# CHAPTER 20 Nursing Care of Clients with Diabetes Mellitus

## LEARNING OUTCOMES

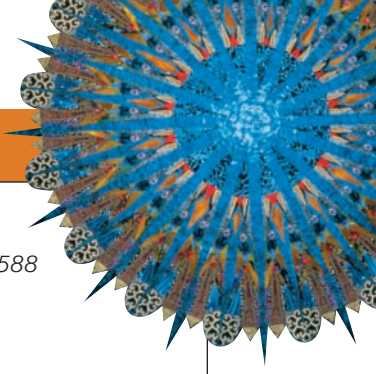
- Apply knowledge of normal endocrine anatomy, physiology, and assessments when providing nursing care for clients with diabetes mellitus.
- Describe the prevalence and incidence of diabetes mellitus.
- Explain the pathophysiology, risk factors, manifestations, and complications of type 1 and type 2 diabetes mellitus.
- Compare and contrast the manifestations and interdisciplinary care of hypoglycemia, diabetic ketoacidosis, and hyperosmolar hyperglycemic state.
- Identify the diagnostic tests used for screening, diagnosis, and monitoring of diabetes mellitus.
- Discuss the nursing implications for insulin and oral hypoglycemic agents used to treat clients with diabetes mellitus.
- Provide accurate information to clients with diabetes mellitus to facilitate self-management of medications, diet planning, exercise, and self-assessment, including foot care.
- Use the nursing process as a framework for providing individualized care to clients with diabetes mellitus.

## CLINICAL COMPETENCIES

- Assess blood glucose levels and patterns of hyper- and hypoglycemia in clients with diabetes mellitus.
- Recognize the importance of early diagnosis and control of blood glucose to prevent complications.
- Determine priority nursing diagnoses, based on assessed data, to select and implement individualized nursing interventions for clients with type 1 and type 2 diabetes mellitus.
- Administer oral and injectable medications used to treat type 1 and type 2 diabetes mellitus knowledgeably and safely.
- Provide skilled care to clients with diabetic ketoacidosis and hyperosmolar hyperglycemic states.
- Integrate interdisciplinary care into care of clients with type 1 and type 2 diabetes mellitus, especially foot and eye care.
- Provide appropriate teaching to facilitate blood glucose monitoring, administration of oral and injectable hypoglycemic medications, diabetic diet, appropriate exercise, and foot care.
- Revise plan of care as needed to provide effective interventions to promote, maintain, or restore normal glucose levels.
- Teach the relationship of hygiene, neuropathy, and impaired microcirculation to infection; teach the principles and procedures of effective foot care.
- Assess clients' ability to read markings on syringes and to identify correct insulin and hypoglycemics.
- Relate insulin (endogenous and exogenous), dietary intake, and exercise to control of blood glucose.

**MEDIALINK**

Resources for this chapter can be found on the Prentice Hall Nursing MediaLink DVD-ROM accompanying this textbook, and on the Companion Website at http://www.prenhall.com/lemone



KEY TERMS

**dawn phenomenon,** *582*
**diabetes mellitus (DM),** *563*
**diabetic ketoacidosis (DKA),** *582*
**diabetic nephropathy,** *588*
**diabetic neuropathies,** *588*
**diabetic retinopathy,** *588*
**endogenous insulin,** *566*
**exogenous insulin,** *566*
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**glucosuria,** *566*
**glycogenolysis,** *564*
**hyperglycemia,** *565*
**hyperosmolar hyperglycemic state (HHS),** *585*
**hypoglycemia,** *586*
**insulin,** *564*
**insulin reaction,** *586*
**ketonuria,** *569*
**ketosis,** *565*
**lipoatrophy,** *575*
**lipodystrophy,** *575*
**microalbuminuria,** *588*
**polydipsia,** *566*
**polyphagia,** *566*
**polyuria,** *566*
**Somogyi phenomenon,** *582*
**type 1 DM,** *563*
**type 2 DM,** *563*

**Diabetes mellitus (DM)** is a common chronic disease of adults requiring continuing medical supervision and client self-care education. However, depending on the type of diabetes and the age of the client, both client needs and nursing care may vary greatly. Consider the following examples:

- Cheryl Draheim is a 45-year-old schoolteacher. She developed diabetes at age 34 after an automobile accident caused severe pancreatic injuries. Cheryl has always been very careful about taking her insulin, following her diet, and exercising regularly. However, she is beginning to notice that her vision is getting worse and that she is having increasing pain in her legs, especially after standing for long periods of time. Cheryl says that sometimes she believes the disease controls her more than she controls it.
- Tom Chang is 53 years old. Early in his 40s, Tom was diagnosed with type 2 diabetes. Although Tom was taught about the disease and the importance of taking his oral medications, following his diet plan, and getting exercise, he rarely did more than take the medication. Five years ago, he was hospitalized for hyperglycemia and started taking insulin. Last year Tom had a stroke, leaving him unable to walk. He has now been admitted to the hospital for treatment of gangrene of the large toe on his left foot.
- Grace Staples is an independent 82-year-old woman who lives alone and happily takes care of her two cats. She is slightly overweight. Last year, during Grace's annual eye examination, eye changes typical for diabetes were found. She was referred to her family doctor, who diagnosed type 2 diabetes and started her on oral medications. Grace sticks to her diet, walks a mile every day, and plans to live to be 100.

As illustrated in these examples, diabetes mellitus is not a single disorder but a group of chronic disorders of the endocrine pancreas, all categorized under a broad diagnostic label. The condition is characterized by inappropriate hyperglycemia caused by a relative or absolute deficiency of insulin or by a cellular resistance to the action of insulin. Of the several classifications of diabetes, this chapter will focus on the two major types, type 1 and type 2. **Type 1 DM** is the result of pancreatic islet cell destruction and a total deficit of circulating insulin; **type 2 DM** results from insulin resistance with a defect in compensatory insulin secretion.

Diabetes mellitus has been recognized as a disease for centuries. *Diabetes* derives from a Greek word meaning "to siphon," referring to the increased output of urine. *Mellitus* derives from a Latin word meaning "sweet." The two words together identify the disease as an outpouring of sweet urine. It was not until 1921 that techniques were developed for extracting insulin from pancreatic tissue and for measuring blood glucose. At the same time, researchers discovered that insulin, when injected, produces a dramatic drop in blood glucose. This meant that diabetes was no longer a terminal illness because hyperglycemia could be controlled. Since that time, oral hypoglycemic drugs, human insulin products, insulin pumps, home blood glucose monitoring, and transplantation of the pancreas or of pancreatic islet or beta cells have advanced the treatment and care of people with diabetes.

Clients with DM face lifelong changes in lifestyle and health status. Nursing care is provided in many settings for the diagnosis and care of the disease and treatment of complications. A major role of the nurse is that of educator in both hospital and community settings.

## INCIDENCE AND PREVALENCE

Approximately 1.3 million new cases of DM are diagnosed each year in the United States. This chronic illness affects an estimated 18.2 million people; of that number, 13 million have been diagnosed and an estimated 5.2 million are undiagnosed (National Institutes of Health [NIH], 2004). There is an increased prevalence of diabetes (especially type 2 diabetes) among older adults and in minority populations. See the Focus on Cultural Diversity box on page 564.

Diabetes is the sixth leading cause of death by disease in the United States, primarily because of the widespread cardiovascular effects that result in atherosclerosis, coronary artery disease, and stroke (Centers for Disease Control and Prevention [CDC], 2005). People with diabetes are two to four times more likely to have heart disease, and two to four times more likely to have a stroke than people who do not have diabetes. Diabetes is the leading cause of end-stage renal disease (kidney failure), and the major cause of newly diagnosed blindness in people ages 20 to 74. Diabetes

**FOCUS ON CULTURAL DIVERSITY**
**Risk and Incidence of Diabetes Mellitus**

- 13.1 million (8.7%) of all non-Hispanic whites aged 20 years or older have diabetes.
- 3.2 million (13.3%) of all non-Hispanic African Americans have diabetes, and are 1.8 times as likely to have diabetes as non-Hispanic whites of similar age. African Americans with type 2 diabetes have higher rates of coronary heart disease, CVA, and end-stage renal disease than do Caucasians with the disease.
- 2.5 million (9.5%) Hispanic/Latino Americans have diabetes, and are 1.7 times as likely to have diabetes as non-Hispanic whites of similar age. Mexican Americans are twice as likely to have diabetes as non-Hispanic whites of similar age.
- American Indians and Alaska Natives are 2.2 times more likely to have diabetes than non-Hispanic whites, and diabetes is especially prevalent in middle-aged and older American Indians. Diabetes mellitus is most common among Native Americans of the southern United States (27.8%) and least common among Alaska natives (8.1%) (CDC, 2005).

is also the most frequent cause of nontraumatic amputations with an estimated 82,000 amputations in 2002 in people with diabetes.

Americans with diabetes use a disproportionate share of the nation's healthcare services. They visit outpatient services and physicians' offices more often than people who do not have the disease, and they require more frequent hospitalizations with longer days of in-hospital treatment. The cost of illness and resulting loss of productivity for people with diabetes exceeds $132 billion per year, according to an estimate by the American Diabetes Association in 2002 (CDC, 2005).

# OVERVIEW OF ENDOCRINE PANCREATIC HORMONES AND GLUCOSE HOMEOSTASIS

## Hormones

The endocrine pancreas produces hormones necessary for the metabolism and cellular utilization of carbohydrates, proteins, and fats. The cells that produce these hormones are clustered in groups of cells called the islets of Langerhans. These islets have three different types of cells:

- Alpha cells produce the hormone *glucagon,* which stimulates the breakdown of glycogen in the liver, the formation of carbohydrates in the liver, and the breakdown of lipids in both the liver and adipose tissue. The primary function of glucagon is to decrease glucose oxidation and to increase blood glucose levels. Through **glycogenolysis** (the breakdown of liver glycogen) and **gluconeogenesis** (the formation of glucose from fats and proteins), glucagon prevents blood glucose from decreasing below a certain level when the body is fasting or in between meals. The action of glucagon is initiated in most people when blood glucose falls below about 70 mg/dL.
- Beta cells secrete the hormone **insulin**, which facilitates the movement of glucose across cell membranes into cells, decreasing blood glucose levels. Insulin prevents the excessive breakdown of glycogen in the liver and in muscle, facilitates lipid formation while inhibiting the breakdown of stored fats, and helps move amino acids into cells for protein synthesis. After secretion by the beta cells, insulin enters the portal circulation, travels directly to the liver, and is then released into the general circulation. Circulating insulin is rapidly bound to receptor sites on peripheral tissues (especially muscle and fat cells) or is destroyed by the liver or kidneys. Insulin release is regulated by blood glucose; it increases when blood glucose levels increase, and it decreases when blood glucose levels decrease. When a person eats food, insulin levels begin to rise in minutes, peak in 30 to 60 minutes, and return to baseline in 2 to 3 hours.
- Delta cells produce *somatostatin,* which is believed to be a neurotransmitter that inhibits the production of both glucagon and insulin.

## Blood Glucose Homeostasis

All body tissues and organs require a constant supply of glucose; however, not all tissues require insulin for glucose uptake. The brain, liver, intestines, and renal tubules do not require insulin to transfer glucose into their cells. Skeletal muscle, cardiac muscle, and adipose tissue do require insulin for glucose movement into the cells.

Normal blood glucose is maintained in healthy people primarily through the actions of insulin and glucagon. Increased blood glucose levels, amino acids, and fatty acids stimulate pancreatic beta cells to produce insulin. As cells of cardiac muscle, skeletal muscle, and adipose tissue take up glucose, plasma levels of nutrients decrease, suppressing the stimulus to produce insulin. If blood glucose falls, glucagon is released to raise hepatic glucose output, raising glucose levels. Epinephrine, growth hormone, thyroxine, and glucocorticoids (often referred to as glucose counterregulatory hormones) also stimulate an increase in glucose in times of hypoglycemia, stress, growth, or increased metabolic demand. The regulation of blood glucose levels by insulin and glucagon is illustrated in Figure 20–1 ■.

# PATHOPHYSIOLOGY OF DIABETES

DM is a group of metabolic diseases characterized by hyperglycemia resulting from defects in the secretion of insulin, the action of insulin, or both. There are four major types of DM. Type 1 diabetes (5% to 10% of diagnosed cases) was formerly called juvenile-onset diabetes or insulin-dependent diabetes mellitus (IDDM). Type 2 diabetes (90% to 95% of diagnosed cases) was formerly labeled non-insulin-dependent diabetes mellitus (NIDDM) or adult-onset diabetes. The other major types are gestational diabetes (2% to 5% of all pregnancies) and other specific types of diabetes (1% to 2% of diagnosed

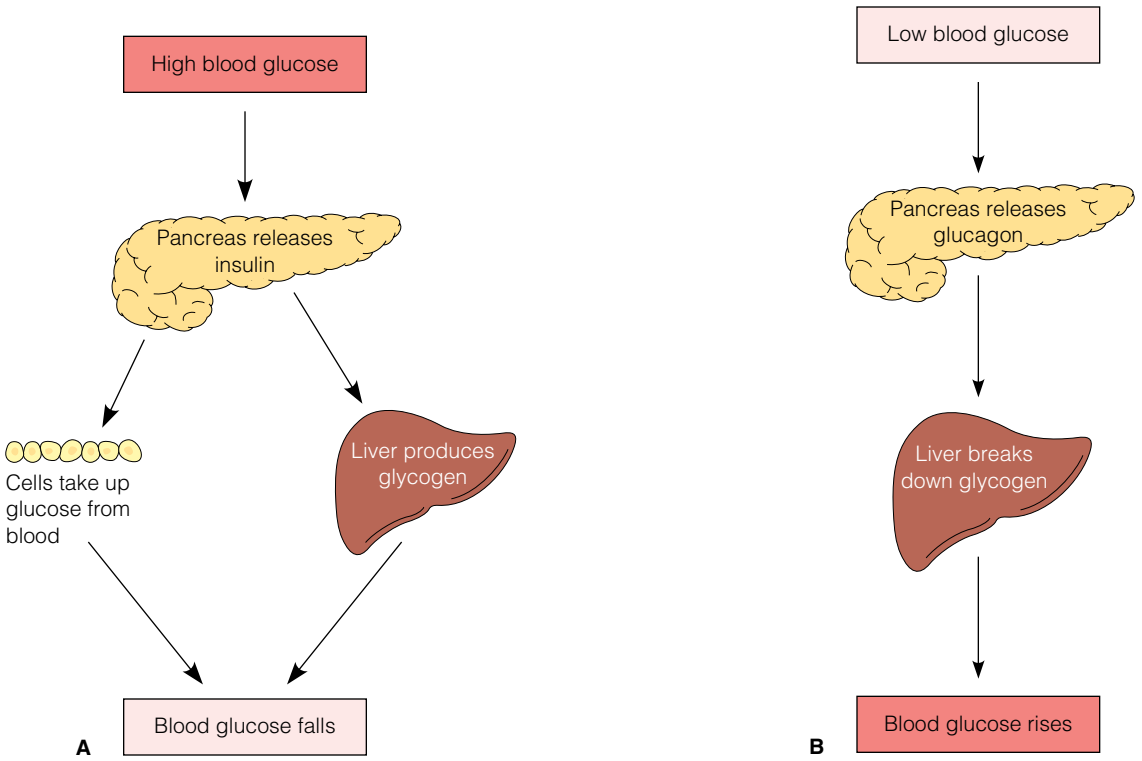



**Figure 20–1** ■ Regulation (homeostasis) of blood glucose levels by insulin and glucagon. *A,* High blood glucose is lowered by insulin release. *B,* Low blood glucose is raised by glucagon release.

cases). The classification and characteristics of the four types are described in Table 20–1.

## Type 1 Diabetes

Type 1 diabetes most often occurs in childhood and adolescence, but it may occur at any age, even in the 80s and 90s. This disorder is characterized by **hyperglycemia** (elevated blood glucose levels), a breakdown of body fats and proteins, and the development of **ketosis** (an accumulation of ketone bodies produced during the oxidation of fatty acids). Type 1 DM is the result of the destruction of the beta cells of the islets of Langerhans in the pancreas, the only cells in the body that make insulin. When beta cells are destroyed, insulin is no longer produced. Although type 1 DM may be classified as either an autoimmune or idiopathic disorder, 90% of the cases are immune mediated. The disorder begins with insulinitis, a chronic inflammatory process that occurs in response to the autoimmune destruction of islet cells. This process slowly destroys beta cell production of insulin, with the onset of hyperglycemia occurring when 80% to 90% of beta cell function is lost. This process usually occurs over a long preclinical period. It is believed that both alpha-cell and beta-cell functions are abnormal, with a lack of insulin and a relative excess of glucagon resulting in hyperglycemia.

### Risk Factors

Genetic predisposition plays a role in the development of type 1 DM. Although the risk in the general population ranges from 1 in 400 to 1 in 1000, the child of a person with diabetes has a 1 in 20 to 1 in 50 risk. Genetic markers that determine immune responses—specifically, DR3 and DR4 antigens on chromosome 6 of the human leukocyte antigen (HLA) system—have been found in 95% of people diagnosed with type 1 DM. (HLAs are cell surface proteins, controlled by genes on chromosome 6.) Although the presence of these markers does not guarantee that the person will develop type 1 DM, they do indicate increased susceptibility (Porth, 2005).

Environmental factors are believed to trigger the development of type 1 DM. The trigger can be a viral infection (mumps, rubella, or coxsackievirus B4) or a chemical toxin, such as those found in smoked and cured meats. As a result of exposure to the virus or chemical, an abnormal autoimmune response occurs in which antibodies respond to normal islet beta cells as though they were foreign substances, destroying them. The manifestations of type 1 DM appear when approximately 90% of the beta cells are destroyed. However, manifestations may appear at any time during the loss of beta cells if an acute illness or stress increases the demand for insulin beyond the reserves of the damaged cells. The actual cause and exact sequence are not completely understood, but research continues to identify the genetic markers of this disorder and to investigate ways of altering the immune response to prevent or cure type 1 DM.

### Manifestations

The manifestations of type 1 DM are the result of a lack of insulin to transport glucose across the cell membrane into the cells

MEDIALINK Case Study: DM Type 1

TABLE 20–1 **Classification and Characteristics of Diabetes**

| | CLASSIFICATION | CHARACTERISTICS |
|---|---|---|
| Type 1 Diabetes | Immune mediated | Beta cells are destroyed, usually leading to absolute insulin deficiency. Markers to the immune destruction of the beta cells include islet cell autoantibodies (ICAs) and insulin autoantibodies (IAAs). The rate of beta cell destruction is variable, usually more rapid in infants and children and slower in adults. Destruction of the beta cells has genetic predispositions and is also related to environmental factors as yet undefined. |
| | Idiopathic | Has no known etiologic causes. Most clients are of African or Asian descent. Is strongly inherited. Need for insulin may be intermittent. |
| Type 2 Diabetes | | May range from predominantly insulin resistance with relative insulin deficiency to a predominantly secretory defect with insulin resistance. There is no immune destruction of beta cells. Initially, and in some cases for the entire life, insulin is not necessary. Most people with this form are obese, or have an increased amount of abdominal fat. Risks for development include increasing age, obesity, and a sedentary lifestyle. Occurs more frequently in women who have had gestational diabetes, and in people with lipid disorders or hypertension. There is a strong genetic predisposition. |
| Other Specific Types | Genetic defects of beta cell | Hyperglycemia occurs at an early age (usually before age 25). This type is referred to as maturity-onset diabetes of the young (MODY). |
| | Genetic defects in insulin action | Are genetically determined. Dysfunctions may range from hyperinsulinemia to severe diabetes. |
| | Diseases of the exocrine pancreas | Acquired processes causing diabetes include pancreatitis, trauma, infection, pancreatectomy, and pancreatic cancer. Severe forms of cystic fibrosis and hemochromatosis may also damage beta cells and impair insulin secretion. |
| | Endocrine disorders | Excess amount of hormones (e.g., growth hormone, cortisol, glucagon, and epinephrine) impair insulin secretion, resulting in diabetes in people with Cushing's syndrome, acromegaly, and pheochromocytoma. |
| | Drug or chemical induced | Many drugs impair insulin secretion, precipitating diabetes in people with predisposing insulin resistance. Examples are nicotinic acid, glucocorticoids, thyroid hormone, thiazides, and Dilantin. |
| | Infections | Certain viruses may cause beta cell destruction, including congenital measles, cytomegalovirus, adenovirus, and mumps. |
| Gestational Diabetes Mellitus (GDM) | | Any degree of glucose intolerance with onset or first recognition during pregnancy. |

(Figure 20–2 ■). Glucose molecules accumulate in the circulating blood, resulting in hyperglycemia. Hyperglycemia causes serum hyperosmolality, drawing water from the intracellular spaces into the general circulation. The increased blood volume increases renal blood flow, and the hyperglycemia acts as an osmotic diuretic. The resulting osmotic diuresis increases urine output. This condition is called **polyuria**. When the blood glucose level exceeds the renal threshold for glucose—usually about 180 mg/dL—glucose is excreted in the urine, a condition called **glucosuria**. The decrease in intracellular volume and the increased urinary output cause dehydration. The mouth becomes dry and thirst sensors are activated, causing the person to drink increased amounts of fluid (**polydipsia**).

Because glucose cannot enter the cell without insulin, energy production decreases. This decrease in energy stimulates hunger, and the person eats more food (**polyphagia**). Despite increased food intake, the person loses weight as the body loses water and breaks down proteins and fats in an attempt to restore energy sources. Malaise and fatigue accompany the decrease in energy. Blurred vision is also common, resulting from osmotic effects that cause swelling of the lenses of the eyes.

Thus, the classic manifestations are polyuria, polydipsia, and polyphagia, accompanied by weight loss, malaise, and fatigue. Depending on the degree of insulin lack, the manifestations vary from slight to severe. People with type 1 DM require **exogenous insulin** to maintain life.

