chapter 49

Antidiabetic Drugs

Key Terms

diabetes mellitus
diabetic ketoacidosis
Escherichia coli
glucagon
glucometer
glycosylated hemoglobin
hyperglycemia
hypoglycemia
insulin
lipodystrophy
secondary failure

Chapter Objectives

On completion of this chapter, the student will:

- Describe the two types of diabetes mellitus.
- Discuss the types, uses, general drug actions, adverse reactions, contraindications, precautions, and interactions of the antidiabetic drugs.
- Discuss important preadministration and ongoing assessment activities the nurse should perform on the patient taking an antidiabetic drug.
- List some nursing diagnoses particular to a patient taking an antidiabetic drug.
- Discuss ways to promote an optimal response to therapy, how to manage common adverse reactions, and important points to keep in mind when educating patients about the use of the antidiabetic drugs.

Insulin, a hormone produced by the pancreas, acts to maintain blood glucose levels within normal limits (60–120 mg/dL). This is accomplished by the release of small amounts of insulin into the bloodstream throughout the day in response to changes in blood glucose levels. Insulin is essential for the utilization of glucose in cellular metabolism and for the proper metabolism of protein and fat.

Diabetes mellitus is a complicated, chronic disorder characterized by either insufficient insulin production by the beta cells of the pancreas or by cellular resistance to insulin. Insulin insufficiency results in elevated blood glucose levels, or hyperglycemia. As a result of the disease, individuals with diabetes are at greater risk for a number of disorders, including myocardial infarction, cerebrovascular accident (stroke), blindness, kidney disease, and lower limb amputations.

Insulin and the oral antidiabetic drugs, along with diet and exercise, are the cornerstones of treatment for diabetes mellitus. They are used to prevent episodes of hypoglycemia and to normalize carbohydrate metabolism.

There are two major types of diabetes mellitus:

- Type 1—Insulin-dependent diabetes mellitus (IDDM). Former names of this type of diabetes mellitus include juvenile diabetes, juvenile-onset diabetes, and brittle diabetes.
- Type 2—Noninsulin-dependent diabetes mellitus (NIDDM). Former names of this type of diabetes mellitus include maturity-onset diabetes, adult-onset diabetes, and stable diabetes.

Those with type 1 diabetes mellitus produce insulin in insufficient amounts and therefore must have insulin supplementation to survive. Type 1 diabetes usually has a rapid onset, occurs before the age of 20 years, produces more severe symptoms than type 2 diabetes, and is more difficult to control. Major symptoms of type 1 diabetes include hyperglycemia, polydipsia (increased thirst), polyphagia (increased appetite), polyuria (increased urination), and weight loss. Treatment of type 1 diabetes is particularly difficult to control because of the lack of insulin production by the pancreas. Treatment requires a strict regimen that typically includes a carefully calculated diet, planned physical activity, home glucose testing several times a day, and multiple daily insulin injections.

Type 2 diabetes mellitus affects about 90% to 95% of individuals with diabetes. Those with type 2 diabetes mellitus either have a decreased production of insulin

by the beta cells of the pancreas or a decreased sensitivity of the cells to insulin, making the cells insulin resistant. Although type 2 diabetes mellitus may occur at any age, the disorder occurs most often after the age of 40 years. The onset of type 2 diabetes is usually insidious, symptoms are less severe than in type 1 diabetes mellitus, and because it tends to be more stable, it is easier to control than type 1 diabetes. Risk factors for type 2 diabetes include:

- Obesity
- Older age
- Family history of diabetes
- History of gestational diabetes (diabetes that develops during pregnancy but disappears when pregnancy is over)
- Impaired glucose tolerance
- Minimal or no physical activity
- Race/ethnicity (African Americans, Hispanic/Latino Americans, American Indians, and some Asian Americans)

Obesity is thought to contribute to type 2 diabetes by placing additional stress on the pancreas, which makes it less able to respond and produce adequate insulin to meet the body's metabolic needs.

Many individuals with type 2 diabetes are able to control the disorder with diet, exercise, and oral antidiabetic drugs. However, about 40% of those with type 2 diabetes do not have a good response to the oral antidiabetic drugs and require the addition of insulin to control the diabetes.

INSULIN

Insulin is a hormone manufactured by the beta cells of the pancreas. It is the principal hormone required for the proper use of glucose (carbohydrate) by the body. Insulin also controls the storage and utilization of amino acids and fatty acids. Insulin lowers blood glucose levels by inhibiting glucose production by the liver.

Insulin is available as purified extracts from beef and pork pancreas and is biologically similar to human insulin. However, these animal source insulins are used less frequently today than in years past. They are being replaced by synthetic insulins, including human insulin or insulin analogs.

Human insulin is derived from a biosynthetic process using strains of ***Escherichia coli*** (recombinant DNA, rDNA). Human insulin appears to cause fewer allergic reactions than does insulin obtained from animal sources. Insulin analogs, insulin lispro, and insulin aspart are newer forms of human insulin made by using recombinant DNA technology and are structurally similar to human insulin.

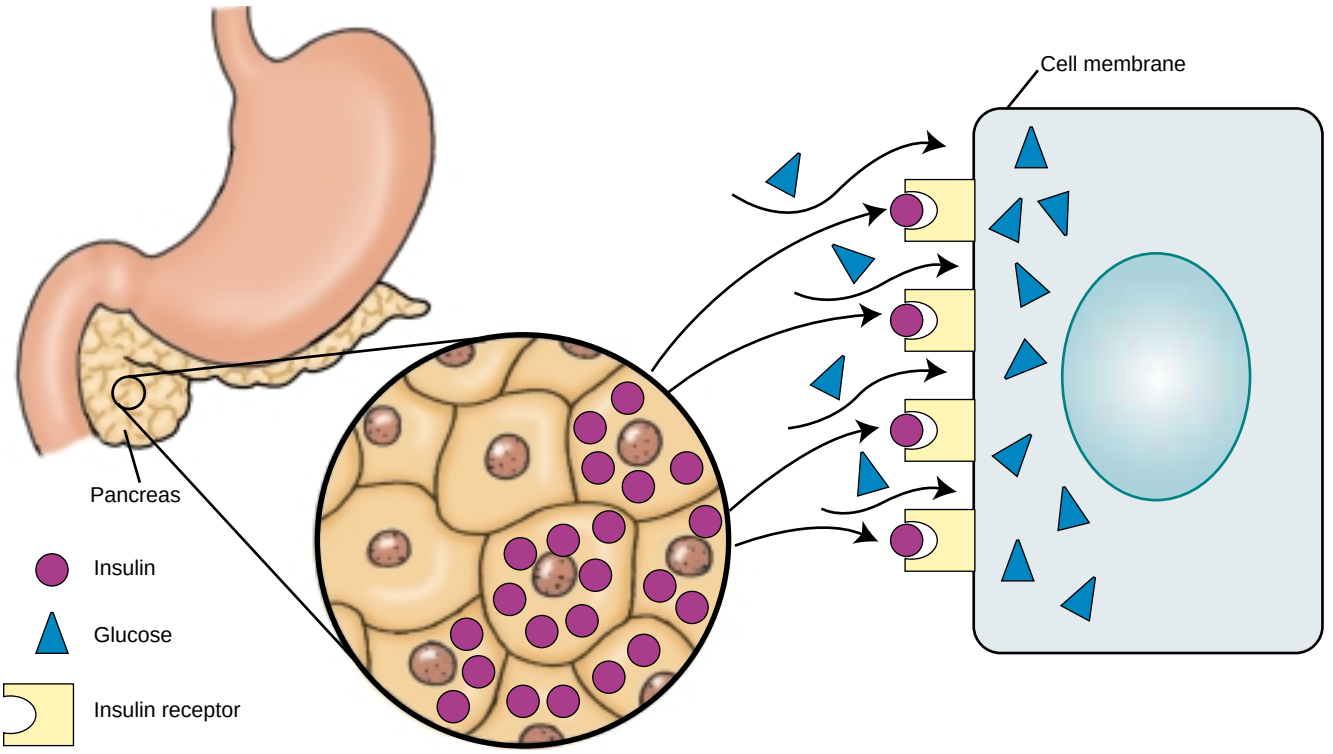


FIGURE 49-1 Normal glucose metabolism. Once insulin binds with receptors on the cell membrane, glucose can move into the cell, promoting cellular metabolism and energy production.

ACTIONS

Insulin appears to activate a process that helps glucose molecules enter the cells of striated muscle and adipose tissue. Figure 49-1 depicts normal glucose metabolism. Insulin also stimulates the synthesis of glycogen by the liver. In addition, insulin promotes protein synthesis and helps the body store fat by preventing its breakdown for energy.

Onset, Peak, and Duration of Action

Onset, peak, and duration are three properties of insulin that are of clinical importance.

- Onset—when insulin first begins to act in the body
- Peak—when the insulin is exerting maximum action
- Duration—the length of time the insulin remains in effect

To meet the needs of those with diabetes mellitus, various insulin preparations have been developed to delay the onset and prolong the duration of action of insulin. When insulin is combined with protamine (a protein), the absorption of insulin from the injection site is slowed and the duration of action is prolonged. The addition of zinc also modifies the onset and duration of action of insulin. Insulin preparations are classified as rapid-acting, intermediate-acting, or long-acting. The Summary Drug Table: Insulin Preparations gives information concerning the onset, peak, and duration of various insulins.

