hormones, partially inhibits the peripheral conversion of T\textsubscript{4} to T\textsubscript{3}.

**Pharmacokinetics:**

<table>
<thead>
<tr>
<th>Route</th>
<th>Onset</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO</td>
<td>Varies</td>
</tr>
</tbody>
</table>

**T\textsubscript{1/2}:** 1 to 2 hours; metabolized in the liver and excreted in the urine.

**Adverse effects:** Paresthesias, neuritis, vertigo, drowsiness, skin rash, urticaria, skin pigmentation, nausea, vomiting, epigastric distress, nephritis, bone marrow suppression, arthralgia, myalgia, edema.

** Prototype Summary: Strong Iodine Products**

**Indications:** Adjunct therapy for hyperthyroidism; thyroid blocking in a radiation emergency.

**Actions:** Inhibit the synthesis of thyroid hormones and inhibit the release of these hormones into the circulation.

**Pharmacokinetics:**

<table>
<thead>
<tr>
<th>Route</th>
<th>Onset</th>
<th>Peak</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO</td>
<td>24 h</td>
<td>10–15 d</td>
<td>6 wk</td>
</tr>
</tbody>
</table>

**T\textsubscript{1/2}:** Unknown; metabolized in the liver and excreted in the urine.

**Adverse effects:** Rash, hypothyroidism, goiter, swelling of the salivary glands, iodism (metallic taste, burning mouth and throat, sore teeth and gums, head cold symptoms, stomach upset, diarrhea), allergic reactions.
Nursing Considerations for Patients Receiving Antithyroid Agents

Assessment: History and Examination

- Assess for history of allergy to any antithyroid drug; pregnancy and lactation status; and pulmonary edema or pulmonary tuberculosis if using strong iodine solutions, which could be cautions or contraindications to use of the drug.
- Assess for skin lesions; orientation and affect; baseline pulse, blood pressure, and ECG; respiration and adventitious sounds; and thyroid function tests, to determine baseline status before beginning therapy and for any potential adverse effects.

Nursing Diagnoses

Nursing diagnoses related to drug therapy might include the following:

- Decreased Cardiac Output related to cardiac effects
- Imbalanced Nutrition: More Than Body Requirements related to changes in metabolism
- Risk for Injury related to bone marrow suppression
- Deficient Knowledge regarding drug therapy

Implementation With Rationale

- Administer propylthiouracil three times a day, around the clock, to ensure consistent therapeutic levels.
- Give iodine solution through a straw to decrease staining of teeth; tablets can be crushed.
- Monitor response carefully and arrange for periodic blood tests to assess patient response and to monitor for adverse effects.
- Monitor patients receiving iodine solution for any sign of iodism so the drug can be stopped immediately if such signs appear.
- Provide thorough patient teaching, including measures to avoid adverse effects, warning signs of problems, and the need for regular evaluation if used for longer than recommended, to enhance patient knowledge of drug therapy and promote compliance.

Evaluation

- Monitor patient response to the drug (lowering of thyroid hormone levels).
- Monitor for adverse effects (bradycardia, anxiety, blood dyscrasias, skin rash).
- Evaluate the effectiveness of the teaching plan (patient can name drug, dosage, adverse effects to watch for, and specific measures to avoid them).
- Monitor the effectiveness of comfort measures and compliance to the regimen.

KEY POINTS

- Hypothyroidism, or lower-than-normal levels of thyroid hormone, is treated with replacement thyroid hormone.
- Hyperthyroidism, or higher-than-normal levels of thyroid hormone, is treated with thioamides, which block the thyroid from producing thyroid hormone, or with iodines, which prevent thyroid hormone production or destroy parts of the gland.

THE PARATHYROID GLANDS

The parathyroid glands are four very small groups of glandular tissue located on the back of the thyroid gland (Figure 37.3). The parathyroid glands produce parathyroid hormone, an important regulator of serum calcium levels.