## Type 2 Diabetes

Type 2 DM is a condition of fasting hyperglycemia that occurs despite the availability of **endogenous insulin**. Type 2 DM can occur at any age, but it is usually seen in middle-age and older people. Heredity plays a role in its transmission. The level of insulin produced varies in type 2 DM, and despite its availability, its

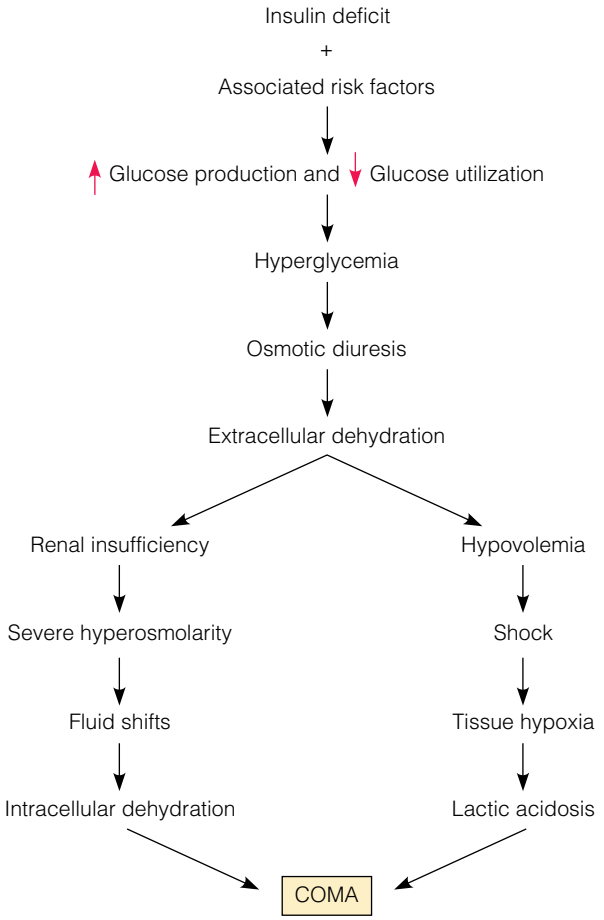



**Figure 20–2** ■ Pathophysiologic results of type 1 DM.

function is impaired by insulin resistance. Insulin resistance forces the pancreas to work harder and produce more insulin, but when demand exceeds supply, DM results (Saudek & Margolis, 2005). Whatever the cause, there is sufficient insulin production to prevent the breakdown of fats with resultant ketosis; thus, type 2 DM is characterized as a nonketotic form of diabetes. However, the amount of insulin available is not sufficient to lower blood glucose levels through the uptake of glucose by muscle and fat cells. A major factor in the development of type 2 DM is cellular resistance to the effect of insulin. This resistance is increased by obesity, inactivity, illnesses, medications, and increasing age. In obesity, insulin has a decreased ability to influence glucose metabolism and uptake by the liver, skeletal muscles, and adipose tissue. Although the exact reason for this is not clear, it is known that weight loss and exercise may improve the mechanism responsible for insulin receptor binding or postreceptor activity (McCance & Huether, 2002). Type 2 diabetes has increased 33% in the past decade in the United States. Hyperglycemia increases gradually and may exist over a long time before diabetes is diagnosed, thus approximately half the newly diagnosed type 2 diabetics already have complications (Capriotti, 2005). Treatment usually begins with prescriptions for weight loss and increased activity. If these changes can be sustained, no further treatment will be necessary for many individuals. Hypoglycemic medications are begun when lifestyle changes are insufficient. Often, a combination of insulin and hypoglycemic medication is used to achieve the best glycemic control in the client with type 2 DM.

### Risk Factors

The major risk factors for type 2 DM are as follows:

- History of diabetes in parents or siblings. Although there is no identified HLA linkage, the children of a person with type 2 DM have a 15% chance of developing type 2 DM and a 30% risk of developing a glucose intolerance (the inability to metabolize carbohydrate normally).
- Obesity, defined as being at least 20% over desired body weight or having a body mass index of at least 27 kg/m$^2$. Obesity, especially of the upper body, decreases the number of available insulin receptor sites in cells of skeletal muscles and adipose tissues, a process called *peripheral insulin resistance*. In addition, obesity impairs the ability of the beta cells to release insulin in response to increasing glucose levels.
- Physical inactivity.
- Race/ethnicity (see the box on page 564).
- In women, a history of gestational DM, polycystic ovary syndrome, or delivering a baby weighing more than 9 lb.
- Hypertension (≥130/85 in adults), HDL cholesterol of ≥35 mg/dL, and/or a triglyceride level of ≥250 mg/dL
- Metabolic syndrome is a cluster of manifestations associated with type 2 DM and thought to link cardiovascular disease with insulin resistance (Larsen et al., 2003). Hypertension, abdominal obesity, dyslipidemia, elevated C-reactive protein, and a fasting blood glucose greater than 110 mg/dL increase the risk of DM, coronary heart disease, and stroke (Porth, 2005; Saudek & Margolis, 2005). This syndrome is thought to exist in more than half of Americans over 50 years old. Although there is widespread acknowledgment that these manifestations are associated, clinicians differ about appropriate treatment (Larsen et al., 2003; Tierney et al., 2005).

### Manifestations

The person with type 2 DM experiences a slow onset of manifestations and is often unaware of the disease until seeking health care for some other problem. The hyperglycemia in type 2 is usually not as severe as in type 1, but similar symptoms occur, especially polyuria and polydipsia. Polyphagia is not often seen, and weight loss is uncommon. Other manifestations are also the result of hyperglycemia: blurred vision, fatigue, paresthesias, and skin infections. If available insulin decreases, especially in times of physical or emotional stress, the person with type 2 DM may develop diabetic ketoacidosis (DKA), but this occurrence is uncommon.

## Diabetes in the Older Adult

Although the older adult may have either type 1 or type 2 DM, most have type 2. The National Institute of Diabetes and Kidney Disease estimates that nearly 11% of the U.S. population between the ages of 65 and 74 has diabetes. The prevalence of diabetes becomes greater with age, increasing from 8.2% with diagnosed diabetes in those age 20 years or older to 18.4% for those equal to or older than age 65 (American Diabetes Association [ADA],

2005). It is predicted that the number of older adults with diabetes will continue to increase, because the incidence of the disease increases with age and because the number of people over age 65 is increasing.

Although most older adults with diabetes have type 2 DM, the improved survival rates for people with diabetes have resulted in an increased number of older adults with type 1. The picture is complicated by the fact that blood glucose levels increase with age, beginning in the 50s. For this reason, it is more difficult to diagnose diabetes in the older adult; conversely, the older adult may be mistakenly diagnosed with the disease simply for exhibiting essentially normal age-related changes in glucose. The relationship between normal increases in glucose levels and the presence of diabetes is not yet understood.

The older adult with diabetes has multiple, complex healthcare problems and needs including risks for polypharmacy, depression, cognitive impairment, urinary incontinence, injurious falls, and persistent pain (ADA, 2005). The normal physiologic changes of aging may mask manifestations of the onset of diabetes. Signs and symptoms of diabetes in elders may not include the classic symptoms of polyuria and thirst. Conditions such as orthostatic hypotension, periodontal disease, infections, stroke, gastric hypotony, impotence, neuropathy, confusion, and glaucoma should be considered potential indicators of diabetes (Eliopoulos, 2005), and may also increase the potential for complications from the disease or its treatment. Table 20–2 presents common problems in the older adult that make the diagnosis and management of diabetes more difficult. The older adult with diabetes also has a longer recovery period after surgery or serious illness, often requiring insulin to maintain blood glucose levels. The benefits and risks of treatment to maintain glycemic control as well as blood pressure and lipid management must be carefully balanced.

## INTERDISCIPLINARY CARE

The results of a 10-year Diabetes Control and Complications Trial, sponsored by the NIH, have significant implications for the management of type 1 DM. People in the study who kept their blood glucose levels close to normal by frequent monitoring, several daily insulin injections, and lifestyle changes that included exercise and a healthier diet reduced by 60% their risk for the development and progression of complications involving the eyes, the kidneys, and the nervous system. The DIGAMI study of 1995 stimulated interest in greater glycemic control in clients with type 2 DM (Cummings et al., 1999;

TABLE 20–2 **Implications for Nursing Care of the Older Adult with Diabetes**

| HEALTH PROBLEM/COMPLICATION | IMPLICATIONS FOR NURSING CARE |
|---|---|
| Urinary incontinence | Polyuria, a classic manifestation of diabetes, often is ignored. This problem also often leads to social isolation. |
| Decreased thirst | Polydipsia, a classic manifestation of diabetes, often is ignored. This further increases the risk of dehydration and electrolyte imbalances. |
| Decreased hunger and weight loss | Polyphagia, a classic manifestation of diabetes, often is ignored. The aging process, medications, depression, or lack of socialization may decrease hunger. Weight loss may be gradual and go unnoticed. |
| Fatigue | Fatigue is a common symptom of diabetes but may be blamed on increased age. |
| Hypoglycemia | The older adult may have either very mild manifestations or none at all. As a result, hypoglycemia is often ignored until it causes serious effects. |
| Peripheral neuropathy | Manifestations may be thought to be due to arthritis, and over-the-counter drugs often are used to self-medicate. The risk of falls increases, as does the risk of gangrene and amputation. |
| Peripheral vascular disease | May go undetected if the person does not get enough exercise to cause claudication. May also impair abilities to climb stairs and walk. |
| Diabetic retinopathy | May be undetected if the person has cataracts. Diabetic clients also have an increased incidence of cataracts and glaucoma. Deficits in vision threaten independence, mobility, and social interactions. Yellowing of the lens with age makes it difficult to read colored test strips; numeric meters are preferable. Filling insulin syringes may be impossible for the client with macular degeneration or other causes of visual loss. |
| Hypertension | Treatment with diuretics may further impair glucose tolerance and result in electrolyte imbalances. |
| Arthritis | Older adults may believe the pain from arthritis to be more important than the diabetes management. Also, depression from chronic pain as well as inactivity and loss of appetite may interfere with diabetes self-care. |
| Parkinson's disease | The tremors and rigidity of this disease make self-care involving fine and gross motor skills difficult or impossible. |
| Medications | Older adults commonly take more than one type of medication and are at increased risk for problems relating to drug interactions. |

*Source:* Adapted from "Diabetes Mellitus and the Older Adult" by M. M. Funnell and J. H. Merritt, pp. 755–830, in D. Haire-Joshu (Ed.), *Management of Diabetes Mellitus: Perspectives of Care Across the Lifespan* (2nd ed.), 1996, St. Louis, MO: Mosby; Eliopoulos, C., *Gerontological Nursing,* 2005, Philadelphia: Lippincott Williams & Wilkins.

Malmberg et al., 1995). Treatment of the client with diabetes focuses on maintaining blood glucose at levels as nearly normal as possible through medications, dietary management, and exercise. Type 2 DM benefits from similar levels of control.

## Diagnosis

Diagnostic tests are conducted for screening purposes to diagnose diabetes, and ongoing laboratory tests are conducted to evaluate the effectiveness of diabetic management. Definitions of normal blood glucose levels vary in clinical practice, depending on the laboratory that performs the assay.

***DIAGNOSTIC SCREENING*** Three diagnostic tests may be used to diagnose DM, and each must be confirmed, on a subsequent day, with one of the three tests. The following diagnostic criteria are recommended by the ADA (2005):

1. Symptoms of diabetes plus casual plasma glucose (PG) concentration > 200 mg/dL (11.1 mmol/L). Causal is defined as any time of day without regard to time since last meal.
2. Fasting plasma glucose (FPG) > 126 mg/dL (7.0 mmol/L). Fasting is defined as no caloric intake for 8 hours.
3. Two-hour PG > 200 mg/dL (11.1 mmol/L) during an oral glucose tolerance test (OGTT). The test should be performed with a glucose load containing the equivalent of 75 anhydrous glucose dissolved in water.

When using these criteria, the following levels are used for the FPG:

- Normal fasting glucose = 100 mg/dL (6.1 mmol/L)
- Impaired fasting glucose (IFG) > 100 (6.1 mmol/L) and <126 mg/dL (7.0 mmol/L)
- Diagnosis of diabetes > 126 mg/dL (7.0 mmol/L).

When using these criteria, the following levels are used for the OGTT:

- Normal glucose tolerance = 2-h PG < 140 mg/dL (7.8 mmol/L)
- Impaired glucose tolerance (IGT) = 2-h PG ≥ 140 (7.8 mmol/L) and < 200 mg/dL (11.1 mmol/L)
- Diagnosis of diabetes = 2-h PG ≥ 200 mg/dL (11.1 mmol/L).

Note that although either method may be used to diagnose diabetes, in a clinical setting the FPG is the recommended screening test for nonpregnant adults (ADA, 2002).

**Prediabetes** *Prediabetes* is a term used to describe people who are at increased risk of developing diabetes. Prediabetes is characterized by blood sugar between 100 and 126 mg/dL after fasting overnight, which is high but not high enough to be classified as diabetes. In 2000, an estimated 41 million adults ages 40 to 74 had prediabetes. These test results indicate there is a risk for progression to diabetes, but it is not inevitable. Studies suggest that weight loss and increased physical activity among people with prediabetes prevent or delay diabetes and may return blood glucose levels to normal. People with prediabetes are already at increased risk for other adverse health outcomes such as heart disease and stroke (CDC, 2005).

***DIAGNOSTIC TESTS TO MONITOR DIABETES MANAGEMENT*** The following diagnostic tests may be used to monitor diabetes management:

- *Fasting blood glucose (FBG).* This test is often ordered, especially if the client is experiencing symptoms of hypoglycemia or hyperglycemia. In most people, the normal range is 70 to 110 mg/dL.
- *Glycosylated hemoglobin (c) (A1c).* This test determines the average blood glucose level over approximately the previous 2 to 3 months. When glucose is elevated or control of glucose is erratic, glucose attaches to the hemoglobin molecule and remains attached for the life of the hemoglobin, which is about 120 days. The normal level depends on the type of assay done, but values above 7% to 9% are considered elevated. The ADA recommends that A1c be performed at the initial assessment, and then at regular intervals, individualized to the medical regimen used.
- *Urine glucose and ketone levels.* These are not as accurate in monitoring changes in blood glucose as blood levels. The presence of glucose in the urine indicates hyperglycemia. Most people have a renal threshold for glucose of 180 mg/dL; that is, when the blood glucose exceeds 180 mg/dL, glucose is not reabsorbed by the kidney and spills over into the urine. This number varies highly, however. **Ketonuria** (the presence of ketones in the urine) occurs with the breakdown of fats and is an indicator of DKA; however, fat breakdown and ketonuria also occur in states of less than normal nutrition.
- *Urine test* for the presence of protein as albumin (*albuminuria*). If albuminuria is present, a 24-hour urine test for creatinine clearance is used to detect the early onset of nephropathy.
- *Serum cholesterol and triglyceride levels.* These are indicators of atherosclerosis and an increased risk of cardiovascular impairments. The ADA (2005) recommends treatment goals to lower LDL cholesterol to <100 mg/dL, raise HDL cholesterol to >45 mg/dL, and lower triglycerides to <150 mg/dL.
- *Serum electrolytes.* Levels are measured in clients who have DKA or hyperosmolar hyperglycemic state (HHS) to determine imbalances.

## Monitoring Blood Glucose

People with diabetes must monitor their condition daily by testing glucose levels. Two types of tests are available. The first type, long used prior to the development of devices to directly measure blood glucose, is urine testing for glucose and ketones. Urine testing is less commonly used today. The second type, direct measurement of blood glucose, is widely used in all types of healthcare settings and in the home.

***URINE TESTING FOR KETONES AND GLUCOSE*** Urine testing for glucose and ketones was at one time the only available method for evaluating the management of diabetes. An inexpensive, noninvasive, and painless test, it has unpredictable results and cannot be used to detect or measure hypoglycemia. In the healthy state, glucose is not present in the urine because insulin maintains serum glucose below the renal threshold of 180 mg/dL. The accuracy of this measurement is not reliable in diabetes because the renal threshold may rise with aging or secondary to diabetes. Urine testing is recommended to monitor hyperglycemia and ketoacidosis in people with type 1 DM who have unexplained hyperglycemia during illness or pregnancy. Ketones may be detected through urine testing and reflect the

presence of DKA. Urine testing may also be used by people who choose not to self-monitor blood glucose by other methods. (See Procedure 20–1: Testing Urine for Ketones and Glucose.)

***SELF-MONITORING OF BLOOD GLUCOSE*** Self-monitoring of blood glucose (SMBG) allows the person with diabetes to monitor and achieve metabolic control and decrease the danger of hypoglycemia. The ADA recommends that all clients with diabetes must be taught some method of monitoring glycemic control. The timing of SMBG is highly individualized, depending on the person's diagnosis, general disease control, and physical state. SMBG is recommended three or more times a day for clients with type 1 DM; for clients with type 2 DM, testing should be sufficient to help them reach glucose goals. When adding or modifying therapy, clients with both types of DM should test more often than usual. SMBG is also useful when the person is ill or pregnant, or has symptoms of hypoglycemia or hyperglycemia (ADA, 2006).

The ADA annually publishes a comprehensive list of currently available blood glucose monitoring machines and strips with approximate prices in *Diabetes Forecast.* Most medical insurance policies cover the cost of these machines. A new technology for continuous blood glucose monitoring is now available and clients are learning to use these monitors, especially if they use insulin pumps. A new insulin pump receives transmitted data from a continuous glucose monitor (CGM) worn on the skin. Like the insulin pump, the CGM has a sensor that is inserted under the skin. This sensor continuously sends data to the transmitter, which sends the information to the pump by radio-frequency wireless technology. This data can warn of high or low glucose levels. Fingerstick measurements are required before making therapy adjustments (Medtronic MiniMed, 2006). The CGM is also used for diagnostic evaluation; clients wear the pump for 3 days under the supervision of physicians and nurses. The data reveal patterns of glycemic control useful for clinical recommendations.

Following is the equipment needed for SMBG:

- Some type of lancet device to perform a fingerstick for obtaining a drop of blood (such as an Autolet, Penlet, or Soft Touch).
- Chemically impregnated test strips that change color when they come into contact with glucose or that can be read by machine (e.g., Glucostix and Chemstrip bG). The strip may also be read by comparing its color with a color chart on the side of the container or on an insert (Figure 20–3 ■).
- A blood glucose monitor (e.g., the Glucometer, the Accu-Chek, or the One Touch) if the most accurate measurement is desired or recommended. The manufacturer's instructions must be followed carefully. If the timing of the blood on the strip is not exact, the test will not be accurate. In addition, the machine must be cleaned according to the manufacturer's directions to ensure accuracy. Monitors that use no-wipe technology improve the accuracy of glucose measurement. Other monitors are computerized and/or include a memory of previous glucose readings to show a pattern of control. The stored information is useful for clinicians to review and determine therapeutic needs.

***FACTORS THAT AFFECT GLUCOSE METER PERFORMANCE*** According to the U.S. Food and Drug Administration (FDA), several factors affect the accuracy of blood glucose test results. The quality of the meter and test strips, and training to use the meter contribute to the degree of accuracy. Other factors can create false positive or negative readings.

**Figure 20–3** ■ Determination of blood glucose levels by visual reading. The color of the strip is compared with the color chart on the side of the container.

## PROCEDURE 20-1 TESTING URINE FOR KETONES AND GLUCOSE

### TO TEST THE URINE FOR KETONES

1. Ask the client to void, discard the urine, and drink a full glass of water.
2. Thirty minutes later, collect a urine sample.
3. For Acidtest tablets: Place the tablet on a white paper towel, place 1 drop of urine on the tablet, and wait 30 seconds. If the tablet turns any shade from lavender to deep purple, the test is positive for ketones.
4. For Ketostix: Dip the reagent stick into the urine sample. Wait 15 seconds, and compare the color of the pad at the end of the stick to an accompanying color chart. Purple is indicative of ketones.

### TO TEST THE URINE FOR GLUCOSE

1. Follow the same procedure to collect a urine sample.
2. Dip the reagent stick into the urine sample, and wait the time indicated. Compare the color of the pad on the end of the reagent stick with an accompanying color chart. The glucose is expressed as a percentage (for example, 0.5%, 1%, 2%). Remember that normally no glucose is found in the urine, so the presence of glucose is an abnormal manifestation indicating hyperglycemia.

**Hematocrit** Clients with higher hematocrit values will usually test falsely low in blood glucose and clients with lower hematocrit will test falsely higher. Anemia and sickle cell anemia are two conditions that can affect hematocrit values.

**Other Substances** Overdoses of many medications will cause inaccurate results. Meters and supplies vary in sensitivity to medications. Uric acid (a natural substance in the body that can be more concentrated in some people with diabetes), glutathione (an antioxidant also called *GSH*), and ascorbic acid (vitamin C) are known to interfere. Check the package insert for each meter to find what substances might affect its testing accuracy (U.S. FDA, 2005).

**Use of Correct Supplies and Sample Volume** Be sure the test strips are compatible with the glucose meter and that they are not outdated or exposed to air and humidity, which can alter strip sensitivity. Insufficient amounts of blood on the testing strip cause inaccurate results. Although a meter may indicate a sufficient amount of blood on the test strip, it is best to observe that the receptacle is full of capillary blood. Yared et al. (2005) found that meters read significantly smaller than reference volumes and gave results varying 40% to 68% from the reference volume results. The erroneous results underestimated the true glucose value.

## Medications

The pharmacologic treatment for diabetes mellitus depends on the type of diabetes. People with type 1 DM must have insulin; those with type 2 DM are usually able to control glucose levels with an oral hypoglycemic medication, but they may require insulin if control is inadequate.

***INSULIN*** The person with type 1 DM requires a lifelong exogenous source of the insulin hormone to maintain life. Insulin is not a cure for diabetes; rather, it is a means of controlling hyperglycemia. Insulin is also necessary in other situations, such as these:

- People with diabetes who are unable to control glucose levels with oral antidiabetic drugs and/or diet. Introduced when beta cell function declines, insulin maintains glycemic control and prevents complications (Funnell, Kruger, & Spencer, 2004).
- People with diabetes who are experiencing physical stress (such as an infection or surgery) or who are taking corticosteroids.
- Women with gestational diabetes who are unable to control glucose with diet.
- People with DKA or HHS.
- People who are receiving high-calorie tube feedings or parenteral nutrition.

**Sources of Insulin** Preparations of insulin are derived from animal (pork pancreas) or synthesized in the laboratory from either an alteration of pork insulin or recombinant DNA technology, using strains of *E. coli* to form a biosynthetic human insulin. Insulin analogs have been developed by modifying the amino acid sequence of the insulin molecule. Although different types are prescribed on an individualized basis, it is standard practice to prescribe human insulin.

**Insulin Preparations** Insulins are available in rapid-acting, short-acting, intermediate-acting, and long-acting preparations. The trade names and times of onset, peak, and duration of action are listed in Table 20–3.

Insulin lispro (Humalog) is a human insulin analog that is derived from genetically altered *E. coli* that includes the gene for insulin lispro. It is classified as a rapid-acting or ultra-short-acting insulin. Compared to regular insulin, insulin lispro has a more rapid onset (<15 minutes), an earlier peak of glucose lowering (30 to 60 minutes), and a shorter duration of activity (3 to 4 hours). This means that lispro should be administered 15 minutes before a meal, rather than 30 to 60 minutes before as recommended for regular insulin. Clients with type 1 DM usually also require concurrent use of a longer acting insulin product. Lispro is much less likely than regular insulin to cause tissue changes and may lower the risk of nocturnal hypoglycemia in clients with type 1 DM.

Regular insulin is unmodified crystalline insulin, classified as a short-acting insulin. Regular insulin is clear in appearance and is the only insulin preparation that can be given by the intravenous route; the other types are suspensions and could be harmful if given by this route. Regular insulin is also used to treat DKA, to initiate treatment for newly diagnosed type 1

TABLE 20–3 **Insulin Preparations**

| PREPARATION | NAME | ONSET (H) | PEAK (H) | DURATION (H) |
|---|---|---|---|---|
| Rapid acting | Lispro | 0.25 | 1–1.5 | 3–4 |
| | Aspart (NovoLog) | 0.25 | 40–50 minutes | 3–5 |
| | Glulisine (Apidra) | 0.25 | 1–1.5 | 3–5 |
| Short acting | Regular (Novolin-R, Humulin-R) | 0.5–1.0 | 2–3 | 4–6 |
| Intermediate acting | NPH Humulin (N)<br>NPH | 2 | 6–8 | 12–16 |
| Long acting | Lantus | 2<br>(Onset and peak not defined) | 16–20 | 24+<br>24 |
| Combinations | Humulin 50/50<br>Humulin 70/30<br>Novolin 70/30 | 0.5<br>0.5<br>0.5 | 3<br>4–8<br>4–8 | 22–24<br>24<br>24 |

DM, and in combination with intermediate-acting insulins to provide better glucose control.