SUMMARY DRUG TABLE INSULIN PREPARATIONS

TYPES OF INSULIN	TRADE NAME	ACTIVITY		
		Onset	Peak	Duration
Rapid-Acting Insulins				
insulin injection (regular)	Humulin R, Iletin II Regular, Novolin R, Novolin R PenFill, Novolin R Prefilled, Velosulin BR	30–60 min	2–4 h	6–8 h
insulin lispro (insulin analog)	Humalog, Humalog Mix 50/50, Humalog Mix 75/25	45 min 30–60 min then 1–2 h	.1 h 2–4 h then 6–12 h	3.5–4.5 h 6–8 h then 8–24 h
insulin aspart solution (insulin analog)	Novolog	5–10 min	30–60 min	2–3 h
Intermediate-Acting Insulin				
isophane insulin suspension (NPH)	Humulin N, Novolin N, Novolin N PenFill, Novolin N Prefilled, NPH Iletin II	1–2 h	6–12 h	18–24 h
insulin zinc suspension (Lente)	Humulin L, Lente Iletin II, Novolin L	1–2.5 h	6–12 h	18–24 h
Long-Acting Insulins				
Insulin glargine solution	Lantus	30–60 min	none	8 h
extended insulin zinc suspension (Ultralente)	Humulin U	4–8 h	8–20 h	24–48 h
Mixed Insulins				
isophane insulin suspension and insulin injections (NPH)	Humulin 70/30, Novolin 70/30, Novolin 70/30 PenFill, Novolin 70/30 Prefilled	30–60 min then 1–2 h	2–4 h then 6–12 h	6–8 h then 18–24 h
isophane insulin suspension and insulin injection	Humulin 50/50	30–60 min then 1–2 h	2–4 h then 6–12 h	6–8 h then 18–24 h
High-Potency Insulin				
insulin injection concentrated	Humulin R Regular U-500			24 h

USES

Insulin is necessary for controlling type 1 diabetes mellitus that is caused by a marked decrease in the amount of insulin produced by the pancreas. Insulin is also used to control the more severe and complicated forms of type 2 diabetes mellitus. However, many patients can control type 2 diabetes with diet and exercise alone or with diet, exercise, and an oral antidiabetic drug (see section "Oral Antidiabetic Drugs"). Insulin may also be used in the treatment of severe diabetic ketoacidosis (DKA) or diabetic coma. Insulin is also used in combination with glucose to treat hypokalemia by producing a shift of potassium from the blood and into the cells.

ADVERSE REACTIONS

The two major adverse reactions seen with insulin administration are **hypoglycemia** (low blood glucose or sugar) and **hyperglycemia** (elevated blood glucose or sugar). The symptoms of hypoglycemia and hyperglycemia are listed in Table 49-1.

Hypoglycemia may occur when there is too much insulin in the bloodstream in relation to the available glucose (hyperinsulinism). Hypoglycemia may occur:

- When the patient eats too little food
- When the insulin dose is incorrectly measured and is greater than that prescribed
- When the patient drastically increases physical activity

Hyperglycemia may occur if there is too little insulin in the bloodstream in relation to the available glucose (hypoinsulinism). Hyperglycemia may occur:

- When the patient eats too much food
- When too little or no insulin is given
- When the patient experiences emotional stress, infection, surgery, pregnancy, or an acute illness

Another potential adverse reaction may be if the patient has an allergy to the animal (pig or cow) from which the insulin is obtained or to the protein or zinc added to insulin. To minimize the possibility of an allergic reaction, some health care providers prescribe human insulin or purified insulin. However, on rare occasions, some individuals become allergic to the human and purified insulins.

An individual can also become insulin resistant because of the development of antibodies against insulin. These patients have impaired receptor function and become so unresponsive to insulin that the daily dose requirement may be in excess of 500 units per day (U/d), rather than the usual 40 to 60 U/d. High-potency insulin in a concentrated form (U500; see the Summary Drug Table: Insulin Preparations) is used for patients requiring more than 200 U/d.

CONTRAINDICATIONS

Insulin is contraindicated in patients with hypersensitivity to any ingredient of the product (eg, beef or pork) and when the patient is hypoglycemic.

PRECAUTIONS

Insulin is used cautiously in patients with renal and hepatic impairment and during pregnancy (Pregnancy Category B and Category C, insulin glargine and insulin

TABLE 49-1 Hypoglycemia Versus Hyperglycemia

SYMPTOMS	HYPOGLYCEMIA (INSULIN REACTION)	HYPERGLYCEMIA (DIABETIC COMA, KETOACIDOSIS)
Onset	Sudden	Gradual (hours or days)
Blood glucose	<60 mg/dL	>200 mg/dL
Central nervous system	Fatigue, weakness, nervousness, agitation, confusion, headache, diplopia, convulsions, dizziness, unconsciousness	Drowsiness, dim vision
Respirations	Normal to rapid, shallow	Deep, rapid (air hunger)
Gastrointestinal	Hunger, nausea	Thirst, nausea, vomiting, abdominal pain, loss of appetite, excessive urination
Skin	Pale, moist, cool, diaphoretic	Dry, flushed, warm
Pulse	Normal or uncharacteristic	Rapid, weak
Miscellaneous	Numbness, tingling of the lips or tongue	Acetone breath

aspart) and lactation (may inhibit milk formation with large doses of insulin). Insulin appears to inhibit milk production in lactating women and could interfere with breastfeeding. Lactating women may require adjustment in insulin dose and diet.

Nursing Alert

Pregnancy makes diabetes more difficult to manage. Insulin requirements usually decrease in the first trimester, increase during the second and third trimester, and decrease rapidly after delivery. The patient with diabetes or a history of gestational diabetes must be encouraged to maintain good metabolic control before conception and throughout pregnancy. Frequent monitoring is necessary.

INTERACTIONS

When certain drugs are administered with insulin, a resultant decrease or increase in hypoglycemic effect can occur. Display 49-1 identifies selected drugs that decrease the hypoglycemic effect of insulin.

Display 49-2 identifies select drugs which, when administered with insulin, may increase the hypoglycemic effect of insulin.

DISPLAY 49-1 ● Select Drugs That Decrease the Hypoglycemic Effect of Insulin

- AIDS antivirals
- albuterol
- contraceptives, oral
- corticosteroids
- diltiazem
- diuretics
- dobutamine
- epinephrine
- estrogens
- lithium
- morphine sulfate
- niacin
- phenothiazines
- thyroid hormones

DISPLAY 49-2 ● Drugs That Increase the Hypoglycemic Effect of Insulin

- alcohol
- angiotensin-converting enzyme (ACE) inhibitors
- antidiabetic drugs, oral
- beta blocking drugs
- calcium
- clonidine
- disopyramide
- lithium
- monoamine oxidase inhibitors (MAOIs)
- salicylates
- sulfonamides
- tetracycline

NURSING PROCESS

● The Patient Receiving Insulin

ASSESSMENT

Preadministration Assessment

If the patient has recently received a diagnosis of diabetes mellitus and has not received insulin or if the patient is known to have diabetes, the initial physical assessment before administering the first dose of insulin includes taking the blood pressure, pulse, and respiratory rate, and weighing the patient. The nurse makes a general assessment of the skin, mucous membranes, and extremities, with special attention given to any sores or cuts that appear to be infected or healing poorly, as well as any ulcerations or other skin or mucous membrane changes. The nurse obtains the following information and includes it in the patient's chart:

- Dietary habits
- Family history of diabetes (if any)
- Type and duration of symptoms experienced

The nurse reviews the patient's chart for recent laboratory and diagnostic tests. If the patient has diabetes and has been receiving insulin, the nurse includes the type and dosage of insulin used, the type of diabetic diet, and the average results of glucose testing in the patient's chart. The nurse evaluates the patient's past compliance to the prescribed therapeutic regimen, such as diet, weight control, and periodic evaluation by a health care provider.

Ongoing Assessment

The number and amount of daily insulin doses, times of administration, and diet and exercise requirements require continual assessment. Dosage adjustments may be necessary when changing types of insulin, particularly when changing from the single-peak to the more pure Humulin insulins.

The nurse must assess the patient for signs and symptoms of hypoglycemia and hyperglycemia (see Table 49-1) throughout insulin therapy. The patient is particularly prone to hypoglycemic reactions at the time of peak insulin action (see the Summary Drug Table: Insulin Preparations) or when the patient has not eaten for some time or has skipped a meal. In acute care settings, frequent blood glucose monitoring is routinely done to help detect abnormalities of blood glucose.

Testing usually occurs before meals and at bedtime (see section on "Managing Hypoglycemia").

Nursing Alert

The nurse must closely observe the patient after administering any insulin, but particularly U500 insulin, because secondary hypoglycemic reactions may occur as long as 24 hours after the administration.

Blood glucose levels are monitored frequently in patients with diabetes. Patients in the acute care setting are monitored closely for hyperglycemia. Insulin needs increase in times of stress or illness. The health care provider may order regular insulin as a supplement to the drug regimen to "cover" any episodes of hyperglycemia. For example, blood glucose levels are monitored every 6 hours or before meals and at bedtime, with insulin prescribed to cover any hyperglycemia detected. This coverage is sometimes referred to as a sliding scale or insulin coverage. Table 49-2 provides an example of a sliding scale by which regular insulin may be administered.

The nurse administers supplemental insulin based on blood glucose readings and the amount of insulin prescribed by the health care provider in the sliding scale. The nurse must notify the health care provider if the blood glucose level is greater than 400 mg/dL.

The primary care provider may prescribe use of a sliding scale at various times, such as every 4 hours, every 6 hours, or at specified times (eg, 7:00 AM, 11:00 AM, 4 PM, and 11 PM), depending on the patient's individual needs.

NURSING DIAGNOSES

Drug-specific nursing diagnoses are highlighted in the Nursing Diagnoses Checklist. Other nursing diagnoses applicable to these drugs are discussed in depth in Chapter 4.

TABLE 49-2 Example of Insulin Administration Using a Sliding Scale

Administer regular humulin insulin subcutaneously 30 minutes before meals and at bedtime according to the following blood glucose levels.

BLOOD GLUCOSE LEVEL	REGULAR HUMULIN INSULIN TO BE ADMINISTERED
150–200 mg/dL	2 U
201–250 mg/dL	4 U
251–300 mg/dL	6 U
301–350 mg/dL	8 U
351–400 mg/dL	10 U
> 400 mg/dL	Call physician

Nursing Diagnoses Checklist

- ✓ **Confusion** related to adverse drug reaction (hypoglycemia)
- ✓ **Anxiety** related to diagnosis, fear of giving own injections, dietary restrictions, other factors (specify)
- ✓ **Ineffective Coping** related to inability to accept diagnosis, other factors (specify)
- ✓ **Fear** related to diagnosis, consequences of diabetes
- ✓ **Ineffective Health Maintenance** related to inability to comprehend drug regimen, lack of equipment to monitor drug effects, lack of knowledge
- ✓ **Risk for Ineffective Therapeutic Regimen Management** related to lack of knowledge, misunderstanding, or complexity of prescribed treatment program, other factors (specify)

PLANNING

The expected outcomes of the patient may include an optimal response to therapy, management of common adverse drug reactions, a reduction in anxiety and fear, improved ability to cope with the diagnosis, and an understanding of and compliance with the prescribed therapeutic regimen.

IMPLEMENTATION

Nursing management of a patient with diabetes requires diligent, skillful, and comprehensive nursing care.

Promoting an Optimal Response to Therapy

There is no standard dose of insulin as there is for most other drugs. Insulin dosage is highly individualized. Sometimes the health care provider finds that the patient achieves best control with one injection of insulin per day; sometimes the patient requires two or more injections per day. In addition, two different types of insulin may be combined, such as a rapid-acting and a long-acting preparation. The number of insulin injections, dosage, times of administration, and type of insulin are determined by the health care provider after careful evaluation of the patient's metabolic needs and response to therapy. The dosage prescribed for the patient may require changes until the dosage is found that best meets the patient's needs.