Structure and Function

As mentioned earlier, the parafollicular cells of the thyroid gland produce the hormone calcitonin. Calcitonin responds to high calcium levels to cause lower serum calcium levels and acts to balance the effects of the PTH, which works to elevate calcium levels. PTH is the most important regulator of serum calcium levels in the body. PTH has many actions, including the following:

- Stimulation of osteoclasts or bone cells to release calcium from the bone
- Increased intestinal absorption of calcium
- Increased calcium resorption from the kidneys
- Stimulation of cells in the kidney to produce calcitriol, the active form of vitamin D, which stimulates intestinal transport of calcium into the blood

Control

Calcium is an electrolyte that is used in many of the body’s metabolic processes. These processes include membrane transport systems, conduction of nerve impulses, muscle contraction, and blood clotting. To achieve all of these effects, serum levels of calcium must be maintained between 9 and 11 mg/dL. This is achieved through regulation of serum calcium by PTH and calcitonin (Figure 37.4).

The release of calcitonin is not controlled by the hypothalamic-pituitary axis but is regulated locally at the cellular level. Calcitonin is released when serum calcium levels rise. Calcitonin works to reduce calcium levels by blocking bone resorption and enhancing bone formation. This action pulls calcium out of the serum for deposit into the bone. When serum calcium levels are low, PTH release is stimulated. When serum calcium levels are high, PTH release is blocked.

Another electrolyte—magnesium—also affects PTH secretion by mobilizing calcium and inhibiting the release of PTH when concentrations rise above or fall below normal.
An increased serum phosphate level indirectly stimulates parathyroid activity. Renal tubular phosphate reabsorption is balanced by calcium secretion into the urine, which causes a drop in serum calcium, stimulating PTH secretion. The hormones PTH and calcitonin work together to maintain the delicate balance of serum calcium levels in the body and to keep serum calcium levels within the normal range.

Parathyroid Dysfunction and Related Disorders

Parathyroid dysfunction involves either absence of PTH (hypoparathyroidism) or overproduction of PTH (hyperparathyroidism). This dysfunction can affect any age group. Box 37.1 explains the use of parathyroid agents across the lifespan.

Hypoparathyroidism

The absence of PTH results in a low calcium level (hypocalcemia) and a rarely rare condition called hypoparathyroidism. This is most likely to occur with the accidental removal of the parathyroid glands during thyroid surgery. Treatment consists in calcium and vitamin D therapy to increase serum calcium levels (see section on antihypocalcemic agents).

Hyperparathyroidism

The excessive production of PTH leads to an elevated calcium level (hypercalcemia) and a condition called
hyperparathyroidism. This can occur as a result of parathyroid tumor or certain genetic disorders. The patient presents with signs of high calcium levels (see Table 37.3). Primary hyperparathyroidism occurs more often in women between 60 and 70 years of age. Secondary hyperparathyroidism occurs most frequently in patients with chronic renal failure (see Box 37.3 for more information). When plasma concentrations of calcium are elevated secondary to high PTH levels, inorganic phosphate levels are usually decreased. Pseudohypoparathyroidism (renal fibroplastic osteitis or renal rickets) may occur as a result of this phosphorus retention (hyperphosphatemia), which results from increased stimulation of the parathyroid glands and increased PTH secretion.

The genetically linked disorder Paget disease is a condition of overactive osteoclasts that are eventually replaced by enlarged and softened bony structures. Patients with this disease complain of deep bone pain, headaches, and hearing loss and usually have cardiac failure and bone malformation.

Postmenopausal osteoporosis can occur when dropping levels of estrogen allow calcium to be pulled out of the bone, resulting in a weakened and hollow bone structure. Estrogen normally prevents the deposit of calcium in the bone; osteoporosis is one of the many complications that accompany the loss of estrogen at menopause (Box 37.4).

**KEY POINTS**

- Parathyroid glands produce PTH, which, together with calcitonin, maintain the body's calcium balance.
- A low calcium level (hypocalcemia) is treated with vitamin D and calcium replacement therapy.
- Hypercalcemia and hyperparathyroid states are associated with postmenopausal osteoporosis, Paget disease, and malignancies.