The onset and peak and duration of action of insulin can be changed by adding acetate buffers and protamine. Zinc and protamine are added to NPH insulin to prolong their action, and they are classified as intermediate- or long-acting insulins. These preparations appear cloudy when properly mixed prior to injection. Protamine and zinc are foreign substances and may cause hypersensitivity reactions. As of July 6, 2005, Lilly discontinued manufacture of pork insulins and Humulin U and Humulin Lente insulin.

Insulin glargine (Lantus) is a 24-hour, long-acting rDNA human insulin analog that is given subcutaneously once a day, usually at bedtime, to treat clients with both type 1 and type 2 diabetes. It has a relatively constant effect (meaning it does not have a peak time of effect). It is not recommended for use in pregnancy. Do not mix this with other insulins; the pH is incompatible (Lehne, 2004; Tierney et al., 2005).

**PRACTICE ALERT**

Insulin glargine is clear unlike other intermediate or long-acting insulins. Do not mistake this for regular insulin. Do not mix with **any** other insulins. Do not inject intravenously, only subcutaneously.

**Concentrations of Insulin** Insulin is dispensed as 100 unit/mL (U-100) and 500 unit/mL (U-500) in the United States. U-100 is the standard insulin concentration used. U-500 insulin is only used in rare cases of insulin resistance when clients require very large doses. U-500 and the insulin analog lispro are the only insulins that require a prescription.

**Insulin Administration** Nursing implications for administering insulin are outlined in the Medication Administration box on the following page and further discussion follows in the chapter. The considerations for administering insulin include routes of administration, syringe and needle selection, preparing the injection, sites of injection, mixing insulins, and insulin regimens.

*Routes of Administration.* All insulins are given parenterally, although current research is investigating the development of a nasal spray and an oral preparation of insulin. Only regular insulin is given by both subcutaneous and intravenous routes; all others are given only subcutaneously. If the intravenous route is not available, regular insulin may also be administered intramuscularly in an emergency situation.

*Continuous Subcutaneous Insulin Infusion.* Regular or rapid-acting insulins are used in continuous subcutaneous insulin infusion (CSII) devices, often called *insulin pumps* (e.g., MiniMed and Disetronic pumps). CSII devices have a small pump that holds a syringe of insulin, connected to a subcutaneous needle by tubing. The pump is about the size of a pager and can be worn on a belt or tucked into a pocket. The needle is placed in the skin, usually in the abdomen, and is changed every 3 days. This device delivers a constant amount of programmed insulin throughout each 24-hour period. It also can be used to deliver a bolus of insulin manually (e.g., before meals).

*Sliding Scale Insulin.* Treatment of hospitalized type 1 and type 2 clients requires a medication regimen that is responsive to glycemic changes secondary to the admitting condition and its treatment, including surgery (Clement et al., 2004). Type 2 diabetics cannot manage with oral medications during hospitalization because of the risk of hypoglycemia from not eating and the slow response of these medications to correct hyperglycemia. There is growing acceptance of the need to achieve tighter control of blood sugar in individuals who are hospitalized with hyperglycemia, whether they are diagnosed with diabetes, have unrecognized diabetes, or have hospital-related diabetes (Clement et al., 2004; Magee, 2006). Researchers first recognized the benefit of normal blood sugars (80 to 110 mg/dL) maintained by intensive insulin therapy (intravenous regular insulin) in surgical ICU patients; the optimum degree of blood sugar control in medical ICU patients remains undetermined through research at this time although levels equal to or <180 mg/dL are generally accepted (Magee, 2006; Malmberg et al., 1995; Van den Berghe et al., 2006).

In a study of 1200 medical ICU patients, Van den Berghe et al. (2006) compared those receiving intensive insulin therapy with patients receiving conventional therapy (insulin administered when the blood glucose reached 215 mg/dL). Those in the intensively treated group who were in the ICU for 3 days or more had significantly reduced morbidity, slightly more incidents of hypoglycemia (although significantly less mortality related to hypoglycemia than those treated conventionally), and significantly reduced acquired kidney injury (defined as a serum creatinine level at least twice the admission level).

Maintaining normal blood glucose during hospitalization decreases the risk of postoperative infections and shortens hospital stays. Healing is impaired when hemoglobin is glycosylated (hemoglobin $A_{1c}$ ); glycosylated Hgb has increased affinity for oxygen, putting tissues at risk for ischemia (McCance & Huether, 2002). Further, diabetes leads to small-vessel disease, which impairs circulation and oxygenation of tissue for healing.

Intravenous insulin infusions are preferable for maintaining normal blood glucose during hospitalization, although their use is dependent on frequent blood glucose monitoring and intensive nursing care. Supplements of regular insulin following sliding scale prescriptions (relative to monitored blood glucose levels) are ineffective management protocols, risking both hyperglycemia and hypoglycemia. These supplements treat hyperglycemia after it has occurred rather than preventing it. When medical conditions lead to observable periods of hyperglycemia outside the ICU, it is preferable to provide a basal subcutaneous insulin such as insulin glargine or NPH and mealtime supplements with regular or aspart insulin. Correctional doses can be added to the mealtime doses

## MEDICATION ADMINISTRATION **Insulin**

### Nursing Responsibilities

- Discard vials of insulin that have been open for several weeks or whose expiration date has passed.
- Refrigerate extra insulin vials not currently in use, but do not freeze them.
- Store insulin in a cool place, and avoid exposure to temperature extremes or sunlight.
- Store compatible mixtures of insulin for no longer than 1 month at room temperature or 3 months at 36° to 46°F (2° to 8°C).
- Discard any vials with discoloration, clumping, granules, or solid deposits on the sides.
- If breakfast is delayed, also delay the administration of rapid-acting insulin.
- Monitor and maintain a record of blood glucose readings 30 minutes before each meal and bedtime (or as prescribed).
- Monitor food intake, and notify the physician if food is not being consumed.
- Monitor electrolytes (especially potassium), blood urea nitrogen (BUN) levels, and creatinine.
- Observe injection sites for manifestations of hypersensitivity, lipodystrophy, and lipoatrophy.
- If symptoms of hypoglycemia occur, confirm by testing blood glucose level, and administer an oral source of a fast-acting carbohydrate, such as juice, milk, or crackers. Hypoglycemic symptoms may vary but commonly include feelings of shakiness, hunger, and/or nervousness accompanied by sweating, tachycardia, or palpitations.
- If symptoms of hyperglycemia occur, confirm by testing blood glucose level, and notify the physician.

### Health Education for the Client and Family

- The manifestations of diabetes mellitus.
- Self-administration of insulin, with a return demonstration.
  a. Wash hands carefully.
  b. Have a vial of insulin, the insulin syringe with needle, and alcohol pads ready to use.
  c. Remove the cover from the needle.
  d. Fill the syringe with an amount of air equal to the number of units of insulin, and insert the needle into the vial.
  e. Push air into the vial, invert the vial, and withdraw the prescribed units of insulin.
  f. Replace the cover over the needle.
  g. Wipe the selected site with alcohol. The injection is less likely to be painful if the alcohol is allowed to dry.
  h. Pinch up a fold of skin, and insert the needle into the tissue at the recommended angle.
  i. Insert the insulin.
  j. Withdraw the needle; if desired, apply firm pressure to the site for a few seconds.
  k. Recap the needle. Many people with diabetes reuse disposable syringes with attached needles without adverse effects. The primary reason for discarding after several uses is that the needle becomes dull and makes the injection painful.
- Follow instructions for mixing insulins (refer to Box 20–3 on page 576).
- Always keep an extra vial of insulin available.
- Always have a vial of regular insulin available for emergencies.
- Be aware of the signs of hypersensitivity responses, hypoglycemia, and hyperglycemia.
- Keep candy or a sugar source available at all times to treat hypoglycemia, if it occurs. Eat within 15 minutes of injecting rapid-acting insulins.
- Vision may be blurred during the first 6 to 8 weeks of insulin therapy; this is the result of fluid changes in the eye and should clear up in 8 weeks.
- Avoid alcoholic beverages, which may cause hypoglycemia.
- Follow these guidelines for sick days:
  a. Never omit insulin.
  b. Always monitor blood glucose and/or urine ketones at least every 2 to 4 hours.
  c. Always drink plenty of fluids, try to drink at least one glass of water or other calorie-free, caffeine-free liquid each hour.
  d. Get as much rest as possible.
  e. Contact the physician if there is persistent fever, vomiting, shortness of breath, severe pain in the abdomen, dehydration, loss of vision, chest pain, persistent diarrhea, blood glucose levels above 250, or ketones in the urine.
- Establish a plan for rotating injection sites, and observe closely for changes in tissues such as hardness, dimpling, or sunken areas.

to keep serum glucose below 180 mg/dL (ADA, 2005; Clement et al., 2004).

See Box 20–1 for methods to calculate basal and bolus doses for hospitalized patients on scheduled subcutaneous insulin doses and patients with insulin pumps.

Programming the amount of insulin to be delivered with a pump is determined by frequent blood glucose monitoring. Several different pumps are available, and each has rechargeable batteries, a syringe, a programmable computer, and a motor and drive mechanism. The rapid-acting insulin analog lispro is an appropriate insulin for insulin pumps, and short-acting regular insulin may also be used. Lispro is not approved for use in pregnancy (Tierney et al., 2005).

Many people with diabetes believe the pump allows more normal regulation of blood glucose and provides greater lifestyle flexibility. Pumps are as safe as multiple-injection therapy when recommended procedures are followed. A potential complication is an undetected interruption in insulin delivery, which may result in a rapid onset of DKA. The needle site must be kept clean and changed on a regular basis (usually every 2 to 3 days) to prevent inflammation and infection. Although the client who chooses an insulin pump has much to learn, many are very satisfied with having more normal glucose control.

*Syringe and Needle Selection.* Insulin is administered in sterile, single-use, disposable insulin syringes, calibrated in units per

## BOX 20–1 **Insulin Total Daily Dose**

1. The total amount of insulin that the patient administered daily by injection (rapid- or short-acting with intermediate- or long-acting); for example, 48 units (30 units NPH and 18 units regular insulin).
   **OR**
2. 0.5–1 unit/kg (normal kidney/liver function already on insulin), for example, 48 units for a 96-kg patient
   **OR**
3. 0.3–0.5 unit/kg (reduced kidney/liver function or initial insulin therapy).
   Test blood glucose with test strip AC and HS.

### Basal Dose: 40% to 50% of the insulin total daily dose (ITDD).

1. *Insulin pump:* Multiply the ITDD by 50% (48.0 × 0.5 = 24 units). The basal insulin pump dose for this patient is 24 units. Divide the basal insulin pump dose by 24 to get the hourly basal pump dose and rate (24/24 = 1.0 unit/hour). Use rapid-acting or regular insulin.
2. *Subcutaneous insulin:* Multiply the ITDD by 50% (48.0 × 0.5 = 24 units. This will be administered as one insulin glargine SQ injection daily or NPH injections of 12 units each twice daily. These basal doses are made with long-acting or intermediate-acting insulins.

### Mealtime Bolus Dose

1. *Insulin pump:* To calculate bolus doses, take the remaining 50% of insulin and divide it by four doses according to the patient's meal plan for the day. For example, the remaining 50% could be divided thus: 20% at breakfast = 10 units; 10% at lunch = 5 units; 15% at dinner = 8 units, and 5% with a bedtime snack = 2 units.

   To calculate the units for each of these four daily bolus doses, multiply the percent of each meal bolus times the total daily insulin pump dose. For example, for 48 units for a total daily dose:

   Breakfast dose is

   20% (or 0.2) × 48 units = 10 units

   Lunch dose is

   10% (or 0.1) × 48 units = 5 units

   Dinner dose is

   15% (or 0.15) × 48 units = 8 units

   Bedtime snack dose is

   5% (or 0.05) × 48 = 2 units. (Nursing, 2005).

   Correction doses may be needed if the client is hyperglycemic.
2. *Subcutaneous insulin mealtime dose:* Divide half of the ITDD into 3 mealtime doses.

   Breakfast = 6 units; lunch = 6 units; supper = 6 units.
   No bedtime dose is given.

   Rapid-acting insulin (regular or aspart) is given in conjunction with the meal.

### Mealtime Correction Dose

This is different from sliding scale dosing because it is given with a scheduled insulin dose to prevent hyperglycemia after the meals. It is given with rapid-acting insulin combined with the mealtime dose.

1. Test blood glucose prior to each meal.
   If blood glucose mg/dL is:
   <80 or symptomatic for hypoglycemia
   Follow hypoglycemia protocol

| | |
|---|---|
| 81–100 | No correction dose needed. |
| 101–150 | Add 1 or 2 units if mealtime dose is >20 units. |
| 151–200 | Add 2 or 3 units if mealtime dose is >20 units. |
| 201–250 | Add 3 or 4 units if mealtime dose is >20 units. |
| 251–300 | Add 4 or 5 units if mealtime dose is >20 units. |
| >300 | Add 5 or 10 units if mealtime dose is >20 units. |

*Note:* When correction doses are needed, the scheduled doses of rapid-acting insulin need to be reordered at higher doses.

milliliter. This means that in U-100 insulin, there are 100 units of insulin in 1 mL. Syringes for administering U-100 insulin can be purchased in either 0.3-mL (30-unit), 0.5-mL (50-unit), or 1.0-mL (100-unit) size. The advantage of the 0.3- and 0.5-mL sizes is that the distance between unit markings is greater, making it easier to measure the dose accurately. Although manufactured as "single-use," in the home environment clients may choose to reuse these syringes as long as the needles are sharp.

Most insulin syringes are manufactured with the needle permanently attached in a 25- to 27-gauge, 0.5-inch size. If this type of syringe is not available, an insulin syringe and a 25-gauge, 0.5-inch or 0.75-inch needle should be used.

Other special injection products are available for people with physical handicaps. These products include automatic injectors and jet spray injectors. Prefilled syringes are useful for people who are visually impaired or traveling. Prefilled syringes are stable for up to 30 days if stored in the refrigerator.

*Preparing the Injection.* The vial of insulin in use may be kept at room temperature for up to 4 weeks. Stored vials should be kept in the refrigerator and brought to room temperature prior to administration.

Regular insulin does not require mixing. If the solution is cloudy or discolored, the vial should be discarded. The other types of insulin must be mixed to disperse the particles evenly throughout the solution. Mix the vial by gently rolling it between the hands; vigorous shaking causes bubble formation and frothing, which makes the dose inaccurate. It is critical that no air bubbles remain in the prepared dose, because even a small bubble can displace several units of insulin.

*Sites of Injection.* Although in theory any area of the body with subcutaneous tissue can be used for injections of insulin, certain sites are recommended (Figure 20–4 ■). The rate of absorption and peak of action of insulin differ according to the site. The site

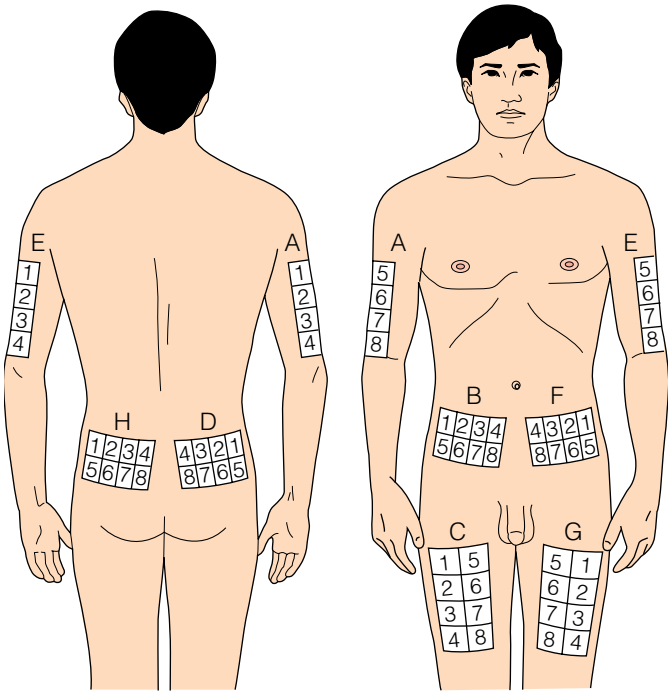



**Figure 20–4** ■ Sites of insulin injection.

that allows the most rapid absorption is the abdomen, followed by the deltoid muscle, then the thigh, and then the hip. Because of the rapid absorption, the abdomen is the recommended site. See Box 20–2 for techniques to minimize painful injections.

When administering insulin, gently pinch a fold of skin and inject the needle at a 90-degree angle. If the person is very thin, a 45-degree angle may be required to avoid injecting into muscle. Routine aspiration to check for blood is not necessary. Do not massage the site after administering the injection, because this may interfere with absorption; pressure, however, may be applied for about 1 minute. Rotation of injection sites is recommended for clients using pork insulin; rotation within sites is recommended for those using human or purified pork insulin. The distance between injections should be about 1 inch (avoiding the area within a 2-inch radius around the umbilicus).

## BOX 20–2 Techniques to Minimize Painful Injections

- Inject insulin that is at room temperature.
- Make sure no air bubbles remain in the syringe before the injection.
- Wait until alcohol on the skin completely dries before the injection.
- Relax muscles in the injection area.
- Penetrate the skin with the needle quickly.
- Don't change the direction of the needle during insertion or withdrawal.
- Don't reuse dull needles.

*Source:* Adapted from "Insulin Administration" by the American Diabetes Association, 1998, *Diabetes Care, 21* (Supplement 1), 572–575.

Insulin should not be injected into an area to be exercised (such as the thigh before a vigorous walk) or to which heat will be applied; exercise or heat may increase the rate of absorption and cause a more rapid onset and peak of action.

*Lipodystrophy.* **Lipodystrophy** (hypertrophy of subcutaneous tissue) or **lipoatrophy** (atrophy of subcutaneous tissue) may result if the same injection sites are used repeatedly, especially with pork and beef insulins. The tissues become hardened and have an orange-peel appearance. The use of refrigerated insulin may trigger the development of tissue atrophy or hypertrophy. These problems rarely occur with the use of human insulins. Lipodystrophy and lipoatrophy alter insulin absorption, delaying its onset or retaining the insulin in the tissue for a period of time instead of allowing it to be absorbed into the body. Lipodystrophy usually resolves if the area is unused for a minimum of 6 months.

*Mixing Insulins.* When a person with diabetes requires more than one type of insulin, mixing is recommended to avoid administering two injections per dose. Two different concentrations are administered, because a single dose of intermediate-acting or long-acting insulin rarely provides adequate control of blood glucose levels. The procedure for mixing insulins is described in Box 20–3. Following are some general guidelines:

- Commercially mixed insulins are recommended if the insulin ratio is appropriate for the requirements of the client.
- Regular insulin may be mixed with all types of insulin except glargine; it may be injected immediately after mixing or stored for future use.
- NPH insulin and PZI insulin may be mixed only with regular insulin.
- Do not mix human and animal insulins.
- Always withdraw regular insulin first to avoid contaminating the regular insulin with intermediate-acting insulin.

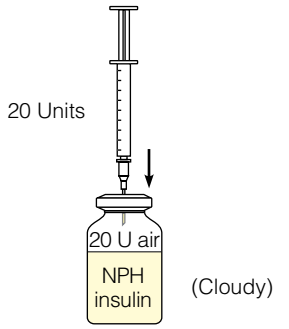
*Insulin Regimens.* The appropriate insulin dosage is individualized by achieving a balance among insulin, diet, and exercise. For most people with diabetes, the timing of insulin action requires two or more injections each day, often a mixture of rapid-acting and intermediate-acting insulins. Timing of the injections depends on blood glucose levels, food consumption, exercise, and types of insulin used. The objective is to avoid daytime hypoglycemia while achieving adequate blood glucose control overnight. Typical insulin regimens are discussed in Table 20–4.

***HYPERSENSITIVITY RESPONSES*** When injected, insulin may cause local and systemic hypersensitivity responses. Manifestations of local reactions are a hardening and reddening of the area that develops over several hours. Local reactions result from a contaminant in the insulin and are more likely to occur when less purified insulin products are used.

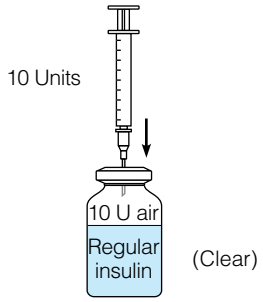
Systemic reactions occur rapidly and are characterized by widespread red, intensely pruritic welts. Respiratory difficulty may occur if the respiratory system is involved. Systemic responses are due to an allergy to the insulin itself and are most common with beef insulin. The client can be desensitized by

## BOX 20–3 Mixing Insulins: 10 Units of Regular and 20 Units of NPH

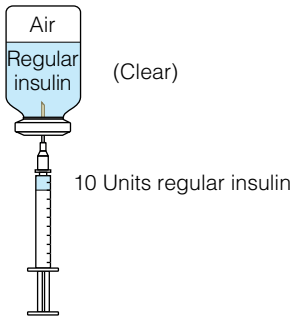
1. Wash hands.
2. Inspect regular insulin for clarity.
3. Gently rotate NPH insulin to mix well.
4. Wipe off the top of both vials with an alcohol pad.
5. Draw 20 units of air into the syringe, and inject air into the NPH vial (Figure A). Withdraw needle.
6. Draw 10 units of air into the syringe, and inject air into the regular vial (Figure B).
7. Invert the vial, and withdraw 10 units of regular insulin (Figure C). Withdraw the needle.
8. Insert the needle into the NPH vial, and carefully withdraw 20 units of NPH insulin (Figure D).
9. Administer the insulin.
10. Wash hands, and properly dispose of the syringe.



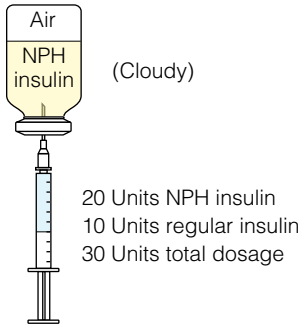

**A** Injecting air into the NPH vial.




**B** Injecting air into the regular insulin vial.




**C** Withdrawing regular insulin.




**D** Withdrawing NPH insulin.

administering small doses of purified pork or human insulin, followed by progressively larger doses.

***HYPOGLYCEMIC AGENTS*** Hypoglycemic agents are used to treat people with type 2 DM. Nursing implications for this category of drugs are discussed in the Medication Administration box on page 578. These medications lower blood sugar by stimulating or increasing insulin secretion, preventing breakdown of glycogen to glucose by the liver, and increasing peripheral uptake of glucose by making cells less resistant to insulin. Peripheral uptake refers to uptake by muscles and fat in the arms and legs rather than in the trunk. Some hypoglycemics keep blood sugar low by blocking absorption of carbohydrates in the intestines. A new hypoglycemic that is not insulin but is only available as an injectable is exenatide (Byetta). It has several modes of action: (1) signals the pancreas to make insulin when nutrients are ingested and stop insulin release as blood sugar normalizes, (2) stops liver conversion of glycogen to glucose, and (3) decreases absorption of sugar from the intestines. The goal of therapy with these agents is to reduce glycosylated hemoglobin and lower fasting and postprandial glucose (Capriotti, 2005).

