Diabetes Type 1
Patient Care for Nurses and Other Healthcare Professionals

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LEARNING OUTCOME AND OBJECTIVES: Upon completion of this course, you will be better prepared to appropriately care for patients with type 1 diabetes mellitus (T1DM) by identifying its health effects, evidence-based treatment guidelines, and management strategies. Specific learning objectives to address potential knowledge gaps include:

- Describe T1DM.
- Summarize the impacts of diabetes.
- Explain the pathogenesis of T1DM.
- Discuss the diagnostic process for diabetes.
- Explain management strategies for T1DM.
- Identify acute and chronic complications and interventions to prevent and treat these complications.

INTRODUCTION

Type 1 diabetes mellitus (T1DM) is a chronic, pathologic condition that must be managed consistently by collaboration between the patient and healthcare providers to prevent serious short- and long-term complications. Careful treatment and patient adherence to lifestyle changes and appropriate therapies are necessary to prevent or minimize these complications.

T1DM is a serious endocrine condition characterized by the body’s inability to produce insulin or to produce it in only very small amounts because of autoimmune destruction of the beta cells in the pancreas (Khardori, 2018). Without sufficient amounts of insulin, the body’s tissues do not have access to essential nutrients for fuel and storage. The entry of glucose into the cells is impaired, and blood glucose levels increase (Rebar et al., 2019).
T1DM can be subdivided into idiopathic and immune-mediated types. The **idiopathic type** is characterized by a permanent insulin deficiency without evidence of autoimmunity. In the **immune-mediated type**, it is believed that a local or organ-specific deficit may stimulate an autoimmune attack on pancreatic beta cells. Such an attack leads to an inflammatory response in the pancreas called **insulitis** (Rebar et al., 2019).

Acute hyperglycemic episodes involving extremely high glucose levels are considered a medical emergency that can result in life-threatening dehydration or coma. Similarly, chronic hyperglycemia may lead to serious complications such as renal failure, neurological damage, blindness, and/or cardiovascular damage (Rebar et al., 2019).

Although diabetes is a serious disease, patients with T1DM can take several steps to manage their disease and thus lower their risk for complications and premature death.

**IMPACT OF DIABETES**

According to the American Diabetes Association (ADA, 2018a) and the Centers for Disease Control and Prevention (CDC, 2017a), in 2015:

- 30.3 million Americans, or 9.4% of the population had diabetes of any type.
- 1.5 million Americans were diagnosed with diabetes.
- 84.1 million Americans age 18 and older had prediabetes.
- Among Americans under the age of 20, about 193,000 (0.24%) were estimated to have diagnosed diabetes.

Diabetes was the seventh leading cause of death in 2015. This is based on 79,535 death certificates that list diabetes as the underlying cause of death and a total of 252,806 death certificates listing diabetes as an underlying or contributing cause of death (ADA, 2018).

The rates of diagnosed diabetes in U.S. adults **by race/ethnic background** are:

- 7.4% of non-Hispanic whites
- 8.0% of Asian Americans
- 12.1% of Hispanics
- 12.7% of non-Hispanic blacks
- 15.1% of Native Americans/Alaskan Natives

Data specific to T1DM based on a CDC study indicate that:

- Of the 30.3 million Americans with diabetes, 1.25 million American children and adults have T1DM.
Across all racial/ethnic groups, the rate of newly diagnosed cases of T1DM increased more annually from 2003–2012 in males (2.2%) than in females (1.4%) ages 0–19.

Among youth ages 0–19, the rate of newly diagnosed cases of T1DM increased most sharply in Hispanic youth.

(CDC, 2017c)

The economic impact of diabetes is sizable. Data from 2018 regarding the monetary cost of diabetes in the United States show that:

- Total costs of diagnosed diabetes was $327 billion.
- Direct medical costs were $237 billion.
- Costs of reduced productivity was $90 billion.

(ADA, 2018)

PATHOGENESIS OF TYPE 1 DIABETES

Pathophysiology

T1DM is due to an autoimmune destruction of pancreatic beta cells, although a small percentage of affected patients (<10%) are classified as type 1B (idiopathic) and have no evidence of autoimmunity (Paschou et al., 2018).

As beta cells are destroyed and beta cell mass declines, insulin levels decline until the body is no longer able to maintain normal blood glucose levels. Exogenous insulin is required to maintain homeostasis.

Currently, autoimmunity is considered to be the primary factor in T1DM pathophysiology. In a genetically susceptible person, a viral infection may trigger production of antibodies against a viral protein that result in an autoimmune response against antigenically similar beta cell molecules. Research shows that the prevalence of T1DM is higher in patients with other autoimmune diseases such as Graves disease, Addison disease, and autoimmune thyroiditis (Kharadori, 2018).

T1DM in adults is typically caused by a loss of pancreatic function, resulting in reduced or no insulin production. For example, loss of pancreatic function may occur as a consequence of chronic pancreatitis, in which repeated and prolonged inflammatory episodes cause damage or death of the insulin-producing cells of the pancreas (Levitisky & Madhusmita, 2016).

Risk Factors

It is important for healthcare professionals to recognize persons who are at risk for developing T1DM. A number of risk factors are associated with the condition.
FAMILY HISTORY

One risk factor for the development of T1DM is family history. Individuals with a first-degree relative (i.e., parent, child, or sibling) diagnosed with T1DM are at greater risk for developing the disease themselves (Mayo Clinic, 2017).

GENETIC FACTORS

T1DM is generally thought to be an autoimmune disorder. Some HLA genes are associated with T1DM development. These genes (e.g., HLA-DOA1, HLA-DQB1) have many variations, and particular combinations of the genes result in an increased risk for T1DM development. HLA variations account for about 40% of the genetic risk for this type of diabetes (NIH, 2019).

Since T1DM is primarily an autoimmune condition, it may be that other autoimmune conditions share a similar HLA complex. Thus, if someone has one such disorder, risk for T1DM may increase. Examples of other autoimmune conditions include Graves’ disease, multiple sclerosis, and pernicious anemia.

OVERWEIGHT AND OBESITY

Overweight and obesity is not only associated with T2DM, but with T1DM as well. Historically, patients with T1DM were viewed as slender people, but recent research shows that the obesity rate of persons with T1DM surpasses that of the general population.

Patients with T1DM who show clinical signs of T2DM (e.g., obesity and insulin resistance) are considered to have “double diabetes,” which is a relatively new term. Double diabetes is more likely to occur when the proinflammatory state associated with metabolic syndrome causes reduced glycemic control. This leads to reduced glycemic control, which eventually requires higher daily doses of insulin (Mottalib et al., 2017).

It is critical that strategies to reduce/prevent overweight and obesity in children and adolescents with T1DM be implemented. Recent research suggests that 1 out of 3 children and adolescents with T1DM are overweight (Sheth, 2018).

ENVIRONMENTAL FACTORS

Viral infection is a possible environmental risk factor for T1DM. The connection between viral infection and the onset of T1DM is unclear, but it may be that viral infection triggers an autoimmune response. Viruses suggested to play a role in the pathogenesis of T1DM include the coxsackievirus, the mumps virus, and the German measles (rubella) virus (Smith-Marsh, 2016).

Geography may also play a role in T1DM development. Research shows that people who live in northern climates with colder temperatures are at an increased risk for T1DM. It is suggested that those who live in northern countries are indoors more, thus in closer proximity to others, which makes it easier to transmit viral infections. Conversely, people who live in southern climates with warmer temperatures, such as in South America, have a decreased risk for T1DM. It is
interesting to note that more cases are diagnosed in the winter in northern countries, and the diagnosis rate decreases in the summer (Smith-Marsh, 2016).

**DIABETES TYPE 1 DIAGNOSIS**

Diagnosis is based on clinical presentation and results of diagnostic studies. However, symptoms of T1DM can arise from other medical conditions as well as some medication interactions. Therefore, alternative explanations should be explored.

**Diabetes Type 1 Symptoms**

Individuals with T1DM may present with any of a variety of symptoms. Unlike the stereotypical presentation of an overweight or obese patient with T2DM, however, patients with T1DM may previously appear healthy and have a normal weight then present with a sudden onset of several symptoms at once. Rarely, a diagnosis of T1DM may occur as a result of a routine health screening and blood work. More typically, observation of hyperglycemia during a medical examination performed in response to an onset of symptoms over days or weeks alerts the clinician to the possibility of T1DM.

The hallmark clinical sign of T1DM is **hyperglycemia**, and the most common symptoms noted by persons with T1DM are polyuria, polydipsia, and polyphagia. These and other signs and symptoms are described below:

- **Polyuria** (the excretion of large volumes of urine) is due to a condition known as *osmotic diuresis*, or the build-up of substances in the kidney tubules. This increase changes the osmotic pressure within the tubules, thereby inducing water retention. The excess volume is then excreted as urine. In patients with T1DM, hyperglycemia causes glucose to accumulate in the kidney tubules, and thus osmotic diuresis occurs secondary to hyperglycemia. In young children especially, nighttime enuresis (bed-wetting) may be present.

- **Polydipsia** (excessive thirst) often accompanies polyuria. The ingestion of large volumes of liquid contributes to the polyuria experienced by these patients.

- **Polyphagia** (excessive hunger) is another common symptom of T1DM. Despite the consumption of large amounts of food, patients may experience weight loss. In the patient with T1DM, weight loss in the presence of normal food consumption or polyphagia is a result of both dehydration and the catabolic state (due to insulin depletion and the reduced availability of glycogen, proteins, and triglycerides).

- **Fatigue and weakness** is common among patients with T1DM due to catabolic muscle wasting.

- **Muscle cramps** can result from an imbalance in electrolytes, including sodium, chloride, and potassium.
• **Gastrointestinal symptoms** (e.g., nausea, abdominal pain) and **neurologic changes** (e.g., cerebral edema and coma) can be caused by **diabetic ketoacidosis (DKA)**, a dangerous condition that occurs when insufficient insulin levels cause the body to break down fats instead of glucose for energy. DKA may occur if the patient does not adhere to their prescribed insulin therapy or if the insulin regimen is not properly tailored to the patient’s needs. Alternatively, DKA can be triggered by stress, injury, or illness that alters the balance of insulin and glucose.

• **Peripheral neuropathy** (nerve damage occurring in the extremities) is a frequent symptom of T1DM. This is due to the build-up of sorbitol, a product of glucose conversion in the sensory nerves of the periphery. Patients experience the onset of peripheral neuropathy first as a numbness and tingling sensation in the hands and feet. The extremities are typically affected in a “glove and stocking” pattern. Notably, peripheral neuropathy associated with diabetes is bilateral and symmetrical. (This condition is described in more detail later in this course.)

• **Blurred vision** can result from glucose-induced swelling of the lens of the eye. (Khardori, 2018; Mayo Clinic, 2017)

**Diagnostic Tests**

Blood glucose tests are used for the definitive diagnosis of diabetes mellitus. Four blood glucose tests are used for this purpose.

**FASTING PLASMA GLUCOSE (FPG) TEST**

The FPG test is a measure of the blood glucose level in an individual after a period of fasting. This method assesses the ability of the body to properly store glucose following a meal. It is performed after the patient has not eaten for at least 8 hours and is most reliable when done in the morning (Pagana & Pagana, 2018).

In the FPG test, normal levels of blood glucose are considered to be <100 mg/dL, while levels between 100 and 125 mg/dL are considered to indicate prediabetes. Blood glucose levels of ≥126 mg/dL indicate diabetes but must be confirmed by repeating the FPG test on a different day (ADA, 2016).

<table>
<thead>
<tr>
<th>Plasma Glucose Level (mg/dL)</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;100</td>
<td>Normal</td>
</tr>
<tr>
<td>100–125</td>
<td>Prediabetes</td>
</tr>
<tr>
<td>≥126</td>
<td>Diabetes*</td>
</tr>
</tbody>
</table>

* Confirmed by repeating the test on a different day

Sources: ADA, 2019a; ADA, 2016; Pagana & Pagana, 2018.
ORAL GLUCOSE TOLERANCE TEST (OGTT)

The OGTT measures blood glucose levels in an individual who has fasted for at least 8 hours and is administered 2 hours after that person has consumed a glucose-containing liquid. This method assesses the ability of the body to tolerate an influx of glucose. Generally, the liquid is composed of 75 grams of glucose dissolved in water (ADA, 2019a; Pagana & Pagana, 2018).

Using the OGTT test, blood glucose levels of <140 mg/dL are considered normal, between 140 and 199 mg/dL indicate prediabetes, and ≥200 mg/dL are diagnostic of diabetes. As with the FPG test, a positive diagnosis of diabetes using the OGTT must be repeated on a different day for confirmation (ADA, 2016).