**PARATHYROID AGENTS**

The drugs used to treat disorders associated with parathyroid function are drugs that affect serum calcium levels. There is one parathyroid replacement hormone available and one form

**TABLE 37.3 Signs and Symptoms of Calcium Imbalance**

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>HYPOCALCEMIA</th>
<th>HYPERCALCEMIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central nervous</td>
<td>Hyperactive reflexes, paraesthesias, positive Chvostek and Trousseau signs</td>
<td>Lethargy, personality and behavior changes, polydipsia, stupor, coma</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>Hypertension, prolonged QT interval, edema, and signs of cardiac insufficiency</td>
<td>Hypertension, shortening of the QT interval, atrioventricular block</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>Abdominal spasms and cramps</td>
<td>Anorexia, nausea, vomiting, constipation</td>
</tr>
<tr>
<td>Muscular</td>
<td>Tetany, skeletal muscle cramps, carpopedal spasm, laryngeal spasm, tetany</td>
<td>Muscle weakness, muscle atrophy, ataxia, loss of muscle tone</td>
</tr>
<tr>
<td>Renal</td>
<td>Bone pain, osteomalacia, bone deformities, fractures</td>
<td>Polyuria, flank pain, kidney stones, acute and/or chronic renal insufficiency</td>
</tr>
<tr>
<td>Skeletal</td>
<td>Bone pain, osteomalacia, bone deformities, fractures</td>
<td>Osteopenia, osteoporosis</td>
</tr>
</tbody>
</table>

**BOX 37.3 Treatments for Secondary Hyperparathyroidism**

In 2004, a new drug in a new class of calcimimetic agents, cinacalcet hydrochloride (Sensipar), was approved for treatment of secondary hyperparathyroidism in patients undergoing dialysis for chronic kidney disease and for treatment of hypercalcemia in patients with parathyroid carcinoma. Cinacalcet is a calcimimetic drug that increases the sensitivity of the calcium-sensing receptor to activation by extracellular calcium. In increasing the receptors’ sensitivity, cinacalcet lowers parathyroid hormone (PTH) levels, causing a concomitant decrease in serum calcium levels.

The usual initial adult doses for secondary hyperparathyroidism are 30 mg/d PO, after which PTH, serum calcium, and serum phosphorus levels are monitored to achieve the desired therapeutic effect. The usual dose range is 60 to 180 mg/d. The drug must be used in combination with vitamin D and/or phosphate binders.

For parathyroid carcinoma, the initial dose is 30 mg PO twice a day titrated every 2 to 4 weeks to maintain serum calcium levels within a normal range; 30 to 90 mg twice a day up to 90 mg three to four times daily may be needed. Side effects that the patient may experience include nausea, vomiting, diarrhea, and dizziness.

Another treatment available for secondary hyperparathyroidism related to renal failure is paricalcitol (Zemplar). Paricalcitol is an analogue of vitamin D. Vitamin D levels are decreased in renal disease, leading to an increase in PTH levels and signs and symptoms of hyperparathyroidism. Zemplar is taken orally or can be injected during hemodialysis. The body recognizes the vitamin D and subsequently decreases the synthesis and storage of PTH, allowing a control over calcium levels.

The usual dose is 1 to 4 mcg PO from once a day to three times a week, based on the patient’s calcium levels, or 0.04 to 0.1 mcg/kg injected during hemodialysis. The drug is rapidly absorbed with peak levels within 3 hours. The drug has a half-life of 12 to 20 hours. Patients will need regular serum calcium checks, and dose will be adjusted based on individual response. Adverse effects are usually mild, as long as the calcium levels are monitored. Diarrhea, headache, and mild hypertension have been reported.
of calcitonin; the other drugs affect calcium levels in other ways.