***ASPIRIN THERAPY*** People with diabetes are up to four times more likely to die from cardiovascular disease. It is recommended that a once daily dose of 81 to 325 mg of enteric-coated aspirin be given to reduce atherosclerosis in clients with vascular disease or increased cardiovascular risk factors. Aspirin therapy is contraindicated for clients with aspirin allergy, bleeding tendency, anticoagulant therapy, recent gastrointestinal bleeding, or active liver disease (ADA, 2003).

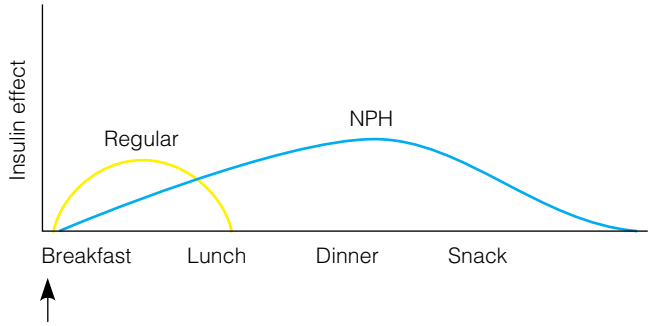
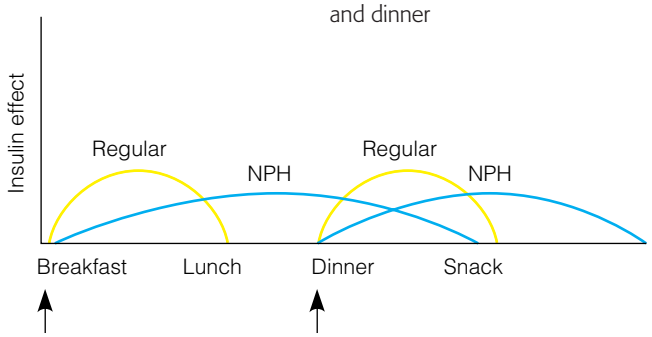
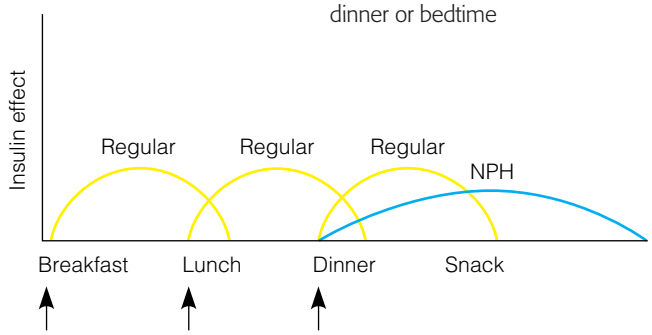
## Nutrition

The management of diabetes requires a careful balance between the intake of nutrients, the expenditure of energy, and the dose and timing of insulin or oral antidiabetic agents. Although everyone has the same need for basic nutrition, the person with diabetes must eat a more structured diet to prevent hyperglycemia. The goals for dietary management for adults with diabetes, based on guidelines established by the ADA (2002), are as follows:

- Maintain as near normal blood glucose levels as possible by balancing food intake with insulin or oral glucose.
- Achieve optimal serum lipid levels.
- Provide adequate calories to maintain or attain reasonable weights, and to recover from catabolic illness.
- Prevent and treat the acute complications of insulin-treated DM, short-term illnesses, and exercise-related problems; or the long-term complications of diabetes.
- Improve overall health through optimal nutrition, using Dietary Guidelines for Americans and the Food Guide Pyramid (see Chapter 2 ∞).

***CARBOHYDRATES*** The ADA recommends that carbohydrates should be individualized to the client's needs, with recommended allowances of 45% to 65% of the daily diet. Carbohydrates contain 4 kcal per gram and intake should not be restricted to less than 130 g/day (Sheard et al., 2004). This group of nutrients consists

TABLE 20–4 **Insulin Regimens**

| REGIMEN | INSULIN TYPE* | GENERAL INFORMATION |
|---|---|---|
| One injection per day   | NPH or NPH/R before breakfast | One injection is used to cover all meals (see figure at left). This is a simple regimen, but it is often difficult to control FBG levels, and afternoon hypoglycemia may result from increases in NPH. |
| Two injections per day   | NPH or NPH/R before breakfast and dinner | This regimen is the least complex of those aiming to mimic normal pancreatic function; the person must have a fairly rigid schedule of food intake and exercise. |
| Three or four injections per day   | R before each meal; NPH at dinner or bedtime | This regimen more closely mimics normal pancreatic function; it allows greater choice in mealtimes and exercise (see figure at left). However, each preprandial dose of R must be determined by blood glucose tests. |

*Insulin types are abbreviated as follows: NPH = intermediate acting, R = regular, rapid acting.

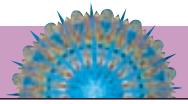
of plant foods (grains, fruits, vegetables), milk, and some dairy products. Carbohydrates can be divided into simple sugars and complex carbohydrates. Glycemic index is the rate a food raises blood glucose and, thus, insulin. Proponents of low-carbohydrate diets use glycemic index as the scientific foundation for decreasing intake of foods with a high glycemic index. However, many factors affect the digestion of carbohydrates; to date research does not support using glycemic index as a basis for therapy. The ADA does not recommend reliance on glycemic index as a method to treat or prevent diabetes (ADA, 2006).

The use of sucrose as part of the total carbohydrate content in the diet does not impair blood glucose control in people with diabetes. Sucrose and sucrose-containing foods must be substituted for other carbohydrates gram for gram. Dietary fructose (from fruits and vegetables or from fructose-sweetened foods) produces a smaller rise in plasma glucose than sucrose and most starches, so it may offer an advantage as a sweetening agent. However, large amounts of fructose have potentially adverse effects on serum cholesterol and LDL cholesterol, so amounts used should be controlled.

***PROTEIN*** The recommended daily protein intake is 15% to 20% of total daily kilocalorie intake. Protein has 4 kcal per gram. Sources of protein should be low in fat, low in saturated fat, and low in cholesterol. Although this amount of protein is much less than that which most people normally consume, it is

MEDIALINK Clipizide Animation

## MEDICATION ADMINISTRATION Oral Hypoglycemic Agents



### SULFONYLUREAS

**Glimepiride (Amaryl)**
**Glipizide (Glucotrol, Glucotrol XL)**
**Glyburide (Diabeta, Micronase)**
**Tolazamide (Tolinase)**
**Tolbutamide (Orinase)**

These drugs are used primarily to treat mild, nonketotic type 2 DM in people who are not obese. Glimepiride, glipizide, and glyburide, are 100 to 200 times more potent than tolbutamide. These clients cannot control the symptoms by diet alone, but they do not require insulin. The drugs act by stimulating the pancreatic cells to secrete more insulin and by increasing the sensitivity of peripheral tissues to insulin. Dose adjustments must be made gradually and therefore these drugs are not useful for meeting acute changes that occur in illness or surgery. The most common side effect is hypoglycemia and this is exacerbated by NPO status. These drugs are usually suspended during hospitalization (ADA, 2005).

### MEGLITINIDES

**Repaglinide (Prandin)**

This drug lowers blood glucose levels by stimulating release of insulin from the pancreatic islet cells.

### BIGUANIDES

**Metformin (Glucophage)**

Metformin reduces both the FBG and the degree of postprandial hyperglycemia in clients with type 2 DM. It primarily decreases the overproduction of glucose by the liver, and may also make insulin more effective in peripheral tissues. If renal insufficiency develops, metformin must be discontinued. It is used as an adjunct to diet, especially in clients who are obese or not responding to the sulfonylureas. Because of an increased risk of metformin-induced lactic acidosis, metformin is usually suspended during hospitalization. It should be discontinued temporarily before and after using contrast media for diagnostic imaging and anesthesia (Capriotti, 2005).

In recent studies, metformin has been successful in preventing diabetes. In the Diabetes Prevention Program, people treated with metformin reduced their risk of developing diabetes by 31% over 3 years. Treatment with metformin was most effective among younger, heavier people (those 25 to 40 years of age who were 50 to 80 pounds overweight) and less effective among older people and people who were not as overweight. Lifestyle changes including diet and regular moderate exercise were part of preventing or delaying the onset of diabetes.

### ALPHA-GLUCOSIDE INHIBITORS

**Acarbose (Precose)**
**Miglitol (Glyset)**

These drugs work locally in the small intestine to slow carbohydrate digestion and delay glucose absorption. As a result, postprandial glucose and glycosylated hemoglobin are better controlled, reducing the risk of long-term complications. Like metformin, acarbose administered to those with prediabetes reduced the risk of developing diabetes by 25% over 3 years. In addition to preventing progression from IGT to diabetes, the combination of lifestyle changes and medications facilitated return to normal glucose tolerance (www.cdc.gov/diabetes/pubs/general.htm).

### THIAZOLIDINEDIONES

**Rosiglitazone (Avandia)**
**Pioglitazone (Actos)**

This class of drugs acts by sensitizing peripheral tissue to insulin. Both drugs can be used alone or in combination with sulfonylureas, metformin, and insulin. These drugs increase intravascular volume and therefore create problems for anyone with acute coronary ischemia or CHF.

### D-Phenylalanine (Amino Acid) Derivative

**Nateglinide (Starlix)**
**Repaglinide (Prandin)**

This is a new class of oral medications for treatment of type 2 diabetes. They stimulate rapid and short insulin secretion from the pancreatic beta cells to decrease spikes in glucose following meals and also reduce the overall blood glucose level. They should be taken shortly before meals; without a meal, hypoglycemia is a risk.

### Nursing Responsibilities

- Assess clients taking oral hypoglycemic agents closely for the first 7 days to determine therapeutic response.
- Administer the drug with food.
- Teach the client the importance of maintaining a prescribed diet and exercise program.
- Monitor for hypoglycemia if the client is also taking nonsteroidal anti-inflammatory agents (NSAIDs), sulfonamide antibiotics, ranitidine, cimetidine, or beta blockers; these drugs intensify the action of sulfonylureas.
- Monitor for hyperglycemia if the client is also taking calcium channel blockers, oral contraceptives, glucocorticoids, phenothiazines, or thiazide diuretics; these drugs decrease the hypoglycemic responses to sulfonylureas.
- Do not administer these drugs to pregnant or lactating women.
- Assess for side effects: nausea, heartburn, diarrhea, dizziness, fever, headache, jaundice, skin rash, urticaria, photophobia, thrombocytopenia, leukopenia, or anemia.
- If the client is to have a thyroid test, determine whether the drug has been taken; sulfonylureas interfere with the uptake of radioactive iodine.
- Monitor for hypoglycemia with concurrent administration of an oral antidiabetic agent and insulin.
- Temporarily hold metformin for 2 days prior to injection of any radiocontrast agent to avoid potential lactic acidosis if renal failure occurs.
- Closely monitor liver function tests with administration of rosiglitazone and pioglitazone.

### Health Education for the Client and Family

- Maintain prescribed diet and exercise regimen.
- You may need insulin if you have surgery, trauma, fever, or infection.
- Follow instructions to monitor blood glucose.
- Report illness or side effects to the healthcare provider.
- Undergo periodic laboratory evaluations as prescribed by your healthcare provider.
- Avoid alcohol intake, which may cause a reaction involving flushing, palpitations, and nausea.
- The medication interferes with the effectiveness of oral contraceptives; other birth control measures may be required.
- Mild symptoms of hyperglycemia may appear if a different agent is begun.
- Take medications as prescribed; for example, once a day at the same time each day. If you are taking acarbose, take the pill with the first bite of food at breakfast, lunch, and dinner.

recommended to help prevent or delay renal complications. To help the client accept the decrease in the amount of protein, the nurse may suggest a less severe restriction at diagnosis with a gradual decrease to take place over a period of years.

***FATS*** Dietary fats should be low in saturated fat and cholesterol. Saturated fats should be no higher than 10% of the total kilocalories allowed per day, with dietary cholesterol less than 300 mg per day. Fat has 9 kcal per gram. Sources of the different types of fat include:

- *Saturated fat.* Sources are animal meats (meat and butter fats, lard, bacon), cocoa butter, coconut oil, palm oil, and hydrogenated oils.
- *Polyunsaturated fat.* Sources are oils of corn, safflower, sunflower, soybean, sesame seed, and cottonseed.
- *Monosaturated fat.* Sources are peanut oil, olive oil, and canola oil.

Limiting fat and cholesterol intake may help prevent or delay the onset of atherosclerosis, a common complication of diabetes.

***FIBER*** Dietary fiber may be helpful in treating or preventing constipation and other gastrointestinal disorders, including colon cancer. It also helps provide a feeling of fullness, and large amounts of soluble fiber may be beneficial to serum lipids. Soluble fiber is found in dried beans, oats, barley, and in some vegetables and fruits (e.g., peas, corn, zucchini, cauliflower, broccoli, prunes, pears, apples, bananas, oranges). Insoluble fiber, which is found in wheat, corn, and in some vegetables and fruits (e.g., carrots, brussels sprouts, eggplant, green beans, pears, apples, strawberries), does facilitate intestinal motility and give a feeling of fullness.

The ideal level of fiber has not been determined, but an intake of 20 to 35 grams per day is recommended. An increase in fiber may cause nausea, diarrhea, or constipation, and increased flatulence, especially if the person does not also increase fluid intake. Fiber in the diet should therefore be increased gradually.

***SODIUM*** Although the body requires sodium, most people consume much more than is needed each day, especially in processed foods. The recommended daily intake is 1000 mg of sodium per 1000 kcal, not to exceed 3000 mg. The primary concern with sodium is its association with hypertension, a common health problem in people with diabetes. It is suggested that table salt (which is 40% sodium) and processed foods high in sodium be avoided in the diabetes meal plan.

***SWEETENERS*** The diet plan for people with diabetes restricts the amount of refined sugars. As a result, many people use noncaloric sweeteners and foods or drinks made with noncaloric sweeteners. Commercially produced nonnutritive sweeteners are approved for use by the FDA. Although questions have been raised about the safety of these substances in laboratory animal studies, they are considered safe for use by humans. Included in this category of sweeteners are saccharin (Sweet & Low), aspartame or neotame (Nutrasweet, Equal), sucralose (Splenda), and acesulfame potassium (Sunnette). The nonnutritive sweeteners have negligent amounts of or no kilocalories, do not produce dental caries, and produce very little or no changes in blood glucose levels.

People with diabetes also use nutritive sweeteners, including fructose, sorbitol, and xylitol. The kilocalorie content of these substances is similar to that of table sugar (sucrose), but they cause less elevation in blood glucose. They are often included in foods labeled as "sugar free." Sorbitol may cause flatulence and diarrhea.

Researchers are continuing to study the safety and effectiveness of the sweeteners. In addition, the FDA recommends that the food industry label products with the amount of each ingredient in milligrams per serving and the number of servings per container. When teaching clients about diet, the nurse should include information about the kilocalorie content of sweeteners and the meaning of such phrases as *sugar free* and *dietetic* on labels.

***ALCOHOL*** Although drinking alcoholic beverages is not encouraged, neither is it totally prohibited for the client with diabetes. Alcohol consumption may potentiate the hypoglycemic effects of insulin and oral agents. The ADA recommends that men with diabetes consume no more than two drinks and women with diabetes no more than one drink per day. In the following list are guidelines for people who include alcohol in their diet plan:

- The signs of intoxication and hypoglycemia are similar; thus, the person with type 1 DM is at increased risk for an insulin reaction.
- Two oral hypoglycemic agents (chlorpropamide and tolbutamide) may interact with the alcohol, causing headache, flushing, and nausea.
- Liqueurs, sweet wines, wine coolers, and sweet mixes contain large amounts of carbohydrate.
- Light beer is the recommended alcoholic drink.
- Alcohol should be consumed with meals and added to the daily food intake. In most instances, the alcohol is substituted for fat in calculating the diet; a drink with 1.5 oz of alcohol is the equivalent of two fat exchanges (90 kcal). (Food exchanges are discussed below.)

***MEAL PLANNING*** Several different systems for meal planning are available to the person with diabetes. These systems include a consistent-carbohydrate diabetes meal plan, exchange lists, point systems, food groups, carbohydrate counting, and calorie counting. No matter what system is used, however, it must take into account the person's individualized eating habits, diet history, food values, and special needs. Altering foods and meal patterns is often one of the most difficult parts of diabetes management; careful consideration of individualized preferences enhances compliance with the diet. Although the ADA recommends that a registered dietitian provide the nutrition prescription, nurses must know what is prescribed and be able to reinforce teaching and answer questions.

**Consistent-Carbohydrate Diabetes Meal Plan** The consistent-carbohydrate diabetes meal plan, which is replacing the traditional exchange list plan, focuses on carbohydrate content. The client eats a similar amount of carbohydrates at each meal or snack each day, based on an individual diet prescription and the Food Guide Pyramid. Carbohydrates in a meal have the most effect on postprandial (after meals) blood glucose levels. They also

determine, to a greater extent than do proteins and fats, insulin requirements before meals. Clients should be taught to count carbohydrates so they can administer 1 unit of regular insulin or insulin lispro for each 10 or 15 g of carbohydrate eaten at a meal. This method provides a better connection between food, medications, and exercise.

**The Exchange Lists** The exchange list diet is based on the person's ideal (or reasonable) weight, activity level, age, and occupation. These factors determine the total kilocalories that the person may consume each day. After the calories have been determined, the proportions of carbohydrates, proteins, and fats are calculated, using guidelines established by the American Diabetes Association and the American Dietetic Association.

The distribution of foods throughout the day is based on exchange lists. The name and quantity of food that make up one exchange (or serving) are listed; standard household measurements are used. One food portion on the list can be substituted ("exchanged") for another with very little difference in calories or amount of carbohydrates, proteins, and fats. The meal plan prescribes how many exchanges are allowed for each food group per meal and snacks.

**Diet Plan for Type 1 Diabetes** Diet and insulin prescription must be integrated for optimal energy metabolism and the prevention of hyperglycemia or hypoglycemia. The goals of the diet plan are to achieve optimal glucose and lipid levels, improve overall health, and maintain reasonable body weight. To meet these goals, the following strategies must be implemented:

- Glucose regulation requires correlating eating patterns with insulin onset and peak of action.
- Meals, snacks, and insulin regimens should be based on the person's lifestyle.
- Meal planning depends on the specific insulin regimen prescribed.
- Snacks are an important consideration in relation to the amount and timing of exercise.
- The diet plan must consider the availability of foods, based on occupational, financial, religious, and ethnic constraints.
- Self-monitoring of blood glucose levels helps the client make adjustments for planned and unplanned changes in routines.

**Diet Plan for Type 2 Diabetes** The goals of the diet plan are to improve blood glucose levels, improve overall health, prevent or delay complications, and attain or maintain reasonable body weight. Because the majority of these clients are overweight, weight loss is important and facilitates achieving the other goals.

There are no specific guidelines for the type 2 diet, but in addition to decreasing kilocalories, it is recommended that the client consume three meals of equal size, evenly spaced approximately 4 to 5 hours apart, with one or two snacks. The person with type 2 DM should also decrease fat intake. If the exchange list is difficult to use, calorie counting or designing the diet by grams of fat may be more useful.

***SICK-DAY MANAGEMENT*** When the person with diabetes is sick or has surgery, blood glucose levels increase, even though food intake decreases. The person often mistakenly alters or omits the insulin dose, causing further problems. The guidelines for dietary management during illness focus on preventing dehydration and providing nutrition for promoting recovery. In general, sick-day management includes the following:

- Monitoring blood glucose at least four times a day throughout an illness
- Testing urine for ketones if blood glucose is greater than 240 mg/dL
- Continuing to take the usual insulin dose or oral hypoglycemic agent
- Sipping 8 to 12 oz of fluid each hour
- Substituting easily digested liquids or soft foods if solid foods are not tolerated (The substituted liquids and foods should be carbohydrate equivalents, for example, 1/2 cup sweetened gelatin, 1/2 cup fruit juice, one Popsicle, 1/4 cup sherbet, and 1/2 cup regular soft drink.)
- Calling the healthcare provider if the client is unable to eat for more than 24 hours or if vomiting and diarrhea last for more than 6 hours.

***DIET PLAN FOR THE OLDER ADULT*** The majority of older adults have type 2 DM and should follow the general guidelines for that diet plan. However, special considerations for the older adult are important if the diet plan is to be followed, including:

- Dietary likes and dislikes
- Who prepares the meals
- Age-related changes in taste perception
- Dental health
- Transportation to buy foods
- Available income.

Other factors to consider in planning the diet for the older adult include the age-related decline in kilocalorie requirements, decline in physical activity due to age and/or chronic illnesses, and the onset or progression of other chronic illnesses. The older adult who is overweight should reduce kilocalorie intake to ensure weight loss, but at the same time, careful monitoring for malnutrition is necessary. It is possible for the older adult to revert to normal glucose tolerance if ideal body weight is regained.

## Exercise

The third component of diabetes management is a regular exercise program. The benefits of exercise are the same for everyone, with or without diabetes: improved physical fitness, improved emotional state, weight control, and improved work capacity. In people with diabetes, exercise increases the uptake of glucose by muscle cells, potentially reducing the need for insulin. Exercise also decreases cholesterol and triglycerides, reducing the risk of cardiovascular disorders. People with diabetes should consult their primary healthcare provider before beginning or changing an exercise program. The ability to maintain an exercise program is affected by many different factors, including fatigue and glucose levels. It is as important to assess the person's usual lifestyle before establishing an exercise program as it is before planning a diet. Factors to consider include the client's usual exercise habits, living environment, and community programs. The exercise that the person enjoys most is probably the one that he or she will continue throughout life.

Use proper footwear, inspect the feet daily and after exercise, avoid exercise in extreme heat or cold, and avoid exercise during periods of poor glucose control. Stress EKG tests to detect ischemia are no longer recommended in asymptomatic individuals at low CAD risk (<10% risk of a cardiac event over 10 years) (Sigal, Kenny, Wasserman, & Castaneda-Sceppa, 2004).

***TYPE 1 DIABETES*** In the person with type 1 DM, glycemic responses to exercise vary according to the type, intensity, and duration of the exercise. Other factors that influence responses include the timing of exercise in relation to meals and insulin injections, and the time of day of the activity. Unless these factors are integrated into the exercise program, the person with type 1 DM has an increased risk of hypoglycemia and hyperglycemia. Following are general guidelines for an exercise program:

- People who have frequent hyperglycemia or hypoglycemia should avoid prolonged exercise until glucose control improves.
- The risk of exercise-induced hypoglycemia is lowest before breakfast, when free-insulin levels tend to be lower than they are before meals later in the day or at bedtime.
- Low-impact aerobic exercises are encouraged.
- Exercise should be moderate and regular; brief, intense exercise tends to cause mild hyperglycemia, and prolonged exercise can lead to hypoglycemia.
- Exercising at a peak insulin action time may lead to hypoglycemia.
- Self-monitoring of blood glucose levels is essential both before and after exercise.
- Food intake may need to be increased to compensate for the activity.
- Fluid intake, especially water, is essential.