<table>
<thead>
<tr>
<th>2-Hour Plasma Glucose Level (mg/dL)</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;140</td>
<td>Normal</td>
</tr>
<tr>
<td>140–199</td>
<td>Prediabetes</td>
</tr>
<tr>
<td>≥200</td>
<td>Diabetes*</td>
</tr>
</tbody>
</table>

* Confirmed by repeating the test on a different day

Source: ADA, 2016; ADA, 2019a.

GLYcosylated Hemoglobin (A1C) TEST

Under conditions of hyperglycemia, excess glucose enters the red blood cells circulating throughout the blood. Red blood cells also contain hemoglobin, the protein responsible for oxygen transport within the blood. When glucose enters a red blood cell, it links to the hemoglobin molecules, forming glycosylated hemoglobin (HbA1C, commonly referred to as A1C). As glucose levels increase, the amount of glycosylated hemoglobin also increases (NIDDK, 2018; Pagana & Pagana, 2018).

The A1C test is a measure of the percentage of hemoglobin molecules that have glucose molecules attached to them. The A1C value is indicative of the average blood glucose level in an individual over the previous two to three months. Therefore, it is considered a long-term assessment of glucose control. A1C levels less than 5.7% are considered normal (ADA, 2016, 2019a).

<table>
<thead>
<tr>
<th>A1C Level</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5.7%</td>
<td>Normal</td>
</tr>
<tr>
<td>5.7%–6.4%</td>
<td>Prediabetes</td>
</tr>
<tr>
<td>≥6.5%</td>
<td>Diabetes*</td>
</tr>
</tbody>
</table>

* Confirmed by repeating the test on a different day

Sources: ADA, 2019a, 2016; NIDDK, 2018; Pagana & Pagana, 2018.
The A1C test has several advantages when compared to the FPG and OGTT. These include:

- Greater convenience, since fasting is not necessary
- Greater preanalytical stability
- Fewer day-to-day perturbations during illness and stress

However, experts warn that these advantages may be offset because of the lower sensitivity of the A1C, greater cost, limited availability of A1C testing in certain portions of the developing world, and the imperfect correlation between A1C and average glucose in certain individuals (ADA, 2019a).

**RANDOM PLASMA GLUCOSE TEST**

A random plasma glucose test is an informal measure of the blood glucose level. This method is performed at random, with no fasting requirement. Using this test, a blood glucose level of $\geq 200$ mg/dL in the presence of other symptoms may indicate that a patient has diabetes. In the case of a positive random plasma glucose test, a diagnosis of diabetes is confirmed using either an FPG, OGTT, or A1C test (ADA, 2016; ADA, 2019a).

**Differentiating between Type 1 and Type 2 Diabetes**

Once diabetes mellitus has been diagnosed, it is necessary to establish whether the patient has T1DM or T2DM in order to determine the proper course of treatment (McCulloch, 2016).

**DIFFERENCES IN ETIOLOGY**

T1DM is a chronic condition in which the pancreas produces little or no insulin, most likely due to an autoimmune reaction. Various factors such as genetics and some viruses may contribute to the development of T1DM (Mayo Clinic, 2017).

In T2DM the body is unable to properly utilize insulin and blood glucose levels cannot be maintained at normal levels (CDC, 2017b). Possible causes of T2DM include:

- Resistance to insulin action in target body tissues
- Abnormal insulin secretion
- Gluconeogenesis (overproduction of glucose)
- Development as a consequence of obesity (Rebar et al., 2019)

**DIAGNOSIS BASED ON AGE**

Until fairly recently, age at diagnosis or onset was considered to be one of the factors that helped to differentiate between T1DM and T2DM. Previously, T1DM was referred to as
juvenile diabetes and T2DM as adult-onset diabetes. Today, however, age is considered less as a diagnostic factor due to more current research findings.

T1DM, once considered a childhood disease, is now known to be similarly prevalent in adults. In one study, researchers found that adults are just as likely to develop T1DM as children, with more than 40% of T1DM cases diagnosed after the age of 30 (Thomas et al., 2017).

T1DM cases are more difficult to recognize and accurately diagnose in adults because considerably more people develop T2DM later in life. A significant clue to the possibility of adult T1DM is the failure of oral diabetic agents to control blood glucose. Additionally, adult-onset T1DM patients are likely to be slim compared to patients with T2DM, who are often overweight or obese (Thomas et al., 2017).

It is absolutely critical that T1DM be promptly and accurately diagnosed and treated in adults. Failure to recognize T1DM in adults can have serious, even fatal consequences. One study determined that 1 in 9 patients with adult-onset T1DM were admitted to the hospital with diabetic ketoacidosis (Thomas et al, 2017).

Once considered to be a condition that affected only adults, T2DM is an increasing problem in children and adolescents throughout the world. About 12 out of every 100,000 American youths under the age of 20 have been diagnosed with T2DM, and diagnosis is occurring at an average age of 14 (Huizen, 2017).

TESTING TO DIFFERENTIATE TYPE 1 DIABETES FROM TYPE 2 DIABETES

- **Insulin levels** can be measured to determine if an individual is producing the hormone. Similarly, levels of **C-peptide** (a molecule formed when proinsulin is converted to insulin) are also measured to determine whether the patient’s body is producing insulin. An insulin level of <5 µU/mL or a C-peptide test ≤0.6 mg/mL is suggestive of T1DM. Notably, patients with T2DM and a very high blood glucose level may be mistakenly diagnosed as having T1DM due to the decrease in insulin production resulting from the elevated blood glucose levels. Unlike patients with T1DM, these patients will resume normal insulin production once glucose levels are regulated.

- Because T1DM is considered an autoimmune disease, further blood work can be used to test for the presence of **autoantibodies**. Pancreatic islet cell antibodies are present in nearly 85% of patients with T1DM. Although they may differ, the majority of islet cell antibodies are directed against glutamic acid decarboxylase (GAD), an enzyme expressed in pancreatic beta cells. Many of these patients also have anti-insulin antibodies.

- A **urinalysis** may be performed to assay for the presence of ketones, the acidic byproduct of the breakdown of fat molecules. Accumulation of ketones can result in diabetic ketoacidosis (DKA). This condition rarely occurs in patients with T2DM, and therefore their presence in urine is considered indicative of T1DM.
CASE

A 35-year-old woman is evaluated by her primary care physician because of an approximate 10-pound weight loss over the previous two months and frequent episodes of increased thirst and increased urination including nocturia. She states she has not been experiencing nausea, vomiting, or abdominal pain, though she admits to increased headaches. The patient has been previously healthy and states she does not consume alcohol, tobacco, or illicit drugs. Her medications include only vitamin supplements, and she is physically sedentary. Her father has had T2DM for 22 years and her sister was diagnosed with T1DM at age 18 years.

Physical examination reveals a white female of normal body weight who is in no acute distress. Mucous membranes are dry, but the rest of the examination findings are normal. Laboratory analysis reveals a blood glucose level of 350 mg/dL, an A1C level of 8.0%, and ketones present in the patient’s urine. She is diagnosed with diabetes and hospitalized overnight for subcutaneous insulin therapy and rehydration by oral fluid therapy.

Over the next 18 hours, the patient’s blood glucose level decreases to 140 mg/dL. She is diagnosed with presumed T2DM and released from the hospital after initial diabetes education regarding diet and exercise. She is also prescribed metformin (Glucophage) and instructed to monitor her blood glucose levels four times daily and advised to see her primary care physician four days after discharge.

The patient returns to her physician’s office three days later complaining of awakening in the middle of the night “feeling shaky.” She also notes continued hyperglycemia, with fingerstick readings typically >300mg/dL. She is then referred to an endocrinologist and, after further testing, found to have T1DM rather than T2DM. The endocrinologist stops the metformin and collaborates with a diabetes educator to educate the patient about insulin therapy and appropriate meal planning. The patient is started on long-acting, once-daily insulin with ongoing blood sugar monitoring both before and after meals. After three months on insulin, the patient’s A1C level is 6.1%, and she has regained four pounds.

Discussion

Making a correct diagnosis of T1DM versus T2DM can be challenging, in part because the autoimmune destruction of the pancreatic islets cells that produce insulin can occur at any age. Also, although DKA is a common feature of T1DM, it may not be present early in the disease, occurring in only approximately 20% of patients with new-onset T1DM. Antibody testing is an essential tool in differentiating the diagnosis, as antibodies to pancreatic islet cells or insulin are present in a majority of patients with T1DM. Finally, levels of insulin and C-peptide can be measured to determine whether the patient’s body is producing insulin. Low levels of insulin or C-peptide help confirm the diagnosis.
MANAGEMENT OF TYPE 1 DIABETES

There is presently no cure for T1DM. Instead, it is a chronic and lifelong condition that requires patients to adhere to a prescribed diet and therapeutic regimen. With faithful adherence, patients with T1DM may live a long life and experience less-frequent and less-severe diabetes-related complications. The lifelong commitment these patients must make includes:

- Frequent monitoring of blood glucose levels
- Taking regular doses of insulin
- Following a diet designed to manage blood sugar levels
- Participating in an active exercise routine

(Gersch et al., 2017)

The most effective management of T1DM occurs when a multidisciplinary team approach is taken. The multidisciplinary team typically includes primary care providers, nurses, endocrinologists, registered dietitians, and diabetes educators. A pediatrician is a crucial member of the care team in the case of juvenile patients with T1DM (Gersch et al., 2017).

Patients with T1DM must commit to regular clinician visits to be sure that their disease is properly controlled. The two primary goals of therapy for T1DM are to prevent the development of diabetes-related complications and to keep blood glucose levels near normal (Gersch et al., 2017).

CHRONIC CARE MODEL

The ADA (2019a) recommends the Chronic Care Model (CCM) as an effective framework for improving the quality of diabetes care. The CCM includes six core elements:

1. Delivery system design (moving from a reactive to a proactive care delivery system where planned visits are coordinated through a team-based approach)
2. Self-management support
3. Decision support (basing care on evidence-based, effective care guidelines)
4. Clinical information systems (using registries that can provide patient-specific and population-based support to the care team)
5. Community resources and policies (identifying or developing resources to support healthy lifestyles)
6. Health systems (to create a quality-oriented culture)
Patient and Family Teaching and Follow-Up

Patient and family teaching and follow-up are critically important parts of successful management of the disease. Patient and family teaching regarding T1DM is provided to the patient and family initially at the time of the patient’s diagnosis then reinforced at follow-up visits. It should include the following:

- Explanation of T1DM
- Carbohydrate counting and the patient’s diet
- Checking the patient’s blood sugar level
- Giving insulin
- Maintaining target blood sugar levels
- Managing illness and infections
- Regular physical exams with clinicians
- A1C testing
- What is involved in staying healthy
- Managing diabetes in school or at work
- Preventing long-term complications
  (ADA, 2019a)

TEACHING CHILDREN

When teaching children about their T1DM, it is important to talk to them in age-appropriate ways and to always be honest. Children need to know that getting diabetes is not their fault, that it is not going to go away, and that it is okay to feel sad or upset.

Some tips for talking to a child about T1DM based on age include:

- **Infants and toddlers:** At this age children do not understand the need for medications, injections, etc. Experts suggest making actions such as blood sugar testing and administering insulin part of the child’s daily routine.

- **Preschoolers:** Simple terms should be used to describe diabetes care. Let the child have some sense of control over their care, such as choosing a snack from recommended options.

- **Grade school through middle school:** Children at this age are assuming some responsibility for their care, but parental supervision is still needed. Parents should not be overprotective but supportive as the child begins to assume responsibility for diabetes
management. Praise should be offered for new self-care accomplishments and temporary setbacks met with understanding.

- **Teens:** Teens may make poor decisions in response to peer pressure and fear of being different from their friends. They may not take their insulin, consume alcohol, and ignore dietary guidelines. Parents should express their concerns in a caring, supportive manner and reiterate how diabetes can affect the teen’s health if not managed correctly. (Dowshen, 2018)

### Multidisciplinary Approach to Care

Treatment success is enhanced by a multidisciplinary team approach to teaching the patient and family and supporting them during ongoing, long-term follow-up. It is important to remember that the most important member of the multidisciplinary team is the patient (and, as appropriate, family members). The patient is the person who must adhere to the agreed-upon management regimen, is the first to notice any problems, and is the most affected by diabetes (ADA, 2019c).

Other members of the healthcare team may include:

- **Primary care provider:** Primary care providers may include a family practice physician, internist, nurse practitioner, or physician’s assistant, all of whom should have experience caring for patients with T1DM.

- **Endocrinologist:** Endocrinologists specialize in treating diseases of the endocrine system, such as diabetes.

- **Nurse educator or diabetes nurse practitioner:** Nurse educators or diabetes nurse practitioners are RNs with special training and education in caring for and teaching people with diabetes.