**Antihypocalcemic Agents**

Deficient levels of PTH result in hypocalcemia (calcium deficiency). Vitamin D stimulates calcium absorption from the intestine and restores the serum calcium to a normal level. Hypoparathyroidism is treated primarily with vitamin D and, if necessary, dietary supplements of calcium. However, there is one parathyroid hormone available for therapeutic use, teriparatide (Forteo), a parathyroid hormone genetically engineered from *Escherichia coli* bacteria using recombinant DNA technology. The drug was approved in 2002 to increase bone mass in postmenopausal women and men with primary or hypogonadal osteoporosis who are at high risk for fracture. Additional hypocalcemic agents include calcitriol (Roocaltrol), which is the most commonly used form of vitamin D, and dihydrotachysterol (Hytakerol) (Table 37.4).

**Therapeutic Actions and Indications**

Vitamin D compounds regulate the absorption of calcium and phosphate from the small intestine, mineral resorption in bone, and reabsorption of phosphate from the renal tubules. Working along with PTH and calcitonin to reestablish calcium homeostasis, vitamin D actually functions as a hormone. With the once-daily administration, teriparatide stimulates new bone formation, leading to an increase in skeletal mass. It increases serum calcium and decreases serum phosphorus.

Use of these agents is indicated for the management of hypocalcemia in patients undergoing chronic renal dialysis and for the treatment of hypoparathyroidism; teriparatide is used for the treatment of postmenopausal or hypogonadal osteoporosis (see Table 37.4).**

**Pharmacokinetics**

Calcitriol and dihydrotachysterol are well absorbed from the GI tract and widely distributed throughout the body. They are stored in the liver, fat, muscle, skin, and bones. Calcitriol has a half-life of approximately 5 to 8 hours and a duration of action of 3 to 5 days. Dihydrotachysterol has a shorter half-life of 1 to 3 hours, and the duration of effect is less, usually 1 to 3 days. After being metabolized in the liver, they are primarily excreted in the bile, with some found in the urine (see Contraindications and Cautions for use of these drugs during pregnancy and lactation).

Teriparatide is given by subcutaneous injection every day. It is rapidly absorbed from the subcutaneous tissues, reaching peak concentration within 3 hours. The half-life of teriparatide is about 1 hour. Serum calcium levels will begin to decline after about 6 hours and return to baseline 16 to 24 hours after dosing. Parathyroid hormone is believed to be metabolized in the liver and excreted through the kidneys.

**Contraindications and Cautions**

These drugs should not be used in the presence of any known allergy to any component of the drug, to avoid hypersensitivity reactions, or hypercalcemia or vitamin D toxicity which would be exacerbated by these drugs. At therapeutic levels, these drugs should be used during pregnancy only if the benefit to the mother clearly outweighs the potential for adverse effects on the fetus. Calcitriol has been associated with hypercalcemia (excessive calcium levels in the blood) in the baby when used by nursing mothers. Another method of feeding the baby
should be used if these drugs are needed during lactation. Caution should be used with a history of renal stones or during lactation, when high calcium levels could cause problems.

Teriparatide is associated with osteosarcoma—a bone cancer—in animal studies, so its use is limited to postmenopausal women who have osteoporosis, are at high risk for fractures, and are intolerant to standard therapies and to men with primary or hypogonadal osteoporosis who are at high risk for fracture and are intolerant to standard therapies.

Patients should be informed of the risk of osteosarcoma. These patients should also take supplemental calcium and vitamin D, increase weight-bearing exercise, and decrease risk factors such as smoking and alcohol consumption.

### Adverse Effects

The adverse effects most commonly seen with these drugs are related to GI effects: metallic taste, nausea, vomiting, dry
mouth, constipation, and anorexia. CNS effects such as weakness, headache, somnolence, and irritability may also occur. These are possibly related to the changes in electrolytes that occur with these drugs. Patients with liver or renal dysfunction may experience increased levels of the drugs and/or toxic effects.

Clinically Important Drug–Drug Interactions

The risk of hypermagnesemia increases if these drugs are taken with magnesium-containing antacids. This combination should be avoided.