Young adults may continue participating in sports with some modifications in diet and insulin dosage. Athletes should begin training slowly, extend activity over a prolonged period, take a carbohydrate source (such as a drink consisting of 5% to 10% carbohydrate) after about 1 hour of exercise, and monitor blood glucose levels for possible adjustments. In addition, a snack should be available after the activity is completed. It may be necessary to omit the usual regular insulin dose prior to an athletic event; even if the athlete is hyperglycemic at the beginning of the event, blood glucose levels will fall to normal after the first 60 to 90 minutes of exercise.

***TYPE 2 DIABETES*** An exercise program for the person with type 2 DM is especially important. The benefits of regular exercise include weight loss in those who are overweight, improved glycemic control, increased well-being, socialization with others, and a reduction of cardiovascular risk factors. A combination of diet, exercise, and weight loss often decreases the need for oral hypoglycemic agents. This decrease is due to an increased sensitivity to insulin, increased kilocalorie expenditure, and increased self-esteem. Regular exercise may prevent type 2 DM in high-risk individuals (Roberts & Barnard, 2005).

Following are general guidelines for an exercise program:

- Before beginning the program, have a medical screening for previously undiagnosed hypertension, neuropathy, retinopathy, and nephropathy.
- Begin the program with mild exercises, and gradually increase intensity and duration.
- Self-monitor blood glucose before and after exercise.
- Exercise at least three times a week or every other day, for at least 20 to 30 minutes.
- Include muscle-strengthening and low-impact aerobic exercises in the program.

## Treatments

***SURGERY*** Surgical management of diabetes involves replacing or transplanting the pancreas, pancreatic cells, or beta cells. Although it is still in the investigative stage, many researchers believe that transplantation of the tail of the pancreas is the most promising technique for achieving long-term disease control. Islet cell transplantation has had moderate success, and research is continuing. Other research is being conducted in the use of an internally implanted artificial pancreas, or closed-loop artificial beta cell.

Surgery is a stressor that often alters self-management and glycemic control in people with diabetes. In response to stress, levels of catecholamines, cortisol, glucagon, and growth hormones increase, as does insulin resistance. Hyperglycemia occurs, and protein stores are decreased. In addition, diet and activity patterns change, and medication types and dosages vary. As a result, surgical clients who have diabetes are at increased risk for postoperative infection, delayed wound healing, fluid and electrolyte imbalances, hypoglycemia, and DKA (Aragon et al., 2003).

Preoperatively, all clients should be in the best possible metabolic state. Screening for complications and regular blood glucose monitoring are part of preoperative preparation. Oral hypoglycemic agents may be withheld for 1 or 2 days before surgery, and regular insulin is often administered to the client with type 2 DM during the perioperative period. The client with type 1 DM follows a carefully prescribed insulin regimen individualized to specific needs.

The insulin regimen in the preoperative, intraoperative, and immediate postoperative periods is individualized and may involve any of the following:

- No intermediate- or long-acting insulin is given the day of surgery; regular insulin is given with intravenous glucose. When the client is NPO, short-acting insulin should not be given without intravenous glucose.
- Half of the usual intermediate- or long-acting insulin is given before surgery and the remaining half is given in the recovery room.
- The total daily dose of insulin is divided into four equal doses of regular insulin, and one dose is administered subcutaneously every 6 hours. An intravenous solution of 5% dextrose in 0.45% normal saline is administered for fluid replacement, and blood glucose monitoring precedes each insulin dose (Guthrie & Guthrie, 1997).
- Clients with type 1 DM or type 2 DM with preoperative blood glucose greater than 200 receive IV glucose and insulin infusion. The target blood glucose level during surgery is between 125 and 200 mg/dL. This avoids hypoglycemia,

which is difficult to detect under anesthesia, and prevents glycosuria, dehydration, and impaired wound healing. IV infusion of glucose, insulin, and added potassium is appropriate for all hyperglycemic patients undergoing surgery (Amiel & Alberti, 2005; Mabrey, 2004).

The surgical procedure should be scheduled for as early as possible in the morning to minimize the length of fasting. If there is no food intake after surgery, intravenous dextrose should be administered, accompanied by subcutaneous regular insulin every 6 hours. The dose can be adjusted to blood glucose levels. Although kilocalorie intake is decreased postoperatively, stress can increase insulin requirements. Glucose control is also affected postoperatively by nausea and vomiting, anorexia, and gastrointestinal suction.

During the postoperative period, the client with type 2 DM may continue to require insulin or may resume oral medications, depending on glucose control. The client with type 1 DM may require reduced insulin as healing progresses and stress diminishes. Regular blood glucose monitoring is essential, as are assessments for hypoglycemia.

## COMPLICATIONS OF DIABETES

The person with DM, regardless of type, is at increased risk for complications involving many different body systems. Alterations in blood glucose levels, alterations in the cardiovascular system, neuropathies, an increased susceptibility to infection, and periodontal disease are common. In addition, the interaction of several complications can cause problems of the feet. The *Multisystem Effects of Diabetes Mellitus* illustration on the next page shows the progression from cardinal signs to acute and late complications for the client with diabetes. A discussion of each of these complications follows; related interdisciplinary care and nursing care are discussed later in the chapter.

### Acute Complications: Alterations in Blood Glucose Levels

The following discussion provides additional information about hyperglycemia and hypoglycemia. Table 20–5 compares DKA, HHS, and hypoglycemia.

#### Hyperglycemia

The major problems resulting from hyperglycemia in the person with diabetes are DKA and HHS. Two other problems are the dawn phenomenon and the Somogyi phenomenon.

The **dawn phenomenon** is a rise in blood glucose between 4 A.M. and 8 A.M. that is not a response to hypoglycemia. This condition occurs in people with both type 1 and type 2 DM. The exact cause is unknown but is believed to be related to nocturnal increases in growth hormone, which decreases peripheral uptake of glucose. The **Somogyi phenomenon** is a combination of hypoglycemia during the night with a rebound morning rise in blood glucose to hyperglycemic levels. The hyperglycemia stimulates the counterregulatory hormones, which stimulate gluconeogenesis and glycogenolysis and also inhibit peripheral glucose use. This may cause insulin resistance for 12 to 48 hours (McCance & Huether, 2002).

***DIABETIC KETOACIDOSIS*** As the pathophysiology of untreated type 1 DM continues, the insulin deficit causes fat stores to break down, resulting in continued hyperglycemia and mobilization of fatty acids with a subsequent ketosis. **Diabetic ketoacidosis (DKA)** develops when there is an absolute deficiency of insulin and an increase in the insulin counterregulatory hormones. Glucose production by the liver increases, peripheral glucose use decreases, fat mobilization increases, and ketogenesis (ketone formation) is stimulated. Increased glucagon levels activate the gluconeogenic and ketogenic pathways in the liver. In the presence of insulin deficiency, hepatic overproduction of beta-hydroxybutyrate and acetoacetic acids (ketone bodies) causes increased ketone concentrations and an increased release of free fatty acids. As a result of a loss of bicarbonate (which occurs when the ketone is formed), bicarbonate buffering does not occur, and a metabolic acidosis occurs, called DKA. Depression of the central nervous system from the accumulation of ketones and the resulting acidosis may cause coma and death if left untreated (Porth, 2005). See Figure 20–5 ■.

DKA also may occur in a person with diagnosed diabetes when energy requirements increase during physical or emotional stress. Stress states initiate the release of gluconeogenic hormones, resulting in the formation of carbohydrates from protein or fat. The person who is sick, has an infection, or who decreases or omits insulin doses is at a greatly increased risk for developing DKA.

DKA involves four metabolic problems:

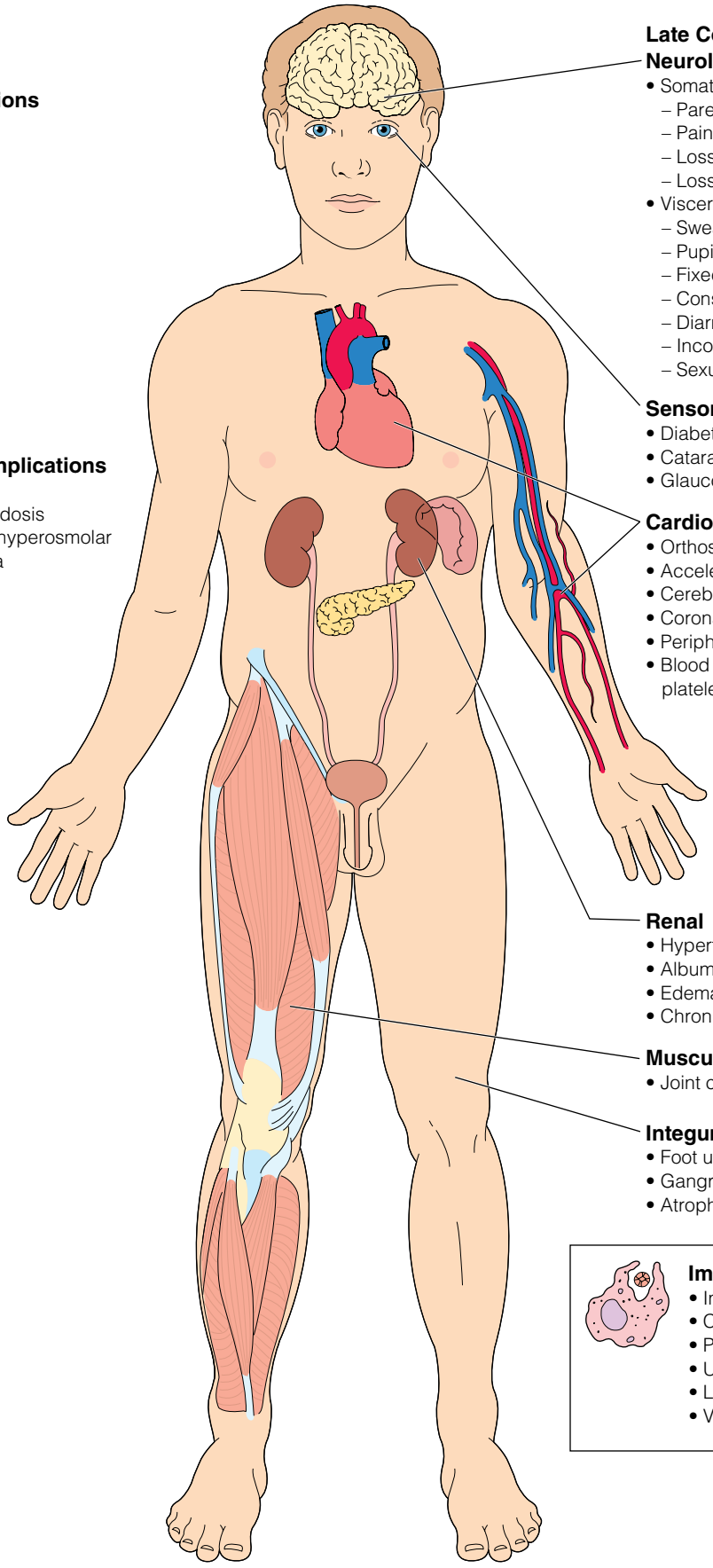
- Hyperosmolarity from hyperglycemia and dehydration
- Metabolic acidosis from an accumulation of ketoacids
- Extracellular volume depletion from osmotic diuresis
- Electrolyte imbalances (such as loss of potassium and sodium) from osmotic diuresis.

Manifestations of DKA result from severe dehydration and acidosis. These manifestations are summarized in the box on page 585. Laboratory findings include the following:

- Blood glucose levels higher than 250 mg/dL
- Plasma pH less than 7.3
- Plasma bicarbonate less than 15 mEq/L
- Presence of serum ketones
- Presence of urine ketones and glucose
- Abnormal levels of serum sodium, potassium, and chloride.

**Treatment of DKA** DKA requires immediate medical attention. Admission to the hospital is appropriate when the person has a blood glucose of greater than 250 mg/dL, a decreasing pH, and ketones in the urine. If the client is alert and conscious, fluids may be replaced orally. In the first 12 hours of treatment, adults usually require 8 to 10 L of fluid to replace losses from polyuria and vomiting (Lehne, 2004). However, alterations in level of consciousness, vomiting, and acidosis are common, necessitating intravenous fluid replacement. The initial fluid replacement may be accomplished by administering 0.9% saline solution at a rate of 500 to 1000 mL/h. After 2 to 3 hours

# MULTISYSTEM EFFECTS OF **Diabetes Mellitus**



## Early Manifestations

- Type 1 DM
  - Polyuria
  - Polydipsia
  - Polyphagia
  - Weight loss
  - Glycosuria
  - Fatigue
- Type 2 DM
  - Polyuria
  - Polydipsia
  - Blurred vision

## Progressive Complications

- Hyperglycemia
  - Diabetic ketoacidosis
  - Hyperglycemic hyperosmolar nonketotic coma
- Hypoglycemia

## Late Complications

### Neurologic

- Somatic neuropathies
  - Paresthesias
  - Pain
  - Loss of cutaneous sensation
  - Loss of fine motor control
- Visceral neuropathies
  - Sweating dysfunction
  - Pupillary constriction
  - Fixed heart rate
  - Constipation
  - Diarrhea
  - Incomplete bladder emptying
  - Sexual dysfunction

### Sensory

- Diabetic retinopathy
- Cataracts
- Glaucoma

### Cardiovascular

- Orthostatic hypotension
- Accelerated atherosclerosis
- Cerebrovascular disease (stroke)
- Coronary artery disease (MI)
- Peripheral vascular disease
- Blood viscosity and platelet disorders

### Renal

- Hypertension
- Albuminuria
- Edema
- Chronic renal failure

### Musculoskeletal

- Joint contractures

### Integumentary

- Foot ulcers
- Gangrene of the feet
- Atrophic changes



### Immune System

- Impaired healing
- Chronic skin infections
- Periodontal disease
- Urinary tract infections
- Lung infections
- Vaginitis

TABLE 20–5 **DKA, HHS, and Hypoglycemia Comparison**

| | | DKA | HHS | HYPOGLYCEMIA |
|---|---|---|---|---|
| **Diabetes Type** | | Primary type 1 | Type 2 | Both |
| **Onset** | | Slow | Slow | Rapid |
| **Cause** | | ↓ Insulin<br>Infection | ↓ Insulin<br>Older age | ↑ Insulin<br>Omitted meal/snack<br>Error in insulin dose |
| **Risk Factors** | | Surgery<br>Trauma<br>Illness<br>Omitted insulin<br>Stress | Surgery<br>Trauma<br>Illness<br>Dehydration<br>Medications<br>Dialysis<br>Hyperalimentation | Surgery<br>Trauma<br>Illness<br>Exercise<br>Medications<br>Lipodystrophy<br>Renal failure<br>Alcohol intake |
| **Assessments** | Skin | Flushed; dry; warm | Flushed; dry; warm | Pallor; moist; cool |
| | Perspiration | None | None | Profuse |
| | Thirst | Increased | Increased | Normal |
| | Breath | Fruity | Normal | Normal |
| | Vital signs | BP ↓<br>P ↑<br>R Kussmaul's | BP ↓<br>P ↑<br>R normal | BP ↓<br>P ↑<br>R normal |
| | Mental status | Confused | Lethargic | Anxious; restless |
| | Thirst | Increased | Increased | Normal |
| | Fluid intake | Increased | Increased | Normal |
| | Gastrointestinal effects | Nausea/vomiting; abdominal pain | Nausea/vomiting; abdominal pain | Hunger |
| | Fluid loss | Moderate | Profound | Normal |
| | Level of consciousness | Decreasing | Decreasing | Decreasing |
| | Energy level | Weak | Weak | Fatigue |
| | Other | Weight loss<br>Blurred vision | Weight loss<br>Malaise<br>Extreme thirst<br>Seizures | Headache<br>Altered vision<br>Mood changes<br>Seizures |
| **Laboratory Findings** | Blood glucose | >300 mg/dL | >600 mg/dL | <50 mg/dL |
| | Plasma ketones | Increased | Normal | Normal |
| | Urine glucose | Increased | Increased | Normal |
| | Urine ketones | Increased | Normal | Normal |
| | Serum potassium | Abnormal | Abnormal | Normal |
| | Serum sodium | Abnormal | Abnormal | Normal |
| | Serum chloride | Abnormal | Abnormal | Normal |
| | Plasma pH | <7.3 | Normal | Normal |
| | Osmolality | >340 mOsm/L | >340 mOsm/L | Normal |
| **Treatment** | | Insulin<br>Treatment<br>Intravenous fluids<br>Electrolytes | Insulin<br>Intravenous fluids<br>Electrolytes | Glucagon<br>Rapid-acting carbohydrate<br>Intravenous solution of 50% glucose |

(or when blood pressure is returning to normal), the administration of 0.45% saline at 200 to 500 mL/h may continue for several more hours. When the blood glucose levels reach 250 mg/dL, dextrose is added to prevent rapid decreases in glucose; hypoglycemia could result in fatal cerebral edema.

Regular insulin is used in the management of DKA and may be given by various routes, depending on the severity of the condition. Mild ketosis may be treated with subcutaneous insulin, whereas severe ketosis requires intravenous insulin infusion. Nursing responsibilities for the client receiving intravenous insulin are described in the Medication Administration box on page 586.

The electrolyte imbalance of primary concern is depletion of body stores of potassium. Initially, serum potassium levels may be normal, but they decrease during treatment. In DKA (and from rehydration), the body loses potassium from in-

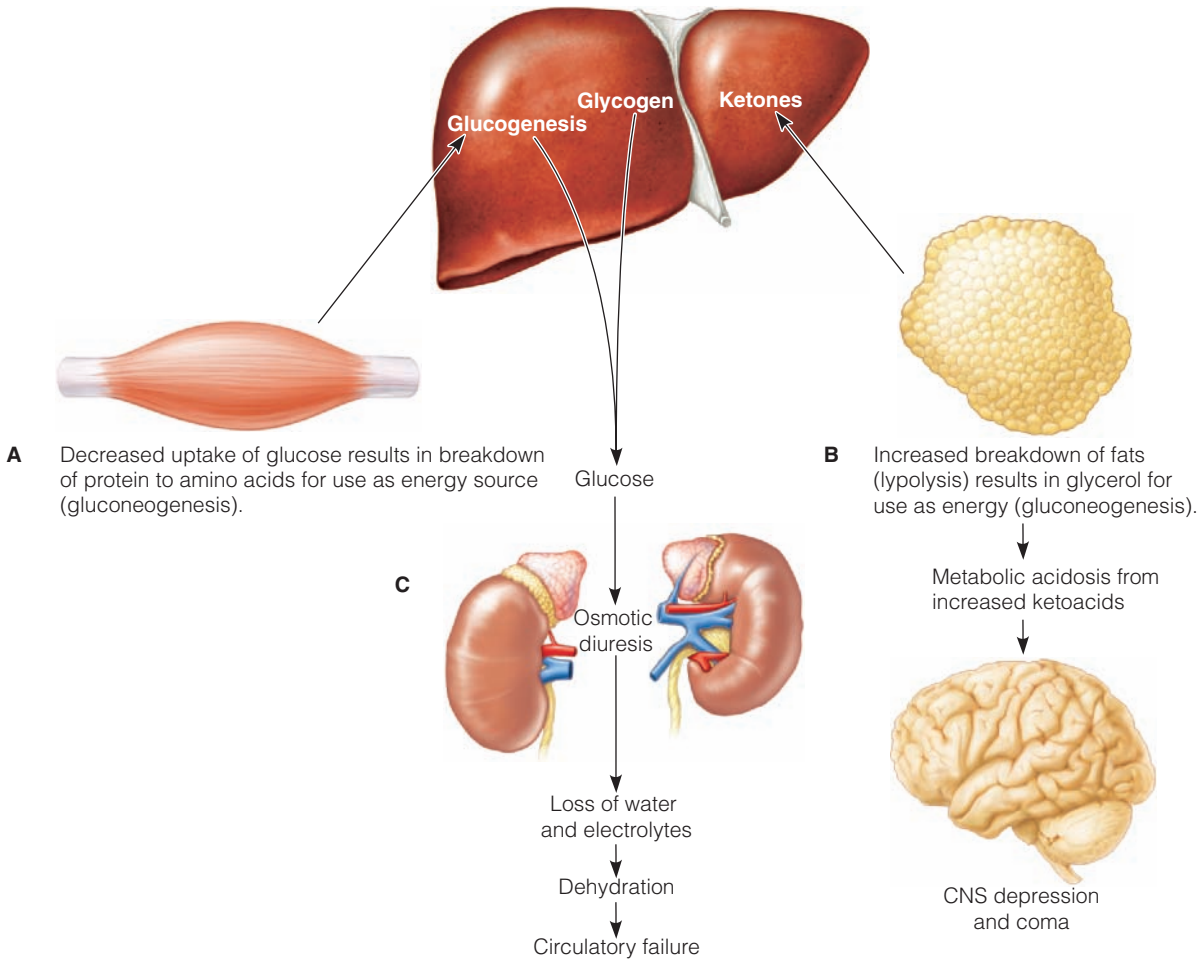



**Figure 20–5** ■ In Type I diabetes mellitus, without adequate insulin, muscle (a) and fat (b) cells are metabolized to provide sources of energy. Amino acids from skeletal muscle are converted to glucose in the liver; glycerol from fat cells is converted to glucose and fatty acids (ketoacids) which cause CNS depression and coma. Increased glucose (c) causes osmotic diuresis leading to dehydration and decreased circulatory volume. These processes create the symptoms of diabetic ketoacidosis (DKA). The symptoms can be reversed with intravenous insulin to lower blood glucose. Blood pressure is raised to prevent circulatory failure by administering intravenous fluids; electrolytes are monitored and corrected.

### MANIFESTATIONS of Diabetic Ketoacidosis (DKA)

**DEHYDRATION (FROM HYPERGLYCEMIA)**

- Thirst
- Warm, dry skin with poor turgor
- Soft eyeballs
- Dry mucous membranes
- Weakness
- Malaise
- Rapid, weak pulse
- Hypotension

**METABOLIC ACIDOSIS (FROM KETOSIS)**

- Nausea and vomiting
- Ketone (fruity, alcohol-like) breath odor
- Lethargy
- Coma

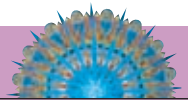
**OTHER MANIFESTATIONS**

- Abdominal pain (cause unknown)
- Kussmaul's respirations (increased rate and depth of respirations, with a longer expiration; a compensatory response to prevent a further decrease in pH)

creased urinary output, acidosis, catabolic state, and vomiting or diarrhea. Potassium replacement is begun early in the course of treatment, usually by adding potassium to the rehydration fluids. Replacement is essential for preventing cardiac dysrhythmias secondary to hypokalemia. Cardiac rhythms and potassium levels must be monitored every 2 to 4 hours.