- **Registered dietitian:** Dietitians help patients determine food needs based on target weight, lifestyle, and medication.

- **Certified diabetes educator (CDE):** CDEs may be nurses, dietitians, pharmacists, podiatrists, counselors, or exercise physiologists. CDEs must pass a national test to become certified in diabetes education and must pass a recertification test every five years.

- **Ophthalmologist:** Ophthalmologists should evaluate the patient’s eyes annually. Ideally, they should have expertise in caring for persons with diabetes.

- **Mental health expert:** Mental health experts such as psychiatrists, psychologists, and family therapists help patients and families deal with the personal and emotional factors of living with diabetes.
• Occupational therapist: Occupational therapists focus on lifestyle modifications, health promotion, remediation of physical and visual impairments, and maximizing self-care and independence.

• Physical therapist: Physical therapists assess strength, flexibility, endurance, and balance in order to design personalized therapeutic exercise programs to address functional limitations. Physical therapists may also assess footwear, teach patients to perform skin inspections, and provide wound evaluations/treatments.

• Podiatrist: Podiatrists treat problems of the feet and lower legs, which are common among patients with diabetes.

• Pharmacist: Pharmacists are experts in the pharmacological side of diabetes treatment and can be valuable educational resources.

• Dentist: People with diabetes may be at higher risk for gum disease. Regular dental visits (every 6 months) for a checkup and cleaning are important.

• Exercise physiologist: Exercise physiologists help to plan patients’ fitness and exercise programs. Patients should always get their primary healthcare provider’s approval for any exercise and fitness program.

(ADA, 2019c; American Occupational Therapy Association, n.d.)

Other specialists may include cardiologists, nephrologists, neurologists, homeopathic practitioners, and members of the clergy, depending on the individual patient and the healthcare team’s management plan.

Diet Planning for Patients with Diabetes

Diet is one of the first and major steps addressed when developing a strategy to manage T1DM. Maintaining a healthy diet is a crucial part of managing blood glucose levels for the patient with T1DM.

Patients’ preferred eating habits and lifestyle should be carefully taken into consideration when designing a diet plan for those with T1DM. This plan should include a recommended daily caloric intake based on the age and physical activity level of the patient as well as guidance for how these calories should be divided throughout the day. Contrary to general belief, there is not a specific “diabetic diet” followed by all patients with T1DM.

RECOMMENDED FOODS

The key to healthy eating with diabetes is to eat a variety of healthy foods from all food groups:

Vegetables
• Nonstarchy, such as broccoli, carrots, greens, peppers, and tomatoes
• Starchy, such as potatoes, corn, and green peas
Fruits
- Examples include oranges, melons, berries, apples, bananas, and grapes

Grains
- At least half should be whole grains
- Examples include wheat, rice, oats, cornmeal, barley, whole grain bread, pasta, and cereal, and quinoa

Protein
- Lean meat
- Chicken or turkey without the skin
- Fish
- Eggs
- Nuts and peanuts
- Dried beans and certain peas, such as chickpeas and split peas
- Meat alternatives such as tofu

Nonfat or low-fat dairy
- Milk (or lactose-free milk if there is lactose intolerance)
- Yogurt
- Cheese

Heart-healthy fats
- Oils that are liquid at room temperature, such as canola and olive oil
- Nuts and seeds
- Heart-healthy fish such as salmon, tuna, and mackerel
- Avocado

Use oils when cooking food instead of butter, cream, shortening, lard, or stick margarine (NIDDK, 2016a).

NUTRIENT AMOUNTS

A dietitian or diabetes educator can recommend the amounts of nutrients that should be consumed by the patient. Amounts are individualized depending on the needs of the patient; for example, reduced protein intake is indicated in the case of a patient with a complication such as nephropathy.

There are generally two meal plan methods to help determine nutrient consumption: the plate method and carbohydrate counting (NIDDK, 2016a).
Plate Method

The plate method helps patients to control portion sizes. Recommendations include:

- Use a 9-inch plate.

- Place nonstarchy vegetables on half of the plate, a meat or other protein on one fourth of the plate, and a grain or other starch on the last one fourth. (Starchy vegetables include items like corn or peas.)

- A small bowl of fruit or a piece of fruit and a small glass of milk may be part of the meal plan.

(NIDDK, 2016a)

Plate Method, showing the proportion of each food group that should be eaten—1/4 protein, 1/4 grain, and 1/2 nonstarchy vegetables. (Source: NIDDK, 2016a.)

JUDGING PORTION SIZES

Every-day objects can help patients and families judge portion sizes:

- One serving of meat or poultry is the size of the palm of the hand or a deck of cards.
- One 3-ounce serving of fish is the size of a checkbook.
- One serving of cheese is the size of six dice.
- 1/2 cup of cooked rice or pasta is the size of rounded handful or a tennis ball.
- One serving of a pancake or waffle is the size of a DVD.
- 2 tablespoons of peanut butter are the size of a ping-pong ball.

(NIDDK, 2016a)
**Carbohydrate Counting**

Carbohydrate counting involves keeping track of the amount of carbohydrates eaten and drunk each day. Carbohydrates (carbs) affect blood glucose levels more than other foods do, and carbohydrate counting can help with the management of blood glucose levels. Counting carbs can help patients know the amount of insulin to take. Most carbohydrates come from starches, fruits, milk, and sweets. Carbohydrates with added sugars or refined with grains (e.g., white bread and white rice) should be limited. Instead, fruit, vegetables, whole grains, beans, and low-fat or nonfat milk are recommended (NIDDK, 2016a).

Other foods and drinks that should be limited include:

- Fried foods and other foods high in saturated fat and trans fats
- Foods high in sodium
- Sweets, such as baked goods, candy, and ice cream
- Beverages with added sugars, such as juice, regular soda, and regular sports or energy drinks (drink water instead)  
  (NIDDK, 2016a)

Consider using a sugar substitute in coffee or tea.

**Physical Activity**

Exercise is one of the cornerstones of a comprehensive program for the management of T1DM. Patients are encouraged to maintain a regular exercise routine. Experts suggest target exercise goals of 30 minutes of moderate or vigorous physical activity 5 days a week. Exercise should be undertaken only with approval of the patient’s physician and under the supervision of a physical therapist or exercise physiologist, and may include strengthening exercises such as weight training and stretching exercises such as yoga (NIDDK, 2016c).

The benefits of exercise can be significant. Physical activity:

- Lowers blood glucose levels
- Lowers blood pressure
- Improves blood flow
- Burns extra calories to help with weight management
- Improves mood
- Can prevent falls and improve memory in older adults
- Can improve sleep  
  (NIDDK, 2016c)
Managing Blood Glucose Levels

It is important for patients with T1DM to maintain normal blood glucose levels. Achieving and maintaining glycemic control is associated with reductions in the frequency and severity of diabetes-related complications. Target blood sugar levels are:

- 80 to 130 immediately before meals
- <180 two hours after the start of the meal

CONTINUOUS GLUCOSE MONITORING (CGM)

Patients with T1DM should frequently monitor their blood glucose levels, as this can be used to determine whether their disease is being properly treated. Self-monitoring of blood glucose allows patients to evaluate their individual response to therapy and assess whether glycemic targets are being achieved on a daily basis.

Computerized blood glucose meters provide the most accurate and precise measure of the amount of glucose circulating within the blood at a particular time. Research indicates that CGM helps to reduce hypoglycemia and improve glucose control (Lakhanigam, 2019).

CGM automatically tracks blood glucose levels 24 hours per day. Results are available any time at a glance. CGM works via a tiny sensor inserted under the skin, usually on the abdomen or arm. The sensor measures the interstitial glucose level. The sensor tests glucose every few minutes, and a transmitter wirelessly sends the information to a monitor. This monitor may be part of an insulin pump or a separate device that can be carried in a pocket or purse. Some CGMs are able to send information directly to a smartphone or tablet. Sensors must be replaced every 3 to 7 days, depending on the model (NIDDK, 2017e).

Special features of a CGM can include:

- An alarm that sounds when glucose levels are too low or too high
- Tracking for meals, physical activity, and medications
- Data that can be downloaded to a computer or a smart device to more easily assess glucose results and trends
- Data transfer to a second person’s smartphone (such as a parent, partner, or caregiver). For example, if a child’s blood glucose level drops overnight, the CGM could be set to wake up a parent who is sleeping elsewhere in the home. (NIDDK, 2017e)

Some patients may also need to validate the CGM readings twice a day by testing a drop of blood on a standard glucose meter. The reading should be similar on both devices.
The majority of people who use CGMs have T1DM. Research is being conducted to determine how CGMs might help people who have T2DM (NIDDK, 2017e).

A1C TESTING

The A1C test is a measure of the percentage of hemoglobin molecules that have glucose molecules attached. The A1C level is reflective of the average blood glucose level in an individual over the previous two to three months and is considered a long-term assessment of glucose control (NIDDK, 2016c).

The 2019 ADA recommendations include the following A1C goals for adults with diabetes:

- A reasonable A1C goal for many nonpregnant adults is <7% (53 mmol/mol).
- Providers might reasonably suggest more stringent A1C goals (such as <6.5%, or 48 mmol/mol) for select individual patients if this can be achieved without significant hypoglycemia or other adverse effects of treatment.
- Less stringent A1C goals (such as <8%, or 64 mmol/mol) may be appropriate for patients with a history of severe hypoglycemia, limited life expectancy, advanced microvascular or macrovascular complications, extensive comorbid conditions, or long-standing diabetes in whom the goal is difficult to achieve despite diabetes self-management, education, appropriate glucose monitoring, and effective doses of multiple glucose-lowering agents including insulin.
- Reassess glycemic targets over time based on the ADA criteria.

(See also “Glycosylated Hemoglobin (A1C) Test” earlier in this course.)
ESTIMATED AVERAGE GLUCOSE (eAG)

The estimated average glucose (eAG) is a method for understanding the management of diabetes. Estimated average glucose is determined by converting the A1C percentage to mg/dL units. Because these units are the same as those used on blood glucose meters, they are considered to be more familiar to patients with diabetes. Therefore, providing the A1C percentage in these units may help patients to better understand how effectively their T1DM is being controlled (Gilles, 2019).

Insulin Therapy

Because T1DM is a disease caused by a loss of the ability to produce insulin, the primary treatment is insulin therapy.

In addition, other medications may be prescribed to work in conjunction with insulin in an effort to reduce hyperglycemia. Patients who develop diabetes-related complications often require medication specific to their complication. For example, patients with cardiac complications may be treated with low-dose aspirin therapy, cholesterol-lowering drugs, or high blood pressure medications.

The 2019 ADA recommendations regarding pharmacologic therapy for T1DM are:

- Most people with T1DM should be treated with multiple daily injections of prandial and basal insulin or continuous subcutaneous insulin infusion. (Subcutaneous insulin infusion is the continuous infusion of a short-acting insulin driven by a mechanical force and delivered via a soft cannula under the skin [National Diabetes Center, n.d.].)
- Most individuals with T1DM should use rapid-acting insulin analogs to reduce hypoglycemia risk.
- Consider educating individuals with T1DM on matching prandial insulin doses to carbohydrate intake, premeal blood glucose levels, and anticipated physical activity.
- Individuals with T1DM who have been successfully using continuous subcutaneous insulin infusion should have continued access to this therapy after they turn 65 years of age. (ADA, 2019a)

DOSAGE

In adults, the initial daily dose of insulin is calculated based on the weight of the patient. Because it is quickly degraded, insulin must be administered throughout the day to maintain steady levels, with doses frequently adjusted based on self-monitoring of blood glucose levels. Insulin therapy is typically accomplished by giving a basal insulin in combination with preprandial insulin doses. The basal insulin is either a long-acting (glargine or detemir) or intermediate-acting (NPH) insulin, and the preprandial insulin is either rapid-acting (lispro, aspart, or glulisine) or short-acting (regular) insulin (ADA, 2019a).
Common insulin regimens include:

- **Split or mixed regimen**: NPH plus rapid-acting or regular insulin before breakfast and the evening meal

- **Split or mixed variant regimen**: NPH with rapid-acting or regular insulin before breakfast, rapid-acting or regular insulin before the evening meal, with NPH before bedtime (to reduce fasting hyperglycemia)

- **Multiple daily injections (MDI)**: A long-acting insulin once daily in the morning or evening (given twice daily in some patients), plus a rapid-acting insulin before meals and snacks (dose adjusted based on blood glucose level)

- **Continuous subcutaneous insulin infusion (CSII)**: Rapid-acting insulin infused continuously through an insulin pump at one or more basal rates, with additional short-acting insulin given if blood glucose levels exceed target levels

  (Khardori, 2018)

**ADMINISTRATION**

Subcutaneously injected insulin is the first-line therapy. Insulin injections are self-administered using either a needle and syringe or an insulin pen—a device that resembles an ink pen, with the “ink” cartridge instead filled with insulin. Insulin may also be administered via a battery-operated infusion pump. A form of inhaled insulin is also currently available.