Reduced absorption of these compounds may occur if they are taken with cholestyramine or mineral oil because they are fat-soluble vitamins. If this combination is used, the drugs should be separated by at least 2 hours.

Prototype Summary: Calcitriol

**Indications:** Management of hypocalcemia in patients on chronic renal dialysis, management of hypocalcemia associated with hypoparathyroidism.

**Actions:** A vitamin D compound that regulates the absorption of calcium and phosphate from the small intestine, mineral resorption in bone, and reabsorption of phosphate from the renal tubules, increasing the serum calcium level.

**Pharmacokinetics:**

<table>
<thead>
<tr>
<th>Route</th>
<th>Onset</th>
<th>Peak</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO</td>
<td>Slow</td>
<td>4 h</td>
<td>3–5 d</td>
</tr>
</tbody>
</table>

T$_{1/2}$: 5 to 8 hours; metabolized in the liver and excreted in the bile.

**Adverse effects:** Weakness, headache, nausea, vomiting, dry mouth, constipation, muscle pain, bone pain, metallic taste.

Nursing Considerations for Patients Receiving Antihypercalcemic Agents

**Assessment: History and Examination**

- Assess for history of allergy to any component of the drugs, hypercalcemia, vitamin toxicity, renal stone, and pregnancy or lactation, which could be cautions or contraindications to use of the drug.
- Assess for the presence of any skin lesions; orientation and affect; liver evaluation; serum calcium, magnesium, and alkaline phosphate levels; and radiographs of bones as appropriate, to determine baseline status before beginning therapy and any potential adverse effects.

**Nursing Diagnoses**

Nursing diagnoses related to drug therapy might include the following:

- Acute Pain related to GI or CNS effects
- Imbalanced Nutrition: Less Than Body Requirements related to GI effects
- Deficient Knowledge regarding drug therapy

Evaluation

- Monitor patient response to the drug (return of serum calcium levels to normal).
- Monitor for adverse effects (weakness, headache, GI effects).
- Evaluate the effectiveness of the teaching plan (patient can name drug, dosage, adverse effects to watch for, and specific measures to avoid them).
- Monitor the effectiveness of comfort measures and compliance with the regimen.

Antihypercalcemic Agents

Drugs used to treat PTH excess or hypercalcemia include the bisphosphonates and calcitonin salmon. These drugs act on the serum levels of calcium and do not suppress the parathyroid gland or PTH (see Table 37.4).

Therapeutic Actions and Indications

Bisphosphonates

The bisphosphonates act to slow or block bone resorption; by doing this, they help to lower serum calcium levels, but they do not inhibit normal bone formation and mineralization. Bisphosphonates include etidronate (Didronel), ibandronate (Boniva), pamidronate (Aredia), risendronate (Actonel), tiludronate (Skelid), alendronate (Fosamax), and zoledronic acid (Zometa). These drugs are used in the treatment of Paget disease and of postmenopausal osteoporosis in women, and alendronate is also used to treat osteoporosis in men. See Table 37.4 for usual indications for each drug.

Calcitonins

The calcitonins are hormones secreted by the thyroid gland to balance the effects of PTH. Currently the only calcitonin readily available is calcitonin salmon (Fortical, Miacalcin). These hormones inhibit bone resorption, lower serum calcium levels in children and in patients with Paget disease, and increase the excretion of phosphate, calcium, and sodium from the kidney. See Table 37.4 for usual indications for each drug.
Pharmacokinetics

**Bisphosphonates**

These drugs are well absorbed from the small intestine and do not undergo metabolism. They are excreted relatively unchanged in the urine. The onset of action is slow, and the duration of action is days to weeks. Patients with renal dysfunction may experience toxic levels of the drug and should be evaluated for a dose reduction. See Contraindications and Cautions for use of these drugs during pregnancy and lactation.