Nursing Alert

Insulin requirements may change when the patient experiences any form of stress and with any illness, particularly illnesses resulting in nausea and vomiting.

Insulin is ordered by the generic name (insulin zinc suspension, extended) or the trade (brand) name (Humulin U) (see the Summary Drug Table: Insulin Preparations). The nurse must never substitute one brand of insulin for another unless the substitution is approved by the health care provider because some patients may be sensitive to changes in brands of insulin. In addition, it is important never to substitute one type of insulin for another. For example, do not use insulin zinc suspension instead of the prescribed protamine zinc insulin.

Care must be taken when giving insulin to use the correct insulin. Names and packaging are similar and can easily be confused. The nurse carefully reads all drug labels before preparing any insulin preparation. For example, Humalog (insulin lispro) and Humulin R (regular human insulin) are easily confused because of the similar names.

Insulin must be administered via the parenteral route, usually the subcutaneous (SC) route. Insulin cannot be administered orally because it is a protein and readily destroyed in the gastrointestinal tract. Regular insulin is the only insulin preparation given intravenously (IV). Regular insulin is given 30 to 60 minutes before a meal to achieve optimal results.

Insulin aspart is given immediately before a meal (within 5 to 10 minutes of beginning a meal). Insulin lispro is given 15 minutes before a meal or immediately after a meal. Insulin aspart and lispro make insulin administration more convenient for many patients who find taking a drug 30 to 60 minutes before meals bothersome. In addition, insulin lispro (Humalog) appears to lower the blood sugar level 1 to 2 hours after meals better than does regular human insulin because it more closely mimics the body's natural insulin. It also lowers the risk of low blood sugar reactions from midnight to 6 AM in patients with type l diabetes. The longer acting insulins are given before breakfast or at bedtime (depending on the health care provider's instructions). Many patients are maintained on a single dose of intermediate-acting insulin administered SC in the morning.

Insulin glargine is given SC once daily at bedtime. This type of insulin is used in the treatment of adults and children with type 1 diabetes mellitus and in adults with type 2 diabetes who need long-acting insulin for the control of hyperglycemia.

Insulin is available in concentrations of U100 and U500. The nurse must read the label of the insulin bottle carefully for the name, source of insulin (eg, human, beef, pork, beef and pork, purified beef), and the number of units per milliliter (U/mL). The dose of insulin is measured in units (U). U100 insulin has 100 units in each milliliter; U500 has 500 units in each milliliter. Most people with diabetes use the U100 concentration. Patients who are resistant to insulin and require large insulin doses require the U500 concentration.

MIXING INSULINS. If the patient is to receive regular insulin and NPH insulin, or regular and Lente insulin, the nurse must clarify with the health care provider whether two separate injections are to be given or if the insulins may be mixed in the same syringe. If the two insulins are to be given in the same syringe, the short-acting insulin (regular or lispro) is drawn into the syringe first (see Fig. 49-2). Even small amounts of

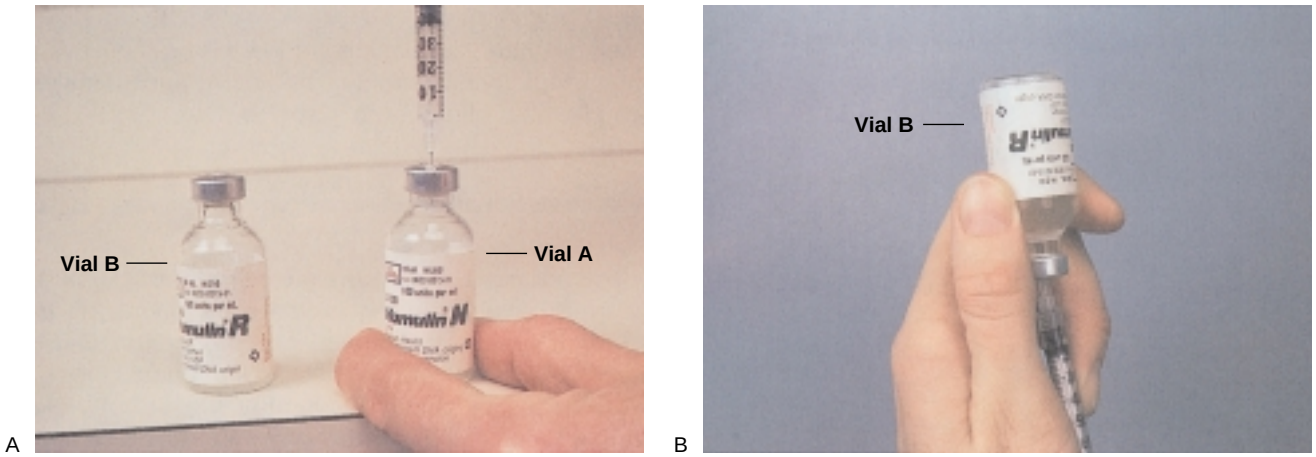


FIGURE 49-2. **(A)** After cleansing tops of both the Humulin R (Regular) insulin and Humulin N (intermediate acting insulin), the nurse injects air into the Humulin N insulin equal to the prescribed dosage of Humulin N. The nurse then injects the amount of air into the prescribed dosage of the regular insulin and withdraws the prescribed dosage of regular insulin into the syringe. **(B)** After removing any air bubbles and determining what the total combined volume of the two insulins would measure, the nurse inverts the vial with the NPH insulin and carefully withdraws the correct volume of medication. *Note*: The nurse must be sure to check medication and dosage again before returning or discarding vials or administering the insulin.

intermediate- or long-acting insulin, if mixed with the short-acting insulin, can bind with the short-acting insulin and delay its onset. (Hint: Regular insulin is clear, whereas intermediate- and long-acting insulins are cloudy. The clear insulin should be drawn up first.) When insulin lispro is mixed with a longer-acting insulin, the insulin lispro is drawn up first.

An unexpected response may be obtained when changing from mixed injections to separate injections or vice versa. If the patient had been using insulin mixtures before admission, the nurse asks whether the insulins were given separately or together.

Several types of premixed insulins are currently available. These insulins combine regular insulin with the longer-acting NPH insulin. The mixtures are available in ratios of 70/30 and 50/50 of NPH to regular. Although these premixed insulins are helpful for patients who have difficulty drawing up their insulin or seeing the markings on the syringe, they prohibit individualizing the dosage. For patients who have difficulty controlling their diabetes, these premixed insulins may not be effective.

Nursing Alert

Do not mix or dilute insulin glargine with any other insulin or solution because glucose control will be lost and the insulin will not be effective.

PREPARING INSULIN FOR ADMINISTRATION. The nurse always checks the expiration date printed on the label of the insulin bottle before withdrawing the insulin. An insulin syringe that matches the concentration of insulin to be given is always used. For example, a syringe labeled as U100 is used only with insulin labeled U100. U500 insulin is given only via the SC route or the intramuscular (IM) route, and may be administered using a tuberculin syringe if necessary.

When insulin is in a suspension (this can be seen when looking at a vial that has been untouched for about 1 hour), the nurse gently rotates the vial between the palms of the hands and tilts it gently end-to-end immediately before withdrawing the insulin. This ensures even distribution of the suspended particles. Care is taken not to shake the insulin vigorously.

The nurse carefully checks the health care provider's order for the type and dosage of insulin immediately before withdrawing the insulin from the vial. All air bubbles must be eliminated from the syringe barrel and hub of the needle before withdrawing the syringe from the insulin vial.

Nursing Alert

Accuracy is of the utmost importance when measuring any insulin preparation because of the potential danger of administering an incorrect dosage. If possible, the nurse should check and compare with another nurse for accuracy of the insulin dosage by comparing the insulin container, the syringe, and the primary health care provider's order before administration.

When regular insulin and another insulin are mixed in the same syringe, the nurse must administer the insulin within 5 minutes of withdrawing the two insulins from the two vials.

ROTATING INJECTION SITES. Insulin may be injected into the arms, thighs, abdomen, or buttocks (see Home Care Checklist: Rotating Insulin Injection Sites). Sites of insulin injection are rotated to prevent **lipodystrophy** (atrophy of SC fat), a problem that can interfere with the absorption of insulin from the injection site. Lipodystrophy appears as a slight dimpling or pitting of the SC fat. Because absorption rates vary at the different sites, with the abdomen having the most rapid rate of absorption, followed by the upper arm, thigh, and buttocks, some health care providers recommend rotating the injection sites within one specific area, rather than rotating areas. For example, all available sites within the abdomen would be used before moving to the thigh.

The nurse carefully plans the pattern of rotation of the injection sites and writes this plan in the patient's chart. Before each dose of insulin is given, the nurse checks the patient's chart for the site of the previous injection and uses the next site (according to the rotation plan) for injection. After giving the injection, the nurse records the site used for injection. Each time insulin is given, previous injection sites are inspected for inflammation, which may indicate a localized allergic reaction. The nurse notes any inflammation or other skin reactions. The nurse reports localized allergic reactions, signs of inflammation, or other skin changes to the health care provider as soon as possible because a different type of insulin may be necessary.

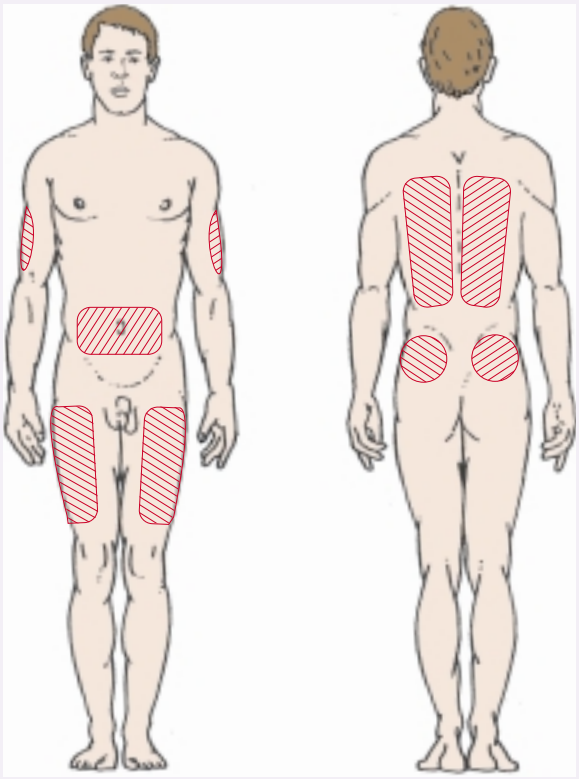
METHODS OF ADMINISTERING INSULIN. Several methods can be used to administer insulin. The most common method is the use of a needle and syringe. Use of microfine needles has reduced the discomfort associated with an injection. Another method is the jet injection system, which uses pressure to deliver a fine stream of insulin below the skin. Another method uses a disposable needle and special syringe. The syringe uses a cartridge that is prefilled with a specific type of insulin (eg, regular human insulin, isophane [NPH] insulin, or a mixture of isophane and regular insulin).