***HYPEROSMOLAR HYPERGLYCEMIC STATE (HHS)*** The metabolic problem called **hyperosmolar hyperglycemic state (HHS)** occurs in people who have type 2 DM. HHS is characterized by a plasma osmolarity of 340 mOsm/L or greater (the normal range is 280 to 300 mOsm/L), greatly elevated blood glucose levels (over 600 mg/dL and often 1000 to 2000 mg/dL), and altered levels of consciousness. HHS is a serious, life-threatening medical emergency and has a higher mortality rate than DKA. Mortality is high not only because the metabolic changes are serious but also because people with diabetes are usually older and have other medical problems that either

## MEDICATION ADMINISTRATION Intravenous Insulin



### GENERAL GUIDELINES

- Regular insulin may be given undiluted directly into the vein or through a Y-tube or three-way stopcock.
- Insulin is usually diluted in 0.9% saline or 0.45% saline solution for infusion.
- The glass or plastic infusion container and plastic tubing may reduce insulin potency by at least 20% and possibly by up to 80% before the insulin reaches the venous system.

### Nursing Responsibilities

- Monitor blood glucose levels hourly.
- Infuse the insulin solution separately from the hydration solution.
- Flush the intravenous tubing with 50 mL of insulin mixed with normal saline solution to saturate binding sites on the tubing before administering the insulin to the client; this step increases the amount of insulin delivered over the first few hours.
- Do not discontinue the intravenous infusion until subcutaneous administration of insulin is resumed.
- Monitor for manifestations of hypoglycemia.
- Ensure that glucagons and $D_{50}$ is readily available as an antidote for insulin overdose.

cause or are caused by HHS. The precipitating factors associated with HHS include infection, therapeutic agents, therapeutic procedures, acute illness, and chronic illness (Box 20–4). The most common precipitating factor is infection. The manifestations of this disorder may be slow to appear, with onset ranging from 24 hours to 2 weeks. The manifestations are initiated by hyperglycemia, which causes increased urine output. With increased output, plasma volume decreases and glomerular filtration rate drops. As a result, glucose is retained and water is lost. Glucose and sodium accumulate in the blood and increase serum osmolarity.

Serum hyperosmolarity results in severe dehydration, reducing intracellular water in all tissues, including the brain. The person has dry skin and mucous membranes, extreme thirst, and altered levels of consciousness (progressing from lethargy to coma). Neurologic deficits may include hyperthermia, motor and sensory impairment, positive Babinski's sign, and seizures. *Metabolic acidosis is not part of the pathology; despite elevated blood glucose, sufficient insulin is present to prevent metabolism of fats with the resulting fatty acids and ketones of DKA.* Treatment is directed toward correcting fluid and electrolyte imbalances, lowering blood glucose levels with insulin, and treating underlying conditions.

### BOX 20–4 Factors Associated with Hyperosmolar Hyperglycemic State

**Therapeutic Agents**

- Glucocorticoids
- Diuretics
- Beta-adrenergic blocking agents
- Immunosuppressants
- Chlorpromazine
- Diazoxide

**Acute Illness**

- Infection
- Gangrene
- Urinary infection
- Burns
- Gastrointestinal bleeding
- Myocardial infarction
- Pancreatitis
- Stroke

**Therapeutic Procedures**

- Peritoneal dialysis
- Hemodialysis
- Hyperosmolar alimentation (oral or parenteral)
- Surgery

**Chronic Illness**

- Renal disease
- Cardiac disease
- Hypertension
- Previous stroke
- Alcoholism

**Treatment of HHS** HHS is a serious, life-threatening metabolic condition. The client admitted to the ICU for treatment typically manifests blood glucose levels over 700 mg/dL, increased serum osmolarity, and altered levels of consciousness or seizures. Treatment is similar to that of DKA: correcting fluid and electrolyte imbalances and providing insulin to lower hyperglycemia. In general, treatment modalities include the following:

- Establishing and maintaining adequate ventilation
- Correcting shock with adequate intravenous fluids
- Instituting nasogastric suction if comatose to prevent aspiration
- Maintaining fluid volume with intravenous isotonic or colloid solutions
- Administering potassium intravenously to replace losses
- Administering insulin to reduce blood glucose, usually discontinuing administration when blood glucose levels reach 250 mg/dL (Because ketosis is not present, there is no need to continue insulin, as with DKA.)

## Hypoglycemia

**Hypoglycemia** (low blood glucose levels) is common in people with type 1 DM and occasionally occurs in people with type 2 DM who are treated with oral hypoglycemic agents. This condition is often called insulin shock, **insulin reaction**, or "the lows" in clients with type 1 DM. Hypoglycemia results primarily from a mismatch between insulin intake (e.g., an error in insulin dose), physical activity, and carbohydrate availability (e.g., omitting a meal). The intake of alcohol and drugs such as chloramphenicol (Chloromycetin), Coumadin, monoamine oxidase inhibitors, probenecid (Benemid), salicylates, and sulfonamides can also cause hypoglycemia.

The manifestations of hypoglycemia (see the box on the next page) result from a compensatory autonomic nervous system (ANS) response and from impaired cerebral function due to a decrease in glucose available for use by the brain. The manifestations vary, particularly in older adults. The onset is sudden, and blood glucose is usually less than 45 to 60 mg/dL. Severe hypoglycemia may cause death.

### MANIFESTATIONS of Hypoglycemia

**MANIFESTATIONS CAUSED BY RESPONSES OF THE AUTONOMIC NERVOUS SYSTEM**

- Hunger
- Nausea
- Anxiety
- Pale, cool skin
- Sweating
- Shakiness
- Irritability
- Rapid pulse
- Hypotension

**MANIFESTATIONS CAUSED BY IMPAIRED CEREBRAL FUNCTION**

- Strange or unusual feelings
- Headache
- Difficulty in thinking
- Inability to concentrate
- Change in emotional behavior
- Slurred speech
- Blurred vision
- Decreasing levels of consciousness
- Seizures
- Coma

People who have type 1 DM for 4 or 5 years fail to secrete glucagon in response to a decrease in blood glucose. They then depend on epinephrine to serve as a counterregulatory response to hypoglycemia. However, this compensatory response can become absent or blunted. The person then develops a syndrome called *hypoglycemia unawareness.* The person does not experience symptoms of hypoglycemia, even though it is present. Because treatment is not initiated in the absence of symptoms, the person is likely to have episodes of severe hypoglycemia.

***TREATMENT OF HYPOGLYCEMIA*** **Mild Hypoglycemia** When mild hypoglycemia occurs, immediate treatment is necessary. People experiencing hypoglycemia should take about 15 g of a rapid-acting sugar. This amount of sugar is found, for example, in three glucose tablets, 1/2 cup of fruit juice or regular soda, 8 oz of skim milk, five Life Savers candies, three large marshmallows, or 3 tsp of sugar or honey. Sugar should not be added to fruit juice. Adding sugar to the fruit sugar already in the juice could cause a rapid rise in blood glucose, with persistent hyperglycemia.

If the manifestations continue, the 15/15 rule should be followed: Wait 15 minutes, monitor blood glucose, and, if it is low, eat another 15 g of carbohydrate. This procedure can be repeated until blood glucose levels return to normal (Haire-Joshu, 1996). People with diabetes should have some source of carbohydrate readily available at all times so that hypoglycemic symptoms can be quickly reversed. If hypoglycemia occurs more than two or three times a week, the diabetes management plan should be adjusted.

**Severe Hypoglycemia** People with diabetes who have severe hypoglycemia are often hospitalized. The criteria for hospitalization are one or more of the following:

- Blood glucose is less than 50 mg/dL, and the prompt treatment of hypoglycemia has not resulted in recovery of sensorium.
- The client has coma, seizures, or altered behavior.
- The hypoglycemia has been treated, but a responsible adult cannot be with the client for the following 12 hours.
- The hypoglycemia was caused by a sulfonylurea drug.

If the client is conscious and alert, 10 to 15 g of an oral carbohydrate may be given. If the client has altered levels of consciousness, parenteral glucose or glucagon is administered.

Glucose is administered intravenously as a 25% to 50% solution, usually at a rate of 10 mL over 1 minute by intravenous push, followed by intravenous infusion of 5% dextrose in water ($D_5W$) at 5 to 10 g/h (Haire-Joshu, 1996). This is the most rapid method of increasing blood glucose levels.

Glucagon is an antihypoglycemic agent that raises blood glucose by promoting the conversion of hepatic glycogen to glucose. It is used in severe insulin-induced hypoglycemia and may be given in the recommended dose of 1 mg by the subcutaneous, intramuscular, or intravenous route. Glucagon has a short period of action; an oral (if the client is conscious) or intravenous carbohydrate should be administered following the glucagon to prevent a recurrence of hypoglycemia. If the client has been unconscious, glucagon may cause vomiting when consciousness returns.

## Chronic Complications

### Alterations in the Cardiovascular System

The macrocirculation (large blood vessels) in people with diabetes undergoes changes due to atherosclerosis; abnormalities in platelets, red blood cells, and clotting factors; and changes in arterial walls. It has been established that atherosclerosis has an increased incidence and earlier age of onset in people with diabetes (although the reason is unknown). Other risk factors that contribute to the development of macrovascular disease of diabetes are hypertension, hyperlipidemia, cigarette smoking, and obesity. Alterations in the vascular system increase the risk of the long-term complications of coronary artery disease, cerebral vascular disease, and peripheral vascular disease.

Alterations in the microcirculation in the person with diabetes involve structural defects in the basement membrane of smaller blood vessels and capillaries. (The basement membrane is the structure that supports and serves as the boundary around the space occupied by epithelial cells.) These defects cause the capillary basement membrane to thicken, eventually resulting in decreased tissue perfusion. Changes in basement membranes are believed to be due to one or more of the following: the presence of increased amounts of sorbitol (a substance formed as an intermediate step in the conversion of glucose to fructose), the formation of abnormal glycoproteins, or problems in the release of oxygen from hemoglobin (Porth, 2005). The effects of alterations in the microcirculation affect all body tissues but are seen primarily in the eyes and the kidneys.

***CORONARY ARTERY DISEASE*** Coronary artery disease is a major risk factor in the development of myocardial infarction in people with diabetes, especially in the middle to older adult with type 2 DM. Coronary artery disease is the most common cause of death in people with diabetes (NIH, 2004). People with diabetes who have myocardial infarction are more prone to develop congestive heart failure as a complication of the infarction and are also less likely to survive in

the period immediately following the infarction. (Myocardial infarction is discussed in Chapter 31 ∞.)

***HYPERTENSION*** Hypertension (blood pressure ≥140/90 mmHg) is a common complication of DM. It affects 20% to 60% of all people with diabetes, and is a major risk factor for cardiovascular disease and microvascular complications such as retinopathy and nephropathy. Hypertension may be reduced by weight loss, exercise, and decreasing sodium intake and alcohol consumption. If these methods are not effective, treatment with antihypertensive medications is necessary.

***STROKE (CEREBROVASCULAR ACCIDENT)*** People with diabetes, especially older adults with type 2 DM, are 2 to 6 times more likely to have a stroke. Although the exact relationship between diabetes and cerebral vascular disease is unknown, hypertension (a risk factor for stroke) is a common health problem in those who have diabetes. In addition, atherosclerosis of the cerebral vessels develops at an earlier age and is more extensive in people with diabetes (Porth, 2005).

The manifestations of impaired cerebral circulation are often similar to those of hypoglycemia or HHS: blurred vision, slurred speech, weakness, and dizziness. People with these manifestations have potentially life-threatening health problems and require constant medical attention.

***PERIPHERAL VASCULAR DISEASE*** Peripheral vascular disease of the lower extremities accompanies both types of DM, but the incidence is greater in people with type 2 DM. Atherosclerosis of vessels in the legs of people with diabetes begins at an earlier age, advances more rapidly, and is equally common in both men and women. Impaired peripheral vascular circulation leads to peripheral vascular insufficiency with intermittent claudication (pain) in the lower legs and ulcerations of the feet. Occlusion and thrombosis of large vessels and small arteries and arterioles, as well as alterations in neurologic function and infection, result in gangrene (necrosis, or the death of tissue). Gangrene from diabetes is the most common cause of nontraumatic amputations of the lower leg. In people with diabetes, dry gangrene is most common, manifested by cold, dry, shriveled, and black tissues of the toes and feet. The gangrene usually begins in the toes and moves proximally into the foot.

***DIABETIC RETINOPATHY*** **Diabetic retinopathy** is the name for the changes in the retina that occur in the person with diabetes. The retinal capillary structure undergoes alterations in blood flow, leading to retinal ischemia and a breakdown in the blood–retinal barrier. Diabetic retinopathy is the leading cause of blindness in people between ages 20 and 74 (NIH, 2004). Retinopathy has three stages:

- *Stage I: nonproliferative retinopathy.* Dilated veins, microaneurysms, edema of the macula, and the presence of exudates characterize this stage.
- *Stage II: preproliferative retinopathy.* Retinal ischemia causes infarcts of the nerve fiber layer, with characteristic "cotton wool" patches on the retina. Shunts form between occluded and patent vessels.
- *Stage III: proliferative retinopathy.* As fibrous tissue and new vessels form in the retina or optic disc, traction on the vitreous humor may cause hemorrhage or retinal detachment.

After 20 years of diabetes, almost all clients with type 1 DM and more than 70% of clients with type 2 DM will have some degree of retinopathy, in most cases without vision loss (Saudek & Margolis, 2005). If exudate, edema, hemorrhage, or ischemia occurs near the fovea, the person experiences visual impairment at any stage. In addition, the person with diabetes is at increased risk for developing cataracts (opacity of the lens) as a result of increased glucose levels within the lens itself. Screening for retinopathy is important, as laser photocoagulation surgery has proven beneficial in preventing loss of vision.

***DIABETIC NEPHROPATHY*** **Diabetic nephropathy** is a disease of the kidneys characterized by the presence of albumin in the urine, hypertension, edema, and progressive renal insufficiency. This disorder accounts for 44% of new cases of end-stage renal disease requiring dialysis or transplantation in the United States. Nephropathy occurs in 30%–40% of people with type 1 DM and 20% of those with type 2 (Saudek & Margolis, 2005).

Despite research, the exact pathologic origin of diabetic nephropathy is unknown; it has been established, however, that thickening of the basement membrane of the glomeruli eventually impairs renal function. It has been suggested that an increased intracellular concentration of glucose supports the formation of abnormal glycoproteins in the basement membrane and mesangium. The accumulation of these large proteins stimulates glomerulosclerosis (fibrosis of the glomerular tissue). Glomerulosclerosis thickens the basement membrane and simultaneously makes it functionally leaky allowing large molecules such as protein to be lost in the urine. *Kimmelstiel-Wilson syndrome* is a type of glomerulosclerosis found only in people with diabetes. In advanced nephropathy, tubular atrophy occurs, and end-stage renal disease results. (Renal failure is discussed in Chapter 29 ∞.)

The first indication of nephropathy is **microalbuminuria**, a low but abnormal level of albumin in the urine. Without specific interventions, people with type 1 DM with sustained microalbuminuria will develop overt nephropathy, accompanied by hypertension, over a period of 10 to 15 years. People with type 2 DM often have microalbuminuria and overt nephropathy shortly after diagnosis, because the diabetes has often been present but undiagnosed for many years. Because the hypertension accelerates the progress of diabetic nephropathy, aggressive antihypertensive management should be instituted. Management includes control of hypertension with ACE inhibitors such as captopril (Capoten), weight loss, reduced salt intake, and exercise.

## Alterations in the Peripheral and Autonomic Nervous Systems

Peripheral and visceral neuropathies are disorders of the peripheral nerves and the autonomic nervous system. In people with diabetes, these disorders are often called **diabetic neuropathies.** The etiology of diabetic neuropathies involves (1) a

thickening of the walls of the blood vessels that supply nerves, causing a decrease in nutrients; (2) demyelinization of the Schwann cells that surround and insulate nerves, slowing nerve conduction; and (3) the formation and accumulation of sorbitol within the Schwann cells, impairing nerve conduction. The manifestations depend on the locations of the lesions.

The peripheral neuropathies (also called *somatic neuropathies*) include polyneuropathies and mononeuropathies. *Polyneuropathies,* the most common type of neuropathy associated with diabetes, are bilateral sensory disorders. The manifestations appear first in the toes and feet and progress upward. The fingers and hands may also be involved, but usually only in later stages of diabetes. The manifestations of polyneuropathy depend on the nerve fibers involved.

The person with polyneuropathy commonly has distal paresthesias (a subjective feeling of a change in sensation, such as numbness or tingling); pain described as aching, burning, or shooting; and feelings of cold feet. Other manifestations may include impaired sensations of pain, temperature, light touch, two-point discrimination, and vibration. There is no specific treatment for polyneuropathy.

*Mononeuropathies* are isolated peripheral neuropathies that affect a single nerve. Depending on the nerve involved, manifestations may include the following:

- Palsy of the third cranial (oculomotor) nerve, with headache, eye pain, and an inability to move the eye up, down, or medially
- Radiculopathy, with pain over a dermatome and loss of cutaneous sensation, most often located in the chest
- Diabetic femoral neuropathy, with motor and sensory deficits (pain, weakness, areflexia) in the anterior thigh and medial calf
- Entrapment or compression of the medial nerve at the wrist, resulting in carpal tunnel syndrome with pain and weakness of the hand; the ulnar nerve at the elbow, with weakness and loss of sensation over the palmar surface of the fourth and fifth fingers; and the peroneal nerve at the head of the fibula, with foot drop.

***VISCERAL NEUROPATHIES*** The visceral neuropathies (also called *autonomic neuropathies*) cause various manifestations, depending on the area of the ANS involved. These neuropathies may include the following:

- Sweating dysfunction, with an absence of sweating (*anhydrosis*) on the hands and feet and increased sweating on the face or trunk
- Abnormal pupillary function, most commonly seen as constricted pupils that dilate slowly in the dark
- Cardiovascular dysfunction, resulting in such abnormalities as a fixed cardiac rate that does not change with exercise, postural hypotension, and a failure to increase cardiac output or vascular tone with exercise
- Gastrointestinal dysfunction, with changes in upper gastrointestinal motility (*gastroparesis*) resulting in dysphagia, anorexia, heartburn, nausea, and vomiting and altered blood glucose control. Constipation is one of the most common gastrointestinal symptoms associated with diabetes, possibly a result of hypomotility of the bowel. Diabetic diarrhea is not as common, but it does occur and is often associated with fecal incontinence during sleep due to a defect in internal sphincter function.
- Genitourinary dysfunction, resulting in changes in bladder function and sexual function. Bladder function changes include an inability to empty the bladder completely, loss of sensation of bladder fullness, and an increased risk of urinary tract infections. Sexual dysfunctions in men include ejaculatory changes and impotence. Sexual dysfunctions in women include changes in arousal patterns, vaginal lubrication, and orgasm. Alterations in sexual function in people with diabetes are the result of both neurologic and vascular changes.

## Mood Alterations

Persons with DM, both type 1 and type 2, endure the chronic strains of living with complex self-care and are at a somewhat increased risk for depression, which can negatively affect management of DM. Treating depression has been associated with better control of serum glucose so screening for depression is an important part of assessing the individual's ability to manage the disease. Tests to identify the scope of depression are available (Harper-Jacques, 2004).

Interventions for helping clients with depression include a combination of antidepressant medications and psychotherapy, focused on restoring logical thinking and problem-solving skills (Williams et al., 2004). Nurses can assist depressed clients by correcting misconceptions about depression, identifying individual strengths in managing diabetes, acknowledging negative feelings that may be expressed, and suggesting problem-solving behaviors to better manage the disease.

## Increased Susceptibility to Infection

The person with diabetes has an increased risk of developing infections. The exact relationship between infection and diabetes is not clear, but many dysfunctions that result from diabetic complications predispose the person to develop an infection (Aragon et al., 2003). Vascular and neurologic impairments, hyperglycemia, and altered neutrophil function are believed to be responsible (Porth, 2005).

The person with diabetes may have sensory deficits resulting in inattention to trauma, and vascular deficits that decrease circulation to the injured area; as a result, the normal inflammatory response is diminished and healing is slowed. Nephrosclerosis and inadequate bladder emptying with retention of urine predispose the person with diabetes to pyelonephritis and urinary tract infections. Bacterial and fungal infections of the skin, nails, and mucous membranes are common. Tuberculosis is more prevalent in people with diabetes than in the general population. Hospitalized clients with a blood glucose value greater than 220 mg/dL have higher infection rates (ADA, 2005).

## Periodontal Disease

Although periodontal disease does not occur more often in people with diabetes, it does progress more rapidly, especially if the diabetes is poorly controlled. It is believed to be caused by microangiopathy, with changes in vascularization of the

gums. As a result, gingivitis (inflammation of the gums) and periodontitis (inflammation of the bone underlying the gums) occur.

### Complications Involving the Feet

The high incidence of both amputations and problems with the feet in people with diabetes is the result of angiopathy, neuropathy, and infection. People with diabetes are at high risk for amputation of a lower extremity, with increased risk in those who have had DM for more than 10 years, are male, have poor glucose control, or have cardiovascular, retinal, or renal complications.

Vascular changes in the lower extremities of the person with diabetes result in arteriosclerosis. Diabetes-induced arteriosclerosis tends to occur at an earlier age, occurs equally in men and women, is usually bilateral, and progresses more rapidly. The blood vessels most often affected are located below the knee. Blockages form in the large, medium, and small arteries of the lower legs and feet. Multiple occlusions with decreased blood flow result in the manifestations of peripheral vascular disease (see the box on this page). Peripheral vascular disease is discussed in Chapters 33 and 35 ∞.

Diabetic neuropathy of the foot produces multiple problems. Because the sense of touch and perception of pain are absent, the person with diabetes may have some type of foot trauma without being aware of it. The person thus is at increased risk for trauma to tissues of the feet, leading to ulcer development. Infections commonly occur in traumatized or ulcerated tissue (Figure 20–6 ■).

Despite the many potential sources of foot trauma in the person with diabetes, the most common are cracks and fissures caused by dry skin or infections such as athlete's foot, blisters caused by improperly fitting shoes, pressure from stockings or shoes, ingrown toenails, and direct trauma (cuts, bruises, or burns). It is important to remember that the person with diabetic neuropathy who has lost the perception of pain may not be aware that these injuries have occurred. In addition, when a part of the body loses sensation, the person tends to dissociate from or ignore the part, so that an injury may go unattended for days or weeks. The injury may even be forgotten entirely.

**Figure 20–6** ■ Ulceration following trauma in the foot of the person with diabetes.

*Source:* Harry Przekop, Medichrome/The Stock Shop, Inc.

**MANIFESTATIONS of Peripheral Vascular Disease**

- Loss of hair on lower leg, feet, and toes
- Atrophic skin changes: shininess and thinning
- Cold feet
- Feet and ankles darker than leg
- Dependent rubor, blanching on elevation
- Thick toenails
- Diminished or absent pulses
- Nocturnal pain
- Pain at rest, relieved by standing or walking
- Intermittent claudication
- Patchy areas of gangrene on feet and toes

Foot lesions usually begin as a superficial skin ulcer. In time, the ulcer extends deeper into muscles and bone, leading to abscess or osteomyelitis. Gangrene can develop on one or more toes; if untreated, the whole foot eventually becomes gangrenous. (Care of the feet, an essential part of client and family education, is discussed later in the chapter.)