**Calcitonins**

These drugs are metabolized in the body tissues to inactive fragments, which are excreted by the kidneys. Calcitonins cross the placenta and have been associated with adverse effects on the fetus in animal studies. These drugs inhibit lactation in animals; it is not known whether they are excreted in breast milk (see Contraindications and Cautions). Salmon calcitonin can be given by injection or by nasal spray. By either route, peak effects are seen within 40 minutes, and the duration of effect is 8 to 24 hours.

Contraindications and Cautions

**Bisphosphonates**

These drugs should not be used in the presence of hypocalemia, which could be made worse by lowering calcium levels, or with a history of allergy to bisphosphonates to avoid hypersensitivity reactions. Fetal abnormalities have been associated with these drugs in animal trials, and they should not be used during pregnancy unless the benefit to the mother clearly outweighs the potential risk to the fetus or neonate. Extreme caution should be used when nursing because of the potential for adverse effects on the baby. Alendronate should not be used by nursing mothers. Caution should be used in patients with renal dysfunction, which could interfere with excretion of the drug, or with upper GI disease, which could be aggravated by the drug.

Alendronate, ibandronate, and risedronate need to be taken on arising in the morning, with a full glass of water, fully 30 minutes before an other food or be verage, and the patient must then remain upright for at least 30 minutes; taking the drug with a full glass of water and remaining upright for at least 30 minutes facilitates delivery of the drug to the stomach. These drugs should not be given to anyone who is unable to remain upright for 30 minutes after taking the drug because esophageal erosion can occur.

Zoledronic acid should be used cautiously in aspirin-sensitive asthmatic patients. Alendronate and risedronate are now available in a once-a-week formulation to decrease the number of times the patient must take the drug, which should increase compliance with the drug regimen. Ibandronate is available in a once-a-month formulation.

**Calcitonins**

These drugs should be used in pregnancy only if the benefit to the mother clearly outweighs the potential risk to the fetus. They should not be used during lactation because the calcium-lowering effects could cause problems for the baby. Calcitonin salmon should not be used with a known allergy to salmon or fish products. These drugs should be used with caution in patients with renal dysfunction or pernicious anemia, which could be exacerbated by these drugs.

Adverse Effects

**Bisphosphonates**

The most common adverse effects seen with bisphosphonates are headache, nausea, and diarrhea. There is also an increase in bone pain in patients with Paget disease, but this effect usually passes after a few days to a few weeks. Esophageal erosion has been associated with alendronate, ibandronate, and risedronate if the patient has not remained upright for at least 30 minutes after taking the tablets.

**Calcitonins**

The most common adverse effects seen with these drugs are flushing of the face and hands, skin rash, nausea and vomiting, urinary frequency, and local inflammation at the site of injection. Many of these side effects lessen with time, the time varying with each individual patient.

Clinically Important Drug–Drug Interactions

**Bisphosphonates**

Oral absorption of bisphosphonates is decreased if they are taken concurrently with antacids, calcium products, iron, or multiple vitamins. If these drugs need to be taken, they should be separated by at least 30 minutes.

GI distress may increase if bisphosphonates are combined with aspirin; this combination should be avoided if possible.

**Calcitonins**

There are have been no clinically important drug–drug interactions reported with the use of calcitonins.

Prototype Summary: Alendronate

**Indications:** Treatment and prevention of osteoporosis in postmenopausal women and in men; treatment of glucocorticoid-induced osteoporosis; treatment of Paget disease in certain patients.

**Actions:** Slows normal and abnormal bone resorption without inhibiting bone formation and mineralization.

**Pharmacokinetics:**

<table>
<thead>
<tr>
<th>Route</th>
<th>Onset</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO</td>
<td>Slow</td>
<td>Days</td>
</tr>
</tbody>
</table>

T_{1/2}: Greater than 10 days; not metabolized, but excreted in the urine.

**Adverse effects:** Headache, nausea, diarrhea, increased or recurrent bone pain, esophageal erosion.
**Prototype Summary: Calcitonin Salmon**

**Indications:** Paget disease, postmenopausal osteoporosis, emergency treatment of hypercalcemia.

**Actions:** Inhibits bone resorption; lowers elevated serum calcium in children and patients with Paget disease; increases the excretion of filtered phosphate, calcium, and sodium by the kidney.