Home Care Checklist

ROTATING INSULIN INJECTION SITES

If your patient must self-administer insulin at home, be sure he or she knows where to inject the insulin and how to rotate the site. Site rotation is crucial to prevent injury to the skin and fatty tissue. Review with the patient appropriate sites, including:

- ☑ Upper arms, outer aspect
- ☑ Stomach, except for a 2-inch margin around the umbilicus
- ☑ Back, right, and left sides just below the waist
- ☑ Upper thighs, both front and side



To rotate sites, teach the patient to do the following:

- ☑ Note the site of the last injection
- ☑ Place the side of his or her thumb at the old site and measure across its width—about 1 inch
- ☑ Select a site on the other side of the thumb for the next injection
- ☑ Repeat the procedure for each subsequent injection
- ☑ Use the same area for a total of about 10 to 15 injections and then move to another area

The desired units are selected by turning a dial and the locking ring.

Another method of insulin delivery is the insulin pump, which is intended for a select group of individuals, such as the pregnant woman with diabetes with early long-term complications and those with, or candidates for, renal transplantation. This system attempts to mimic the body's normal pancreatic function, uses only regular insulin, is battery powered, and requires insertion of a needle into SC tissue. The needle is changed every 1 to 3 days. The amount of insulin injected can be adjusted according to blood glucose monitoring, which is usually done four to eight times per day.

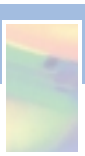
The insulin dosage pattern that most closely follows normal insulin production is a multiple-dose plan sometimes called intensive insulin therapy. In this regimen, a single dose of intermediate- or long-acting insulin is taken in the morning or at bedtime. Small doses of regular insulin are taken before meals based on the patient's blood glucose levels. This allows for greater flexibility in the patient's life-style, but can also be an inconvenience to the patient (eg, the need to always have supplies with them, the lack of privacy, inconvenient schedules).

BLOOD AND URINE TESTING. Blood glucose levels are monitored often in the patient with diabetes. The health care provider may order blood glucose levels to be tested before meals, after meals, and at bedtime. Less frequent monitoring may be performed if the patient's glucose levels are well controlled. The **glucometer** is a device used by the patient with diabetes or the nursing personnel to monitor blood glucose levels. Nursing personnel or the laboratory is responsible for obtaining blood glucose levels during hospitalization, but the patient must be taught to monitor blood glucose levels after dismissal from the acute care setting (see Patient and Family Teaching Checklist: Obtaining a Blood Glucose Reading Using a Glucometer).

Urine testing has been widely used to monitor glucose levels in the past, but this method has largely been replaced with blood glucose monitoring.

Urine testing can play a role in identifying ketone excretion in patients prone to ketoacidosis. If urine testing is done, it is usually recommended that the nurse use the second voided specimen (ie, fresh urine collected 30 minutes after the initial voiding) to check glucose or acetone levels, rather than the first specimen obtained.

Glycosylated hemoglobin (HbA_{1c}) is a blood test used to monitor the patient's average blood glucose level throughout a 3- to 4-month period. When blood glucose levels are high, glucose molecules attach to hemoglobin in the red blood cell. The longer hyperglycemia occurs in the blood, the more glucose binds to the red blood cell and the higher the glycosylated hemoglobin. This binding lasts for the life of the red blood cell (about 4 months). When the patient's diabetes is well controlled with normal or near normal blood glucose levels, the overall HbA_{1c} level will not be greatly elevated. However, if blood glucose levels are consistently high, the HbA_{1c} level will be elevated. The test result (expressed in percentage) refers to the average amount of glucose that has been in the blood throughout the last 4 months. Normal levels vary with the laboratory method used for analysis, but generally levels between 2.5% and 6% indicate good control of the diabetes. Results of 10% or greater indicate poor



Patient and Family Teaching Checklist

Obtaining a Blood Glucose Reading Using a Glucometer

The nurse teaches the patient to:

- ✓ Carefully follow manufacturer's instructions because blood glucose monitoring devices vary greatly.
- ✓ Read all of the manufacturer's instructions before using the glucometer.
- ✓ Prepare the finger using an alcohol wipe to cleanse the area. Wear gloves to comply with the guidelines of the Centers for Disease Control and Prevention (Standard Precautions).
- ✓ Most glucometers require a small sample of capillary blood that is obtained from the fingertip using a spring-loaded lancet.
- ✓ Using the lancet device, perform a finger stick on the side of a finger where there are fewer nerve endings and more capillaries. Milk the finger to produce a large, hanging drop of blood. Use of this technique to obtain a blood sample will help prevent inaccurate readings. Note: Do not smear the blood or try to obtain an extra drop.
- ✓ Drop the blood sample on a reagent test strip, wait 45 to 60 seconds, and then wipe off the excess blood with a cotton ball (some newer glucometers have eliminated the step of excess blood removal from the strip). With these devices, the reagent strip is placed in the glucometer first, allowing all of the blood to remain on the strip for the entire test. Another type of monitoring device uses a sensor cartridge instead of strips to obtain blood glucose levels. The blood is placed on the sensor, and automatic timers provide readings in shorter periods of time than the traditional glucometer.
- ✓ Place the test strip in a glucometer that automatically uses the sample to determine a numerical reading representing the current blood glucose level.
- ✓ The blood glucose level reading should be between 70 and 120 mg/dL.

blood glucose control for the last several months. HbA_{1c} is useful in evaluating the success of treatment of diabetes, comparing new treatment regimens with past regimens used, and in individualizing treatment.

Monitoring and Managing Adverse Reactions

MANAGING HYPOGLYCEMIC REACTIONS. Close observation of the patient with diabetes is important, especially when diabetes is newly diagnosed in the patient, the insulin dosage is changed, the patient is pregnant, the patient has a medical illness or has had surgery, or the patient haÏs failed to adhere to the prescribed diet. Episodes of hypoglycemia are corrected as soon as the symptoms are recognized.

Nursing Alert

The nurse should check the patient for hypoglycemia (see Table 49-1) at the peak time of action of the insulin (see Summary Drug Table: Insulin Preparations). Hypoglycemia, which can develop suddenly, may indicate a need for an adjustment in the insulin dosage or other changes in treatment, such as a change in diet. Hypoglycemic reactions can occur at any time but are most likely to occur when insulin is at its peak activity.

Methods of terminating a hypoglycemic reaction include the administration of one or more of the following:

- Orange juice or other fruit juice
- Hard candy or honey
- Commercial glucose products
- Glucagon by the SC, IM, or IV route
- Glucose 10% or 50% IV

Selection of any one or more of the above methods for terminating a hypoglycemic reaction, as well as other procedures to be followed, such as drawing blood for glucose levels, depends on the written order of the health care provider or hospital policy. The nurse should never give oral fluids or substances (such as candy) used to terminate a hypoglycemic reaction to a patient unless the swallowing and gag reflexes are present. Absence of these reflexes may result in aspiration of the oral fluid or substance into the lungs, which can result in extremely serious consequences and even death. If swallowing and gag reflexes are absent, or if the patient is unconscious, glucose or glucagon is given by the parenteral route.

Glucagon is a hormone produced by the alpha cells of the pancreas; it acts to increase blood sugar by stimulating the conversion of glycogen to glucose in the liver. A return of consciousness is observed within 5 to 20 minutes after parenteral administration of glucagon. Glucagon is effective in treating hypoglycemia only if liver glycogen is available.

The nurse notifies the health care provider of any hypoglycemic reaction, the substance and amount used to terminate the reaction, blood samples drawn (if any), the length of time required for the symptoms of hypoglycemia to disappear, and the current status of the patient. After termination of a hypoglycemic reaction, the nurse closely observes the patient for additional hypoglycemic reactions. The length of time close observation is required depends on the peak and duration of the insulin administered.

Nursing Alert

Hypoglycemic symptoms are more pronounced in patients taking animal-based products than in patients taking human insulin.

MANAGING DIABETIC KETOACIDOSIS. **Diabetic ketoacidosis** (DKA) is a potentially life-threatening deficiency of insulin (hypoinsulinism), resulting in severe hyperglycemia and requiring prompt diagnosis and treatment. Because insulin is unavailable to allow glucose to enter the cell, dangerously high levels of glucose build up in the blood (hyperglycemia). The body, needing energy, begins to break down fat for energy. As fats are broken down, ketones are produced by the liver. As more and more fat is used for energy, higher levels of ketones accumulate in the blood. This increase in ketones disrupts the acid–base balance within the body, leading to DKA. DKA is treated with fluids, correction of acidosis and hypotension, and low-doses of regular insulin.

Nursing Alert

The nurse immediately reports any of the following symptoms of hyperglycemia: elevated blood glucose levels (>200 mg/mL); headache; increased thirst; epigastric pain; nausea; vomiting; hot, dry, flushed skin; restlessness; and diaphoresis (sweating).

Relieving Anxiety and Fear

The patient with newly diagnosed diabetes often has many concerns regarding the diagnosis. For some, initially coping with diabetes and the methods required for controlling the disorder creates many problems. Some of the fears and concerns of these patients may include having to give themselves an injection, having to follow a diet, weight control, the complications associated with diabetes, and changes in eating times and habits. An effective teaching program helps relieve some of this anxiety. The patient in this situation needs time to talk about the disorder, express concerns, and ask questions.

Assisting the Patient With Impaired Adjustment, Coping, and Altered Health Maintenance

The patient with newly diagnosed diabetes may have difficulty accepting the diagnosis, and the complexity of the therapeutic regimen can seem overwhelming. Before patients can be expected to carry out treatment, they must accept that they have diabetes and deal with their feelings about having the disorder. The nurse has an important role in helping these patients gradually accept the diagnosis and begin to understand their feelings. Understanding diabetes may help patients work with health care providers and other medical personnel in managing their diabetes.