**Insulin Pens**

Insulin pens allow the delivery of insulin in a simpler, more accurate, and more convenient way than vial and syringe administration. Several brands and models of insulin pens are available. Most insulin pens belong to one of two categories:

- **Disposable pens**: Disposable pens contain prefilled insulin cartridges; after use, the entire pen unit is discarded.

- **Reusable pens**: Reusable pens contain replaceable insulin cartridges; once empty, the cartridge is discarded and a new one is put in.

  (Biggers, 2017)

A new disposable needle must be used every time insulin is injected. If cared for properly, reusable insulin pens can last for several years (Leonard, 2017).

**Insulin Pumps**

The rapid improvement in the development of continuous glucose sensor technology has allowed progress toward a fully closed-loop insulin delivery system. In 2017, Medtronic began marketing the 670G insulin pump with Guardian 3 sensor. When in automatic mode, this is a hybrid closed-loop insulin delivery system that automatically adjusts basal
insulin delivery every 5 minutes based on sensor glucose to maintain blood glucose levels close to specified, desired glucose targets (Weaver, 2018).

**Inhaled Insulin**

Inhaled insulin was first available on the U.S. market in 2011, but the metered-dose device was cumbersome and ultimately withdrawn by the manufacturer within a year. More recently, the FDA approved the new inhaled insulin Afrezza for use in both T1DM and T2DM (Hulisz, 2019).

Afrezza is a human insulin that is rapidly absorbed with inhalation. A pre-filled cartridge containing either 4, 8, or 12 units of insulin is placed in an inhaler. Patients are instructed to exhale fully, then inhale sharply and hold their breath for as long as comfortable to absorb the medication. Research is underway to determine the usefulness of Afrezza as add-on therapy for uncontrolled T2DM.

The side effects of Afrezza are similar to other insulin products. However, this drug may also cause acute bronchospasms or cough (Hulisz, 2019).

**TYPES OF INSULIN**

Types of insulin are categorized based on their time of onset, peak, and duration of action. Rapid-, short-, intermediate-, and long-acting insulin preparations are available for use in the United States. Various pork, beef, and beef-pork combination insulins were previously widely available. However, recombinant human insulin is now used almost exclusively. Commercially prepared insulin mixtures are also available (ADA, 2019a; Khardori, 2018).

<table>
<thead>
<tr>
<th>Types of Insulin</th>
<th>Onset (hours)</th>
<th>Peak (hours)</th>
<th>Duration (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rapid- and Short-Acting</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glulisine insulin</td>
<td>0.25</td>
<td>0.5–1.5</td>
<td>3–5</td>
</tr>
<tr>
<td>Lispro insulin</td>
<td>0.25</td>
<td>1–3</td>
<td>1–5</td>
</tr>
<tr>
<td>Aspart insulin</td>
<td>0.25</td>
<td>1–3</td>
<td>1–5</td>
</tr>
<tr>
<td>Regular insulin</td>
<td>0.5–1</td>
<td>2.5–5</td>
<td>4–12</td>
</tr>
<tr>
<td><strong>Intermediate-Acting</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutral protamine Hagedorn (NPH)</td>
<td>1–2</td>
<td>4–12</td>
<td>12–18</td>
</tr>
<tr>
<td><strong>Long-Acting</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulin detemir (Levemir)</td>
<td>1</td>
<td>stable levels (no peak)</td>
<td>24</td>
</tr>
<tr>
<td>Insulin glargine (Lantus, Toujeo)</td>
<td>1–2</td>
<td>stable levels (no peak)</td>
<td>24</td>
</tr>
</tbody>
</table>

Sources: ADA, 2019a; Khardori, 2018.
Insulin therapy regimens for patients with T1DM frequently combine insulin types, offering patients the ability to benefit from each class. This is commonly done by drawing calculated doses of two insulin types into the same syringe, allowing for a single injection. This method should only be done immediately before administering the insulin injection. Premixed insulin preparations are also available, but their fixed ratios of each insulin type may limit their use (ADA, 2019a; Khardori, 2018).

**Rapid-Acting and Short-Acting**

Rapid-acting and short-acting insulins include lispro insulin, aspart insulin, glulisine insulin, and regular insulin. These are the only available insulins that can be administered intravenously. Because of their rapid onset of action, they can be used when quick control of blood glucose levels is needed, such as before a meal. A rapid influx of insulin stimulates glucose uptake and storage, reducing blood sugar (Khardori, 2018).

Regular (traditional) insulin is a formulation of zinc insulin crystals suspended in solution. The onset of action for traditional insulin is 5 to 10 minutes, with a peak activity of 45 to 75 minutes, and a duration of 2 to 4 hours (Khardori, 2018).

In September 2017, the FDA approved the rapid-acting insulin aspart injection (Fiasp) for the treatment of adults with diabetes. Dosing can begin at the beginning of a meal or within 20 minutes after the meal begins. Fiasp can be detected in the circulation about 2.5 minutes after administration. Maximum insulin levels occur at about 63 minutes after administration (Khardori, 2018).

**Intermediate-Acting**

Intermediate-acting insulins have a slower onset of action compared to rapid-acting formulations but have a characteristically longer duration of action. Thus, they are often administered in combination with rapid-acting formulations, which maximizes the benefit of both insulin types. Additionally, intermediate-acting insulin formulations are often used at bedtime in order to provide needed insulin throughout the night (Khardori, 2018).

Neutral protamine Hagedorn (NPH) is a suspension of zinc insulin crystals combined with protamine, a positively charged amino acid polypeptide. The onset of action of this class of insulins is between 1 and 2 hours, with a peak effect occurring in 4 to 12 hours. The greatest benefit of intermediate-acting insulins is their long duration of activity of 14 to 24 hours (Khardori, 2018).

**Long-Acting**

Long-acting insulins, as their name suggests, have a very long duration of action. This insulin class is generally combined with rapid-acting insulin, offering patients an improved and steadier control of their insulin and blood glucose levels. Long-acting formulations are often administered in the morning in order to provide all-day insulin...
The pharmacology of long-acting insulin is similar to that of the natural insulin normally secreted by the pancreas. These insulins are generally administered once daily.

**MEDICATIONS THAT MAY REQUIRE INSULIN ADJUSTMENTS**

Patients who are taking the following medications may require an insulin adjustment:

- **Atypical antipsychotics**: May cause weight gain and insulin resistance
- **Corticosteroids**: May cause insulin resistance, sensitivity to glucose, and inability to release insulin in other tissues
- **Niacin**: May slightly increase glucose levels
- **Beta blockers**: May impair insulin release by nonselective beta blockers
- **Thiazide diuretics**: May have a weak inhibitory effect on insulin release from beta cells
- **Fluoroquinolones**: May cause severe blood sugar swings
- **Immunosuppressive agents**: May decrease insulin secretion, have a direct toxic effect on cells, and/or increase insulin resistance
- **Protease inhibitors**: May predispose people to diabetes by increasing insulin resistance
- **Pentamidine**: May cause transient hyperinsulinemia associated with hypoglycemia and beta cell failure
- **Alcohol**: May block hepatic glucose production, which can lead to hypoglycemia

(Waleed, 2019)

**CASE**

An 11-year-old boy is brought by his mother to see his nurse practitioner because of a one-week history of excessive urination, excessive thirst, hunger, and complaints of fatigue. His mother reports that she received a call from a friend’s mother stating that the boy had been up seven to eight times at night to urinate during a sleepover at their home. He has experienced no abdominal pain, nausea, vomiting, or visual changes during this period of time. He has lost one pound in weight since his last clinic visit six months ago. The patient has been previously healthy and has no family history of T1DM.

The patient presents as a happy, active boy. Results of his laboratory studies reveal a random blood glucose reading by glucometer of 260 mg/dL, with the presence of glucose but no ketones in the boy’s urine. His renal function tests are within normal limits. Based on these findings and an accompanying A1C level of 8.6%, the nurse practitioner diagnoses the patient with presumed T1DM without DKA.
Discussion

In the absence of DKA, the focus of therapy is on stabilization of blood glucose levels, beginning insulin therapy, diet planning for the patient, and teaching the patient and family to manage diet and insulin therapy to prevent periods of hypoglycemia and hyperglycemia.

For example, in this patient’s case, the nurse practitioner would prescribe insulin therapy and arrange for his family to be instructed in how to use a glucometer at home to measure the child’s blood glucose levels four times a day. His blood glucose levels may be stabilized by treatment with a long-acting insulin, but daily glucose monitoring is necessary to ensure that he does not need additional short-acting insulin at mealtimes. The family would then be provided with dietary planning information and instructed to return to the office for follow-up evaluation (e.g., in four days) to evaluate the effect of the insulin therapy and the family’s comfort with blood sugar measurement and to reinforce teaching about insulin administration and diet.

The nurse practitioner could also refer the patient and his family to a multidisciplinary diabetes care team (e.g., at a local hospital) for further information about meal planning, insulin therapy, blood glucose measurement, managing illnesses and infections, managing hypoglycemia, and controlling hyperglycemia to prevent long-term complications. The family should also receive psychosocial support regarding stress they may be experiencing regarding the patient’s illness. Ongoing medical supervision of patient care is typically performed by an endocrinologist in collaboration with primary care providers.

Amylin Therapy

Amylin is a 37-amino acid peptide stored in pancreatic beta cells and co-secreted with insulin. Amylin affects glucose control by slowing gastric emptying, regulation of postprandial glucagon, and reduction of food intake (Dungan, 2017). People who take amylin hormone do not need as much pre-meal insulin since they generally do not have extreme spikes in blood sugar (Almekinder, 2016).

The synthetic version of amylin is called pramlintide (Symlin). It comes in an injection pen, similar to insulin pens. Dose is based on blood glucose levels and how well the body adjusts to the medicine. Starting dose is 15 mcg injected under the skin 5–10 minutes before each major meal (at least 250 calories or 30 grams of carbohydrates), with the insulin dose given 5–10 minutes after meals to facilitate the work of pramlintide in the body. The dose is adjusted as needed (Mayo Clinic, 2019b).

Patients taking pramlintide will either have a “sour” feeling in their stomachs and feel full 15–30 minutes after injecting the drug, or blood sugars for the hours following meals will be stable. If patients do not get the “sour” stomach feeling or the stable blood sugars, their healthcare providers will increase the dose of pramlintide.

Nausea is the most common side effect of pramlintide. About 50% of people have some level of stomach upset. The drug’s peak effect is 15–30 minutes after injection, which is why the sour
stomach feeling generally occurs at that time. Fortunately, upset stomach tends to subside after several weeks of therapy.

Other side effects of pramlintide include:

- Drowsiness
- Dizziness
- Vomiting
- Anorexia
- Stomach cramps
- Fatigue
- Rhinitis
- Sore throat
- Cough
- Joint pain
- Headache
- Redness, swelling, or itching at the injection site

(Almedinder, 2016)

**Treating Hyperglycemia**

Hyperglycemia, the hallmark clinical sign of T1DM, occurs when an individual experiences levels of blood glucose above target levels. Nearly all patients with T1DM experience hyperglycemia during the course of their disease. In patients with T1DM, hyperglycemia may be indicative of poor disease management. This may occur as a result of a skipped or forgotten dose of insulin, too low a dosage of insulin, eating too much food, or eating foods that add too much sugar to the diet. Other causes of hyperglycemia in patients with T1DM include infection, illness (such as a cold or flu), increased stress, or decreased physical activity (WebMD, 2017).

Hyperglycemia can be treated by changes in exercise, diet, and/or alterations to the patient’s insulin regimen. Patients can often lower their blood glucose levels sufficiently by making changes in diet or by exercise alone. It is essential, however, that patients do not exercise if they have blood glucose levels ≥240 mg/dL and ketones are present in their urine, as exercising under these conditions can drive blood glucose levels even higher. Patients experiencing chronic hyperglycemia can require changes in the amount, timing, or type of insulin they receive each day (WebMD, 2017).
COMMON SYMPTOMS OF HYPERGLYCEMIA

- Increased thirst
- Blurred vision
- Frequent urination
- Increased hunger
- Numbness or tingling in the hands and feet
- Fatigue

(Gersch et al., 2017)

Patient Adherence to Therapy

Patient nonadherence to type 1 diabetes treatment is an issue of considerable concern and is especially common among adolescent and young adult patients. A nonjudgmental, holistic approach to patient and family teaching that promotes positive family interactions (e.g., interventions focused on increasing parent-child communication about T1DM treatment) have been shown in clinical studies to be associated with better adherence as reflected in enhanced glycemic control in pediatric and adolescent patients (Dowshen, 2018).