## NURSING CARE

The responses of the person with diabetes to the illness are often complex and individual, involving multiple body systems. Assessments, planning, and implementation differ for the person with newly diagnosed diabetes, the person with long-term diabetes, and the person with acute complications of diabetes. The plan of care and content of teaching also differ according to the type of diabetes, the person's age and culture, and the person's intellectual, psychologic, and social resources. However, nursing care often focuses on teaching the client to manage the illness. The Nursing Research box on the following page describes a study of quality of life in people with diabetes.

### Health Promotion

Health promotion activities primarily focus on preventing the complications of diabetes. The prevention of the disease has not been determined, although it is recommended that all people should prevent or decrease excess weight, follow a sensible and well-balanced diet, and maintain a regular physical exercise program. Blood glucose screening at 3-year intervals beginning at age 45 is recommended for those in the high-risk groups. These same activities, when combined with medications and self-monitoring, are also beneficial in reducing the onset of complications.

## NURSING RESEARCH Evidence-Based Practice: Balancing Quality of Life and Living with Diabetes

Adaptation to and management of a chronic illness such as diabetes are simultaneous and interdependent as the person comes to terms with the illness, gains support from caregivers, creates relationships with others, and learns about the illness and its management. Learning about diabetes comes from many sources and in varied settings. Learning in group settings is efficient for the teacher but may not meet the needs of the learner. Printed information may seem impersonal and not applicable to specific needs. Recognizing the need to improve individual understanding and care, Corbett (2003) evaluated individualized educational interventions about foot care for 40 home healthcare clients with type 2 diabetes.

The method was to evaluate and then educate. A systematic assessment of each participant was made for (1) foot ulceration risk, (2) knowledge of appropriate foot self-care, (3) reported foot care practices, and (4) confidence in performing effective foot care (self-efficacy). Following the assessment, feedback was given regarding individual foot ulcer risk, instructions both written and in-person on proper foot care, demonstrated foot care techniques such as toenail care, and addressed concerns of each client. The risk assessments were repeated at entry, at week 6, and at week 12. Individualized education was provided at week 6 in the intervention group. Clients in the control group of the study received only the foot care education at week 12.

A high risk for lower extremity ulceration was found; 70% of participants had sensory loss in their feet, 67% had impaired lower extremity circulation, 61% had inappropriate toenail length, 50% had foot deformity such as bunions or hammer toes, and 49% wore worn-out shoes, wore only socks around the house, or walked barefoot. Fifty percent of the subjects had more than one of these risks. The clients who received the individualized intervention had statistically significant improvements in knowledge, reported practices, and self-efficacy. The control group clients had no significant change in foot care knowledge, reported practices, and self-efficacy. The individually focused interventions led to improved knowledge, self-care skill, and confidence for performing foot care.

Corbett (2003) observed that clients who had individualized education in their homes are able to make significant, satisfying changes in their routines. The interventions were brief and could be performed by home health nurses on routine visits. The home is an ideal setting for diabetic clients to learn how to manage specific cares and involve those who assist and support them.

### IMPLICATIONS FOR NURSING

All teaching plans should be individualized and developed in collaboration with the client. Nurses often focus on diabetes management and control, especially compliance with prescribed regimens. Although clients are sometimes termed "noncompliant," this term conveys judgment about dependence. A focus on individualized education based on assessment of individual needs facilitates higher levels of compliance and improved self-care. It is important to also understand that self-control behaviors can change with variations in life and the disease itself, and that each person with diabetes responds uniquely to situations and interventions. Respecting and valuing what a person has learned from living with diabetes is critical to providing effective care.

### CRITICAL THINKING IN CLIENT CARE

1. You are caring for two clients with diabetes who are receiving home care for complications of long-term diabetes. One client follows the medical regimen faithfully, the other adapts it to his own schedule and needs. What differences can you identify in your own reaction to these two different clients? How would these reactions affect your relationship with the clients?
2. Imagine you have just been diagnosed with type 1 diabetes. Make a list of the questions you would have and the areas that would cause you the most difficulty in complying with your medical care.
3. How would you respond if your client tells you, "Sometimes I eat whatever I want to for several days." What do you think this behavior indicates?

## Assessment

The following data are collected through the health history and physical examination (see Chapter 18 ∞ ). Further focused assessments are described with nursing interventions in the following text. When assessing the older client, be aware of normal aging changes in all body systems that may alter interpretation of findings.

- *Health history:* Family history of diabetes; history of hypertension or other cardiovascular problems; history of any change in vision (e.g., blurring) or speech, dizziness, numbness or tingling in hands or feet; pain when walking; frequent voiding; change in weight, appetite, infections, and healing; problems with gastrointestinal function or urination; or altered sexual function.
- *Physical assessment:* Height/weight ratio, vital signs, visual acuity, cranial nerves, sensory ability (touch, hot/cold, vibration) of extremities, peripheral pulses, skin and mucous membranes (hair loss, appearance, lesions, rash, itching, vaginal discharge).

## Nursing Diagnoses and Interventions

Although many different nursing diagnoses are appropriate for the person with diabetes, those discussed in this section address problems with skin integrity, infection, injury, sexuality, coping, and health maintenance. The goals of care are to maintain function, prevent complications, and teach self-management. See the accompanying Nursing Care Plan for more information.

### Risk for Impaired Skin Integrity

The person with diabetes is at increased risk for altered skin integrity as a result of decreased or absent sensation from neuropathies, decreased tissue perfusion from cardiovascular complications, and infection. In addition, poor vision increases the risk of trauma, and an open lesion is more prone to infection and delayed healing. Impaired skin and tissue integrity, with resultant gangrene, is especially common in the feet and lower extremities.

MEDIALINK Care Plan Activity: DM Type 2

Conduct baseline and ongoing assessments of the feet, including:

- Musculoskeletal assessment that includes foot and ankle joint range of motion, bone abnormalities (bunions, hammertoes, overlapping digits), gait patterns, use of assistive devices for walking, and abnormal wear patterns on shoes.
- Neurologic assessment that includes sensations of touch and position, pain, and temperature.
- Vascular examination that includes assessment of lower-extremity pulses, capillary refill, color and temperature of skin, lesions, and edema.
- Hydration status, including dryness or excessive perspiration.
- Lesions, fissures between toes, corns, calluses, plantar warts, ingrown or overgrown toenails, redness over pressure points, blisters, cellulitis, or gangrene.

  *People with diabetes are at significant risk for lower-extremity gangrene. Peripheral neuropathies may result in alterations in the perception of pain, loss of deep tendon reflexes, loss of cutaneous pressure and position sensation, foot drop, changes in the shape of the foot, and changes in bones and joints. Peripheral vascular disease may cause intermittent claudication, absent pulses, delayed venous filling on elevation, dependent rubor, and gangrene. Injuries, lesions, and changes in skin hydration potentiate infections, delayed healing, and tissue loss in the person with diabetes mellitus.*

**PRACTICE ALERT**

Teach the person with diabetes to always test the water temperature in the shower or bath before stepping in.

- Teach foot hygiene. Wash the feet daily with lukewarm water and mild hand soap; pat dry, and dry well between the toes. Apply a very thin coat of lubricating cream if dryness is present (but not between the toes). *Proper hygiene decreases the chance of infection. Temperature receptors may be impaired, so the water should always be tested before use.*
- Discuss the importance of not smoking if client smokes. *Nicotine in tobacco causes vasoconstriction, further decreasing the blood supply to the feet.*
- Discuss the importance of maintaining blood glucose levels through prescribed diet, medication, and exercise. *Hyperglycemia promotes the growth of microorganisms.*
- Conduct foot care teaching sessions as often as necessary (see the box on page 594). Include information about proper shoe fit and composition, avoiding clothing or activities that decrease circulation to the feet, foot inspections, the care of toenails, and the importance of obtaining medical care for lesions. If the person has visual deficits, is obese, or cannot reach the feet, teach the caregiver how to inspect and care for the feet. Feet should be inspected daily. *Foot care is a priority in diabetes management to prevent serious problems. Many people with diabetes are unaware of lesions or injury until infection and compromised circulation are far advanced. The hows and whys of each component must be included in teaching. A variety of methods may be used, including demonstration, return demonstration, audiovisual aids, and written lists. If the person is wearing shoes and socks, ask him or her to remove them to practice foot care effectively.*

**PRACTICE ALERT**

Suggest the use of a hand mirror to check the bottom of the feet and the back of the heel.

### Risk for Infection

The person with diabetes is at increased risk for infection. The risk of infection is believed to be due to vascular insufficiency that limits the inflammatory response, neurologic abnormalities that limit the awareness of trauma, and a predisposition to bacterial and fungal infections.

- Use and teach meticulous hand washing. *Hand washing is the single most effective method for preventing the spread of infection.*
- Monitor for manifestations of infection: increased temperature, pain, malaise, swelling, redness, discharge, cough. *Early diagnosis and treatment of infections can control their severity and decrease complications.*
- Discuss the importance of skin care. Keep the skin clean and dry, using lukewarm water and mild soap. *People with diabetes are more prone to develop furuncles and carbuncles; the infection often increases the need for insulin. Clean, intact skin and mucous membranes are the first line of defense against infection.*
- Teach dental health measures:
  - Obtain a dental examination every 4 to 6 months.
  - Maintain careful oral hygiene, which includes brushing the teeth with a soft toothbrush and fluoridated toothpaste at least twice a day and flossing as recommended.
  - Be aware of the symptoms requiring dental care: bad breath; unpleasant taste in the mouth; bleeding, red, or sore gums; and tooth pain.
  - If dental surgery is necessary, monitor for need to make adjustments in insulin. *All people with diabetes need to be taught proper oral hygiene, the risk of periodontal disease, and the importance of obtaining dental care for symptoms of oral or dental problems.*
- Teach women with diabetes the symptoms and preventive measures for vaginitis caused by *Candida albicans.* The symptoms are an odorless, white or yellow cheeselike discharge and itching. Sexual transmission is unlikely, but discomfort may cause the client to avoid sexual activity. *Diabetes is a predisposing factor for* Candida albicans *vaginitis, the most common form of vaginitis. Poor personal hygiene and wearing clothing that keeps the vaginal area warm and moist increase the risk of vaginitis. The infection may spread to the urinary tract, resulting in urinary tract infections; preventing and treating vaginitis decrease this risk.*

**PRACTICE ALERT**

Teach women with DM to take preventive measures by maintaining good personal hygiene, wiping front to back after voiding, wearing cotton underwear, avoiding tight jeans and nylon pantyhose, and avoiding douching.

## NURSING CARE PLAN A Client with Type 1 Diabetes

Jim Meligrito, age 24, is a third-year nursing student at a large midwestern university. Mr. Meligrito also works 20 hours a week as a campus student security guard. His working hours are 8 P.M. to midnight, five nights a week. He lives with his father, who is also a student. Neither of the two men likes to cook, and they usually eat "whatever is handy." Mr. Meligrito has smoked 8 to 10 cigarettes a day for 5 years. He was diagnosed with type 1 diabetes mellitus at age 12. Although his insulin dosage has varied, he currently takes a total of 32 units of insulin each day, 10 units of NPH and 6 units of regular insulin each morning and evening. He monitors his blood glucose about three times a week. He feels that he is too busy for a regular exercise program and that he gets enough exercise in clinicals and in weekend sports activities. He has not seen a healthcare provider for over a year.

One day during a 6-hour clinical laboratory in pediatrics, Mr. Meligrito notices that he is urinating frequently, is thirsty, and has blurred vision. He also is very tired but blames all his symptoms on drinking a couple of beers and having had only 4 hours of sleep the night before while studying for an examination, and the stress he has been under lately from school and work. When he remembers that he had forgotten to take his insulin that morning, he realizes he must have hyperglycemia but decides that he will be all right until he gets home in the afternoon. Around noon, he begins having abdominal pain, feels weak, has a rapid pulse, and vomits. When he reports his physical symptoms to his clinical instructor, she sends him immediately to the hospital emergency department, accompanied by another student.

### ASSESSMENT

As soon as Mr. Meligrito arrives at the emergency room, his blood glucose level is measured at 300 mg/dL. Urine samples and additional blood samples are sent to the laboratory for analysis. Blood glucose is 330 mg/dL, HgbA1c is 9.5%, urine shows the presence of ketones, electrolytes are normal, and pH is 7.1. His vital signs are as follows: T 99°F (37.2°C), P 140, R 28, and BP 102/52. An intravenous infusion of 1000 mL normal (0.9%) saline with 40 mEq of KCl is started at a rate of 400 mL/h. Intravenous regular insulin at 5 unit/h (diluted in 0.9% saline) is begun. Hourly blood glucose monitoring is initiated. Mr. Meligrito is nauseated and lethargic but remains oriented. Three hours later, he has a blood glucose level of 160, and his pulse and blood pressure are normal. He is dismissed from the emergency department after making an appointment for the next morning with the hospital's diabetes nurse educator. When he meets with the diabetes educator, he says that he no longer feels in control of the diabetes or his future goal to become a nurse anesthetist.

### DIAGNOSES

- *Powerlessness* related to a perceived lack of control of diabetes due to present demands on time
- *Deficient Knowledge* of self-management of diabetes
- *Risk for Ineffective Role Performance* related to uncertainty about capacity to achieve desired role as registered nurse

### EXPECTED OUTCOMES

- Identify those aspects of diabetes that can be controlled and participate in making decisions about self-managing care.
- Demonstrate an understanding of diabetes self-management through planned medication, diet, exercise, and blood glucose self-monitoring activities.
- Explore and clarify Mr. Meligrito's perceptions of his role as a student nurse, verbalizing his ability to meet his expectations.

### PLANNING AND IMPLEMENTATION

- Mutually establish specific and individualized short-term and long-term goals for self-management to control blood glucose.
- Provide opportunities to express his feelings about himself and his illness.
- Explore perceptions of his own ability to control his illness and his future, and clarify these perceptions by providing information about resources and support groups.
- Facilitate decision-making abilities in self-managing his prescribed treatment regimen.
- Provide positive reinforcement for increasing involvement in self-care activities.
- Provide relevant learning activities about insulin administration, dietary management, exercise, self-monitoring of blood glucose, and healthy lifestyle.

### EVALUATION

After taking an active part in the weekly educational meetings for 2 months, Mr. Meligrito has greatly enhanced his understanding of and compliance with self-management of his diabetes. He states that he finally understands how insulin, food, and exercise affect his body, having previously thought they were "just things I should do when I wanted to." He decides to perform self-management activities 1 week at a time, rather than think too far into (and thereby feel overwhelmed by) the future. Both son and father have developed a workable meal schedule and weekly grocery list, and they have begun eating breakfast and dinner together. Jim and a friend have arranged to walk 2 to 3 miles three times a week on a community hiking trail. To gain a sense of control over his illness, he has also worked out a schedule that allows time for school, health care, and himself.

### CRITICAL THINKING IN THE NURSING PROCESS

1. What is the pathophysiologic basis for the changes in temperature, pulse, respirations, and blood pressure that occurred on Mr. Meligrito's admission to the hospital emergency department?
2. How can smoking and poor self-management of diabetes increase the risk of long-term complications?
3. Is powerlessness a common response to a chronic illness? Why or why not?
4. Consider that you are teaching Mr. Meligrito and another client, Mr. McDaniel (age 75, newly diagnosed with type 2 DM). What components of your teaching plan would be the same and what components would be different?
5. What does the HgbA1c of 9.5% suggest about Mr. Meligrito's control of his diabetes?

*See Evaluating Your Response in Appendix C.*

## MEETING INDIVIDUALIZED NEEDS Foot Care Teaching Session

### BUYING AND WEARING SHOES AND STOCKINGS

- Shoes that allow 1/2 to 3/4 inch of toe room are best; there should be room for toes to spread out and wiggle. The lining and inside stitching should be smooth, and the insole soft. The sole should be flexible and cushion the foot. The heel should fit snugly, and the arch support should give good support.
- Do not wear open-toed shoes, sandals, high heels, or thongs; they increase the risk of trauma.
- Buy shoes late in the afternoon, when feet are at their largest; always buy shoes that feel comfortable and do not need to be "broken in."
- Shoes made of natural fibers (leather, canvas) allow perspiration to escape.
- Check the shoes before each wearing for foreign objects, wrinkled insoles, and cracks that might cause lesions.
- Stockings made of wool or cotton allow perspiration to dry.
- Do not wear garters, knee stockings, or pantyhose; they may interfere with circulation.
- Wear insulated boots in the winter.

### INSPECTING THE FEET

- Check the feet daily for red areas, cuts, blisters, corns, calluses, or cracks in the skin. Check between the toes for cracks or reddened areas.
- Check the skin of the feet for dry or damp areas.
- Use a mirror to check each sole and the back of each heel.
- If you are unable to inspect the feet daily, be sure that someone else does so.

### CARE OF TOENAILS

- Cut the toenails after washing, when they are softer and easier to trim.
- Cut the nails straight across with a clipper, and smooth edges and corners with an emery board.
- Do not use razor blades to trim the toenails.
- If you are unable to see well or to reach the feet easily, have someone else trim the nails. If the nails are very thick or ingrown, if the toes overlap, or if circulation is poor, get professional care from a podiatrist.

### GENERAL INFORMATION

- Never go barefoot. Wear slippers when leaving the bed during the night.
- Do not use commercial corn medicines or pads, chemicals (such as boric acid, iodine, or hydrogen peroxide), or over-the-counter cortisone medications on the feet.
- Do not put heating pads, hot water bottles, or ice packs on the feet. If the feet become cold at night, wear socks or use extra blankets.
- Do not allow the feet to become sunburned.
- Do not put tape on the feet.
- Do not sit with the legs crossed at the knees or ankles.

## Risk for Injury

The person with diabetes is at risk for injury from multiple factors. Neuropathies may alter sensation, gait, and muscle control. Cataracts or retinopathy may cause visual deficits. Hyperglycemia often causes osmotic changes in the lenses of the eye, resulting in blurred vision. In addition, changes in blood glucose alter levels of consciousness and may cause seizures. The impaired mobility, sensory deficits, and neurologic effects of complications of diabetes increase the risk of accidents, burns, falls, and trauma.

- Assess for the presence of contributing or causative factors that increase the risk of injury: blurred vision, cataracts, decreased adaptation to dark, decreased tactile sensitivity, hypoglycemia, hyperglycemia, hypovolemia, joint immobility, unstable gait. *A knowledge base is necessary to develop an individualized plan of care. The risk of injury increases with the number of factors identified.*
- Reduce environmental hazards in the healthcare facility, and teach the client about safety in the home and in the community.

### *IN THE HEALTHCARE FACILITY*

- Orient the client to new surroundings on admission.
- Keep the bed at the lowest level.
- Keep the floors free of objects.
- Use a night-light.
- Check the temperature of the bath or shower water before the client uses it.
- Instruct the client to wear shoes or slippers when out of bed.
- Monitor blood glucose levels regularly.
- Monitor for side effects of prescribed medications, such as dizziness or drowsiness.

### *IN THE HOME AND COMMUNITY*

- Use a night-light, preferably one with a soft, nonglare bulb.
- Turn the head away when switching on a bright light.
- Avoid directly looking into headlights when driving at night.
- Test the temperature of the bath or shower water before use.
- Conduct a daily foot inspection.
- Wear shoes and slippers with nonskid soles.
- Do not use throw rugs.
- Install hand grips in the tub and shower and next to the toilet.
- Wear a seat belt when driving or riding in a car.

*Strange environments and the presence of hazardous environmental factors increase the risk of falls or other accidents. Glare is often responsible for falls in people with visual deficits. The nurse can reduce factors that increase the risk of injury by implementing care and teaching safe practices during the activities of daily life.*

**PRACTICE ALERT**

Make frequent assessments to monitor for symptoms of HHS in the older adult who has had major surgery.

- Monitor for and teach the client and family to recognize and seek care for the manifestations of DKA in the client with type 1 DM: hyperglycemia, thirst, headaches, nausea and vomiting,

increased urine output, ketonuria, dehydration, and decreasing level of consciousness. *Blood glucose levels increase if the insulin need is unmet or insufficiently met; the cellular use of fats for fuel results in ketosis. Osmotic diuresis increases urinary output, resulting in thirst and dehydration.*

- Monitor for and teach the client and family to recognize and seek care for the manifestations of HHS in the client with type 2 DM: extreme hyperglycemia, increased urinary output, thirst, dehydration, hypotension, seizures, and decreasing level of consciousness. *HHS is a life-threatening condition requiring recognition and treatment.*
- Monitor for and teach the client and family to recognize and treat the manifestations of hypoglycemia: low blood glucose, anxiety, headache, uncoordinated movements, sweating, rapid pulse, drowsiness, and visual changes. Teach client and family to carry some form of rapid-acting sugar source at all times. *Severe hypoglycemia causes a decrease in the level of consciousness. The decrease in blood glucose most often results from too much insulin, too little food, or too much exercise.*
- Recommend that the client wear a Medic-Alert bracelet or necklace identifying self as a person with diabetes. *In case of sudden, severe illness or accident, a Medic-Alert bracelet can allow immediate medical attention for diabetes to be instituted.*

## Sexual Dysfunction

Sexuality is a complex and inseparable part of every person. It involves not only physical sexual activities but also a person's self-perception as male or female, roles and relationships, and attractiveness and desirability. Changes in sexual function and in sexuality have been identified in both men and women with diabetes.

Alterations in erectile ability occur in approximately 50% of all men with diabetes. The incidence of impotence increases with the duration of the diabetes and is often associated with peripheral neuropathy. Libido is usually unaffected, even when impotence is present.

**PRACTICE ALERT**

Sexual function is a private matter, and clients rarely share concerns unless the nurse initiates the discussion.

Women with diabetes also have alterations in sexual function, although the reason is less clear. The problems reported by women involve decreased desire and decreased vaginal lubrication. Women with diabetes are also at increased risk for vaginitis and may avoid sexual intercourse in order to avoid pain.

- Include a sexual history as a part of the initial and ongoing assessment of the client with diabetes. A specific history form may be used that addresses sexual development, personal and family values, current sexual practices and concerns, and changes desired. Ask a nonthreatening, open-ended question to elicit information, such as "Tell me about your experience with sexual function since you have been diagnosed with diabetes." *Obtaining accurate information to assess the sexual health of a client is necessary before counseling can begin or referrals can be made.*
- Provide information about the actual and potential physical effects of diabetes on sexual function. Include the effect of poor control of blood glucose on sexual function as part of any teaching plan. *Clients benefit from basic information about male and female anatomy and the sexual response cycle, and how diabetes can affect this part of the body. Changes in blood glucose levels not only may cause changes in desire and physical response but also may alter sexual responses as a result of depression, anxiety, and fatigue.*
- Provide counseling or make referrals as appropriate. The nurse is responsible for knowing about sexuality and sexual health throughout the life span and provides information based on knowledge of the effects of illness and treatment on sexual function. For example, men who are impotent may regain the ability to have sexual intercourse through penile implants, suction apparatus, the use of sildenafil citrate (Viagra), or injections of medications (such as yohimbine, an alpha-2 adrenergic blocker) that increase vascular blood flow into the corpus of the penis. Women with decreased vaginal lubrication can decrease painful intercourse by using vaginal lubricants (such as K-Y Jelly) or estrogen creams.