Educating the Patient and Family

Noncompliance is a problem with some patients with diabetes, making patient and family teaching vital to the proper management of diabetes. Patients may occasionally lapse in their adherence to the prescribed diet, such as around holidays or other special occasions. This slip may not cause a problem if it is brief and not excessive and if the patient immediately returns to the prescribed regimen. However, some patients frequently stray from the prescribed regimen, take extra insulin to cover dietary indiscretions, fast for several days before follow-up blood glucose determinations, and engage in other dangerous behaviors. Although some patients can be convinced that failure to adhere to the prescribed therapeutic regimen is detrimental to their health, others continue to deviate from the prescribed regimen until serious complications develop. Every effort is made to stress the importance of adherence to the prescribed treatment during the initial teaching session and during follow-up office or clinic visits.

The nurse establishes a thorough teaching plan for all patients with newly diagnosed diabetes, for those who have had any change in the management of their diabetes (eg, diet, insulin type, insulin dosage), and for those whose management has changed because of an illness or disability, such as loss of sight or disabling arthritis. The newly diagnosed patient with diabetes and the family must have an explanation of the disease and methods of treatment as soon as the health care provider has revealed the diagnosis to the patient. The nurse should always individualize the teaching plan because the needs of each patient are different.

Self-monitoring of blood glucose is an important component in the management of diabetes (see Patient and Family Teaching Checklist: Obtaining a Blood Glucose Reading Using a Glucometer). It is the preferred method for monitoring glucose by most health care providers for all patients with diabetes, with variations only in the suggested frequency of testing. If the patient is to use a blood glucose monitoring device, the nurse reviews the method of obtaining a small sample of blood from the finger and the use of the device with the patient. Printed instructions and illustrations are supplied with the device and must be reviewed with the patient. The nurse encourages the patient to purchase the brand recommended by the health care provider. Time is allowed for supervised practice. The nurse includes the following information in the teaching plan for a patient with diabetes:

- Blood glucose or urine testing—the testing material recommended by the health care provider; a review of the instructions included with the glucometer or the materials used for urine testing; the technique of collecting the specimen; interpreting test results; number of times a day or week the blood or urine is tested (as recommended by the health care provider); a record of test results.
- Insulin—types; how dosage is expressed; calculating the insulin dosage; importance of using only the type, source, and brand name recommended by the health care provider; importance of not changing brands unless the health care provider approves; keeping a spare vial on hand; prescription for insulin purchase not required.
- Storage of insulin—insulin is kept at room temperature away from heat and direct sunlight if used within 1 month (and up to 3 months if refrigerated); vials not in use are stored in the refrigerator; prefilled insulin in glass or plastic syringes is stable for 1 week under refrigeration. Keep filled syringes in a vertical or oblique position with the needle pointing upward to avoid plugging the needle. Before injection, pull back the plunger and tip the syringe back and forth slightly to agitate and remix the insulins.
- Needle and syringe—purchase the same brand and needle size each time; parts of the syringe; reading the syringe scale.
- Preparation for administration—principles of aseptic technique; how to hold the syringe; how to withdraw insulin from the vial; measurement of insulin in the syringe using the syringe scale; mixing insulin in the same syringe (when appropriate); elimination of air in the syringe and needle; what to do if the syringe or needle is contaminated.
- Administration of insulin—sites to be used; rotation of injection sites (see Home Care Checklist: Rotating Insulin Injection Sites); angle of injection; administration at the time of day prescribed by the health care provider; disposal of the needle and syringe.
- Insulin needs may change in patients who become ill, especially with vomiting or fever and during

periods of stress or emotional disturbances. Contact the primary health care provider if these situations occur.
- Diet—importance of following the prescribed diet; calories allowed; food exchanges; planning daily menus; establishing meal schedules; selecting food from a restaurant menu; reading food labels; use of artificial sweeteners.
- Traveling—importance of carrying an extra supply of insulin and a prescription for needles and syringes; storage of insulin when traveling; protecting needles and syringes from theft; importance of discussing travel plans (especially foreign travel) with the health care provider.
- Hypoglycemia/hyperglycemia—signs and symptoms of hypoglycemia and hyperglycemia; food or fluid used to terminate a hypoglycemic reaction; importance of notifying the health care provider immediately if either reaction occurs.
- Personal hygiene—importance of good skin and foot care, personal cleanliness, frequent dental checkups, and routine eye examinations.
- Exercise—importance of following the health care provider's recommendations regarding physical activity.
- When to notify the health care provider—increase in blood glucose levels; urine positive for ketones; if pregnancy occurs; occurrence of antidiabetic or hyperglycemic episodes; occurrence of illness, infection, or diarrhea (insulin dosage may require adjustment); appearance of new problems (eg, leg ulcers, numbness of the extremities, significant weight gain or loss).
- Identification—wear identification, such as a medical alert tag, to inform medical personnel and others of the use of insulin to control the disease.

EVALUATION

- The therapeutic effect is achieved and normal or near-normal blood glucose levels are maintained.
- Adverse reactions are identified, reported to the health care provider, and managed successfully through appropriate nursing interventions.
- Anxiety and fear are reduced.
- The patient demonstrates a beginning ability to cope with the disorder and its required treatment.
- The patient demonstrates a positive outlook and adjustment to the diagnosis.
- The patient verbalizes a willingness to comply with the prescribed therapeutic regimen.
- The patient and family demonstrate an understanding of the drug regimen.
- The patient is able to test blood glucose levels using a glucometer.
- The patient administers insulin correctly.

ORAL ANTIDIABETIC DRUGS

The oral antidiabetic drugs are used to treat patients with type 2 diabetes that is not controlled by diet and exercise alone. These drugs are not effective for treating type 1 diabetes. Five types of oral antidiabetic drugs are currently in use:

- Sulfonylureas (glimepiride, glyburide)
- Biguanides (metformin)
- Alpha (α)-glucosidase inhibitors (acarbose, miglitol)
- Meglitinides (nateglinide, repaglinide)
- Thiazolidinediones (pioglitazone, rosiglitazone)

Additional drugs are listed in the Summary Drug Table: Antidiabetic Drugs.

USES OF THE ANTIDIABETIC DRUGS

The oral antidiabetic drugs are of value only in the treatment of patients with type 2 (NIDDM) diabetes mellitus whose condition cannot be controlled by diet alone. These drugs may also be used with insulin in the management of some patients with diabetes mellitus. Use of an oral antidiabetic drug with insulin may decrease the insulin dosage in some individuals. Two oral antidiabetic drugs (eg, a sulfonylurea and metformin) may also be used together when one antidiabetic drug and diet do not control blood glucose levels in type 2 diabetes mellitus. Figure 49-3 is a pharmacological algorithm indicating the appropriate medication regimen for type 2 diabetes mellitus.

ACTIONS

Sulfonylureas

The sulfonylureas appear to lower blood glucose by stimulating the beta cells of the pancreas to release insulin. The sulfonylureas are not effective if the beta cells of the pancreas are unable to release a sufficient amount of insulin to meet the individual's needs. The first generation sulfonylureas (eg, chlorpropamide, tolazamide, and tolbutamide) are not commonly used today because they have a long duration of action and a higher incidence of adverse