**Pharmacokinetics:**

<table>
<thead>
<tr>
<th>Route</th>
<th>Onset</th>
<th>Peak</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>IM, SQ</td>
<td>15 min</td>
<td>3–4 h</td>
<td>8–24 h</td>
</tr>
<tr>
<td>Nasal</td>
<td>Rapid</td>
<td>31–39 min</td>
<td>8–24 h</td>
</tr>
</tbody>
</table>

**Adverse effects:** Flushing of face and hands, nausea, vomiting, local inflammatory reactions at injection site, nasal irritation if nasal form is used.

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**Nursing Considerations for Patients Receiving Antihypercalcemic Agents**

**Assessment: History and Examination**

- Assess for history of allergy to any of these products or to fish products with salmon calcitonin to avoid hypersensitivity reaction; pregnancy or lactation; hypocalcemia; and renal dysfunction, which could be cautions or contraindications to use of the drug.
- Assess for the presence of any skin lesions; orientation and affect; abdominal examination; serum electrolytes; and renal function tests, to determine baseline status before beginning therapy and for any potential adverse effects.

**Nursing Diagnoses**

Nursing diagnoses related to drug therapy might include the following:

- Acute Pain related to GI or skin effects
- Imbalanced Nutrition: Less Than Body Requirements related to GI effects
- Anxiety related to the need for parenteral injections (specific drugs)
- Deficient Knowledge regarding drug therapy

**Implementation With Rationale**

- Ensure adequate hydration with any of these agents to reduce the risk of renal complications.
- Arrange for concomitant vitamin D, calcium supplements, and hormone replacement therapy if used to treat postmenopausal osteoporosis.
- Rotate injection sites and monitor for inflammation if using calcitonins to prevent tissue breakdown and irritation.
- Monitor serum calcium regularly to allow for dose adjustment as needed.

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**KEY POINTS**

- The parathyroid glands are located behind the thyroid gland and produce PTH, which works with calcitonin, produced by thyroid cells, to maintain the calcium balance in the body.
- Hypocalcemia, or low levels of calcium, is treated with vitamin D products and calcium replacement therapy.
- Hypercalcemia can occur in postmenopausal osteoporosis and Paget disease, as well as related to malignancy.
- Hypercalcemia is treated with bisphosphonates, which slow or block bone resorption to lower serum calcium levels, or calcitonin, which inhibits bone resorption, lowers serum calcium levels in children and patients with Paget disease, and increases the excretion of phosphate, calcium, and sodium from the kidney.

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**CHAPTER SUMMARY**

- Assess the patient carefully for any potential drug–drug interactions if giving in combination with other drugs to prevent serious effects.
- Arrange for periodic blood tests of renal function if using gallium to monitor for renal dysfunction.
- Provide comfort measures and analgesics to relieve bone pain if it returns as treatment begins.
- Provide thorough patient teaching, including measures to avoid adverse effects, warning signs of problems, the need for regular evaluation if used for longer than recommended, and proper administration of nasal spray, to enhance patient knowledge about drug therapy and promote compliance.

**Evaluation**

- Monitor patient response to the drug (return of calcium levels to normal; prevention of complications of osteoporosis; control of Paget disease).
- Monitor for adverse effects (skin rash; nausea and vomiting; hypocalcemia; renal dysfunction).
- Evaluate the effectiveness of the teaching plan (patient can name drug, dosage, adverse effects to watch for, and specific measures to avoid them).
- Monitor the effectiveness of comfort measures and compliance with the regimen.

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**CHAPTER 37 Thyroid and Parathyroid Agents**
thyroid from producing thyroid hormone, or with iodines, which prevent thyroid hormone production or destroy parts of the gland.