It is important to note that depression occurs frequently among patients with T1DM and may be a cause of nonadherence in many patients. Because of this common correlation, chronically nonadherent patients should be evaluated for the presence of undiagnosed or undertreated depression and treated as necessary to promote optimal adherence to treatment. Depression most often occurs within one year of diagnosis of T1DM (NIMH Psych Central, 2018).

CASE

A 14-year-old boy, diagnosed with T1DM one year ago, has been hospitalized three times in the intervening months for DKA. His blood sugars have fluctuated greatly, and he has reported feeling shaky in the middle of the night on occasion. He does not like to check his blood sugar and often finds himself feeling “sick” between meals. The patient complains that checking his blood sugar at school makes him feel “weird,” and he “just wants to be a normal kid.”

Social service interviews with the family reveal that the boy was also diagnosed with depression six weeks ago but that he does not routinely take his antidepressant medication. He also does not take his insulin without close supervision by his parents, who report that they often have to argue with him about his need to take his insulin doses. It had been suggested that the patient attend a summer camp for youth with diabetes, where he could meet other teenagers coping with the disease, but so far he has refused to go.

The patient is currently admitted for another episode of DKA. He states that he hates being diabetic, is very depressed about it, and is considering trying to kill himself because of these depressed feelings. After he is medically stabilized following the DKA episode, the patient is
transferred to the psychiatric ward of the hospital for observation and treatment for suicidality and severe depression.

**Discussion**

Depression can be a reaction to stress and changes in routine that occur because of the T1DM diagnosis and the demands and responsibilities required by its treatment. Apathy associated with depression can interfere with a patient’s ability to handle these demands and responsibilities. Because of the lifelong nature of T1DM, patients with the disease must contend with these demands and responsibilities on an ongoing basis, which may require long-term emotional support in the form of personal and family counseling to promote optimal motivation and adherence to their plan of care.

After his initial psychiatric hospitalization and stabilization for depression, a teenaged patient such as this one who is having trouble accepting his diagnosis may benefit from individual and family counseling, from being involved in a peer support group, and from short- or long-term antidepressant medication therapy. In addition, the patient and his family may benefit from the support of agencies such as Children with Diabetes, which are dedicated to assisting children and teens with the challenges that accompany the disease. *(See also “Resources” at the end of this course.)*

**Transplantation Procedures**

Transplantation of islet cells and whole pancreases has been performed with the goal of ending patients’ dependence on exogenous insulin. Transplantation of islet cells is performed by isolating islet cells from donor pancreases then injecting the cells directly into a major vein in a patient’s liver. The islet cells are then carried to capillaries in the liver, where they produce insulin.

In addition, whole pancreas transplants and double transplants of pancreases and kidneys have shown favorable long-term success rates for some patients with T1DM. Transplantation of splenocytes has, in addition, been shown to give rise to new islet cells in patients whose underlying autoimmune disease is controlled.

Drawbacks of these procedures are that immunosuppressant agents are required for the patient’s lifetime so that their body does not reject the foreign islet cells or transplanted tissue. In addition, two or more donor pancreases are necessary to supply sufficient pancreatic tissue for one patient. Unfortunately, with the currently limited supply of donor pancreases, this requirement makes these procedures feasible for only 1% of T1DM patients.

Researchers are currently examining alternative approaches to the transplantation of islet cells, including the use of umbilical cord cells, embryonic or adult stem cells, bone marrow transplantation, and other types of cellular therapies to help patients with T1DM reduce their dependence on exogenous insulin *(Dholakia et al., 2016; Lysy et al., 2016; Matsumoto et al., 2016; Rekittke et al., 2016).*
PREVENTING AND TREATING COMPLICATIONS

One of the major impacts of T1DM is the potential for the development of both acute and chronic complications of the disease. Development of diabetes-related complications may necessitate additional specialists, such as cardiologists, ophthalmologists, dermatologists, podiatrists, physical therapists, occupational therapists, and others (Gersch et al., 2017).

Acute Complications

Acute complications are emergency conditions that can become life-threatening if not immediately treated. The two main acute complications that affect patients with T1DM are hypoglycemia and DKA. Additional complications include neuropathies.

HYPOGLYCEMIA

Hypoglycemia (low blood glucose levels) is a serious side effect that can occur in patients with T1DM. Normally, decreased blood glucose levels trigger the pancreatic hormone glucagon to activate the breakdown of glycogen within cells, causing the release of glucose into the bloodstream. This results in restoration of normal blood glucose levels. However, this response is impaired in patients with T1DM, whose disease is controlled by insulin therapy. Because of their lifelong dependence on insulin treatment, patients with T1DM have an increased likelihood of experiencing hypoglycemia compared to patients with T2DM (ADA, 2019a; Gersch et al., 2017).

Recognizing Hypoglycemia

Hypoglycemia may occur when patients with T1DM take a dose of insulin but then miss a meal, have a strenuous exercise workout, or for some reason deplete their blood glucose. Consumption of alcoholic beverages may also cause hypoglycemia in T1DM diabetics. In addition to insulin therapy itself, the injectable medication pramlintide, which is administered in conjunction with insulin to patients with T1DM, is associated with a risk of hypoglycemia (Comerford & Durkin, 2019; Gersch et al., 2017).

Short or mild cases of hypoglycemia can cause weakness and fatigue. Prolonged or serious cases are more dangerous, causing confusion, clumsiness, or unconsciousness. Especially severe cases may lead to irreversible brain damage, seizures, comas, and ultimately death.

Hypoglycemia can have a very sudden onset, and early symptoms may appear to be mild. Patients with T1DM should be made aware of the danger associated with hypoglycemia and educated to recognize its symptoms so that they can intervene before the condition becomes serious (Mayo Clinic, 2017).
COMMON SYMPTOMS OF HYPOGLYCEMIA

- Weakness
- Fatigue
- Hunger
- Shakiness
- Nervousness
- Sweating
- Dizziness
- Light-headedness
- Sleepiness
- Confusion
- Difficulty speaking
- Anxiety

(Comerford & Durkin, 2019; Gersch et al., 2017)

Because a normal night’s sleep can mean that patients experience a prolonged period without a meal, T1DM patients should also be informed that hypoglycemia can occur during sleep. It is important to occasionally monitor blood glucose levels during the night to determine whether they become too low (University Health News, 2019).

SIGNS OF HYPOGLYCEMIA DURING SLEEP

- Crying out or experiencing nightmares
- Damp pajamas or sheets due to excessive perspiration
- Feeling tired, irritable, or confused after waking up

(Gersch et al., 2017; University Health News, 2019)

**Treating and Preventing Hypoglycemia**

When patients recognize the onset of hypoglycemic symptoms, they should immediately check their blood glucose levels. Levels below 70 mg/dL require immediate intervention (ADA, 2019b).

The ADA (2019b) recommends the “15-15 Rule” to treat hypoglycemia. This rule states that patients should consume 15 grams of carbohydrate to raise blood sugar and check it after 15 minutes. If it is still below 70 mg/dL, another 15 grams of carbohydrate should be consumed. These steps should be repeated until blood glucose is at least 70 mg/dL. After blood glucose returns to normal, a meal or snack should be eaten to prevent another hypoglycemic episode.
The 15 grams of carbohydrate may be consumed as:

- Glucose tablets
- Gel tube
- 4 ounces (1/2 cup) of juice or regular soda (not diet)
- 1 tablespoon of sugar, honey, or corn syrup
- Hard candies, jellybeans, or gumdrops (see food labels for how many to consume)

Patients should maintain a record of any episodes of hypoglycemia, when they happened, and the circumstances surrounding the episodes. These records should be shared with healthcare providers.

Many people who experience hypoglycemia want to eat as much as they can until they feel better. This may lead to hyperglycemia. Using the “15-15 Rule” can help avoid hyperglycemia (ADA, 2019b).

Note that young children usually need less than 15 grams of carbohydrates to correct hypoglycemia:

- Infants, 6 grams
- Toddlers, 8 grams
- Small children, 10 grams

Amounts are individualized to the patient, so parents and other caregivers should discuss required amounts with their healthcare providers (ADA, 2019b).

When treating hypoglycemia, the choice of carbohydrate is very important. Complex carbohydrate foods that contain fats along with carbohydrates (e.g., chocolate) can delay glucose absorption and should not be used to treat an emergency hypoglycemic episode (ADA, 2019b).

Because cases of moderate to severe hypoglycemia can cause patients to lose consciousness or otherwise be unable to help themselves, a family member, coworker, or care provider can be trained to give an injection of glucagon, which causes blood glucose levels to be rapidly restored to normal (ADA, 2019b).

Frequent episodes of hypoglycemia may be a sign that the patient’s blood glucose levels are not being effectively managed. These patients could benefit from a different meal plan, a new insulin administration schedule, or a modified physical exercise routine (ADA, 2019b; Gersch et al., 2017).

Patients with T1DM should be educated regarding strategies to prevent and treat hypoglycemia. Frequent monitoring of blood glucose levels can help patients identify activities that cause them to develop hypoglycemia; this is particularly important when
they undertake new physical activities. Patients should be instructed to always have several servings of high-glucose “quick-fix” foods available to treat hypoglycemia if it occurs. Other strategies include encouraging patients with T1DM to carry a medical alert wallet card, wear a medical alert bracelet, and discuss with friends, family, and coworkers how to handle a hypoglycemic emergency if one occurs (ADA, 2019b; Gersch, et al., 2017).

**CASE**

A 26-year-old male has had T1DM since middle school. With very few episodes of hypoglycemia in the last five years, he feels very confident in his ability to manage his disease.

One day, he follows his usual morning routine of wake-up CBG and insulin. When he arrives at work, where he is manager of all the concession booths at a large amusement park, he is immediately informed of a power failure that has affected all the food coolers in the booths. In the rush of responding to this crisis, he forgets about his usual practice of eating a breakfast bar.

Thirty minutes later, his supervisor notices that the man is shaky, sweating, and disoriented. Knowing about his diabetes, the supervisor takes him to the park’s first aid station, where his CBG tests as 26. While waiting for an ambulance to arrive, the nurse on duty coaches the patient in drinking a sweetened electrolyte replacement solution. The EMS team arrives and administers glucose gel orally and monitors his CBG until he meets discharge criteria.

Once he is stable, the man returns to work. Considering the seriousness of this “close call,” he resolves to rethink his self-care plan. He pre-positions energy bars approved by his diabetes educator in his desk, car, and pouch he wears at work.

Knowing that there are several other staff members with diabetes working at the park, as well as likely visitors who may have the same problem, the nurse in charge of first aid takes the EMS team’s recommendation to stock glucose gel and the solution formulation as part of the station’s supplies.

**Discussion**

Patients with type 1 diabetes who have not experienced an episode of hypoglycemia in some time may become complacent. In this case, the patient’s situation was aggravated by the additional stress and physical activity prompted by the power failure. He lost track of the elapsed time since he had taken his insulin and the additional demands being placed on his body. Had he been working alone, he might not have been found and helped in time.

**DIABETIC KETOACIDOSIS**

DKA is a serious acute complication that may lead to cerebral edema, diabetic coma, and if not treated, death. Although DKA may occur in anyone with diabetes, it is far more common in patients with T1DM compared to those with T2DM.
This condition occurs when insufficient insulin levels cause the body to break down fats instead of glucose for energy. DKA may occur if the patient does not adhere to their prescribed insulin therapy or if the insulin regimen is not sufficient for the patient’s needs. Alternatively, the condition may be triggered by stress, injury, or illness that alters the balance of insulin and glucose (Gersch et al., 2017; Mayo Clinic, 2018a).

Triggers of DKA include:

- **Illness**: An infection or other type of illness can cause the body to produce higher amounts of adrenaline or cortisol, which counters the effects of insulin. This can lead to DKA.

- **A problem with insulin regimen**: Missed insulin treatments or insufficient insulin therapy leave the body without adequate insulin, which can lead to DKA.

- **Additional possible triggers of DKA include**:
  - Physical or emotional trauma
  - Heart attack
  - Alcohol or drug use, especially cocaine
  - Some medications such as corticosteroids and some diuretics (Mayo Clinic, 2018a)

### COMMON CAUSES OF DKA

- Infection
- Illness (e.g., pneumonia or influenza)
- Missed insulin dose(s)
- Inadequate insulin dosage
- Stress
- Alcohol abuse
- Surgery
- Trauma
  (Gersch et al., 2017; Mayo Clinic, 2018a)

### Diagnosing and Testing for DKA

The primary evidence that DKA is occurring is the presence of ketones in the urine. Acidic ketones, a byproduct of fat metabolism, become toxic when they accumulate in the blood. Their toxicity is due to their ability to cause acidosis (a drop in blood pH). Normally, the pH of blood is tightly regulated between 7.38 and 7.44; the build-up of
ketones in the blood causes the pH to drop to below 7.3. The severity of DKA can be established with standard laboratory studies and is primarily determined by the blood pH level and bicarbonate level in combination with observing the patient’s mental status.