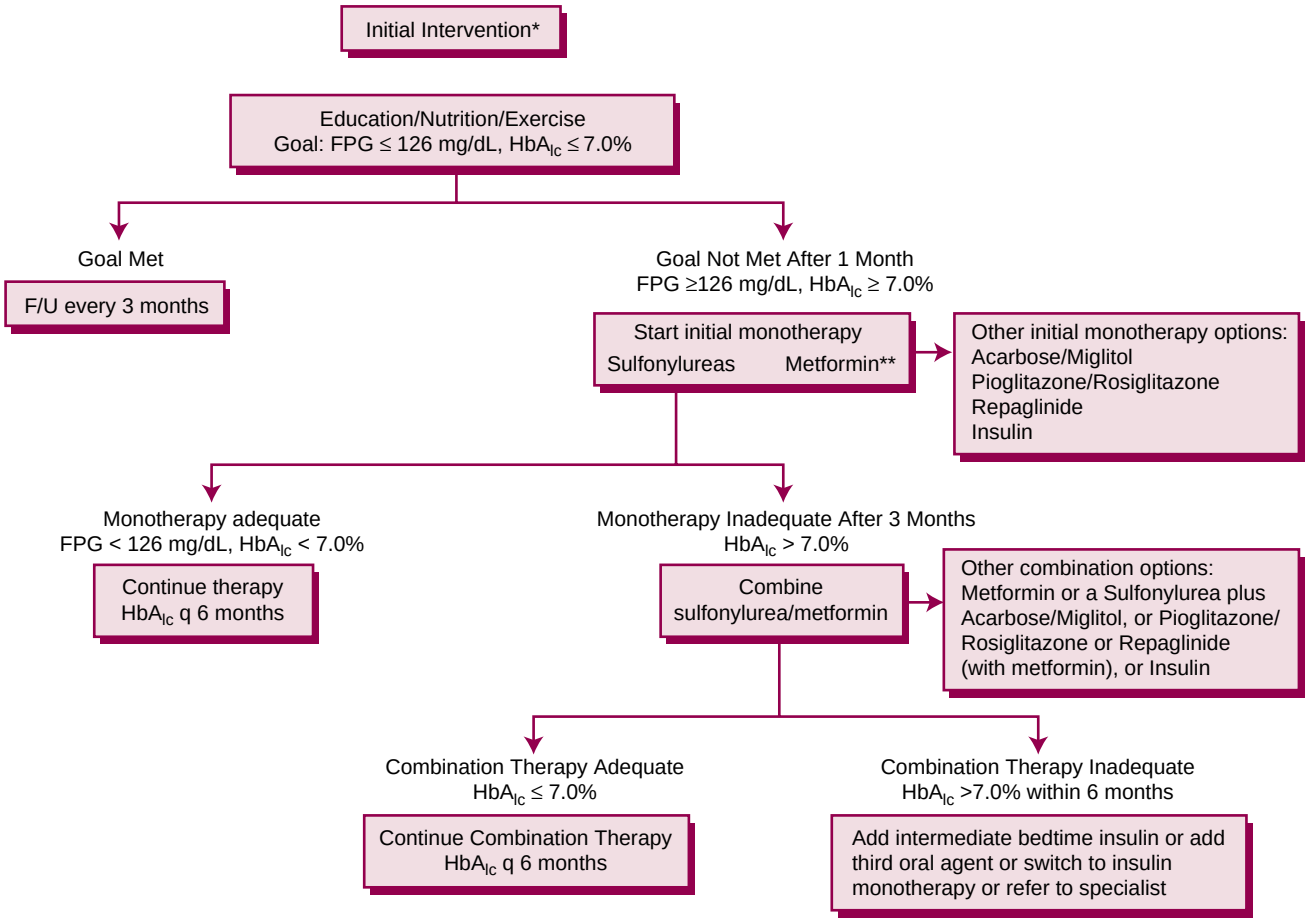
SUMMARY DRUG TABLE ANTIDIABETIC DRUGS

GENERIC NAME	TRADE NAME*	USES	ADVERSE REACTIONS	DOSAGE RANGES
Sulfonylureas				
acetohexamide *a-set-oh-hex'-a-mide*	Dymelor, *generic*	Adjunct to diet to lower blood glucose in type 2 diabetes; adjunct to insulin therapy in certain patients with type 1 diabetes	Anorexia, nausea, vomiting, epigastric discomfort, heartburn, hypoglycemia	250 mg–1.5 g/d PO
chlorpropamide *klor-proe'-pa-mide*	Diabinese, *generic*	Adjunct to diet in type 2 diabetes	Anorexia, nausea, vomiting, epigastric discomfort, heartburn, hypoglycemia	100–500 mg/d PO
glimepiride *glye-meh'-per-ide*	Amaryl	Adjunct to diet to lower blood glucose in type 2 diabetes; adjunct to insulin therapy in certain patients with type 1 diabetes	Anorexia, nausea, vomiting, epigastric discomfort, heartburn, diarrhea, hypoglycemia, allergic skin reactions	1–4 mg/d PO (do not exceed 8 mg/d)
glipizide *glip'-i-zide*	Glucotrol, Glucotrol XL, *generic*	Type 2 diabetes; adjunct to insulin therapy in the stabilization of certain cases of insulin-dependent diabetes (type 1)	Anorexia, nausea, vomiting, epigastric discomfort, heartburn, diarrhea, hypoglycemia, allergic skin reactions	5–40 mg/d PO
glyburide (glibenclamide) *glye-byoor-ide*	DiaBeta, Micronase, *generic*	Type 2 diabetes; adjunct to metformin when adequate results are not achieved with either drug alone; adjunct to insulin in stabilization of certain individuals with type 1 diabetes	Anorexia, nausea, vomiting, epigastric discomfort, heartburn, hypoglycemia	1.25–20 mg/d PO
tolazamide *tole-az'-a-mide*	Tolinase, *generic*	Type 2 diabetes; adjunct to insulin therapy in the stabilization of certain cases of insulin-dependent diabetes (type 1)	Anorexia, nausea, vomiting, epigastric discomfort, heartburn, hypoglycemia	100–1000 mg/d PO
tolbutamide *tole-byoo'-ta-mide*	Orinase, *generic*	Type 2 diabetes; aduct to insulin therapy in the stabilization of certain cases of insulin-dependent diabetes (type 1)	Anorexia, nausea, vomiting, epigastric discomfort, heartburn, hypoglycemia	0.25–3 g/d PO
α-Glucosidase Inhibitors				
acarbose *aye-kar'-bose*	Precose	Type 2 diabetes; combination therapy with a sulfonylurea to enhance glycemic control	Flatulence, diarrhea, abdominal pain	25–100 mg TID PO
miglitol *mi'-gli-tole*	Glyset	Type 2 diabetes; combination therapy with a sulfonylurea to enhance glycemic control	Skin rash, flatulence, diarrhea, abdominal pain	25–100 mg TID PO

SUMMARY DRUG TABLE ANTIDIABETIC DRUGS (*Continued*)

GENERIC NAME	TRADE NAME*	USES	ADVERSE REACTIONS	DOSAGE RANGES
Biguanide				
metformin *met-for'-min*	Glucophage, Glucophage XR, *generic*	Type 2 diabetes; with a sulfonylurea or insulin to improve glycemic control	Anorexia, nausea, vomiting, epigastric pain, heartburn, diarrhea, hypoglycemia, allergic skin reactions	500–3000 mg/d PO; XR (extended release): 500–2000 mg/d
Meglitinides				
nateglinide *nah-teg'-lah-nyde*	Starlix	Type 2 diabetes; in combination with metformin to improve glycemic control	Headache, upper respiratory tract infection, back pain, flu symptoms, bronchitis	60–120 mg TID before meals
Repaglinide *re-pag'-lah-nyd*	Prandin	Type 2 diabetes; in combination with metformin to improve glycemic control	Hyperglycemia, hypoglycemia, nausea, diarrhea, upper respiratory tract infection, sinusitis, headache, arthralgia, back pain	0.5–4 mg before meals PO (maximum dose is 16 mg/d)
Thiazolidinediones				
pioglitazone HCl *pie-oh-glit'-ah-zohn*	Actos	Type 2 diabetes; with sulfonylurea, metformin, or insulin to improve glycemic control	Headache, pain, myalgia, aggravated diabetes, infections, fatigue	15–45 mg/d PO
rosiglitazone maleate *roh-zee-glit'-ah-zohn*	Avandia	Type 2 diabetes; in combination with metformin to improve glycemic control	Headache, pain, diarrhea, hypoglycemia, hyperglycemia, fatigue, infections	4–8 mg/d PO
Antidiabetic Combination Drugs				
glyburide/ metformin HCl	Glucovance	Type 2 diabetes	See individual drugs	Starting dose: 1.25 mg/250 mg PO once or twice daily with meals, second-line therapy: 2.5 mg/500 mg–5 mg/ 500 mg PO BID with meals; maximum daily dosage: 20 mg/2500 mg
Glucose-Elevating Agents				
diazoxide, oral *die-aze-ox'-ide*	Proglycem	Hypoglycemia due to hyperinsulinism	Sodium and fluid retention, hyperglycemia, glycosuria, tachycardia, congestive heart failure	3–8 mg/kg/d PO in 2 or 3 equal doses every 8 or 12 h
glucagon *glue-kuh-gahn*	Glucagon Emergency Kit	Hypoglycemia	Nausea, vomiting, generalized allergic reactions	See instructions on the product

*The term *generic* indicates the drug is available in generic form.



*If initial presentation with fasting glucose ≥ 260 mg/dL is a symptomatic patient, consider insulin as initial intervention.
**Preferred in obese or dyslipidemic patients
–Normal HbA_{1c} = 4-6.1%
–Normal FPG: < 126 mg/dL
–Goals and therapies must be individualized.

FIGURE 49-3. Pharmacological algorithm for treating type 2 diabetes.

reactions, and are more likely to react with other drugs. More commonly used sulfonylureas are the second and third generation drugs, such as glimepiride (Amaryl), glipizide (Glucotrol), and glyburide (DiaBeta, Micronase).

Biguanides

Metformin (Glucophage), currently the only biguanide, acts by reducing hepatic glucose production and increasing insulin sensitivity in muscle and fat cells. The liver normally releases glucose by detecting the level of circulating insulin. When insulin levels are high, glucose is available in the blood, and the liver produces little or no glucose. When insulin levels are low, there is little circulating glucose, so the liver produces more glucose. In type 2 diabetes, the liver may not detect levels of glucose in the blood and, instead of regulating glucose production, releases glucose despite blood sugar levels. Metformin sensitizes the liver to circulating insulin levels and reduces hepatic glucose production.

α-Glucosidase Inhibitors

The α-glucosidase inhibitors, acarbose (Precose) and miglitol (Glyset), lower blood sugar by delaying the digestion of carbohydrates and absorption of carbohydrates in the intestine.

Meglitinides

Like the sulfonylureas, the meglitinides act to lower blood glucose levels by stimulating the release of insulin from the pancreas. This action is dependent on the ability of the beta cell in the pancreas to produce some insulin. However, the action of the meglitinides is more rapid than that of the sulfonylureas and their

duration of action much shorter. Because of this they must be taken three times a day. Examples of the meglitinides include nateglinide (Starlix) and repaglinide (Prandin).

Thiazolidinediones

The thiazolidinediones, also called glitazones, decrease insulin resistance and increase insulin sensitivity by modifying several processes, with the end result being decreasing hepatic glucogenesis (formation of glucose from glycogen) and increasing insulin-dependent muscle glucose uptake. Examples of the thiazolidinediones are rosiglitazone (Avandia) and pioglitazone (Actos).

ADVERSE REACTIONS

Sulfonylureas

Adverse reactions seen with the sulfonylureas include hypoglycemia, anorexia, nausea, vomiting, epigastric discomfort, weight gain, heartburn, and various vague neurologic symptoms, such as weakness and numbness of the extremities. Often, these can be eliminated by reducing the dosage or giving the drug in divided doses. If these reactions become severe, the health care provider may try another oral antidiabetic drug or discontinue the use of these drugs. If the drug therapy is discontinued, it may be necessary to control the diabetes with insulin.

Biguanides

Adverse reactions associated with the biguanide (metformin) include gastrointestinal upsets (such as abdominal bloating, nausea, cramping, diarrhea) and metallic taste (usually self-limiting). These adverse reactions are self-limiting and can be reduced if the patients are started on a low dose with dosage increased slowly and if the drug is taken with meals. Hypoglycemia rarely occurs when metformin is used alone.

Lactic acidosis (buildup of lactic acid in the blood) may also occur with the administration of metformin. Although lactic acidosis is a rare adverse reaction, its occurrence is serious and can be fatal. Lactic acidosis occurs mainly in patients with kidney dysfunction. Symptoms of lactic acidosis include malaise (vague feeling of bodily discomfort), abdominal pain, rapid respirations, shortness of breath, and muscular pain. In some patients vitamin B_{12} levels are decreased. This can be reversed with vitamin B_{12} supplements or with discontinuation of the drug therapy. Because weight loss can occur, metformin is sometimes recommended for obese patients or patients with insulin-resistant diabetes.

α-Glucosidase Inhibitors

Because the α-glucosidase inhibitors, acarbose or miglitol, increase the transit time of food in the digestive tract, gastrointestinal disturbances may occur. The most common adverse reactions are bloating and flatulence. Other adverse reactions, such as abdominal pain, and diarrhea can occur. While most oral antidiabetic drugs produce hypoglycemia, acarbose and miglitol, when used alone, do not cause hypoglycemia.

Meglitinides

Adverse reactions associated with the administration of the meglitinides include upper respiratory infection, headache, rhinitis, bronchitis, headache, back pain, and hypoglycemia.

Thiazolidinediones

Adverse reactions associated with the administration of the thiazolidinediones include aggravated diabetes mellitus, upper respiratory infections, sinusitis, headache, pharyngitis, myalgia, diarrhea, and back pain. When used alone, rosiglitazone and pioglitazone rarely cause hypoglycemia. However, patients receiving these drugs in combination with insulin or other oral hypoglycemics (eg, the sulfonylureas) are at greater risk for hypoglycemia. A reduction in the dosage of insulin or the sulfonylurea may be required to prevent episodes of hypoglycemia.