  *The nurse may make specific suggestions to facilitate positive sexual functioning, referring the client to the appropriate health care provider as necessary for intensive therapy.*

## Ineffective Coping

Coping is the process of responding to internal or environmental stressors or potential stressors. When coping responses are ineffective, the stressors exceed the individual's available resources for responding. The person diagnosed with diabetes is faced with lifelong changes in many parts of his or her life. Diet, exercise habits, and medications must be integrated into the person's lifestyle and be carefully controlled. Daily injections may be a reality. Fear of potential complications and of negative effects on the future is common.

If the person is unable to cope successfully with these changes, emotional stress can interfere with glycemic control. In addition, unsuccessful coping often results in noncompliance with prescribed treatment modalities, further impairing glycemic control and increasing the potential for acute and chronic complications.

- Assess the client's psychosocial resources, including emotional resources, support resources, lifestyle, and communication skills. *Chronic illness affects all dimensions of a person's life, as well as the lives of family members and significant others. A comprehensive assessment of strengths and weaknesses is the first step in developing an individualized plan of care to facilitate coping.*
- Explore with the client and family the effects (actual and perceived) of the diagnosis and treatment of diabetes on finances, occupation, energy levels, and relationships. *Common frustrations associated with diabetes are the disease itself, the treatment modalities, and the healthcare system. Effective coping involves maintaining a healthy self-concept and satisfying relationships, emotional balance, and handling emotional stress.*
- Teach constructive problem-solving techniques. *Problem-focused behaviors include setting attainable and realistic goals, learning about all aspects of the problem, learning*

*new procedures or skills that increase self-esteem, and reaching out to others for support.*

- Provide information about support groups and resources, such as suppliers of products, journals, books, and cookbooks for people with diabetes. *Sharing with others who have similar problems provides opportunities for mutual support and problem solving. Using available resources improves the ability to cope.*

## Using NANDA, NIC, and NOC

Chart 20–1 shows links between NANDA, NIC, and NOC when caring for the client with diabetes.

## Community-Based Care

Teaching the client and family to self-manage diabetes is a nursing responsibility. Even if a formal teaching plan is developed and implemented by advanced practice nurses, all nurses must be able to reinforce knowledge and answer questions. Teaching is necessary for both the person who is newly diagnosed and for the person who has had diabetes for years. In fact, the latter may need almost as much teaching as the newly diagnosed person. Products for diabetes care, especially insulins, have changed dramatically and knowledge about risk reduction to prevent complications has increased.

The American Diabetes Association recommends that teaching be carried out on three levels. The first level focuses on survival skills, with the person learning basic knowledge and skills to be able to provide diabetes management for the first week or two while he or she adjusts to the idea of having the disease. The second level focuses on home management, emphasizing self-reliance and independence in the daily management of diabetes. The third level aims at improving lifestyle and educating clients to individualize self-management of the illness.

NANDA, NIC, AND NOC LINKAGES
CHART 20–1 **The Client with Type 1 DM**

**NANDA**

Deficient Knowledge: Self-Management of DM

↓

**NIC**

Teaching: Individual
Teaching: Disease Process
Teaching: Foot Care
Teaching: Prescribed Diet

↓

**NOC**

Knowledge: Diabetes Management
Knowledge: Disease Process
Knowledge: Treatment Regimen
Knowledge: Health Promotion

Data from *NANDA's Nursing Diagnoses: Definitions & Classification 2005–2006* by NANDA International (2005), Philadelphia; *Nursing Interventions Classification* (NIC) (4th ed.) by J. M. Dochterman & G. M. Bulechek (2004), St. Louis, MO: Mosby; and *Nursing Outcomes Classification (NOC)* (3rd ed.) by S. Moorhead, M. Johnson, and M. Mass (2004), St. Louis, MO: Mosby.

For the hospitalized client with diabetes, teaching should begin on admission. Prior to designing the teaching plan, the nurse makes an initial assessment of the client's and family's knowledge and learning needs, outlining past diabetes management practices and identifying physical, emotional, and sociocultural needs. Educational level, preferred learning methods and style, life experiences, and support systems are also assessed. Paterson (2001) investigated the self-care decision making of clients with long-standing type 1 diabetes, examining their degree of empowerment as equal partners with their healthcare providers. These clients revealed that despite invitations and verbal assurances that clients are equal partners with the provider, accountable for and capable of making self-care decisions, interactions concerning management of the disease frequently included discounting the clients' experiential knowledge of diabetes over time and failure to provide resources necessary to make informed decisions. Nurses must be cautious about adopting an overly hierarchic approach of telling clients how to manage and withholding resources they need to participate in decision making (Larsen et al., 2003).

It is important that the nurse and client mutually establish goals based on the assessment data. It is equally important that family members understand that the responsibility for daily management lies with the client and that the primary role of the family is supportive. The client is the person with the disease, and it is the client who each day must take medications or inject insulin, test blood or urine, calculate and balance foods, exercise, adjust medications, inspect the body for injury, and determine whether and when medical assistance is needed. However, family members require the same knowledge so that they can provide emotional support as well as physical care if necessary.

The following should be included in teaching the client and family about care at home.

- Information about normal metabolism, diabetes mellitus, and how diabetes changes metabolism
- Diet plan: how diet helps keep blood glucose in normal range; number of kcal required and why; amount of carbohydrates, meats, and fats allowed and why; and how to calculate the diet, integrating personal food preferences
- Exercise: how it helps lower blood glucose; the importance of a regular program; types of exercise; integrating personal exercise preferences; how to handle increased activity
- Self-monitoring of blood glucose: how to perform the tests accurately, how to care for equipment, what to do for high or low blood glucose
- Medications:
  - *Insulin:* type, dosage, mixing instructions (if necessary), times of onset and peak actions, how to get and care for equipment, how to give injections, where to give injections

  - *Insulin: Oral agents:* type, dosage, side effects, interaction with other drugs
- Manifestations of acute complications of hypoglycemia and hyperglycemia; what to do when they occur
- Hygiene: skin care, dental care, foot care
- Sick days: what to do about food, fluids, and medications
- Helpful resources:
  - The American Diabetes Association
  - The American Dietetic Association
  - National Diabetes Information Clearinghouse
  - Department of Veterans Affairs
  - Indian Health Service
  - National Council of La Raza

Teaching may have to be adapted to the special needs of the older adult. Because 40% of all people with diabetes are over the age of 65, considering the special needs of this population is essential. Uncontrolled diabetes in the older adult increases the potential for functional loss, social disengagement, and increased morbidity and mortality. Education for self-care allows the older adult to be more actively involved in his or her diabetes management and decreases the potential for acute and long-term complications from the disease. Considerations for teaching the older adult with diabetes include the following:

- Changes in diet may be difficult to implement for many reasons. Favorite foods are difficult to give up. Balanced meals at regular intervals may not have been part of the client's lifestyle. Purchasing, storing, and preparing foods may be a problem. Dentures may not fit well. Changes in taste sensation often cause the client to increase the use of salt and sugar.
- Exercise of any type may not have been part of the activities of daily living. Exercise must be individualized for any physical limitations imposed by other chronic illnesses, such as arthritis, Parkinson's disease, chronic respiratory diseases, and/or cardiovascular diseases.
- The diagnosis of a chronic illness threatens independence and self-worth. After years of taking care of self, the older adult with diabetes may now have to depend on others for help in meeting self-care needs. This in turn often leads to withdrawal from social interactions with others.
- Money to purchase medications and supplies often must be taken out of a fixed income.
- Visual deficits make insulin administration difficult or impossible. Visual deficits also interfere with blood glucose monitoring, food preparation, exercises, and foot care.

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Links to Resources

## CHAPTER HIGHLIGHTS

- The incidence of type 2 DM is increasing in epidemic proportions in all racial and ethnic groups in the United States.
- Approximately 1.3 million new cases of DM are diagnosed each year in the United States. Diabetes is the sixth leading cause of death by disease in the United States, primarily due to widespread cardiovascular effects.
- Type 2 DM has a hereditary link and is characterized by obesity and sedentary lifestyles. Unlike type 1 DM, in which the onset is often sudden, the development of symptoms that bring clients to their healthcare providers for evaluation is slow; it is estimated that 50% of newly diagnosed type 2 DM clients have already developed complications secondary to hyperglycemia.
- The risk factors for acute and chronic complications are known, but clinical practice has not integrated these factors thoroughly into assessment and planning.

- Tighter, more intensive glycemic control is increasingly the focus of care for hospitalized clients with hyperglycemia. Correcting hyperglycemia is considered a benefit to diabetics and nondiabetics alike.
- New products for clients with DM include insulins, noninsulin hypoglycemics, and blood glucose monitoring devices. Nurses must be familiar with these products and help clients become proficient in their use.
- Motivation for self-care by the client with diabetes continues to be a challenge because treatment commonly includes lifestyle changes. Through education and support, clients can achieve control of DM and avoid complications.

## TEST YOURSELF NCLEX-RN® REVIEW

1 Increased susceptibility to the development of type 1 diabetes is indicated by which of the following?
   **1.** genetic markers that determine immune response
   **2.** persistent obesity throughout the adolescent years
   **3.** delivery of a baby that weighs less than 6 lb
   **4.** excessive amounts of plasma glucagon

2 Diabetic ketoacidosis is the result of which pathologic process?
   **1.** An excess amount of insulin drives all glucose into the cells.
   **2.** A decreased amount of glucagon causes low protein levels.
   **3.** A deficit of insulin causes fat stores to be used as an energy source.
   **4.** An increase occurs in the breakdown of glucose molecules with hypoglycemia.

3 Which of the following clients would be most at risk for the development of type 2 DM?
   **1.** young adult who is a professional basketball player
   **2.** middle-age man who maintains normal weight
   **3.** middle-age woman who is the sole caretaker of her parents
   **4.** woman over age 70 who is overweight and sedentary

4 You note that your assigned client has a nursing diagnosis of *Peripheral Neurovascular Dysfunction* involving both feet. Which of the following assessments would support this diagnosis?
   **1.** normal sensation to touch
   **2.** loss of normal reflexes
   **3.** states "I can't feel my feet anymore."
   **4.** states "I have been having chest pain."

5 Which of the following statements would indicate your client understands teaching about foot care at home?
   **1.** "I will walk barefooted as long as I am in the house."
   **2.** "I always buy my shoes as soon as the stores open."
   **3.** "I will check my feet for cuts and bruises every night."
   **4.** "If I get a blister, I just put alcohol on it and bandage it."

6 Lantus insulin, a long-acting insulin, has a unique insulin characteristic that increases the risk for administration error. The nurse understands that this long-acting insulin is:
   **1.** combined with glucose to raise energy levels.
   **2.** subject to being inactivated by light.
   **3.** a clear solution like regular insulin, unlike intermediate and long-acting insulins.
   **4.** activated by vigorous agitation.

7 The nurse is preparing an insulin infusion for a client in diabetic ketoacidosis (DKA). She is careful to select the only type of insulin that can be administered intravenously, which is:
   **1.** Lantus.
   **2.** NPH.
   **3.** regular.
   **4.** Humalog.

8 Glycosylated hemoglobin (HgbA1c) is useful for evaluating the degree of blood glucose control the client with diabetes has been maintaining for the previous 2 to 3 months. The ADA recommended goal for HgbA1c in the general population with diabetes is:
   **1.** >10%.
   **2.** <8%.
   **3.** <6%.
   **4.** <3%.

9 When the insulin-dependent client is NPO on the day of surgery, short-acting regular insulin should be:
   **1.** given intravenously.
   **2.** chilled to slow absorption.
   **3.** given with intravenous glucose.
   **4.** combined with long-acting insulin.

10 Subcutaneous injections of insulin can be made in several locations in the body. The nurse teaches the client that the most rapid absorption occurs in the:
   **1.** hip.
   **2.** thigh.
   **3.** deltoid.
   **4.** abdomen.

*See Test Yourself answers in Appendix C.*

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# UNIT 5 BUILDING CLINICAL COMPETENCE
# Responses to Altered Endocrine Function

## FUNCTIONAL HEALTH PATTERN: Nutritional-Metabolic

**Think about clients with altered nutritional or metabolic function for whom you have cared in your clinical experiences.**

- What were the clients' major medical diagnoses (e.g., Graves' disease, myxedema, thyroid cancer, Cushing's syndrome, Addison's disease, pheochromocytoma, syndrome of inappropriate antidiuretic hormone secretion, or diabetes mellitus)?
- What manifestations did each of these clients have? Were these manifestations similar or different?
- How did the clients' endocrine problems interfere with their nutritional and metabolic status? Were they on a prescribed diet? What was their daily intake of foods and fluids? Did they have an increased appetite with loss of weight? Did they notice their hands and feet getting larger? Did they have difficulty swallowing or notice swelling in the front of their neck? Did they note an increase or decrease in urination? Did they note a change in energy levels? Did they notice any visual changes? Did they complain of sleep disturbances? Did they have any changes in hair distribution, such as facial hair or changes in skin texture? Was there a change in memory or the ability to concentrate? Did the clients use hormones or steroids? Was there a family history of diabetes mellitus, thyroid problems, hypertension, or obesity?

**The Nutritional-Metabolic Pattern includes metabolism, which is the biochemical processes that take place in the body in response to hormones produced and released by the endocrine glands. These processes include the distribution of nutrients after digestion of carbohydrates, proteins, and fats. The endocrine system regulates growth, reproduction, metabolism, fluid and electrolyte balance, and gender differentiation. Endocrine disorders affect metabolic status in two primary ways:**

- A deficit of hormones may result in disorders of the thyroid gland (e.g., hypothyroidism), disorders of the parathyroid gland (e.g., hypoparathyroidism), disorders of the adrenal gland (e.g., chronic adrenocortical insufficiency), disorders of the pituitary gland (e.g., hypopituitarism, diabetes insipidus), or disorders of the pancreas (e.g., hypoglycemia).
- Excess hormones may result in disorders of the thyroid gland (e.g., hyperthyroidism), disorders of the parathyroid gland (e.g., hyperparathyroidism), disorders of the adrenal gland (e.g., hypercortisolism), disorders of the pituitary gland (e.g., hyperpituitarism, SIADH), or disorders of the pancreas (e.g., hyperglycemia).

**Hormones are chemical substances, secreted by the endocrine glands, which initiate or regulate functioning of a target organ by binding to a receptor site located on the surface of the target organ. They are regulated by a negative or positive feedback system in which decreased or increased hormone levels signal the release of hormones to maintain homeostasis of the body's internal environment. Imbalance of hormones can result in endocrine disorders, leading to manifestations such as:**

- Weight loss (associated with varying disorders, including increased thyroid hormones which cause increased metabolism of carbohydrates, proteins, and lipids ▶ resulting in caloric and nutritional deficiencies)
- Blurred vision (for example, a lack of insulin production by the beta cells of the islets of Langerhans of the pancreas ▶ causes osmotic effects in the eye tissue ▶ resulting in swelling of the lenses of the eyes)
- Increased urination (common to several endocrine disorders, including a deficit of antidiuretic hormones ▶ which results in the excretion of large amounts of urine ▶ resulting in dehydration).

**Priority nursing diagnoses within the Nutritional-Metabolic Pattern that may be appropriate for clients with endocrine disorders include:**

- *Imbalanced Nutrition: Less than Body Requirements* as evidenced by increased food intake with weight loss
- *Deficient Fluid Volume* as evidenced by dry mucous membranes, thirst, and decreased urine output
- *Hyperthermia* as evidenced by body temperatures ranging from 102°F (39°C) to 106°F (41°C)
- *Impaired Skin Integrity* as evidenced by dry, rough, reddened, and edematous skin.

**Two nursing diagnoses from other functional health patterns often are of high priority for the client with endocrine disorders because the physiologic responses to these problems interfere with proper metabolism:**

- *Disturbed Body Image* (Self-Perception-Self-Concept)
- *Ineffective Therapeutic Regimen Management* (Health Perception, Health Management)

**Directions:** Read the clinical scenario below and answer the questions that follow. To complete this exercise successfully, you will use not only knowledge of the content in this unit, but also principles related to setting priorities and maintaining client safety.

## CLINICAL SCENARIO

You have been assigned to work with the following four clients for the 0700 shift on a medical-surgical unit. Significant data obtained during report are as follows:

- Mr. Blew is a 54-year-old who is admitted with complaints of polydipsia, polyuria, and polyphagia. There is a fruity odor to his breath and he seems confused at times. Vital signs on admission are T 99°F, P 90, R 30 and deep, BP 110/68. His blood glucose is 650 on admission at 0630.
- Mrs. Rant is a 65-year-old who is admitted with severe back pain in the flank area on the right side, nausea, and vomiting. She is being evaluated for treatment of renal calculi. She has a history of hyperparathyroidism. Vital signs are T 97.6°F with clammy skin, P 100, R 24, and BP of 168/94. She is requesting pain medication for the back pain.
- Mrs. Fox is an 86-year-old who was transferred from the medical ICU yesterday. She was admitted after being found unconscious by her daughter. On admission her blood sugar was 45, serum sodium was 128, T 96.6°F, and P 50. Vital signs this A.M. are T 98.4°F, P 78, R 18, BP 140/86. She is scheduled to have blood drawn for electrolytes at 0730.
- Mr. Rite is a 56-year-old who was admitted 4 days ago after falling from a ladder and hitting his head. He is complaining of a headache and thirst even after drinking 2000 mL of fluids during the night. Vital signs are T 100°F, P 98, R 14, BP 114/84.

## Questions

**1** In what order would you visit these clients after report?

1. _____
2. _____
3. _____
4. _____

**2** What top two priority nursing diagnoses would you choose for each of the clients presented above? Can you explain, if asked, the rationale for your choices?

| | Priority Nursing Diagnosis #1 | Priority Nursing Diagnosis #2 |
|---|---|---|
| Mr. Blew | | |
| Mrs. Rant | | |
| Mrs. Fox | | |
| Mr. Rite | | |

**3** If Mr. Blew's blood glucose drops to 50, which manifestations might he exhibit?

1. bradycardia, nausea, vomiting
2. tachycardia, hypotension, shakiness
3. thirst, diarrhea, fatigue
4. hypertension, edema, dyspnea

**4** Mr. Blew understands diabetic teaching done by the nurse when he states:

1. "I will check my blood glucose before every meal."
2. "If I follow my prescribed diet, I will not have to check my blood sugar."
3. "If my blood glucose drops below 60, I can drink juice or milk to raise it."
4. "If my blood sugar is over 200, I can eat graham crackers to lower it."

**5** The nurse explains to Mrs. Rant the dietary treatment for hyperparathyroidism. Which is the appropriate dietary teaching for this client?

1. Increase fluids in the diet and avoid taking vitamin D supplements.
2. Increase potassium in the diet and avoid taking vitamin C supplements.
3. Decrease sodium in the diet and take vitamin $B_6$ supplements.
4. Decrease phosphorus in the diet and take vitamin A supplements.

**6** The nurse assessing a client with hyperthyroidism may find which manifestations?

1. diaphoresis, diarrhea, alopecia, weight loss
2. dry skin, constipation, hirsutism, obesity
3. hypertension, abdominal pain, constipation, anorexia
4. dry skin, numbness around mouth, tetany

**7** Based on the manifestations of headache and excessive thirst that Mr. Rite is exhibiting 4 days after his fall, the nurse should monitor for symptoms of what complication?

1. migraine headache
2. hypertensive crisis
3. increased intracranial pressure
4. infection

**8** A prescription for levothyroxine sodium (Synthroid) is given to Mrs. Fox after she is diagnosed with hypothyroidism. The client voices understanding of how to take the medication when she states:

1. "I must take the medication with meals."
2. "I must take my pulse before taking the medication and report to the doctor a pulse below 100."
3. "I will only need to take this medication until my thyroid blood levels are back to normal."
4. "I can eat any food I choose because foods do not interfere with the medications."

**9** Which laboratory studies would be conducted for Mr. Blew to monitor his diabetes management? (Select all that apply.)

1. fasting blood glucose
2. glycosylated hemoglobin
3. urinalysis
4. complete blood cell count
5. serum electrolytes
6. serum cholesterol and triglyceride levels

**10** In postoperative thyroidectomy nursing care, it is *most* important for the nurse to monitor the client for which of these complications?

1. hyperthermia
2. laryngeal nerve damage
3. tetany
4. respiratory distress

**11** Metabolic syndrome is a cluster of clinical manifestations associated with type 2 diabetes mellitus. Which clinical manifestations are indicative of metabolic syndrome?

1. hypertension, abdominal obesity, blood glucose > 110 mg/dL
2. tachycardia, weight gain, blood glucose < 110 mg/dL
3. hypotension, weight loss, blood glucose > 150 mg/dL
4. bradycardia, stomach obesity, blood glucose < 100 mg/dL

**12** Which of the following laboratory value results may be seen in a client with untreated Cushing's syndrome?

1. serum sodium 150 mEq/L, serum potassium 2.8 mEq/L
2. blood glucose 68 mg/dL, blood urea nitrogen 28 mg/dL
3. serum calcium 9.0 mg/dL, serum sodium 130 mEq/L
4. blood glucose 350 mg/dL, serum potassium 5.2 mEq/L

## CASE STUDY

Mr. Gregg is a 65-year-old African American male who was admitted with health problems of increased urination, increased thirst, fatigue, blurred vision, and numbness in his feet. He states that he retired 9 months ago after 45 years as a construction worker. He now leads a sedentary lifestyle and doesn't have as much energy as he used to have. He has gained 30 pounds since retirement. Upon assessment, Mr. Gregg weighs 255 pounds and is 5'11" tall. Vital signs are T 98.8°F, P 88, R 20, and BP 150/90. Decreased pulses are palpated in dorsal pedalis and posterior tibial pulses. Both feet are cool to touch with slow capillary refill in toes. The following laboratory studies are ordered to confirm the diagnosis of type 2 diabetes mellitus: plasma glucose concentration, fasting blood glucose, and oral glucose tolerance test.

Type 2 diabetes mellitus is a disease of fasting hyperglycemia despite the production of some insulin by the beta cells of the pancreas. The level of insulin production varies, affecting the amount available cellular metabolism.

With increased age, sedentary lifestyle, and obesity, cells become resistant to insulin. The uptake of glucose by muscle and fat cells is not sufficient to lower the blood glucose. In obesity, insulin has a decreased ability to influence glucose metabolism and affect the uptake of glucose by cells in the liver, skeletal muscles, and adipose tissue, resulting in a high blood glucose level.

The manifestations of type 2 diabetes mellitus include polyuria, polydipsia, blurred vision, fatigue, paresthesias, and skin infections. In times of physical or emotional stress, the client may develop a hyperosmolar hyperglycemic state (HHS). Complications of type 2 diabetes mellitus include coronary heart disease (myocardial infarction), hypertension, stroke, peripheral vascular disease (atherosclerosis, vascular insufficiency, amputations), end-stage renal disease (nephropathy), and blindness (retinopathy).

Based on Mr. Gregg's manifestations and weight gain, a priority nursing diagnosis of *Imbalanced Nutrition: More than Body Requirements* is appropriate for guiding nursing care on this client.