The onset of DKA may occur in less than 24 hours. Once symptoms of DKA occur, DKA quickly develops into a life-threatening condition in only a few hours. Very early signs of DKA result from hyperglycemia and therefore include thirst, dry mouth, frequent urination, and high blood glucose levels. These signs are followed by other symptoms, often beginning in the gastrointestinal system, such as nausea, vomiting, and abdominal pain. Another symptom of DKA is Kussmaul breathing (also referred to as air hunger), resulting from difficulty breathing. Patients also feel constantly tired, have dry or flushed skin, and appear confused. A fruity odor may be apparent to their breath (Mayo Clinic, 2018a; Rebar et al., 2019).

**SYMPTOMS OF DKA**

- Thirst
- Dry mouth
- Frequent urination
- High blood glucose levels
- Nausea and vomiting
- Abdominal pain
- Kussmaul breathing
- Fatigue
- Dry or flushed skin
- Confusion
- Fruity breath odor
  (Mayo Clinic, 2018a; Rebar et al., 2019)

Elevated levels of blood ketones is an important sign that a patient’s blood glucose levels are not properly regulated. The presence of ketones can be tested using a simple urine test strip for ketonuria. Because symptoms of DKA may be slow to develop, it is recommended that patients with T1DM test for the presence of ketonuria if their blood glucose levels exceed 250 mg/dL. Additionally, because DKA is more likely to occur when diabetic patients have an illness, a urine test to check for ketonuria should be performed every 4 to 6 hours (Mayo Clinic, 2018a; Rebar et al, 2019).

Patients should be educated to contact their healthcare provider for guidance if a urine test reveals an accumulation of ketones. Patients should also be warned not to exercise if they experience elevated ketone levels, as this can cause blood glucose levels to rise further.
Treating and Preventing DKA

Treatment, often provided in the emergency department and followed by hospital admission, usually includes:

- Fluid replacement: Fluids lost from excessive urination need to be replaced; patients are given fluids either by mouth or intravenously until they are rehydrated.

- Electrolyte replacement: Lack of insulin can decrease the levels of various electrolytes (e.g., calcium, potassium); patients will receive electrolyte replacement as needed.

- Insulin therapy: Insulin is typically administered intravenously until blood glucose levels decrease to about 200 mg/dL.

(Mayo Clinic, 2018a)

After body chemistry returns to normal, patients are evaluated for possible causes of diabetic ketoacidosis. Based on individual evaluation, treatment regimens may need to be adjusted. Ideally, the best treatment for DKA is prevention.

THE KETO DIET AND DIABETES

Unlike other low-carb diets, which concentrate on protein, the keto diet requires a very high fat intake, supplying as much as 90% of daily calories. For example, in a daily 2,000-calorie diet a keto diet might include an intake of 165 grams of fat, 40 grams of carbs, and 75 grams of protein depending on individual needs. Although healthy unsaturated fats are allowed on the keto diet, saturated fats from oils, lard, butter, and cocoa are encouraged in high amounts (Harvard Health Publishing, 2018).

Research results regarding the benefits of the keto diet for persons with diabetes are mixed. Small studies have shown significant weight loss in persons with T2DM and improved blood glucose control. However, the studies that yielded these results were too small to determine general significance. A study of 316 persons with T1DM showed significant weight loss, but the “drop-out rate was substantial and reports of symptomatic hypoglycemia (1–5 episodes) were experienced by 69% of those in the study” (Doheny et al., 2018).

Joseph Galati, MD, a hepatologist at Liver Specialists of Texas, states that “those with type 1 diabetes should avoid a ketogenic diet. Many patients with type 1 diabetes have some degree of renal impairment, and handling the build-up of ketones and acids in the body may cause too much stress on the kidneys. Of course, any pregnant women with diabetes, especially those requiring insulin should avoid such an extreme diet given the low glucose levels will be a constant health threat” (Doheny et al., 2018).
CASE

A 3-year-old girl presents for care to her pediatrician after one week of bedwetting at night. Her mother explains that the child has also been hungrier and thirstier than usual for the past two weeks and urinates frequently during the day. She has complained of abdominal pain for the past two days but has had no diarrhea or vomiting. The mother states that her child had a viral illness with high fever approximately two months prior. The illness resolved, but she has noticed the girl being increasingly irritable.

Upon physical examination and comparison to her past growth records, the pediatrician notes that the child has lost two pounds over the past six months. Her skin has poor turgor and mucous membranes appear dry. She additionally has signs of thrush, with a white coating on her tongue. Urinalysis reveals the presence of glucose and ketones in her urine, and blood glucose evaluation by glucometer reveals a result of 810 mg/dL, leading the pediatrician to suspect T1DM with DKA. The patient is therefore admitted to the hospital for treatment and observation.

Discussion

DKA is a medical emergency, as patients with DKA are at risk for cerebral edema, coma, and death. The treatment of a patient with new onset T1DM with DKA requires admission to the hospital for intravenous fluid rehydration, insulin drip therapy to control blood glucose levels, and close monitoring of vital signs, neurological status, blood gases, blood glucose levels, and electrolytes. DKA can cause shifts in potassium levels that can result in arrhythmias, difficulty breathing, and fatigue. These patients are hospitalized for several days to allow medical stabilization and, once stabilized, initiation of diabetic teaching by a multidisciplinary care team, often coordinated by an endocrinologist.

Diabetic teaching of the patient and family includes providing information about meal planning, blood glucose measurement, insulin therapy, managing illnesses and infections, managing hypoglycemia, and controlling hyperglycemia to prevent long-term complications. The family should also receive psychosocial support (e.g., referral to a family therapist), as needed, regarding stress they may be experiencing regarding the patient’s illness. Ongoing medical supervision of patient care is typically performed by an endocrinologist in collaboration with primary care providers.

Chronic Complications

Chronic complications may also become serious or life-threatening but typically develop only over an extended period of time after the patient has been living with T1DM for one or more decades. Chronic complications typically result from damage caused by continual or frequent hyperglycemia.

One of the most important interventions to prevent the frequency and severity of chronic complications related to T1DM is to maintain blood glucose levels to as close to normal as possible. This long-term therapeutic goal is a commitment for the patient.
CARDIOVASCULAR CONDITIONS

Patients with T1DM have an increased risk for a number of cardiovascular complications, including heart disease, stroke, and hypertension (NIDDK, 2017a). Because of the seriousness of cardiovascular complications, patients with T1DM should be counseled to follow their diabetic diet, get regular aerobic exercise, and undergo regular screening for risk factors, signs, and symptoms of cardiac disease.

Recent research suggests that autoimmune response in persons with T1DM may lead to heart disease. Initially, the body’s immune system mistakenly attacks beta cells in the pancreas. A similar but delayed process happens to the heart muscle of patients with T1DM when blood sugar is not under close control. Research has also shown that people exposed to higher blood sugar levels were more likely to develop an autoimmune response to the heart proteins that were linked to later development of heart disease. High glucose levels injure the heart muscle tissue, and researchers hypothesize that the immune system of people with T1DM overreacts to this heart injury (AHA News, 2018).

Atherosclerotic cardiovascular disease is the leading cause of morbidity and mortality for people with diabetes. Atherosclerosis occurs as a result of the build-up of fatty material deposits on the arterial wall. As these deposits accumulate, the vessel narrows, reducing and eventually impairing blood flow (ADA, 2019a; Woodruff, 2016). (Source: NHLBI, 2015.)
Hypertension can occur without warning, and many patients do not realize their blood pressure is elevated. Therefore, patients with T1DM should have their blood pressure monitored at every office visit. If hypertension is discovered, lifestyle interventions should be recommended to help lower the blood pressure. These can include an improved diet, weight loss, exercise, and limiting alcohol consumption and tobacco use. ADA 2019 recommendations regarding hypertension include:

- Blood pressure should be measured at every routine clinical visit. Patients found to have elevated blood pressure (≥140/90 mmHg) should have blood pressure confirmed using multiple readings, including measurements on a separate day, to confirm a diagnosis of hypertension.

- All hypertensive patients with diabetes should monitor their blood pressure at home.

- For patients with diabetes and hypertension, blood pressure targets should be individualized through a shared decision-making process that addresses cardiovascular risk, potential adverse effects of antihypertensive medications, and patient preferences.

- For individuals with diabetes and hypertension at higher cardiovascular risk, a blood pressure target of <130/80 mmHg may be appropriate if it can be safely attained.

- For individuals with diabetes and hypertension at lower risk for cardiovascular disease, treat to a blood pressure target of <140/90 mmHg.

- In pregnant patients with diabetes and preexisting hypertension who are treated with antihypertensive therapy, blood pressure targets of 120–160/80–105 mmHg are suggested in the interest of optimizing long-term maternal health and minimizing impaired fetal growth.
  
  (ADA, 2019a)

In addition to lifestyle changes, antihypertensive medications may be prescribed. The type and amount of the medication will depend on the specific needs of each individual patient.

**DIABETIC NEUROPATHY AND FOOT COMPLICATIONS**

Diabetic neuropathy is a type of nerve damage associated with diabetes. Depending on the nerves that are affected, symptoms of diabetic neuropathy can range from pain and numbness in the legs and feet to problems with the digestive system, urinary tract, blood vessels, and heart. Peripheral neuropathy, the most common type of diabetic neuropathy, affects the feet and legs first and progresses to the hands and arms. It frequently begins as a tingling sensation or feeling of numbness in the toes. These sensations gradually travel upward through the feet, ankles, and lower legs (Mayo Clinic, 2018b).
SYMPTOMS OF PERIPHERAL NEUROPATHY

Signs and symptoms of peripheral neuropathy are often worse at night and may include the following:

- Numbness
- Insensitivity to pain or temperature
- Extreme sensitivity to light touch
- Tingling, burning, or prickling sensation
- Sharp pains or cramps
- Loss of balance and/or coordination
- Muscle weakness
- Loss of reflexes, especially in the ankle
- Serious foot problems such as ulcers, infections, and bone and joint pain

(Mayo Clinic, 2018b)

Because peripheral neuropathy is a common complication for patients with diabetes, it should be screened for at each clinic visit. Tests commonly used to diagnose neuropathy include filament testing, quantitative sensory testing, nerve conduction studies, electromyography, and autonomic testing (Mayo Clinic, 2018b). Patients should be taught to monitor their signs and symptoms, including self-testing of foot sensation.

<table>
<thead>
<tr>
<th>NEUROPATHIES OCCURRING IN PATIENTS WITH T1DM</th>
</tr>
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<tbody>
<tr>
<td>Type</td>
</tr>
<tr>
<td>Peripheral neuropathy (most common)</td>
</tr>
<tr>
<td>Autonomic neuropathy</td>
</tr>
<tr>
<td>Radiculoplexus neuropathy (diabetic amyotrophy) (other names include femoral or proximal neuropathy)</td>
</tr>
<tr>
<td>Mono- or focal neuropathy</td>
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</tbody>
</table>

Source: Mayo Clinic, 2018b.
Treating Diabetic Neuropathy

Treatment for the condition focuses on slowing progression of the disease, relieving pain, managing complications, and reducing neuromuscular symptoms. Consistently keeping blood sugar levels within the patient’s target range can delay the progression of peripheral neuropathy and even cause an improvement in existing symptoms in some patients (ADA, 2019; Mayo Clinic, 2018b).

Medications used to treat diabetes-related nerve pain include:

- **Antiseizure drugs**: Pregabalin (Lyrica), gabapentin (Gralise, Neurontin), carbamazepine (Carbatrol, Tegretol). Side effects include drowsiness, dizziness, and swelling.
- **Tricyclic antidepressants**: Desipramine (Norpramin), imipramine (Tofranil). Side effects include dry mouth, sweating, weight gain, constipation, and dizziness.
- **SNRI antidepressants**: Duloxetine (Cymbalta), venlafaxine (Effexor XR). Possible side effects include nausea, sleepiness, dizziness, decreased appetite, and constipation. (Mayo Clinic, 2018b)

Physical therapy can play an important role in developing an appropriate exercise program for patients with peripheral neuropathy. Exercise may help improve metabolic dysregulation and promote nerve function and regeneration. While it was previously thought that weight-bearing exercise should be avoided in patients with DPN, more recent studies have indicated that, while short-term protection of compromised tissues can promote healing, prolonged non-weight-bearing can potentially lead to lowered tissue tolerance for stress and a lowered injury threshold. Effective exercise prescription seeks to gradually increase tissue-level stress in order to promote positive adaptations without exceeding adaptability and causing subsequent tissue injury (Kluding et al., 2017).