CONTRAINDICATIONS, PRECAUTIONS, AND INTERACTIONS

Sulfonylureas

The oral antidiabetic drugs are contraindicated in patients with known hypersensitivity to the drugs, DKA, severe infection, or severe endocrine disease. The first generation sulfonylureas (chlorpropamide, tolazamide, and tolbutamide) are contraindicated in patients with coronary artery disease or liver or renal dysfunction. Other sulfonylureas are used cautiously in patients with impaired liver function because liver dysfunction can prolong the drug's effect. In addition, the sulfonylureas are used cautiously in patients with renal

impairment and severe cardiovascular disease. There is a risk for cross-sensitivity with the sulfonylureas and the sulfonamides.

Many drugs may affect the action of the sulfonylureas; the nurse must monitor blood glucose carefully when beginning therapy, discontinuing therapy, and any time any change is made in the drug regimen with these drugs. The sulfonylureas may have an increased hypoglycemic effect when administered with the anticoagulants, chloramphenicol, clofibrate, fluconazole, histamine H_2 antagonists, methyldopa, monoamine oxidase inhibitors (MAOIs), salicylates, sulfonamides, and tricyclic antidepressants. The hypoglycemic effect of the sulfonylureas may be decreased when the agents are administered with beta blockers, calcium channel blockers, cholestyramine, corticosteroids, estrogens, hydantoins, isoniazid, oral contraceptives, phenothiazines, thiazide diuretics, and thyroid agents.

Biguanides

Metformin is contraindicated in patients with heart failure, renal disease, hypersensitivity to metformin, and acute or chronic metabolic acidosis, including ketoacidosis. The drug is also contraindicated in patients older than 80 years and during pregnancy (Pregnancy Category B) and lactation.

The drug is used cautiously during surgery. Metformin use is temporarily discontinued for surgical procedures. The drug therapy is restarted when the patient's oral intake has been resumed and renal function is normal.

There is a risk of acute renal failure when iodinated contrast material that is used for radiological studies is administered with metformin. Metformin therapy is stopped for 48 hours before and after radiological studies using iodinated material. Alcohol, amiloride, digoxin, morphine, procainamide, quinidine, quinine, ranitidine, triamterene, trimethoprim, vancomycin, cimetidine, and furosemide all increase the risk of hypoglycemia. There is an increased risk of lactic acidosis when metformin is administered with the glucocorticoids.

α-Glucosidase Inhibitors

The α-glucosidase inhibitors are contraindicated in patients with a hypersensitivity to the drug, diabetic ketoacidosis, cirrhosis, inflammatory bowel disease, colonic ulceration, partial intestinal obstruction or predisposition to intestinal obstruction, or chronic intestinal diseases. Acarbose and miglitol are used cautiously in patients with renal impairment or pre-existing gastrointestinal (GI) problems such as irritable bowel syndrome and Crohn's disease. These drugs are Pregnancy Category B drugs and safety for use during pregnancy has not been established. Digestive enzymes may reduce the effect of miglitol. The effects of acarbose may increase when the agent is administered with the loop or thiazide diuretics, glucocorticoids, oral contraceptives, calcium channel blockers, phenytoin, thyroid drugs, or the phenothiazines. Miglitol may decrease absorption of ranitidine and propranolol.

Meglitinides

Theses drugs are contraindicated in patients with hypersensitivity to the drug, type I diabetes, and diabetic ketoacidosis. Both repaglinide and nateglinide are Pregnancy Category C drugs and are not recommended for use during pregnancy and lactation. These drugs are used cautiously in patients with renal or hepatic impairment. Certain drugs, such as NSAIDs, salicylates, MAOIs, and beta adrenergic blocking drugs, may potentiate the hypoglycemic action of the meglitinides. Drugs such as the thiazides, corticosteroids, thyroid drugs, and sympathomimetics may decrease the hypoglycemic action of these drugs. The nurse must closely observe the patient receiving one or more of these drugs along with an oral antidiabetic drug.

Thiazolidinediones

The thiazolidinediones are contraindicated in patients with a hypersensitivity to the drug or any component of the drug and severe heart failure. These drugs are Pregnancy Category C drugs and should not be used during pregnancy unless the potential benefit of therapy outweighs the potential risk to the fetus. The thiazolidinediones are used cautiously in patients with edema, cardiovascular disease, and liver or kidney disease. These drugs may alter the effects of oral contraceptives.

NURSING PROCESS

● The Patient Receiving an Oral Antidiabetic Drug

ASSESSMENT

Preadministration Assessment

If the patient has recently received a diagnosis of diabetes mellitus and has not received an oral antidiabetic drug, or if the patient is known to have diabetes and has been taking one of these drugs, the nurse should include weight, blood pressure, pulse, and

respiratory rate in the initial assessment. The nurse makes a general assessment of the skin, mucous membranes, and extremities, with special attention given to sores or cuts that appear to be healing poorly and ulcerations or other skin or mucous membrane changes. Dietary habits, a family history of diabetes (if any), and an inquiry into the type and duration of symptoms experienced are included in the history. The nurse reviews the patient's chart for recent laboratory and diagnostic tests. If the patient has diabetes and has been receiving an oral antidiabetic drug, the nurse includes the name of the drug and the dosage, the type of diabetic diet, the results of blood glucose testing, and an inquiry into adherence to the dietary and weight control regimen prescribed by the health care provider.

Ongoing Assessment

The most important aspect of the ongoing assessment is observation of the patient every 2 to 4 hours for symptoms of hypoglycemia (see Table 49-1), particularly during initial therapy or after a change in dosage. If both an oral antidiabetic drug and insulin are given, the nurse observes the patient more frequently for hypoglycemic episodes during the initial period of combination therapy. If the patient is receiving only an oral antidiabetic drug and a hypoglycemic reaction occurs, it is often (but not always) less intense than one seen with insulin administration.

The nurse conducts daily ongoing assessments, including monitoring vital signs and observing for adverse drug reactions. The health care provider may also order the patient be weighed daily or weekly. The nurse notifies the health care provider if an adverse reaction occurs or if there is a significant weight gain or loss.

The best way to monitor long-term glycemic control and response to treatment is with HbA_{1c} levels measured at 3-month intervals. If the first HbA_{1c} indicates that glycemic control during the last 3 months was inadequate, the dosage may be increased for better control.

NURSING DIAGNOSES

Drug-specific nursing diagnoses are highlighted in the Nursing Diagnoses Checklist. Other nursing diagnoses applicable to these drugs are discussed in depth in Chapter 4.

PLANNING

The expected outcomes of the patient may include an optimal response to therapy, management of common adverse reactions, a reduction in anxiety, improved ability in coping with the diagnosis, and an understanding of and compliance with the prescribed therapeutic regimen.

Nursing Diagnoses Checklist

- ☑ **Confusion** related to adverse drug reaction (hypoglycemia)
- ☑ **Imbalanced Nutrition: More Than Body Requirements** related to disease process or adverse drug reactions
- ☑ **Anxiety** related to diagnosis, dietary restrictions, other factors (specify)
- ☑ **Ineffective Coping** related to inability to accept diagnosis
- ☑ **Ineffective Health Maintenance** related to inability to comprehend drug regimen, lack of knowledge
- ☑ **Risk of Ineffective Therapeutic Regimen Management** related to lack of knowledge, misunderstanding, or complexity of prescribed treatment program, other factors (specify)

IMPLEMENTATION

Promoting an Optimal Response to Therapy

There is no fixed dosage for the treatment of diabetes. The drug regimen is individualized on the basis of the effectiveness and tolerance of the drug(s) used and the maximum recommended dose of the drug(s). Glycemic control can often be improved when a second oral medication is added to the drug regimen. The choice of a second medication will vary from patient to patient and is prescribed by the health care provider. Glucovance, a combination drug, is a mixture of glyburide and metformin. The drug is useful for individuals needing dual therapy and those who are forgetful (only once-daily dosing is required) or mildly confused.

Nursing Alert

Exposure to stress, such as infection, fever, surgery, or trauma, may cause a loss of control of blood glucose levels in patients who have been stabilized with oral antidiabetic drugs. Should this occur, the health care provider may discontinue use of the oral drug and administer insulin.

Oral antidiabetic drugs are given as a single daily dose or in divided doses. The following sections provide specific information for each group of oral antidiabetic drugs.

SULFONYLUREAS. Acetohexamide (Dymelor), chlorpropamide (Diabinese), tolazamide (Tolinase), and tolbutamide (Orinase) are given with food to prevent gastrointestinal upset. However, because food delays

absorption, the nurse gives glipizide (Glucotrol) 30 minutes before a meal. Glyburide (Micronase) is administered with breakfast or with the first main meal of the day. The health care provider orders the meal with which glyburide is given. Glimepiride is give once daily with breakfast or the first main meal of the day.

Gerontologic Alert

Older adults have an increased sensitivity to the sulfonylureas and may require a dosage reduction.

After the patient has been taking sulfonylureas for a period of time, a condition called secondary failure may occur. **Secondary failure** occurs when the sulfonylurea loses its effectiveness. When the nurse notes that a normally compliant patient has a gradual increase in blood sugar levels, secondary failure may be the cause. This increase in blood glucose levels can be caused by an increase in the severity of the diabetes or a decreased response to the drug. When secondary failure occurs, the health care provider may prescribe another sulfonylurea or add an oral antidiabetic drug such as metformin to the drug regimen. See the Summary Drug Table: Antidiabetic Drugs for additional drugs that can be used in combination with the sulfonylureas.

α-GLUCOSIDASE INHIBITORS. Acarbose and miglitol are given three times as day with the first bite of the meal because food increases absorption. Some patients begin therapy with a lower dose once daily to minimize gastrointestinal effects, such as abdominal discomfort, flatulence, and diarrhea. The dose is then gradually increased to three times daily. The nurse monitors the response to these drugs by periodic testing. Dosage adjustments are made at 4- to 16-week intervals based on 1-hour postprandial glucose levels.

BIGUANIDES. The nurse gives metformin two or three times a day with meals. If the patient has not experienced a response in 4 weeks using the maximum dose of metformin, the primary care giver may add an oral sulfonylurea while continuing metformin at the maximum dose. Glucophage XR (metformin extended release) is administered once daily with the evening meal.

MEGLITINIDES. The nurse usually gives repaglinide 15 minutes before meals but can give it immediately, or up to 30 minutes, before the meal. Nateglinide is taken up to 30 minutes before meals.