- The parathyroid glands are located behind the thyroid gland and produce PTH, which works with calcitonin, produced by thyroid cells, to maintain the calcium balance in the body.
- Hypocalcemia, or low levels of calcium, is treated with vitamin D products and calcium replacement therapy.
- Hypercalcemia and hypercalcemic states include post-menopausal osteoporosis and Paget disease, as well as hypercalcemia related to malignancy.
- Hypercalcemia is treated with bisphosphonates or calcitonin. Bisphosphonates slow or block bone resorption, which lowers serum calcium levels. Calcitonin inhibits bone resorption, lowers serum calcium levels in children and patients with Paget disease, and increases the excretion of phosphate, calcium, and sodium from the kidney.

WEB LINKS

Patients, health care providers, and students may want to consult the following Internet sources:

- [http://www.the-thyroid-society.org](http://www.the-thyroid-society.org)  Information on thyroid diseases, support groups, treatments, and research.
- [http://www.nof.org](http://www.nof.org)  Information on osteoporosis—support groups, screening, treatment, and research.
- [http://www.osteorec.com](http://www.osteorec.com)  Information on national and international research on osteoporosis and related bone diseases.

CHECK YOUR UNDERSTANDING

Answers to the questions in this chapter can be found in Answers to Check Your Understanding Questions on the CD-Rom in the front of the book.

MULTIPLE CHOICE

Select the best answer to the following.

1. The thyroid gland produces the thyroid hormones T₃ and T₄, which are dependent on the availability of
   a. iodine produced in the liver.
   b. iodine found in the diet.
   c. iron absorbed from the gastrointestinal tract.
   d. parathyroid hormone to promote iodine binding.

2. The thyroid gland is dependent on the hypothalamic–pituitary axis for regulation. Increasing the levels of thyroid hormone (by taking replacement thyroid hormone) would
   a. increase hypothalamic release of TRH.
   b. increase pituitary release of TSH.
   c. suppress hypothalamic release of TRH.
   d. stimulate the thyroid gland to produce more T₃ and T₄.

3. Goiter, or enlargement of the thyroid gland, is usually associated with
   a. hypothyroidism.
   b. iodine deficiency.
   c. hyperthyroidism.
   d. underactive thyroid tissue.

4. Thyroid replacement therapy is indicated for the treatment of
   a. obesity.
   b. myxedema.
   c. Graves disease.
   d. acute thyrotoxicosis.

5. Assessing a patient’s knowledge of his or her thyroid replacement therapy would show good understanding if the patient stated:
   a. “My wife may use some of my drug, since she wants to lose weight.”
   b. “I should only need this drug for about 3 months.”
   c. “I can stop taking this drug as soon as I feel like my old self.”
   d. “I should call if I experience unusual sweating, weight gain, or chills and fever.”

6. Administration of propylthiouracil (PTU) would include giving the drug
   a. once a day in the morning.
   b. around the clock to assure therapeutic levels.
   c. once a day at bedtime to decrease adverse effects.
   d. if the patient is experiencing slow heart rate, skin rash, or excessive bleeding.

7. The parathyroid glands produce PTH, which is important in the body as
   a. a modulator of thyroid hormone.
   b. a regulator of potassium.
   c. a regulator of calcium.
   d. an activator of vitamin D.

8. A drug of choice for the treatment of postmenopausal osteoporosis would be
   a. risedronate.
   b. alendronate.
   c. tiludronate.
   d. calcitriol.
CHAPTER 37 Thyroid and Parathyroid Agents

MULTIPLE RESPONSE

Select all that apply.

1. A patient who is receiving a bisphosphonate for the treatment of postmenopausal osteoporosis should be taught
   a. to also take vitamin D, calcium, and hormone replacement.
   b. to restrict fluids as much as possible.
   c. to take the drug before any food for the day, with a full glass of water.

2. Hypothyroidism is a very common and often missed disorder. Signs and symptoms of hypothyroidism include
   a. increased body temperature.
   b. thickening of the tongue.
   c. bradycardia.
   d. loss of hair.
   e. excessive weight loss.
   f. oily skin.

**BIBLIOGRAPHY AND REFERENCES**