Complementary and alternative therapies (e.g., the use of capsaicin cream or acupuncture) may be helpful in relieving pain in some patients with diabetic neuropathy. These treatments are usually used in conjunction with medications but may sometimes be effective on their own. Transcutaneous nerve stimulation has also been used successfully in the treatment of diabetic neuropathic pain. Other therapies include alpha-lipoic acid (a powerful antioxidant) (Mayo Clinic, 2018b).

**CASE**

A 47-year-old woman with a 21-year history of T1DM is treated by her primary care physician for increasing chronic pain in her feet related to peripheral diabetic neuropathy, which was first diagnosed five years ago. In addition, she has been treated for several foot ulcers over the last six months. Her diabetes is also complicated by diabetic retinopathy, which was successfully treated with laser therapy four years ago. Her past medical history is notable for rheumatoid arthritis. She also has well-managed...
hyperlipidemia and mild hypertension but shows no signs or symptoms suggestive of renal disease.

For the past three years, the patient’s diabetes has been well controlled by her use of an insulin infusion pump with additional injections of subcutaneous insulin as needed to control postprandial glucose levels. Pain in her feet and hands related to peripheral neuropathy is currently treated with the tricyclic antidepressant imipramine (Tofranil), and she also receives azathioprine (Imuran) and nonsteroidal anti-inflammatory agents for treatment of her arthritis.

**Discussion**

Interventions for peripheral diabetic neuropathy can be successfully combined for treatment of worsening peripheral pain symptoms, and patients can be counseled in lifestyle changes to slow progression of the nerve damage.

In this case the primary care provider might change the patient’s medication, substituting an anticonvulsant medication (e.g., gabapentin, pregabalin, or carbamazepine) for the tricyclic agent imipramine and recommend the use of an alternative medicine intervention such as capsaicin cream or acupuncture to provide supplemental pain relief. In addition, they could recommend the use of lidocaine patches to provide topical analgesia in painful areas of the patient’s feet. More severe cases of peripheral neuropathic pain might require treatment with opioid pain relievers and/or the addition of transcutaneous nerve stimulation to provide additional pain relief.

Patients with peripheral neuropathy should also receive ongoing instruction and encouragement to maintain lifestyle habits that can delay the progression of the damage to the peripheral nerves. These habits include performing careful daily foot care, exercising, avoiding the use of tobacco, and avoiding alcohol or drinking only in moderation. The patient may benefit from a podiatric referral for care to prevent further foot problems.

**Foot Complications**

Foot complications arising from peripheral neuropathy are common among patients with T1DM. Nerve damage can cause numbness and a loss of feeling in the feet, and therefore patients with these symptoms are more prone to be unaware of foot discomfort (such as a pebble in the shoe causing a blister) until the damage is already done. Nerve damage also reduces the oil and moisture that is normally supplied to the skin of the foot, causing it to peel, crack, and become very dry.

There are also other causes of foot complications in patients with T1DM. Poor blood circulation in the feet occurs due to hyperglycemia-induced narrowing and hardening of the blood vessels. Patients with poor blood circulation in their feet may constantly feel that their feet are cold; however, they should use caution when attempting to warm their
feet, as neuropathy-induced loss of feeling may reduce their ability to realize whether their foot is being burned by water or a heating pad that is too warm.

Poor blood circulation may also cause a build-up of pressure within the foot, causing calluses that can break down and turn into open sores. These foot ulcers, which occur most often on high-pressure areas such as the ball of the foot or the underside of the big toe, are a common cause of foot infections in diabetic patients. If the ulcer becomes infected, the problem may be compounded by poor blood circulation in the foot.

**Foot Amputation**

Together, foot complications may ultimately cause the patient to be forced to undergo amputation. In order to prevent amputation, patients should be counseled to maintain appropriate foot care, which may include special therapeutic shoes, cleaning of foot ulcers, professional removal of calluses, and appropriate exercise. Patients should also be encouraged to stop smoking, since smoking contributes to poor blood circulation and the progression of foot complications (NIDDK, 2017b).

Patients who have undergone amputation are typically cared for collaboratively by an interdisciplinary rehabilitation team including physicians, nurses, physical therapist, prosthetist, and occupational therapist. The team may also include a social worker, vocational rehabilitation specialist, and a dietitian, as needed. Collaboration with nursing specifically includes timing pain management interventions to reduce patient discomfort during physical therapy sessions, wound management, training regarding bed and chair/wheelchair transfers, and patient and family education (Gersch et al., 2017).

*(See also the Wild Iris Medical Education course “Diabetes Care: Prevention and Clinical Care of Diabetic Foot Ulcers.”)*

### AMPUTATION AND PHYSICAL THERAPY

The physical therapist’s **initial evaluation** after a patient’s amputation includes examination and assessment of the following:

- Skin evaluation (e.g., for scarring, sensation, moisture, lesions)
- Residual limb length (for bone and soft tissue length)
- Residual limb shape (e.g., cylindrical, conical, bulbous end, etc.)
- Vascularity and condition of soft tissue of the residual limb (pulses, color, temperature, edema, atrophic changes)
- Neurological condition of remaining limb tissue (e.g., pain, neuropathy)
- Neurologic status of the patient (cognitive state, emotional status)
- Range of motion of the residual limb and opposite lower extremity
• Functional status (transfers, balance, mobility, ability to perform activities of daily living)

• Other issues (patient pre-amputation level of function with regard to work, activity level, degree of independence; whether the patient is accepting of having a prosthesis; and whether the patient has a prior prosthesis on the opposite lower limb)
  (Gersch et al., 2017)

Based on the exam and assessment, the physical therapist determines **initial postoperative physical therapy goals** for the patient as follows:

• Promote optimal wound healing

• Monitor the residual limb (stump) for shape, incision healing/closure, length, sensory integrity, volume, tissue integrity, color, temperature, and pain

• Edema control

• Scar tissue mobilization around the incision to promote optimal scar shape

• Early preparation of the limb for prosthetic fitting

• Maintenance and optimization of range of motion of the residual limb

• Improvement of the patient’s physical endurance

• Patient education

• Bed mobility

• Training regarding safe bed-to-chair/wheelchair transfers

• Balance training
  (Gersch et al., 2017)

Patients requiring amputation have traditionally received soft compressive dressings postoperatively to allow complete residual limb healing prior to initial prosthesis fitting. Patients are now, however, increasingly being treated by immediate postoperative prosthesis placement (IPOP), which allows early initiation of gait training with the practice prosthesis, thereby avoiding prolonged immobility, which can place patients at risk for deconditioning and/or falls with potential for injury to the residual limb (Gersch et al., 2017).

**Later postoperative physical therapy goals** for the patient will likely include the following:

• Evaluation of the prosthesis for correct fit

• Training in the correct use and care of a customized prosthetic limb

• Gait training, including addressing specific gait deviations (hiking, vaulting,
circumduction, etc.)

- Phantom pain management (interventions include careful inspection of the limb to rule out neuroma or wound infection, use of compression, desensitization techniques, and heat; medications, steroid injections, nerve blocks, and/or relaxation/hypnosis to relieve pain may be prescribed or administered by other licensed healthcare professionals)
- Ongoing skin care of the operative and opposite limb
- Monitoring of the residual limb for reddening and/or skin breakdown from use of prosthesis
- Strengthening exercises of the upper and lower extremities and trunk (Gersch et al., 2017)

**CASE**

A 42-year-old man with a 32-year history of T1DM, as well as severe, bilateral lower limb peripheral vascular disease and chronically infected, nonhealing foot ulcers, is admitted for transtibial amputation of his left lower extremity. After the amputation surgery, he is evaluated by an inpatient physical therapist (PT) for management of his residual limb and initial mobility assessment. The PT briskly explains to the patient why she is here and that she will help him learn to move around his room using a front-wheeled walker.

The PT observes that the patient has positioned several pillows under his left knee, leaving the end of his residual limb resting against the bed. The PT demonstrates to the patient how to correctly position his residual limb by placing the pillow so that his knee is straight, not bent (in order to avoid a potential contracture of his knee joint). The patient allows the PT to reposition his leg for him but does not actively participate in the process. When the PT asks the patient to demonstrate sitting up on the edge of the bed for her, he abruptly tells her that he doesn’t feel like it and that she should come back later. He denies being in pain but refuses to engage further.

The PT apologizes for rushing the patient and asks if he feels nervous about trying to get out of bed. The patient hesitates, then confesses that he’s scared of never being able to walk independently. “I’m 42, not 82,” he says, “and it’s bad enough I lost my leg. Now you come in here telling me I have to use a walker like my grandmother!”

The PT assures the patient that the walker is often just the first step in learning how to get around and that he may be able to walk independently once he receives his long-term prosthesis and completes the rehabilitation process. The patient then agrees to participate in the rest of the evaluation.
KIDNEY DISEASE (NEPHROPATHY)

Patients with T1DM have a high risk for the development of kidney disease. Early intervention is a key step to limiting kidney damage. Tight control of blood glucose levels can help to reduce the risk of microalbuminuria (a small amount of protein in the urine) by approximately one third. Several treatments are also available to slow kidney disease when it is caught in the microalbuminuria stage (ADA, 2019a; Gersch et al., 2017; NIDDK, 2017c).

Once microalbuminuria develops, tight control of blood glucose levels can significantly reduce the risk of progressing to macroalbuminuria (higher levels of protein in the urine). However, once the disease reaches the macroalbuminuria stage, it has progressed to advanced stages and is usually followed by the development of end-stage renal disease, which leads to kidney failure (NIDDK, 2017c; Rebar et al., 2019).

Because the kidney overworks to compensate for its decreased efficiency, early stages of kidney disease are often not accompanied by symptoms. Therefore, careful monitoring for signs of kidney deficiency at routine check-ups is an important component of care for patients with T1DM. In addition to a urine test to monitor the presence of protein, a blood test can be performed to check for the presence of waste products. It is not until the disease has progressed that the first symptoms may become noticeable. While these may vary from patient to patient, they often begin with fluid build-up. Other symptoms of kidney disease are listed below (NIDDK, 2017c; Rebar et al., 2019).

SYMPTOMS OF NEPHROPATHY

- Loss of sleep
- Poor appetite
- Nausea and vomiting
- Weakness
- Difficulty concentrating
- Edema
- Pruritis
- Protein in the urine
- Fatigue
- Confusion

(Mayo Clinic, 2017c)

To reduce the risk of developing diabetic kidney disease patients should:

- Carefully adhere to treatment regimens in order to control blood sugar levels
- Manage hypertension and/or other medical conditions
• Follow instructions when purchasing/taking over-the-counter medications (e.g., for persons with diabetic kidney disease, ibuprofen and acetaminophen can lead to kidney damage if taken at incorrect doses)

• Maintain a healthy weight and stay physically active

• Not smoke (cigarette smoking can damage the kidneys and make existing kidney disease worse)

(Mayo Clinic, 2017c)

EYE COMPLICATIONS

High blood glucose levels in patients with T1DM lead to an increased risk of eye complications. Although some of these complications may lead to blindness, many are only minor eye problems. The most serious diabetic diseases of the eye start with blood vessel problems. The four diseases that can threaten sight are:

• **Diabetic retinopathy:** Early in the disease, blood vessels can weaken, bulge, or leak into the retina (referred to as *nonproliferative diabetic retinopathy*). As the disease progresses, some blood vessels literally close off, leading to a growth of new, abnormal blood vessels (proliferate) on the retinal surface, which can cause serious vision disturbances (referred to as *proliferative diabetic retinopathy*).

• **Diabetic macular edema:** Diabetes can cause swelling of the macula (referred to as *diabetic macular edema*). As the disease progresses, partial or complete vision loss may occur. Macular edema usually develops in patients who already have other signs of diabetic retinopathy.

• **Glaucoma:** Glaucoma is a group of eye diseases that can damage the optic nerve. Failure to receive prompt, early treatment for glaucoma can lead to vision loss and blindness.

• **Cataracts:** Patients with diabetes can develop cataracts (cloudy lenses) at an earlier age than people without diabetes. It is believed that high glucose levels cause deposits to build up in the lenses of the eye.