THIAZOLIDINEDIONES. The thiazolidinediones, pioglitazone and rosiglitazone, are given with or without meals. If the dose is missed at the usual meal, the drug is taken at the next meal. If the dose is missed on one day, do not double the dose the following day. If the drug is taken, do not delay the meal. Delay of a meal for as little as ½ hour can cause hypoglycemia.

Monitoring and Managing Adverse Reactions

MANAGING HYPOGLYCEMIA. The nurse must immediately terminate a hypoglycemic reaction. The method of terminating a hypoglycemic reaction is the same as for a hypoglycemic reaction occurring with insulin administration, with the following exception: The nurse notifies the health care provider as soon as possible if episodes of hypoglycemia occur because the dosage of the oral antidiabetic drug (or insulin, when both insulin and an oral antidiabetic drug are given) may need to be changed.

Nursing Alert

When hypoglycemia occurs in a patient taking an α-glucosidase inhibitor (eg, acarbose or miglitol), the nurse gives the patient an oral form of glucose, such as glucose tablets or dextrose, rather than sugar (sucrose). Absorption of sugar is blocked by acarbose or miglitol.

When oral antidiabetic drugs are combined with other antidiabetic drugs (eg, sulfonylureas) or insulin, the hypoglycemic effect may be enhanced. Elderly, debilitated, or malnourished patients are more likely to experience hypoglycemia.

Gerontologic Alert

Although elderly patients taking the oral antidiabetic drugs are particularly susceptible to hypoglycemic reactions, these reactions may be difficult to detect in the elderly. The nurse notifies the health care provider if blood sugar levels are elevated (consistently > 200 mg/dL) or if ketones are present in the urine.

MANAGING HYPERGLYCEMIA AND KETOACIDOSIS. Capillary blood specimens are obtained and tested in the same manner as for insulin (see Patient and Family Teaching Checklist, p. 497). The nurse notifies the health care provider if blood sugar levels are elevated

(consistently > 200 mg/dL) or if ketones are present in the urine.

MANAGING ANXIETY AND PROMOTING COPING SKILLS. The patient with newly diagnosed diabetes often has many concerns about the management of the disease. Some patients, when learning that management of their diabetes can be achieved by diet and an oral drug, may have a tendency to discount the seriousness of the disorder. Without creating additional anxiety, the nurse emphasizes the importance of following the prescribed treatment regimen.

The nurse encourages the patient to talk about the disorder, express concerns, and ask questions. Allowing these patients time to talk may help them begin to cope with their diabetes.

The patient receiving an oral antidiabetic drug may also express concern about the possibility of having to take insulin in the future. The nurse encourages the patient to discuss this and other concerns with the health care provider.

MANAGING LACTIC ACIDOSIS. When taking metformin, the patient is at risk for lactic acidosis. The nurse monitors the patient for symptoms of lactic acidosis, which include unexplained hyperventilation, myalgia, malaise, gastrointestinal symptoms, or unusual somnolence. If the patient experiences these symptoms, the nurse should contact the primary care provider at once. Elevated blood lactate levels of greater than 5 mmol/L are associated with lactic acidosis and should be reported immediately. Once a patient's diabetes is stabilized on metformin therapy, the adverse GI reactions that often occur at the beginning of such therapy are unlikely to be related to the drug therapy. A later occurrence of GI symptoms is more likely to be related to lactic acidosis or other serious disease.

Educating the Patient and Family

Failing to comply with the prescribed treatment regimen may be a problem with patients taking an oral antidiabetic drug because of the erroneous belief that not having to take insulin means that their disease is not serious and therefore does not require strict adherence to the recommended dietary plan. The nurse informs these patients that control of their diabetes is just as important as for patients requiring insulin and that control is achieved only when they adhere to the treatment regimen prescribed by the health care provider.

If the diagnosis of diabetes mellitus is new, the nurse discusses the disease and methods of control with the patient and family after the health care provider has revealed the diagnosis to the patient. Although taking an oral antidiabetic drug is less complicated than self-administration of insulin, the patient with diabetes taking one of these drugs needs a thorough explanation of the management of the disease. The teaching plan is individualized because the needs of each patient are different. The nurse includes the following information in a teaching plan:

- Take the drug exactly as directed on the container (eg, with food, 30 minutes before a meal).
- To control diabetes, follow the diet and drug regimen prescribed by the health care provider exactly.
- This drug is not oral insulin and cannot be substituted for insulin.
- Never stop taking this drug or increase or decrease the dose unless told to do so by the health care provider.
- Take the drug at the same time or times each day.
- Eat meals at about the same time each day. Erratic meal hours or skipped meals may result in difficulty in controlling diabetes with this drug.
- Avoid alcohol, dieting, commercial weight-loss products, and strenuous exercise programs unless use or participation has been approved by the health care provider.
- Test blood for glucose and urine for ketones as directed by the health care provider. Keep a record of test results and bring this record to each visit to the health care provider or clinic.
- Maintain good foot and skin care and routine eye and dental examinations for the early detection of the complications that may occur.
- Exercise should be moderate; avoid strenuous exercise and erratic periods of exercise.
- Wear identification, such as a medical alert tag, to inform medical personnel and others of diabetes and the drug or drugs currently being used to treat the disease.
- Notify the health care provider if any of the following occur: episodes of hypoglycemia, apparent symptoms of hyperglycemia, elevated blood glucose levels, positive results of urine tests for glucose or ketone bodies, or pregnancy. Also notify the health care provider of any serious illness not requiring hospitalization.
- Know the symptoms of hypoglycemia and hyperglycemia and the health care provider's method for terminating a hypoglycemic reaction.

- Metformin—there is a risk of lactic acidosis when using this drug. Discontinue the drug therapy and notify the health care provider immediately if any of the following should occur: respiratory distress, muscular aches, unusual somnolence, unexplained malaise, or nonspecific abdominal distress.
- α-Glucosidase Inhibitors—these drugs do not generally cause hypoglycemia. However, if sulfonylureas or insulin are used in combination with acarbose or miglitol, blood sugar levels can be lowered enough to cause symptoms or even life-threatening hypoglycemia. Have a ready source of glucose to treat symptoms of low blood sugar when taking insulin or a sulfonylurea with these drugs. Adverse reactions generally develop during the first few weeks of therapy and usually involve the gastrointestinal tract: flatulence, diarrhea, or abdominal discomfort.
- Meglitinides—if a meal is skipped, do not take the drug. Similarly, if a meal is added, add a dose of the drug for that meal.

EVALUATION

- The therapeutic drug effect is achieved and normal or near-normal blood glucose levels are maintained.
- Hypoglycemic reactions are identified, reported to the health care provider, and managed successfully.
- Anxiety is reduced.
- The patient begins to demonstrate the ability to cope with the disorder and its required treatment.
- The patient demonstrates a positive outlook and adjustment to the diagnosis.
- The patient verbalizes a willingness to comply with the prescribed treatment regimen.
- The patient demonstrates an understanding of the drug regimen.
- The patient demonstrates an understanding of the information presented in teaching sessions.
- The patient is able to use the glucometer correctly to monitor blood sugar or test urine for glucose and ketones.

● *Critical Thinking Exercises*

1. *Ms. Baxter, age 37 years, has been taking insulin for the past 6 years for type 1 diabetes mellitus. An assessment at the outpatient clinic reveals a blood sugar of 110 mg/dL. In examining Ms. Baxter's skin, the nurse notices several areas on the thighs that appear scarred and other areas that appear as dimples or pitting in the skin. Analyze this problem. Discuss suggestions you would make to Ms. Baxter for better care.*
2. *Mr. Goddard, age 78 years, recently has received a diagnosis of type 2 diabetes mellitus, and the health care provider has ordered an oral antidiabetic drug. Mr. Goddard says his friend with diabetes takes insulin and he wonders why insulin was not prescribed for him. How would you help Mr. Goddard understand why he is taking an oral drug and not insulin? What other information does Mr. Goddard, as a patient with newly diagnosed diabetes, need to have?*
3. *When assessing Jerry Jones, age 24 years, a patient with recently diagnosed diabetes, you note that he is confused and agitated. His skin is cool and clammy, and he is complaining of hunger. Discuss other assessments you could make and what action, if any, you feel should be taken for Jerry.*

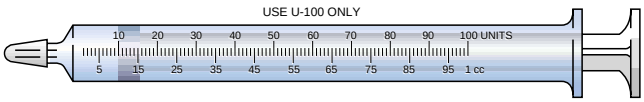
● *Review Questions*

1. Which of the following would the nurse mostly likely choose to terminate a hypoglycemic reaction?
   - **A.** Regular insulin
   - **B.** NPH insulin
   - **C.** Orange juice
   - **D.** Crackers and milk
2. Which of the following would be the correct method of administering insulin glargine?
   - **A.** Within 10 minutes of meals
   - **B.** Immediately before meals
   - **C.** Anytime within 30 minutes before or 30 minutes after a meal
   - **D.** At bedtime
3. Which of the following symptoms would alert the nurse to a possible hyperglycemic reaction?
   - **A.** Fatigue, weakness, confusion
   - **B.** Pale skin, elevated temperature
   - **C.** Thirst, abdominal pain, nausea
   - **D.** Rapid, shallow respirations, headache, nervousness
4. A patient with diabetes received a glycosylated hemoglobin test result of 10%. This indicates _____.
   - **A.** the diabetes is well controlled
   - **B.** poor blood glucose control
   - **C.** the need for an increase in the insulin dosage
   - **D.** the patient is at increased risk for hypoglycemia

5. In patients receiving oral hypoglycemic drugs, the nurse must be aware that hypoglycemic reactions _____.
   - **A.** will most likely occur 1 to 2 hours after a meal
   - **B.** may be more intense than reactions seen with insulin administration
   - **C.** may be less intense than reactions seen with insulin administration
   - **D.** may occur more frequently in patients receiving oral hypoglycemic drugs.

● *Medication Dosage Problems*

1. A patient is prescribed 40 units NPH insulin mixed with 5 units of regular insulin. What is the total insulin dosage? Draw a line on the syringe below showing the total insulin dosage. Describe how you would prepare the insulins.



2. A patient is prescribed metformin (Glucophage) 1000 mg BID PO. The drug is available in 500-mg tablets. The nurse administers_____.What is the total daily dosage of metformin?_____.
3. A patient is prescribed rosiglitazone (Avandia) 8 mg PO daily. Available are 2-mg tablets. The nurse would administer ____.
4. A patient is prescribed insulin Humulin L 32 U. Choose the correct label for the insulin.