(NIDDK, 2017d)

Early diagnosis of diabetic eye disease is the key factor in the ability of treatments to limit the resulting vision loss. Because of this, patients with T1DM should be counseled to have a yearly eye exam starting within 5 years of diagnosis to monitor for evidence of retinopathy. Treatment of diabetic eye disease can include medications, laser treatment, cataract lens surgery, and vitrectomy (removal of the vitreous gel) (NIDDK, 2017d).
SYMPTOMS OF EYE COMPLICATIONS

- Blurry vision
- Difficulty reading signs or books
- Double vision
- Pain in one or both eyes
- Eye redness
- Feeling of pressure in the eye
- Seeing spots or “floaters”
- Straight lines appearing as not straight
- Disrupted peripheral vision
  (NIDDK, 2017d)

ADHESIVE CAPSULITIS (AC)

Commonly referred to as “frozen shoulder,” adhesive capsulitis is a condition marked by painful then increasingly restricted movement of the glenohumeral joint, with limitations most often occurring in the movements of external rotation and abduction. AC may be classified as primary (in cases that are idiopathic in nature) or secondary (in cases that result from a known cause). Causes of secondary AC can be further classified into three subcategories, including:

- Extrinsic: cardiopulmonary disease, cervical disc pathology, humeral fractures, strokes, Parkinson’s disease
- Intrinsic: AC joint arthritis, rotator cuff pathology, biceps tendinopathy, calcific tendinopathy
- Systemic: metabolic conditions, including diabetes mellitus

Research has shown that patients with diabetes are approximately five times more likely to have AC than the general population and that cases in patients with diabetes are often more resistant to treatment. While the reasons for this are not definitively known, causative factors such as nonenzymatic oxidative reactions between glucose and collagen and the presence of inflammatory mediators specific to diabetes may play a role (Physiopedia, 2019, Zreik et al., 2016).

Most cases of AC will spontaneously resolve over varying periods of time, but the resultant loss of motion during the affected period can significantly impact an individual’s ability to perform ADLs and other preferred functional activities. Treatment for AC includes a range of options: corticosteroid injections, manipulation under anesthesia, translation mobilization under anesthesia, arthroscopic capsular release, and suprascapular nerve blocks. NSAIDs, oral steroids, and physical therapy evaluation/intervention are also frequently used in the treatment of AC.
CHRONIC COMPLICATIONS IN CHILDHOOD

Research findings to date indicate that exposure to repeated, severe hypoglycemia, chronic hyperglycemia, and DKA has adverse effects on cognition and learning in youth with T1DM. Experts believe that achieving tighter glycemic control early in childhood could help to minimize the risk for negative impact on cognition (Cato & Hershey, 2016).

Poor glycemic control in children and adolescents is also associated with reduced joint mobility, primarily affecting the hands and feet, and with menstrual irregularities and fingernail changes (paronychia). In addition, slower rates of bone calcium deposition and decreased bone mineral content have been noted among children and adolescents with T1DM compared to healthy children (Dowshen, 2018; Levitsky & Misra, 2016).

CONCLUSION

Type 1 diabetes mellitus is a serious disease whose chronic nature requires a lifelong commitment to therapy. Unlike T2DM, T1DM is caused by an autoimmune reaction, the results of which cause the body to be unable to properly store and process blood glucose. The hallmark clinical sign of T1DM is hyperglycemia. Symptoms of hyperglycemia include increased thirst, blurred vision, frequent urination, and increased hunger.

While there are many strategies to manage T1DM, such as exercise and diet, the primary treatment is insulin therapy to make up for the lack of insulin production in these patients. Insulin administration allows patients to normalize their blood glucose levels. Tight control of blood glucose is an essential step to prevent the development and/or worsening of diabetes-related complications, a common occurrence in these patients.

The long-term therapy of patients with T1DM is best managed by a multidisciplinary care team comprised of primary care providers, nurses, endocrinologists, and other specialists (i.e., cardiologists, ophthalmologists, dermatologists, podiatrists, physical therapists, occupational therapists, registered dietitians, and diabetes educators). Although there is currently no cure, with continued care and oversight as well as careful and committed adherence to lifestyle changes and treatments, patients with T1DM may experience an active and full life.

RESOURCES

American Diabetes Association
http://www.diabetes.org

About diabetes (CDC)

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Children with diabetes (Online community for kids, families, and adults with diabetes)
http://www.childrenwithdiabetes.com

Diabetes (Mayo Clinic)
http://www.mayoclinic.com/health/diabetes/DS01121

Diabetes (NIDDK)
https://www.niddk.nih.gov/health-information/diabetes

Diabetes type 1 (Medline Plus)
https://medlineplus.gov/diabetestype1.html

Exercise and type 1 diabetes (ADA)

International Diabetes Federation
http://www.idf.org

Meal planning for children with type 1 diabetes

Planning meals (ADA)

Type 1 diabetes and exercise
http://www.endocrineweb.com/conditions/type-1-diabetes/type-1-diabetes-exercise

REFERENCES


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1. Which description does the clinician use to explain type 1 diabetes (T1DM) to a patient who was recently diagnosed with the disease?
   a. T1DM is a disease in which the beta cells of the pancreas produce little to no insulin, so the blood glucose levels can become too low.
   b. T1DM is a disease in which the entry of glucose into the cells is impaired and blood glucose levels become too high.
   c. T1DM is a disease in which there is an alteration in the secretion of insulin, so the blood glucose levels can become too low.
   d. T1DM is a disease in which the body makes too much insulin to keep the blood glucose levels normal, so the blood glucose levels can become too high.

2. When discussing the impact of diabetes, the clinician is aware that:
   a. The rate of adult diabetes by racial/ethnic background is highest among Native Americans/Alaskan Natives.
   b. The direct medical costs of diabetes in the United States are $500 billion.
   c. Diabetes is the third leading cause of death.
   d. Of the 30.3 million Americans who have diabetes, nearly half of them have T1DM.

3. Which is an accurate statement regarding risk factors for type 1 diabetes (T1DM)?
   a. Persons who live in southern climates with warmer temperatures are at higher risk for developing T1DM.
   b. Viral infection may trigger an autoimmune response that increases the risk of developing T1DM.
   c. There are no genetic factors that contribute to the risk of developing T1DM.
   d. Individuals with second- or third-degree relatives with T1DM are at greater risk themselves.

4. Which person is at highest risk for developing T1DM?
   a. An 18-year old whose father has heart disease
   b. A 40-year-old whose mother and father are overweight
   c. A 10-year old who was recently vaccinated against the mumps
   d. A 20-year old with an autoimmune disorder
5. Which is an **incorrect** statement regarding signs/symptoms in patients with type 1 diabetes?
   a. An imbalance in electrolytes such as sodium and potassium can lead to muscle cramps.
   b. Peripheral neuropathy is typically experienced on one side of the body.
   c. The most common symptoms are polyuria, polydipsia, and polyphagia.
   d. In young children especially, nighttime bed-wetting may be present.

6. Which glucose test is considered a long-term assessment of blood glucose control?
   a. A random plasma glucose test
   b. An oral glucose tolerance test
   c. A fasting plasma glucose test
   d. An A1C test

7. What A1C level indicates a possible diagnosis of diabetes when confirmed by a repeat test?
   a. 5.2%
   b. 5.7%
   c. 6.3%
   d. 7.0%

8. To differentiate between type 1 diabetes and type 2 diabetes, the clinician orders which test in a patient who was recently diagnosed with diabetes?
   a. Testing for the presence of anti-insulin antibodies
   b. A random plasma glucose test
   c. An oral glucose tolerance test
   d. Testing for long-term blood glucose abnormalities

9. Which is **not** one of the core elements of the Chronic Care Model recommended by the American Diabetes Association for improving the quality of diabetes care?
   a. A proactive care delivery system that includes planned visits
   b. Decision support based on evidence-based guidelines
   c. Community resources to support health lifestyles
   d. Payment for service based on improved health outcomes

10. When teaching children about their type 1 diabetes, the clinician:
    a. Reminds them that their parents should choose all their snacks and mealtime foods.
    b. Supports grade-school children to begin taking some responsibility for their own care.
    c. Uses medical terminology when describing the elements of diabetes care.
    d. Knows that by their teen years, children make good decisions about their care despite peer pressure.
11. When teaching patients about dietary planning, the clinician explains that:
   a. One serving of meat is about the size of the palm of the hand or a deck of cards.
   b. According to the Plate Method, grains or other starches should take up about half the plate.
   c. Broccoli and carrots are examples of starchy vegetables.
   d. Avocados should be avoided because they are not considered a heart-healthy fat.

12. Which is a correct statement regarding continuous blood glucose monitoring (CGM)?
   a. CGM tests the blood glucose level every 10 seconds.
   b. CGM has been shown to improve glucose control.
   c. CGM works via a tiny sensor implanted in the pancreas.
   d. CGM sensors must be replaced every one to two months.

13. When educating the patient with type 1 diabetes regarding insulin administration, the clinician explains that:
   a. Inhaled insulin may cause acute bronchospasm.
   b. Reusable insulin pens must be replaced every week.
   c. First-line insulin therapy is typically via oral hypoglycemic agents.
   d. The FDA has retracted approval for the prescription medication Afrezza in the United States.

14. For a diabetes patient who arrives to the emergency department in ketoacidosis and who needs to receive insulin intravenously, which type of insulin is administered?
   a. Lispro insulin
   b. NPH insulin
   c. Levemir insulin
   d. Lantus insulin

15. Which type of insulin is prescribed for a patient who requires an insulin with an onset of between 1 and 2 hours and a peak effect of 4 to 12 hours?
   a. Lispro
   b. Lantus
   c. Regular
   d. NPH
16. When educating a male patient who is an athlete and newly diagnosed with T1DM, the clinician explains that it is essential **not** to exercise if ketones are present in his urine and his blood glucose levels are:
   a. ≥240 mg/dL.
   b. <200 mg/dL.
   c. 150 mg/dL.
   d. 200 mg/dL.

17. Which symptom is **not** typically associated with hyperglycemia?
   a. Increased thirst
   b. Heart palpitations
   c. Blurred vision
   d. Fatigue

18. A 14-year-old female adolescent with type 1 diabetes, who is hospitalized for more frequent hyperglycemic episodes, is diagnosed with diabetic ketoacidosis. During discharge teaching, the nurse notes that the patient reports sometimes skipping her insulin doses at home and the patient appears generally withdrawn and sad. The nurse suspects that the patient’s nonadherence to insulin therapy may be related to:
   a. Anorexia nervosa.
   b. Anxiety.
   c. Recreational drug use.
   d. Depression.

19. Which is a primary acute complication of type 1 diabetes?
   a. Diabetic ketoacidosis
   b. Nephropathy
   c. Pulmonary infection
   d. Hypertension

20. Patients with type 1 diabetes who begin to experience symptoms of hypoglycemia are instructed to:
   a. Eat 15 grams of carbohydrates and check blood glucose again in 15 minutes.
   b. Eat 15 grams of carbohydrates, and if not feeling better in 15 minutes, consume 30 more grams of carbohydrates.
   c. Contact their healthcare provider to ask for guidance before any intervention.
   d. Immediately sit down to rest and drink plenty of water.
21. When teaching patients and families about diabetic ketoacidosis (DKA), the clinician explains that:
   a. DKA occurs when the patient receives too much insulin.
   b. Insulin is administered subcutaneously to treat DKA.
   c. DKA is seldom a life-threatening condition.
   d. The onset of DKA may occur in less than 24 hours.

22. What target blood pressure range does the ADA recommend for a pregnant woman with diabetes and preexisting hypertension?
   a. 120–160/80–105 mmHg
   b. <120/80 mmHg
   c. <140/80 mmHg
   d. 150/100–120 mmHg

23. When educating a patient following foot amputation due to diabetic peripheral neuropathy, the clinician explains that:
   a. Gait training with the prosthetic limb will begin during the postoperative stage of rehabilitation.
   b. Immediate postoperative prosthesis placement (IPOP) is contraindicated.
   c. Scar tissue mobilization around the incision is important to promote optimal scar shape.
   d. Heat and compression may be applied in the management of phantom limb pain.

24. Which is a correct statement regarding potential eye complications due to type 1 diabetes?
   a. The most serious diabetic diseases of the eye begin with problems in the blood vessels.
   b. Patients with T1DM generally do not develop cataracts any earlier than persons without T1DM.
   c. The majority of patients with T1DM eventually develop eye complications leading to blindness.
   d. A yearly eye exam is recommended beginning immediately after diagnosis with T1DM.
25. A 10-year-old boy with type 1 diabetes (T1DM) for one year develops learning and cognitive problems in school. When his parents ask whether this could be caused by his T1DM, the clinician responds:

a. “Yes, learning difficulties can be caused by T1DM due to inadequate blood sugar control.”

b. “Yes, learning-related difficulties associated with T1DM have been linked to the development of high blood pressure.”

c. “No, learning difficulties in those with T1DM are caused by factors unrelated to diabetes.”

d. “No, problems with thinking and learning are not complications associated with T1DM.”